INEQUALITYANDECONOMICMARGINALISATION

Energy-based poverty indicators: Meeting AsgiSA targets

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ABOUT THIS RESEARCH

The 2007 Annual Report of the Accelerated Shared Growth Initiative of South Africa (AsgiSA) identified a need to focus on what was then called 'the second economy', and on mechanisms to ensure shared growth reaches the margins of the economy. The Second Economy Strategy Project was initiated in this context. It reported to the AsgiSA High Level Task Team in the Presidency, but was located outside government in TIPS.

A review of the performance of government programmes targeting the second economy was completed in early 2008. The project then commissioned research and engaged with practitioners and policymakers inside and outside government. A strategic framework and headline strategies arising from this process were approved by Cabinet in January 2009, and form part of the AsgiSA Annual Report tabled on 16 April 2009.

In South Africa, people with access to wealth experience the country as a developed modern economy, while the poorest still struggle to access even the most basic services. In this context of high inequality, the idea that South Africa has 'two economies' can seem intuitively correct, and has informed approaches that assume there is a structural disconnection between the two economies. The research and analysis conducted as part of the Second Economy Strategy Project highlighted instead the extent to which this high inequality is an outcome of common processes, with wealth and poverty in South Africa connected and interdependent in a range of complex ways. The different emphasis in this analysis leads to different strategic outcomes.

Instead of using the analytical prism of 'two economies', the strategy process placed the emphasis on the role of structural inequality in the South African economy, focused on three crucial legacies of history:

- The structure of the economy: its impacts on unemployment and local economic development, including competition issues, small enterprise, the informal sector, value chains and labour markets.
- Spatial inequality: the legacy of the 1913 Land Act, bantustans and apartheid cities, and the impacts of recent policies, looking at rural development, skewed agriculture patterns, and the scope for payment for environmental services to create rural employment.
- Inequality in the development of human capital: including education and health.

TIPS's work around inequality and economic marginalisation is built on the outcomes of this strategy process.

The research undertaken under the auspices of the Second Economy Strategy Project continues to be relevant today as government explores policy options to reduce inequality and bring people out of the margins of the economy. This report forms part of that research.

A list of the research completed is available at the end of this report. Copies are available on the TIPS website: www.tips.org.za.

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INTRODUCTION

Since 1994 the South African government has identified poverty alleviation as a key policy goal. This objective was formulated under the auspices of the Growth, Employment and Redistribution (GEAR) policy which has arguably had limited success (Hassan, 2001). In 2004 the Accelerated and Shared Growth Initiative for South Africa (AsgiSA) was formed to build on previous economic growth initiatives and it set a target of 4.5% mean growth over the 2004-2009 period (AsgiSA, 2007). AsgiSA also has the task of meeting the government's pledged target of halving both unemployment and poverty by 2014 (HSRC, 2008). The Johannesburg Plan of Implementation' (JPOI) adopted at the Johannesburg World Summit on Sustainable Development in 2002 (GSSD, 2006) has set its goals in alignment with AsgiSA. The JPOI was tasked with helping developing countries face the challenges of sustainable development, namely poverty, inequality and environmental degradation (JPOI Response Strategy, 2003). It also, "highlights access to energy as central to facilitating poverty eradication." (Vera, et al., 2005: 156).

The achievement of equity within a generation rather than across generations is an ambitious, but vital component of sustainable development (Hanley, et al., 1997: 425) and Winkler (2006: 9) states that, 'ecological sustainability [can] not be achieved if poverty was not addressed.' Although there is no consensus on how to define sustainable development or on how to apply it, there is general agreement that sustainable development has three broad dimensions – economic, social and environmental (Winkler, 2006: 9). Poverty eradication becomes central to sustainable development policies and developing useful and reliable poverty indicators is part of this process.

The lack of energy provision pervades all aspects of poverty: shelter, food, health and health services, education and security, and many other elements of well-being also rely heavily on energy provision (Pauchari, et al., 2004; Kemmler and Spreng, 2007). And whilst, "low energy consumption is not the cause of poverty...it is an indicator for many of its elements, such as poor education, bad health care, the hardship imposed on women and children" (Goldemberg and Johansson, 1995).

The link between poverty and energy provision seems indisputable as evidence emerges repeatedly from much of the current economic development literature. Amongst others, Toman and Jemelkova (2002) describe, how "…energy availability can augment the productivity of industrial labor in the formal and informal sectors." (Winkler, et al., 2007: 11).

The Millennium Development Goals (MDGs) as laid out in the United Nation's Millennium Declaration echoes the same sentiments. However, despite the strong link between energy provision and poverty eradication the United Nation's Millennium Declaration, does not stipulate specific targets for energy services. Yet it is recognised that "modern energy services are an essential element enabling a country to meet these goals, [although] it has been difficult to establish quantitative causal relationships between energy and progress toward the MDGs." (Modi, et al., 2006: 38)

The International Energy Agency (IEA) highlights that with prosperity comes demand not only for more, but also for better quality energy (IEA, 2004). It asserts that the absolute amount of energy used per capita and the share of modern energy services (especially electricity) are key contributors to human development and the target of halving the number of people living on less than $1 a day by 2015 is unlikely to be achieved unless access to electricity can be provided to another half-a-billion people. IEA maintains that developing countries need to improve the availability and affordability of commercial energy to especially rural communities in order to alleviate energy poverty and human underdevelopment.

There are a number of reasons for considering commercial energy. Unless the use of natural resources for energy purposes is monitored and curtailed, "there is danger of these resources getting rapidly depleted leading to grave long term consequences" WWF (2003: 2).

Another important aspect regarding the relationship between energy use and poverty is that the real per unit costs of alternative fuels used by poorer households are higher relative to those used in wealthier households that are linked to the national grid (Brook & Besant-Jones, 2000: 2). Collecting fuel wood generates high opportunity costs through lost education, the high toll on the environment and the health of the poor. "Energy services such as lighting, cooking, refrigeration, and power for electronics and motive force are provided most cheaply and conveniently, and with the least local pollution, when they are derived from electricity or gas delivered through networks. Moving from traditional to modern fuels can thus dramatically raise the effective incomes of low-income households." (Brook & Besant-Jones, 2000: 3).

South Africa faces similar challenges to many developing countries and given that poverty alleviation is one of the most pressing goals for South Africa, the link between poverty and energy use must be made clearly. Indeed, attention to energy provision, not just in rural communities but also in poverty stricken urban areas is paramount (Parnell, 2004) and results below demonstrate this. Clear and reliable indicators of energy-poverty will facilitate the formulation of energy provision strategies.

In section one we review the current state of poverty measurement in South Africa and the extent to which the authorities acknowledge (or not) the importance of energy provision as a poverty alleviation strategy. This includes examining trends in social development and some notable South African studies on poverty and poverty alleviation. Section two attempts to define good poverty indicators and to pose energy based poverty indicators against these criteria. Section three identifies some of the weaknesses of current money-metric indicators of poverty and examines the case in favour of using energy-based indicators, not necessarily as a replacement but as a complement to current usage and research. Section four outlines our methodology, and section five presents our results.

POVERTY IN SOUTH AFRICA: MEASURES AND TRENDS

AsgiSA is a South African initiative, set up to meet international targets such as those included in the Millennium Development Goals and JPOI, and needs to find alignment between poverty and provision targets. Yet AsgiSA does not make any explicit links between poverty eradication and energy provision.

In a context where "energy is the life-blood of development" (DME, 1998: 4) and where Prasad (2006: 61) in his discussion of South Africa, notes, "access to electricity is generally seen as an important step in socio-economic development" and "lack of access to electricity makes fighting poverty more difficult, as it hampers individual efforts to advance social and economic development goals", it becomes necessary to analyse what large-scale energy provision would entail, especially in rural areas (Nkomo, 2006: 84). Indeed, "without the opportunity for all citizens to participate in the mainstream energy economy, our national and personal development is limited. In this area we need to explicitly address the previously disadvantaged and especially the circumstances of the rural poor" (DME, 1998: 4).

The Department of Minerals and Energy (DME) aims to create universal access to energy by 2014 that is affordable and reliable. Whilst the focus of the DME is not just on electrification, it still forms a large part of its short-term strategy since, “without access to electricity – a clean, convenient and desirable fuel – human development is ultimately constrained” (DME, 1998: 48). Consequently, it commits to “universal household access to electricity” (DME, 1998: 48), cognisant of the notion that access to all fuels is important when accessing the full ‘energisation’ process thereby “widening access to a safe and effective energy package within grasp of the low-income consumer” (DME, 2001: 2).

Hence the short-term goals of the DME are designed to improve the delivery of household energy services, including electrification and to facilitate the production and management of woodlands for rural households (DME, 1998: 27). More medium-term targets include stimulating the development of new and renewable sources of energy and promote improved combustion techniques and appliances for fuel wood and other traditional fuels (DME, 1998).

The achievement of energy related development goals is hampered by the fact that South Africa has no formal or universally applied poverty line (UCT, 2008) or poverty indicator (Studies in Poverty and Inequality Institute, 2007). Generally there are three poverty measures applied within the South African context: the headcount index, the poverty gap index and the squared poverty gap index; together these make up money-metric based measures of poverty (UCT, 2008). The Headcount index measures the composition of individuals who live below a specified poverty line. The poverty gap index determines an average of the total gaps between the standard of living of poor people and the poverty line, while the squared poverty gap index represents a “weighted sum of poverty gaps (as a proportion of the poverty line)” (UCT, 2008).

The Mid-Term Review (2007) produced by the South African government discusses the headcount index, the poverty gap index and the squared poverty gap index as follows: the headcount index measures the number of people living below a poverty line of R3 000 per capita per annum (in 2000 constant Rand)” (Mid-Term Review, 2007: 25). In 2006 this headcount index was given a value of 43.2%, which represents the lowest this index has been throughout the post-apartheid era (Mid-Term Review, 2007: 25).

Leibbrandt, et al., (2005) conducted a South African study to analyse the changes in inequality and poverty between 1996 and 2001 using access-based measures like the type of dwelling and access to basic services such as energy. These measures were compared to the income based ‘headcount’ measure of poverty[1] which showed that poverty had worsened over time yet the access-based measures indicated an improvement, especially with regard to access to electricity for lighting (Leibbrandt, et al., 2005). This discrepancy has given rise to the need for further investigation.

In a more recent study, van der Berg, et al., (2007) finds that although poverty increased in the late 90’s, from 2001 to 2006 it decreased to a large extent. The findings relating to money-metric poverty and access-based measures show a noticeable difference from the results of the 1996 to 2001 study conducted by Leibbrandt, et al. (2005). Van der Berg, et al. (2007) conclude that from 2000, asset poverty decreased in terms of access to basic services, as well as in terms of money-metric poverty. This may have been due to the expansion of expenditure on social grants, an increase in real remuneration and increased possibilities for job creation. The findings of Meth (2006) and Aguero, et al. (2005) are largely consistent with these conclusions.

Whilst income levels are an obvious and well intentioned measure of poverty, it is problematic because a poverty measure in one dimension only is potentially misleading and

[1] Using $2 and R250 per day as a lower and upper poverty line respectively

contradictory evidence regarding poverty levels is likely to emerge. Analysts must consider more than one measure to gain insight into the true extent, nature and severity of poverty. "While poverty was originally measured exclusively in monetary terms and in terms of income, its conceptualisation and measurement has been extended to encompass the ability of individuals and households to effectively meet their basic needs" (Oosthuizen, 2008:2). Before we look at an energy-based measure of poverty we need a better understanding of the weaknesses of current practice. It is best to begin with an idea of what constitutes a reliable and accurate poverty indicator

FEATURES OF A GOOD POVERTY INDICATOR

Kanjee and Dobie (2003: 31) highlight four important factors which should be considered in the selection or formulation of an indicator:

- the scope of the report for which it will be employed,
- the reason why the indicator is required,
- whether the data required for the indicator is readily available and reliable
- at what institutional level the indicator is required

Atkinson, et al. (2002) state that there are six basic principles that should be applied to any indicator. These include:

- clarity and lack of ambiguity
- robustness and validation
- policy responsiveness (and lack of manipulation)
- comparability (across samples) and consistency (with established international standards)
- timeliness (but subject to revision)
- avoidance of unnecessary information

Many of the above-mentioned criteria are not controversial and are largely shared by others (notably Prennushi, et al., 2001) yet we might argue that much of the expenditure-based poverty indicators used in the literature do not possess all of the features despite claiming best practice. In short, a good poverty indicator is not one that solely relies on income and expenditure.

Energy-based poverty indicators may be quite successful in meeting the above criteria. These indicators provide an objective measure of human quality of life, using physical units that unambiguously measure energy use, which as we have already seen is strongly associated with the poverty evaluation process. Furthermore, measures of energy are constant regardless of variations in other variables, implying that the accuracy of energy poverty indicators is unchanging over time and as such these tools remain largely applicable across sample groups allowing increased reliability given changes in policies or review procedures. Moreover, when assessing policy, objectivity of the indicators limits the amount by which it is possible to manipulate the results. Finally, the cost-effectiveness of energy-poverty indicators should not vary much from that of other indicators, as the method of obtaining data is identical.

As can be seen, energy poverty indicators comply with all the important requirements of a "good" indicator and can therefore at least be placed on a par with other conventional indicators. Nevertheless, the onus remains on the researcher to ensure that the lead indicators used in any research constitute the optimal set in that particular context.

According to Shorrocks (1995: 1225), Sen states that a good poverty measure must have two basic features: the monotonicity axiom,2 and the transfer axiom3. The headcount measure lacks both requirements, while the poverty gap index fails to meet the transfer axiom.

Much of the research on poverty requires accurate income or expenditure data and the quality of this type of information in surveys is somewhat questionable and Bhorat , et al. (2004) suggest that another, less problematic approach would be to use asset-based indicators. These could be useful in providing insight into standards of living of various households and make use of durables owned and other household characteristics.

Leibbrandt, et al. (2005: 5), explored poverty and inequality in both the 1996 and 2001 Census survey data sets, and states the, "income-based approach presents only one of many dimensions to the measurement of wellbeing in South Africa. The narrowness and limitations of this approach are revealed when we show that, over the same 1996/2001 period, there have been important improvements in access to basic goods and services for many households."

Studies in Poverty and Inequality Institute (2007: 31) quote Statistics South Africa (2000: 54) suggesting that poverty should be perceived, "…in a broader perspective than merely the extent of low income or low expenditure in the country. It is seen here as the denial of opportunities and choices most basic to human development to lead a long, healthy, creative life and to enjoy a decent standard of living, freedom, dignity, self-esteem and respect from others."

In sum, there are various problems with using conventional poverty indicators as the sole measure of poverty. This paper certainly does not reject the use of conventional poverty indicators for research purposes but it does find that there are significant gaps. These gaps could be filled with other poverty indicators, complementary to current indicators, and not as substitutes. Below we explore the case for using energy-based poverty indicators in South Africa, as an addition to others.

THE CASE FOR ENERGY-POVERTY INDICATORS

According to Kemmler and Spreng (2007: 2), the use of energy indicators has previously been limited to environmental and economic issues. However, the IAEA presents a core set of energy indicators which constitute the Energy Indicators for Sustainable Development (EISD), which does include a few indicators in the social dimension (IAEA, 2005: 11). In addition, the World Bank (2000: 39) put forward a summary of proposed welfare energy indicators as early as April 2000. These indicators discussed below.

Considering that the many of the most important issues of sustainability relate to the production and use of energy, it would seem logical that the use of energy indicators be extended to the measurement of social development. The IEA (2004: 334) affirms this link between poverty and energy use, by uncovering a strong link between per capita energy consumption and the values of Historically Disadvantaged Individuals (HDI). This applies

[2] "Monotonicity requires that, given other things, a reduction in income o a person below the poverty line must increase the poverty measure. A measure with this property reflects changes that, despite leaving the number of the poor unchanged, cause a rise in the shortfall from the poverty line" from Poverty: an International Glossary (2007) (ed) Spicker P, Alvarez Leguizamo S and Gordon D

[3] "Axiom of transfers requires that, all things being equal, a pure transfer from a person below the poverty line to anyone who is richer, must increase the poverty measure. This property makes a measure sensitive to the distribution of income between the poor" from Poverty: an International Glossary (2007) (ed) Spicker P, Alvarez Leguizamo S and Gordon D

especially to countries that do not belong to Organisation for Economic Cooperation and Development (OECD), in the case of commercial energy. Suaréz (1995: 1) shows how HDI values improve significantly as energy consumption rises above zero until a certain level of consumption equivalent to approximately 1000 kilograms of oil per capita is reached. This illustrates how an increase in quality of life can be associated with an increase in useful energy consumption.

The proposal to use energy-based poverty indicators as a complement to standard economic measures, in measuring the performance of AsgiSA, is based on the premise that an energy dimension to poverty exists. However, the concept of using energy-based indicators of poverty is relatively new and there is no extant literature for South Africa.

None of the UN indices (including the Human Development Index or the Human Poverty Index) explicitly takes energy use into account (IEA, 2004: 331). However, policy relevant indicators could be usefully adopted, to help improve the statistical foundation for international household energy policy, if we could provide basic information on rates of household electrification and the use of modern cooking fuels (Heltberg, 2003).

Such data is not difficult to acquire and may already be available in household data sets for many countries. It may be appropriate to implement and publish quantitative development targets in the field of household energy. Key indicators, in the field of household energy could include the rate of household electrification (share of households with electric light) and household consumption of modern cooking fuels. These indicators would be feasible to measure and to adopt as a quantitative development targets alongside other targets (Heltberg, 2003: 60).

The IEA identifies three key indicators of energy use in developing countries: per capita energy consumption, the share of modern energy services in total energy use, and the share of the population with access to electricity in their homes (IEA, 2004: 334). Kemmler and Spreng (2007) note that the choice of energy indicator to be used within a strong set of lead indicators is important as different indicators will fare worse in measuring social dimensions than others, due to the implied method of measurement according to physical units, and that the if all three indicators are employed, a relatively complete picture of energy use will emerge.

In considering commercial energy alone, the IEA (2004) draws a strong link between per capita energy consumption and HDI values (specifically in non-OECD countries). There appears to be a strong case for extending the use of energy indicators to the social sphere, despite the fact that limitations exist in the process of measuring social dimensions.

Three distinct approaches have been used to measure energy poverty: economics-based approaches, engineering-based approaches, and access-based approaches (Pachauri, 2004: 4). The first two approaches are based on expenditure on and consumption of energy and the latter on access to energy. Therefore, no unanimous definition of energy poverty exists. However, an acceptable working definition may be the same one that is used for poverty in general, namely the establishment of a poverty line. This poverty line ought to be directly related to one of the three approaches mentioned above. For example, if levels of household energy consumption lie below a predetermined level, then these households may be classified as energy-impoverished. The same method can be employed using expenditure or access-based approaches.

The IAEA (2005: 11) divides energy patterns according to accessibility, affordability and quality and presents a core set of indicators (The Energy Indicators for Sustainable Development) which includes indicators in the social dimension, but singles out “Health” as a separate category. This is to track the safety levels of different energy sources. The World Bank (2000: 39) groups the indicators they propose under three different headings: basic needs, monetary and non-monetary. Examples of energy-poverty indicators from the above sources include:

- share of household income spent on fuel and electricity
- average total cost per effective unit of energy,
- exposure rates to indoor air pollutants

Pachauri, et al. (2004) described energy poverty according to not only the quantity of energy used, but also the access to different sources of energy; access being defined as a household's ability to consume fuel. They calculated basic energy needs for the average Indian household by estimating the energy services needed (such as lighting, cooking refrigeration etc.) and then estimated energy requirements from engineering data. They classified households into three levels based on access to different energy sources: (1) using traditional fuels only – such kerosene and biomass; (2) using traditional fuels, as well as electricity and, (3) using traditional fuels, electricity and liquefied petroleum gas (LPG). They stressed the importance of using non-commercial energy as it "avoids the mistake of disregarding well-being accrued from self-production and barter economy. This is often neglected by income-based measures alone" (Pachauri, 2004: 2099). Based on the above classification, it was possible to create an energy access-consumption matrix to measure poverty levels by separating households into three access levels and usage patterns according to a scale of useful energy Watts per capita.

In general they found that "access to higher quality energy sources was clearly associated with much higher expenditure levels and improved living standards" and "the provision and use of energy services may be an important driver of overall development. In particular, the provision of better energy services is clearly associated with significant economic and social benefits for those who are most deprived" Pachauri, et al. (2004: 2100).

What is important to note at this stage is that not all sources of energy have lifecycles that are equally damaging to the environment. As indicated by Saghir (2005: 1), traditional sources of energy are generally associated with high levels of pollution, and lower levels of efficiency as a result of 'fugitive processes'. Modern sources of energy on the other hand generate significantly lower levels of pollution, and renewable sources close to none. Therefore, in the relationship between energy and the environment, it is imperative to understand that the provision of modern sources of energy to the poor can assist not only in the aim of alleviating poverty, but can also help to alleviate the burden on the environment.

In a similar study that focuses more on providing energy-based sustainable development indicators, Kemmler and Spreng (2007), also using the Indian household survey data, assess whether energy-poverty patterns as revealed by the indicators, are viable as sustainable development indicators. They set out the 'energy framework' and we use the same framework below as part of our methodology (see section 5).

From a given stock of natural capital we can begin with the 'primary' stage of the energy framework where energy, embodied in natural resources (renewable and non-renewable sets), is generated for households and industry alike, including transport. From this stage we move to 'end-use' and as the term implies it is energy being carried to the point of use, i.e. the home or factory. At this stage it is important to take note of the different fuels that may be used, especially by households (dung, wood, LPG, electricity, etc.) for lighting, cooking and heating. When each household or factory consumes the energy, the last stage is reached, called 'useful energy'[4], that is, the energy derived from different consumption activities.

The simple domestic task of cooking a meal or lighting a room may be performed by various energy fuel types each having different energy efficiencies. For example, and following some of the figures we use later, suppose we have a primary energy value of 150watts[5]. This converts to an end-use value (in terms of electricity) of 40watts because energy is lost (entropically and through pollution) in the process of converting from one form to another. From the 40watts arriving at say a household, the amount of 'useful energy' for cooking is 26watts[6]. Again, energy is lost. Conversion factors were used by Kemmler and Spreng (2007) to account for these losses and allowed them to derive a useful energy measure. Our conversion ratios to derive the useful energy indicators are shown in table 2 (see p 15).

The Kemmler and Spreng (2007) methodology was akin to the matrix used in Pachauri, et al. (2004) but Kemmler and Spreng omitted households that used dung as a main fuel and incorporated the access dimension into the measurement of the variable. As an alternative they used the same three levels of energy use, i.e., traditional fuels only, traditional fuels with electricity but no LPG and lastly an 'all fuels' category as used by Pachauri, et al. (2004) detailed above. Each category was arbitrarily assigned a weight (one for the lowest category of biomass and kerosene only and three for the 'all fuels' category). This weighting was based on the idea that the useful energy in the third category is three times higher than the first and so on. This gave them an access-adjusted useful energy measure and a similar weighting was carried out on the South African data below.

The three measures of energy-poverty, (primary, useful, and access-adjusted useful energy) were analysed by correlations and decile analysis using information on monetary expenditures and physical quantities of fuel consumption. With respect to the correlation analysis, a good indicator was regarded as one that was characterised by a close relationship between the indicator and the represented dimension (Kemmler and Spreng, 2007), and as such the correlation coefficients (R^2) between the three energy sources and the listed poverty measures were estimated.

Decile analysis was employed due to the difficulty of interpreting correlation coefficients. Decile groups were formed and characterised for each of the three energy measures and in terms of the analysis, a good indicator was one which revealed pronounced differences between the deciles (Kemmler and Spreng, 2007). If one of the energy measures showed high correlation coefficients and distinct deciles were revealed, the given energy measure was regarded to have significance for poverty measurements and was seen as useful for the construction of a poverty indicator.

Kemmler and Spreng (2007) found that the 'access-adjusted useful energy measure' had a stronger correlation than useful energy, which in turn had a stronger correlation than primary energy. They noted that access-adjusted energy gave the highest correlation with the more conventional expenditure based poverty indicators, thereby giving credence to the energy-based measure. The access-adjusted energy measure also correlated well with other variables that signal poverty, notably education, sanitation and size of the home. As such there was compelling evidence to support the use of energy in terms of type used and access, as a basis for a reliable and informative poverty indicator.

[4] The energy described here is not 'consumed' as such, but the nature and usefulness of the energy changes. (Kemmler and Spreng, 2007).

[5] 0.5kg of coal required to produce 1Kw/h of electricity & 27GJ/tonne of coal (Eskom, 2005).

[6] There is a 65% efficiency conversion factor for electricity applied to cooking (Winkler, 2006).

The Leibbrandt study, et al. (2005) mentioned above, found that, in South Africa, access based measures of poverty had improved which contradicted the more money-metric indicators of poverty. The study further noted that when considering energy for cooking, there was yet another dimension to consider beyond affordability and availability and that was effectiveness. The usage of electricity for cooking had shown far less rapid increases than that experienced for lighting purposes. This may be attributable to the fact that the demands on energy sources for the purpose of lighting are significantly lower than those for cooking. This result is clearly shown by the fact that nationally, by 2001, 69.5% of households' used electricity for lighting (Leibbrandt, et al., 2005: 26), but only 50.6% of households' used electricity for cooking (Leibbrandt, et al., 2005: 28). As mentioned, usage of electricity for cooking had increased from 1996 to 2001, but at a much slower rate than the increase in usage of electricity for lighting. In 2001 according to racial demographics, only 38.6% of African households used electricity for cooking purposes. Leibbrandt, et al. (2005: 28) states "of our indicators examined thus far, it appears that fuel used for cooking is most closely linked to income status."

Leibbrandt, et al. (2005: 36) concludes by mentioning that "poorer access tends to be found in the poorest income quintiles," but there is still the concern that income measures display a worsening of poverty while access had improved over the period. Leibbrandt, et al. (2005: 36) completes the analysis by suggesting, "there is an optimistic lack of correspondence between the slight increase in poverty when measured in income terms and the decrease in poverty when measured in access terms."

FEATURES OF A GOOD POVERTY INDICATOR

Dataset

The data are drawn from the 2005/6 Income and Expenditure Survey (IES), a nationally-representative household survey of 24 000 dwelling units, conducted by Statistics South Africa between September 2005 and August 2006. Each household was interviewed using a detailed questionnaire, and was required to keep a diary for a month in which the acquisition of all goods was recorded. 22 600 households were interviewed, and 21 000 households completed the survey fully. The IES is conducted every five years, thus this dataset is the most recent nationally representative household survey in which detailed expenditure data were collected.

In terms of energy data, the survey records spending by the household on the following energy types: Electricity (pre-paid, post-paid, value of free electricity used); gas; paraffin; petrol for household use (not transport); diesel for household use (not transport); firewood (bought and fetched); charcoal; candles; coal; dung (bought and fetched); crop waste; fuel for generators, lawnmowers, heating, etc.

The variables

The following variables (the list is not exhaustive) were created for the analysis allowing a comparison of the energy poverty measure with other socio-economic variables: (All prices and expenditures were for March 2006):

- Total household consumption expenditure, including in-kind consumption per capita;
- the value of all energy acquired by the household, including free electricity per capita;
- the quantity of all energy acquired by the household (in GJ), including free electricity per capita;
- the value of the household's dwelling unit;

- the number of years of education completed by the household head;
- the number of rooms in the dwelling;
- sanitation;
- access to infrastructural services e.g., street lighting; ownership status of main dwelling unit;
- type of structure of the main dwelling unit;
- a measure of material wellbeing, in terms of ownership or access to various goods

Limited data were available for the main energy source used for cooking, lighting and heating. Following Kemmler and Spreng (2007) and Winkler (2006) three categories of energy were created: traditional, transitional and modern. Traditional consists of the non-commercial sources such as dung, wood, biomass (crop waste) and candles. Transitional includes the commercial fuels such as charcoal, coal, paraffin (kerosene) and LPG. Modern includes electricity from mains and generators, solar power and biofuels. All expenditure and energy use values are in annual terms.

The indicators of household energy use (both in terms of monetary value and physical quantity) exclude fuel used for transport and solar power. Fuel for transport is only recorded as a separate diary entry for private transport purposes; when public transport is used, there is no way to distinguish spending on fuel from the other running costs of public transport. Spending on solar power is recorded as part of the diary entry on improvements, additions and alterations to the dwelling, but there is no way to separate spending on solar power from other household improvements.

Some households reported their total spending on water and electricity, but were not able to report separate expenditures for these two categories. In such cases, a value for electricity expenditure was imputed using the average ratio of electricity to water expenditure for households that reported the two quantities separately. A small proportion of households did not report any expenditure on energy. This may have arisen due to stockpiling, in which a household had a store of fuel sources and did not purchase any energy during the month in which the diary was administered. It does not imply that the household did not consume any energy, since the diary recorded the acquisition rather than the use of goods and services. The analysis in this study was conducted conditional on a household having acquired some form of energy during the survey period and households with missing values for the other poverty indicators used in the correlation analysis were omitted. Thus the sample that was analysed consisted of 18 500 households, which represents 10.4 million South African households. All of the results presented in this study are extended to serve as estimates for the South African population[7].

The survey did not record the quantity of energy acquired, but rather the spending on energy. A variable for the quantity of all energy acquired by the household (end-use energy) was thus created by converting the expenditure figures into energy quantities (in gigajoules) using various sources which report Rand-to-energy intensity conversion factors. These conversion factors are shown in table 1 below. Since there are no recorded expenditures on running costs for solar power, it is not possible to compute an energy use value for solar power. Furthermore, all end-use energy prices were converted to 2006 prices using the consumer price index, the same year as our captured expenditure data.

[7] Each household in the dataset has an assigned sampling weight, which is the inverse of the probability of that household being selected into the sample. Thus each sampled household 'represents' a number of households in the South African population. The higher the weight, the more households from the population a sampled household represents.

Table 1: End-use energy Prices: South Africa

	2001 R/GJ	Comment Shadow Prices	Source
Traditional			
Dung	0.00 to 30.00		Winkler(2006)
Wood	0.00 to 33.33		DeVilliers&Matibe(2000)
Candles	70.30		Winkler(2006)
bagasse (bio mass)	0.00 to 28.24		DeVilliers&Matibe(2000)
Transitional			
Charcoal	0.00 to 33.33	as per wood	DeVilliers&Matibe(2000)
Coal	3.45 to 3.50	domestic use	DME(2002) to Winkler(2006)
paraffin (kerosene),	80.50 to 96.90		DME(2001) to Winkler(2006)
LPG	124.40 to 149.40		DME(2001) to Winkler(2006)
Petrol	50.30		DME(2001)
Diesel	44.90		DME(2001)
Modern			
Electricity	44.60 to 105.10	residential	NER(2001) to Winkler(2006)
electricity generator	41.40 to 105.10	proxied by agric price	DME(2001)
Solar	536.15	"@193c/kWh"	Spalding-Fecher(2002)

As a second step, from the quantity data generated by using the prices in table 1, a useful energy indicator was created using efficiency conversion figures as described earlier and these are shown in table 2.

Table 2: Fuel types by energy efficiencies

	Energy efficiency[1] (%)	Comment
Traditional:		
dung,	25	as per wood
wood,	25	
candles,	5	
bagasse (biomass)	25	as per wood
Transitional:		
Charcoal	25	as per wood
coal,	13	
paraffin (kerosene),	42	
LPG,	55	
petrol,	42	as per paraffin
diesel,	42	as per paraffin
Modern:		
Electricity	65	
electricity generator	65	

Solar	100

1. Fuel source conversion factors are for end-use energy sources as applied to cooking ("useful energy") except in the case of candles which is as applied to lighting.

Source: Winkler (2006: 127)

Lastly, the access-adjusted useful energy measure was generated by summing the household's useful energy acquired across all fuel types, but applying a weighting of two to fuel types in the 'transitional' category and a weighting of three to fuel types in the 'modern' category. This closely resembles the approach taken by Kemmler and Spreng (2007: 2474).

On the basis of this methodology, the report presents descriptive statistics on South African households' access to modern, affordable energy, and the correlations between different poverty indicators and the energy measures described above. Quintile analysis was also used to complement and compare the correlations.

As a last step we conducted comprehensive sensitivity analysis focusing on the assumptions underlying the creation of the end-use and useful-energy measures, and we report on how such assumptions impact on the findings.

RESULTS

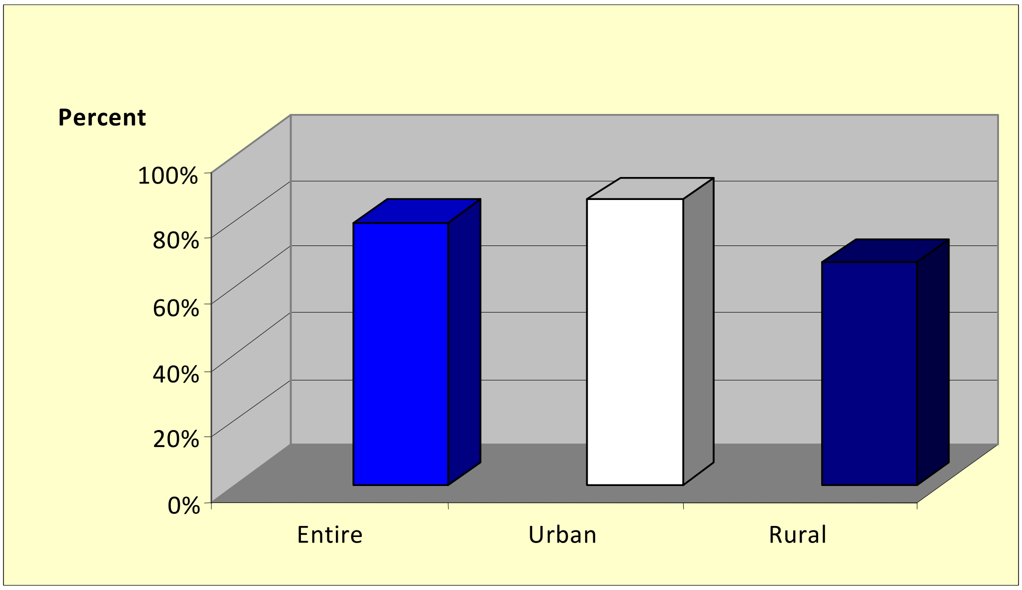
Firstly, the results present descriptive statistics based upon the principles of access to electricity and solid/non-solid fuels. This includes a breakdown of the access to our different fuel categories, traditional, transitional and modern (i.e. access to the different quality of fuels used).

Access indicators

Electricity access

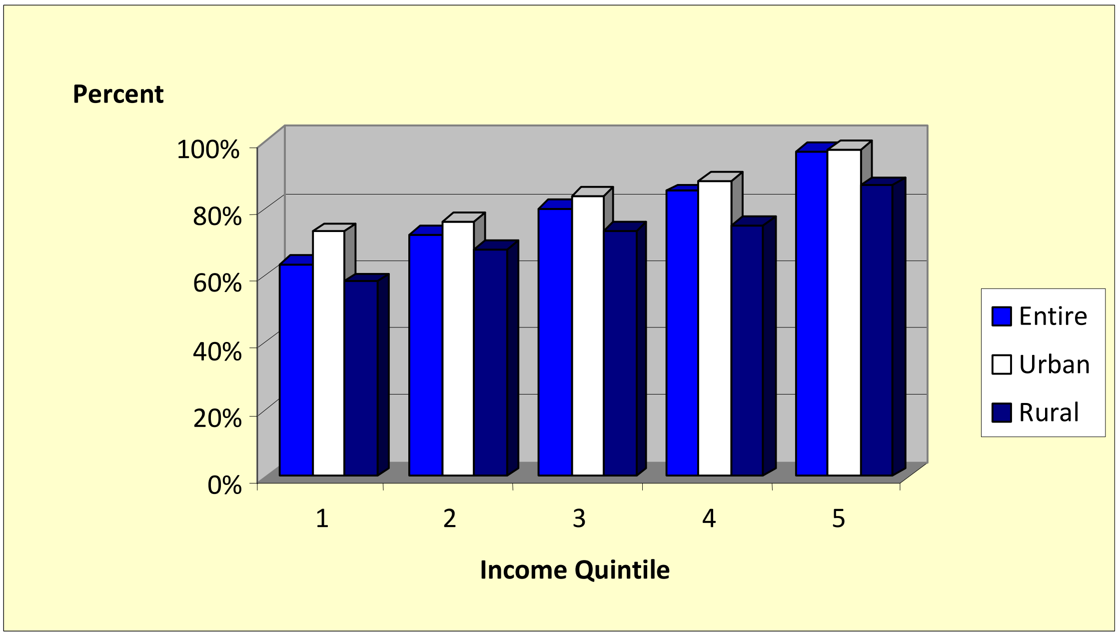
As can be seen from Figure 1 below, 79% of households have a connection to the main electricity grid and this connection rate rises. Figure 2 shows that connection rates are higher in urban than in rural areas at all quintiles which is largely to be expected.

Figure 1: National electricity access



Source: Own Calculations

Figure 2: National electricity access

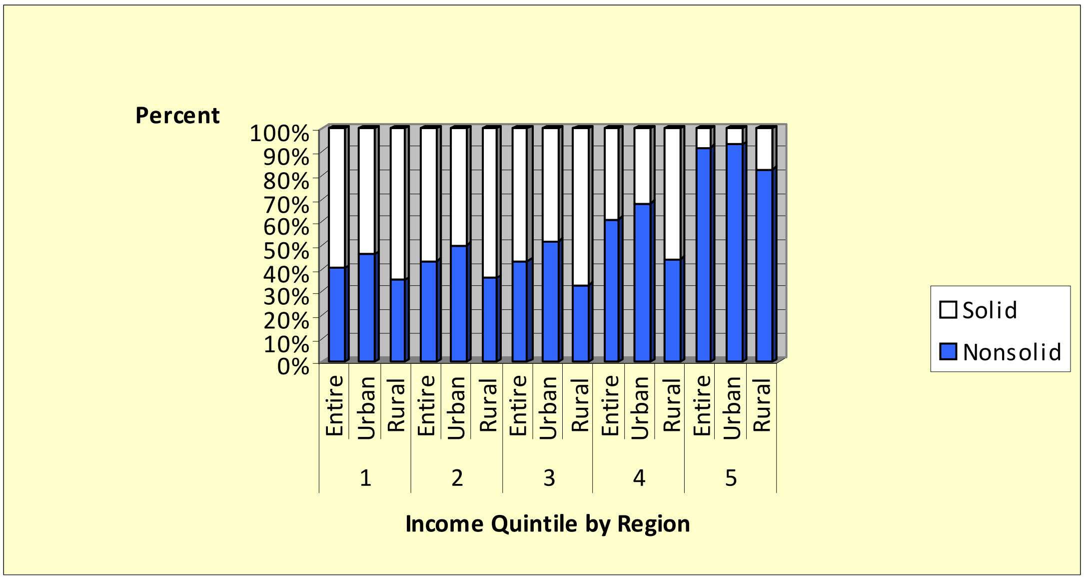


Source: Own Calculations

Solid/non-solid fuels access

Figure 3 below shows that as quintile rises, an increasing proportion of household energy use comes from non-solid fuels, and a decreasing proportion from solid fuels. At every quintile, solid fuel use is higher in rural than in urban areas.

Figure 3: Household access to solid and non-solid fuel

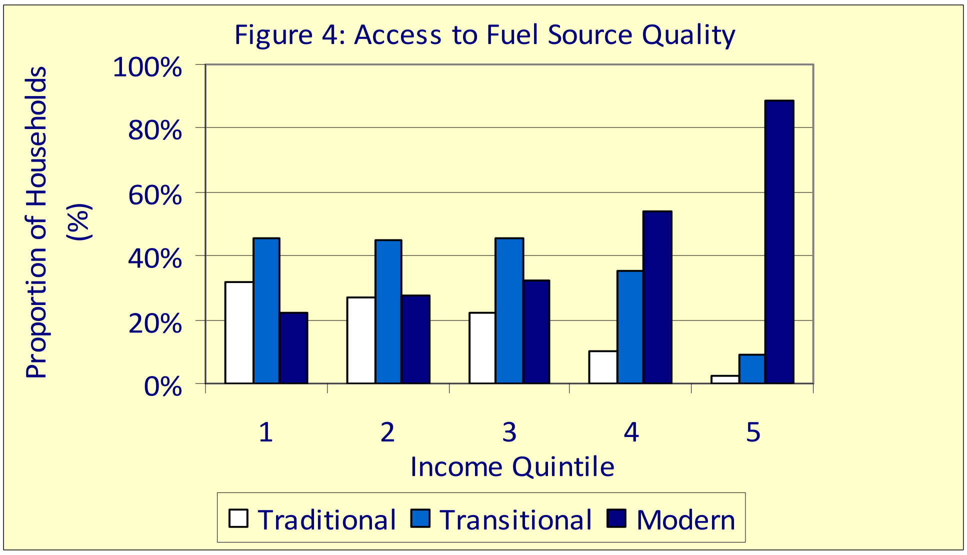


Source: Own Calculations

Quality of fuels access

Figure 4 looks at the trend of the three categories of fuel type described above. As the quintile rises, an increasing proportion of household energy use comes from modern sources, and a decreasing proportion from traditional sources. The transition from traditional to modern energy sources is more pronounced in urban than in rural areas and can be seen in the appendix (Figure 4a and 4b).

Figure4: Access to fuel source quality



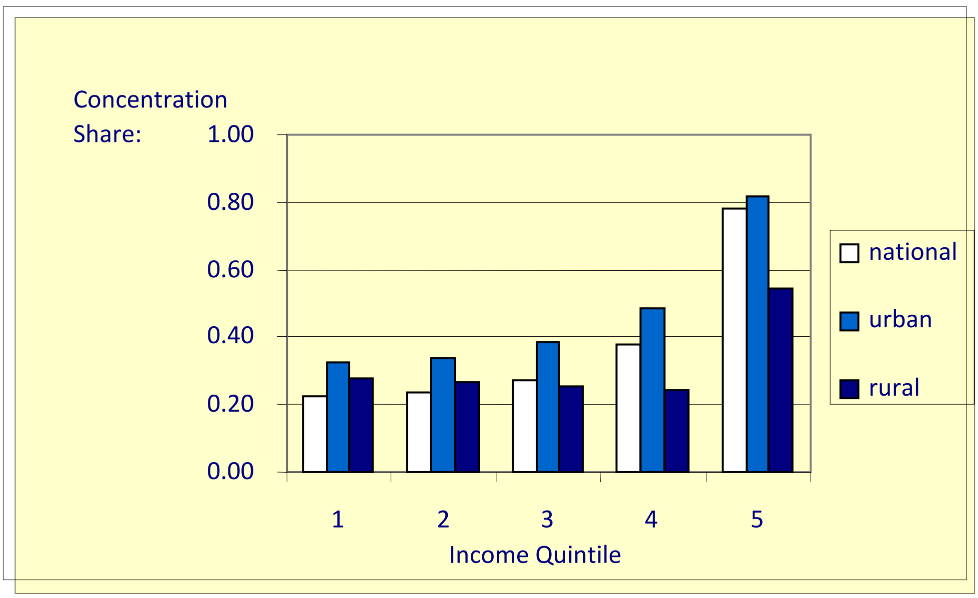
Source: Own Calculations

Concentration indicators

Energy consumption concentration measures the extent of diversity of energy use. A value of 1 indicates all energy is obtained from one source, while lower values indicate that multiple energy sources are used. The share in percentages has been calculated for end-use energy, shown in figure 5.

The energy consumption concentration index rises overall by quintile and rises steadily amongst urban households, namely from 0.33 to 0.82 in quintiles 1 to 5. This shows us that energy use becomes more concentrated to a single fuel source as households become wealthier. The concentration results for rural households, falls from 0.28 to 0.24 in quintiles 1 to 4, then rises to 0.54 in quintile 5 showing that energy use first diversifies into multiple fuel sources, and then becomes more concentrated. There is a clear difference between the concentration ratio trends between rural and urban as households get wealthier. This is not surprising as urban areas have easier access to electricity infrastructure.

Figure 5: Diversity of energy use – Households



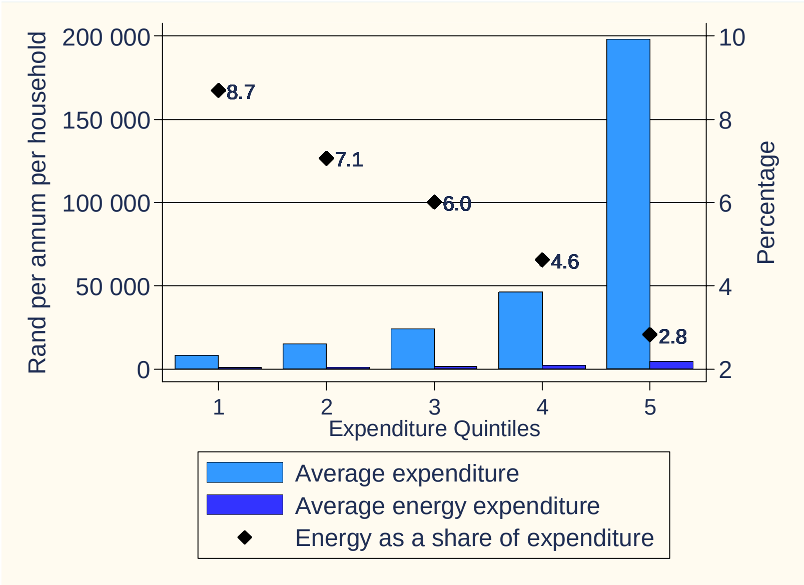
Source: Own Calculations

Affordability and Disparity indicators

Affordability

Figure 6 shows average per annum expenditure and energy expenditures for the five levels of income (bars) and the share of expenditure devoted to fuels (diamonds). It becomes clear that those on a lower income spend a much higher proportion of it on energy. This indicates that energy costs are critical when it comes to meeting basic needs. Rising energy costs will divert expenditures away from other vital services such as education.

Figure5: Average expenditure and fuel expenditure by quantile



Source: own calculations

Disparities in household energy use (per capita)

Measured in gigajoules, energy use per capita rises with income and is clearly seen as a trend in figure 7. This energy use is higher in urban than rural areas at quintiles 1 and 2 but then the trend switches for quintiles 3-5. The last quintile presents with the largest increase in use for both rural and urban areas.

Figure 6: Household energy use (per capita)

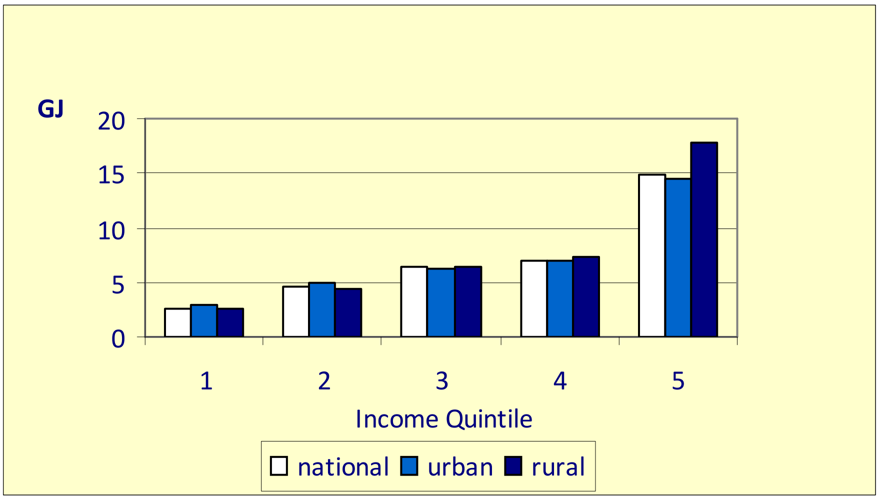
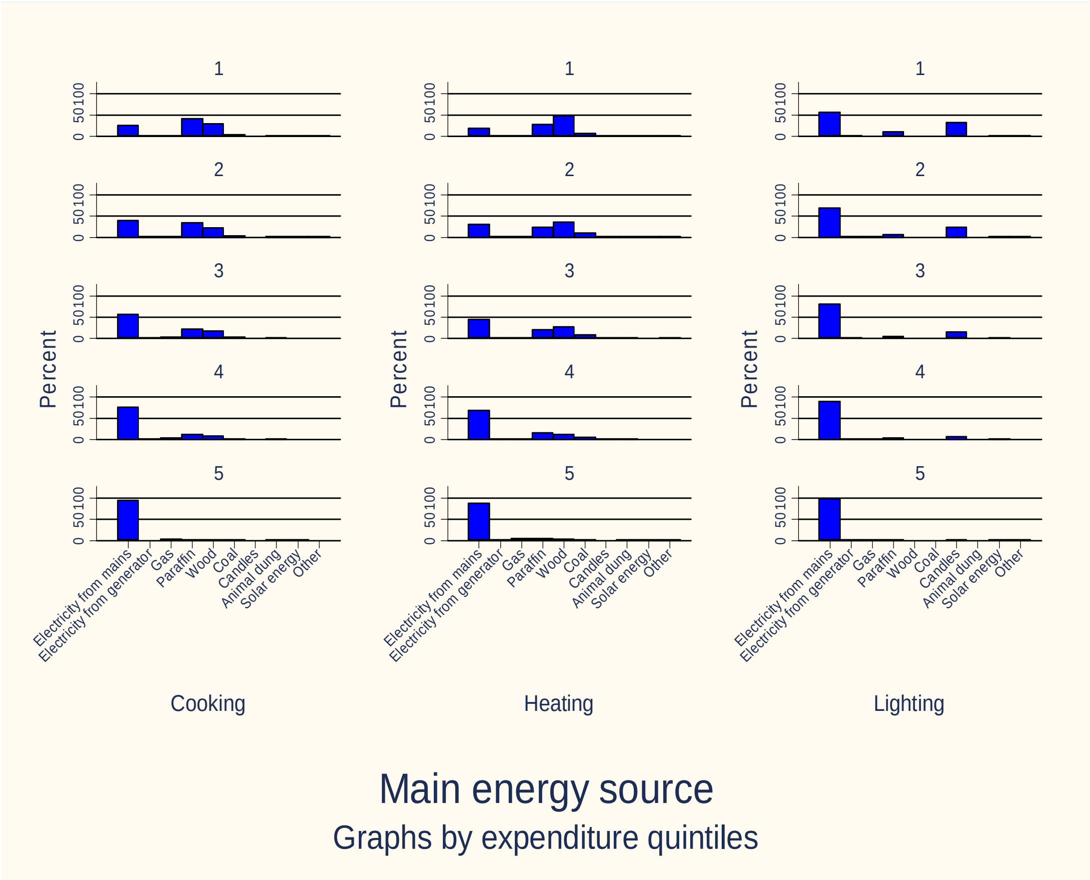


Figure 8 extracts the percentage expenditures on energy by different fuel types and fuel use across the five quintiles. Figure 8 shows which income group uses which fuel as their main source for cooking, heating and lighting.

Figure 7: Percentage of income spent on the 'main' fuel used for cooking, heating and lighting by quintile



Source: own calculations

Correlations towards access adjusted affordability

Spearman correlation coefficients, which measure the strength of the relationships between ordinal variables, were calculated for the different poverty indicators and energy measures. The national results are shown in figure 9 with the actual correlations shown in table 3. All correlations are significantly different from 0 at better than a 1% significance level. (Separate results for urban and rural areas are shown in figures 9a and 9b respectively of the appendix.)

Total household expenditure correlates fairly strongly with all other poverty indicators except house ownership. This is likely because it is not possible to distinguish between a wealthy household that has fully paid off their expensive bond against a poor household who has no bond either because the house was inherited or built by themselves from basic materials. Households in these cases would record the same ownership response in the survey, but was included in the results for completeness and comparative purposes.

The energy indicator that best correlates with all of the poverty measures is access-adjusted useful energy. It correlates most strongly with total household expenditure, house value, material well-being (belongings), sanitation and infrastructure (correlation coefficients above 0.5). It is also correlates very closely with the other energy indicators (energy expenditure and end-use energy in GJ).

Of the other energy indicators, the strongest correlation with the poverty measures is total household energy expenditure; it correlates most strongly with total household expenditure and other poverty indicators (especially house value, material well-being (belongings), sanitation and number of rooms). The energy indicator that has the weakest correlations with all of the poverty measures is end-use energy in GJ.

As a last exercise we conducted the same correlations for rural and urban areas separately[8]. We found that the correlations between energy indicators and our poverty variables were stronger for urban than for rural households in almost all cases. This could mean either that energy indicators are better measures of poverty in urban than in rural areas, or that the poverty measures used in this study are better at detecting poverty in urban than in rural areas.

Figure 8: Poverty variables compared with expenditure and three energy poverty measures at the national level

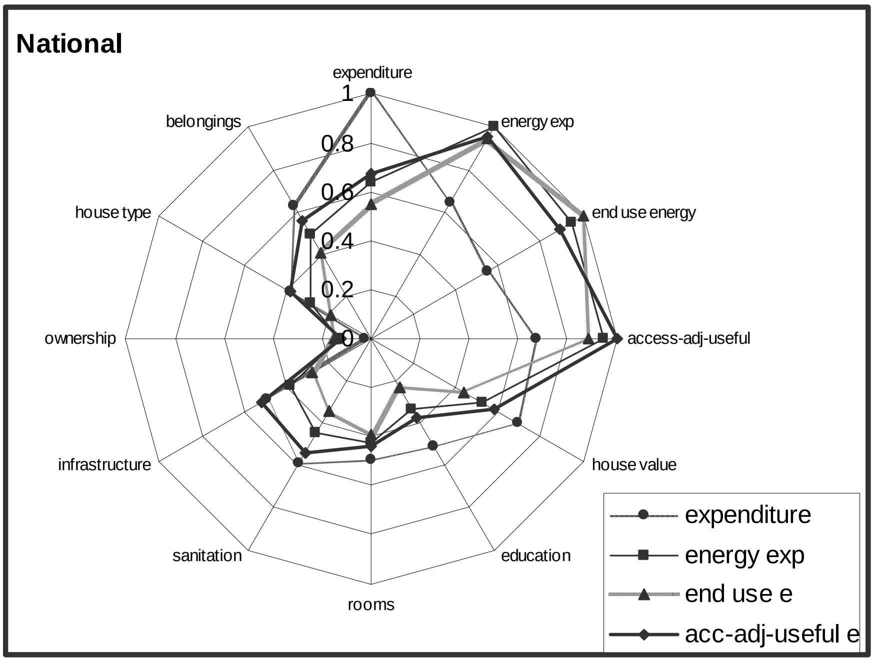


Table 3: Correlation coefficients for all SA sampled households

	expenditure	energy exp	end use	acc-adj-useful
expenditure	1	0.6369	0.549	0.6686
energy exp	0.6369	1	0.9398	0.9451
end use energy	0.549	0.9398	1	0.8833
access-adj-useful	0.6686	0.9451	0.8833	1
house value	0.6849	0.5179	0.4326	0.5755
education	0.505	0.3255	0.234	0.3726
rooms	0.4945	0.4244	0.3893	0.4365
sanitation	0.5919	0.4451	0.3435	0.5332
infrastructure	0.4906	0.3802	0.2714	0.5112
ownership	0.0306	0.1334	0.1495	0.1206
house type	0.3837	0.2784	0.1888	0.3761
belongings	0.6253	0.4951	0.4069	0.5581

8 See the appendix for the rural, urban results.

In addition to the above there are other correlation relationships which are not shown in the table, that warrant some comment. The main energy source (of any given household by category, i.e. modern, transitional or traditional) correlates closely with infrastructure, sanitation and material wellbeing. These sources also correlate (albeit less strongly) with total household expenditure, house structure, house value and education.

Poverty indicators

The following results rely on an energy use poverty line (in gigajoules per annum per capita). As mentioned earlier, the choice of a particular line is value laden. Given this we have chosen different lines to provide comparisons and selected those used in previous studies.

The results by individual (headcount) are summarised in table 4 which indicate that if 2.09GJ is the energy required to meet basic needs (Modi, et al., 2005), 35% of households are energy-poor; this translates as 28% of urban and 49% of rural households. In terms of individuals: 45% are energy-poor; this translates as 37% of urban 57% of rural individuals. It is unsurprising that results at the individual levels are higher because in general, because poorer households tend to be larger.

Table 4: SA poverty levels by headcount

Poverty line	National	Urban	Rural
$2 per day			
2006[9]	0.256	0.134	0.421
2001[10]	0.282	0.162	0.461
1996[8]	0.260	0.129	0.448
3.154GJ[11] per annum			
2006[12]	0.608	0.529	0.714
2.09GJ[13] per annum			
2006[10]	0.454	0.369	0.570
0.60GJ[14] per annum			
2006[10]	0.115	0.062	0.188

Using the same criteria but at the 3.154GJ poverty line (Pachauri, et al., 2004) 50% of households are energy-poor (42% of urban and 64% of rural households). 61% of individuals are energy-poor (53% of urban and 71% of rural individuals).

As a last poverty line, in a purely South African context, we looked at the DME's suggested energy provision target. They have advocated that the energy required to meet basic needs is 0.6GJ per capita per year. It can therefore be suggested that this number serve as a target poverty line to create policies that ensure no one is exposed to energy less than this. However, the data shows that 11.5% of individuals use less than 0.6GJ per person per year. Thus, even if this quantity of energy is provided free to all individuals in SA, it would lift only 11.5% individuals out of poverty. Poverty rates at the 'basic needs' poverty lines identified earlier are much higher than 11.5%, suggesting the DME target to be inadequate.

[9] Own calculations by per capita expenditure.
[10] Leibbrandt, et al. (2005) by per capita income (excl zeros).
[11] Basic Direct Energy Needs reported by Pachauri, et al. (2004).
[12] Own calculations by per capita energy consumption.
[13] Basic Direct Energy Needs estimated by Modi, et al. (2005).
[14] DME (2003) energy poverty tariff = 50KWh/HH per month.

By means of contrast, 17% of households and 26% of individuals fall below the $2 per day poverty line in terms of total expenditure. The energy poverty rate would have to be lifted from 0.6GJ to 1.16GJ per person per year according to our estimates for the individual energy poverty rate to be the same as the $2 per day poverty rate.

Sensitivity analysis

Sensitivity testing was performed on various aspects of the data analysis which might a priori have had a potential effect upon the results. The price-to-energy conversion factors we used for solid fuels had ranges so we used the midpoint of the ranges and experimented with using the upper and lower limits (as long as the lower limit was not zero).

This adjustment did change the estimates of end-use and useful energy, but did not change expenditure on energy. Generally the adjustment resulted in estimates of higher energy use, but did not change the overall patterns of energy use described previously (using the "access" and "modern" criteria). Correlations were generally slightly lower than before, but all correlations remained statistically significantly different from 0 at better than a 1% significance level. The overall findings were thus robust in the light of different price-to-GJ conversions.

Sensitivity testing continued on the creation of access-adjusted useful energy. If the efficiency rates for each energy source were raised or lowered by 20%, the correlations were mostly slightly weaker, but changed by less than 7% which we felt was an acceptable margin.

If we increased/decreased the weighting of more modern fuel types in the access-adjusted energy measure, the correlations became mostly stronger /weaker, but the change in the strength of the correlations was less than the change in the weighting. Importantly, all correlations remained statistically significantly, different from 0 at better than a 1% significance level. Overall, we found that the results were robust in the light of different efficiency and weighting assumptions.

CONCLUSION

Many of the claims regarding the importance and legitimacy of explicitly linking poverty to energy use are supported in this paper. Whilst a further strengthening of links between energy use and sustainable development can be made we do not claim that a single measure of poverty such as those created in our analysis can capture all its dimensions. Yet we do claim that these new indicators (particularly the access-adjusted indicator) perform as well as other non-energy based measures and should therefore be used to supplement existing indicators. Energy dimensions of development are vital and need a stronger profile in policy deliberations in the (sustainable) development field.

Any policy recommendations based on our analysis would be premature before revisiting some of the issues raised by the chosen methodology. Our study is limited by the data available and it is worth noting a few issues that weaken the study. The access-adjustment on the useful energy measure, i.e. the 3:2:1 weighting for modern, transitional and traditional fuels is arbitrary. However we did follow well-reported methodology and sensitivity analysis was conducted revealing that this is not significant. Linked to this is the lack of fuel use quantity data in the IES survey. We converted to quantities using single price-to-GJ conversion factors which if incorrect could be misleading. It is possible that fuel wood purchased in an urban area is quite different to that found in a rural area. Again sensitivity analysis did not show this to be a destabilising influence.

A significant omission in our work is the exclusion of transport fuel which relates to the issue of not using poverty measurements at energy service level. In a sense this is the ideal level as it would tell exactly how much fuel is used for each appliance according to the fuel used. The data demanded for such an exercise is huge and it was felt to be impractical.

Finally, regarding the methodology used in this study, it needs to be noted that the setting of any poverty line is arbitrary and this is true of this research, too. However, we did follow conventional wisdom as outlined in the literature and followed those poverty lines rather than having to justify any new ones, and thereby avoiding unnecessary value judgments (at least directly). We leave it to the reader to decide which line is the most appropriate. Our recommendation would be to agree on an 'official' poverty line, thereby aligning all poverty measurement results. The poverty lines chosen in this exercise were varied but included the current DME target of 0.6GJ per capita. It became clear that if South Africa wished to get all households above the $2 a day poverty line, that 0.6GJ must be raised to above 1.16GJ. This conclusion emphasises not only the important link between energy provision and poverty eradication but also how removed current policy is from achieving the JOIP target of halving poverty within the next 7 years.

The implications of this study are far-reaching and recommendations can be made to both AsgiSA and Statistics South Africa (SSA) who are responsible for survey data collection. A single indicator such as an energy poverty indicator could be most useful when comparing basic household provision of energy sources and monitoring the success of energy-related government set targets that relate to poverty alleviation per se or in a broader context of sustainable development. In order to aid this process we recommend that shorter-term interim targets (perhaps every two years) are set in order to ensure South Africa meets the objective of halving poverty by 2014.

The legitimacy of using energy poverty indicators is borne out by strong correlations and quintile analysis and has the advantage of providing a relatively easy method of tracking poverty trends and forecasting poverty levels associated with different development paths into the future. In developing a set of lead indicators to assess the progress of AsgiSA, the South African government would do well to diversify its scope by including energy-poverty indicators based both on consumption and accessibility; all of which should be updated regularly. Although the a complete set of necessary inputs may not be available at this point in the research, the relevant government departments could focus on gathering substantial energy use data for future population data surveys. As of yet, AsgiSA has not paid sufficient attention to energy provision strategies.

It is our contention that this study can serve as a baseline against which to measure future progress and that the indicators developed here should be tracked over time to assess progress in poverty alleviation. However, the IES is conducted every five years only, which is be sufficiently regular to make up-to-date assessments of the state of energy poverty in South Africa. It is recommended that more detailed questions on energy use (by each type of fuel per purpose, not just 'main' use), both in terms of spending on energy and the quantity of energy used, be incorporated into the SSA questions in the more often conducted household surveys, such as the General Household Survey or Community Survey. This should include details on any free fuel used, stock piling of fuels and a measure of time spent collecting fuels.

Further recommendations for government policy would be to provide sufficient modern energy services (between 0.6 and 2.09GJ per capita per annum) to cover basic energy needs for all households in South Africa. As agreed by authorities, this needs to be done through the provision of modern energy sources such as electricity. Since electricity is more efficient and less harmful in terms of air pollution (certainly in the home) this also contributes towards the more general sustainable development goals.

Liberalisation need to be considered whereby private sector initiatives in the generation and distribution of energy could lead to increased efficiency and lower unit energy costs. This could include targeting unemployment and redistribution through direct channels such as electricity provision for impoverished areas and possibly small household solar systems, rather than indirectly through GDP growth that is more reliant on foreign investments and speculator sentiment.

The recognition that energy provision is a necessary condition for poverty alleviation and that dependency on traditional, polluting, inefficient fuels need to be transformed into the higher, more advanced forms of energy would make a substantial social impact. To do this we need reliable indicators like the ones developed here and track them over time.

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APPENDIX

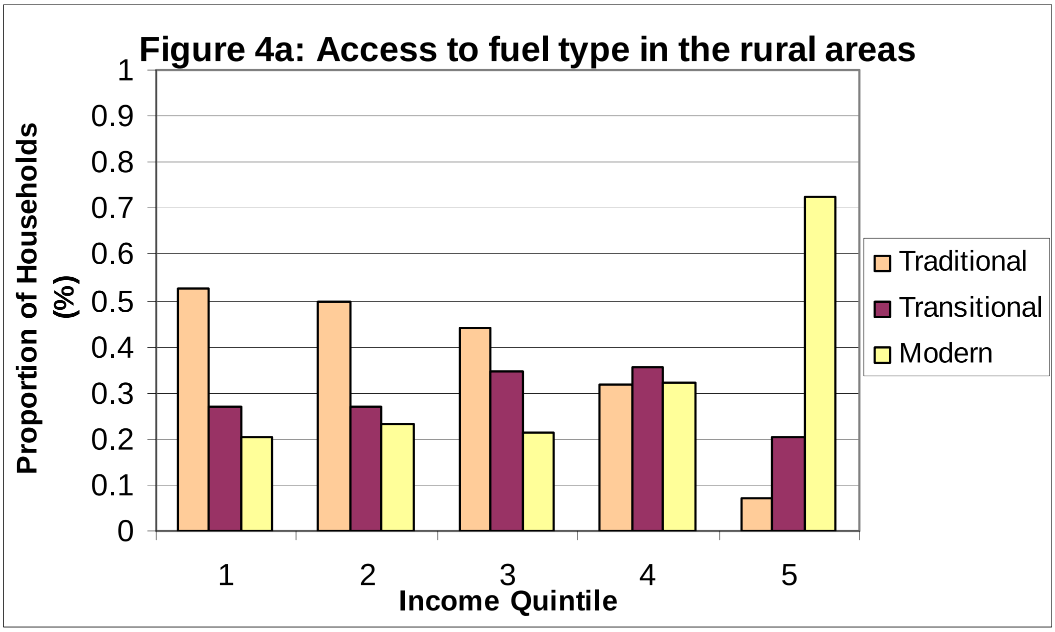

Figure 4a: Access to fuel type in the rural areas
Proportion of Households (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Income Quintile
Traditional
Transitional
Modern

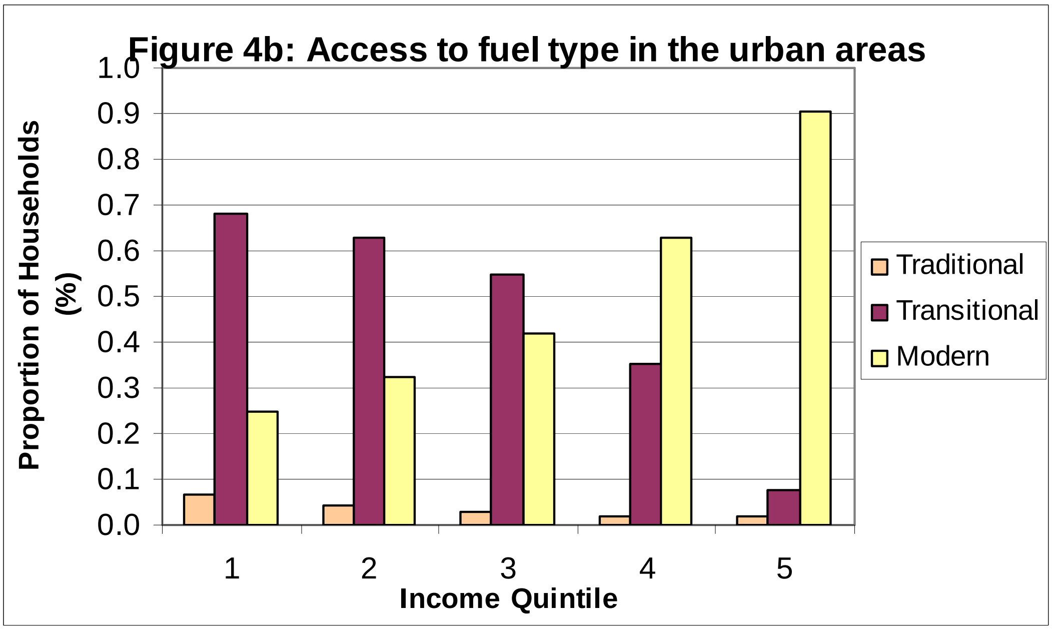

Figure 4b: Access to fuel type in the urban areas
Proportion of Households (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1
2
3
4
5
Income Quintile
Traditional
Transitional
Modern

Figure 9a: Poverty variables compared with expenditure and three energy poverty measures for urban areas.

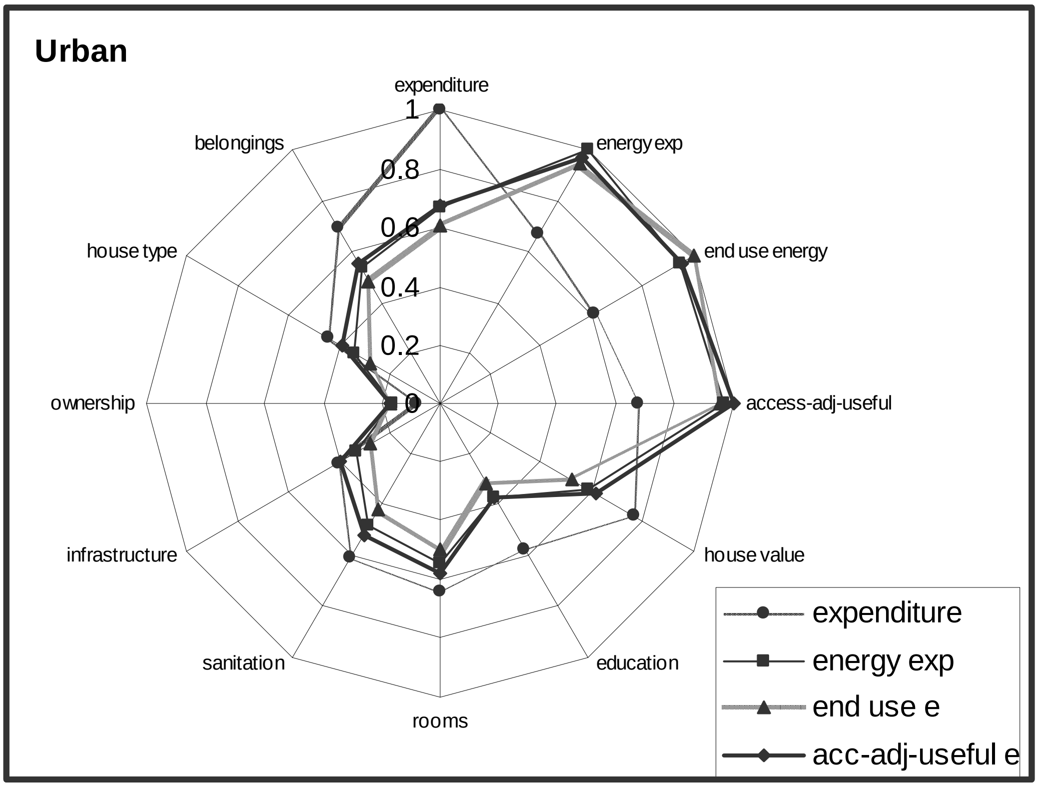

Table 3a: Correlation coefficients for urban based SA sampled households

	expenditure	energy exp	end use	acc-adj-useful
expenditure	1	0.6654	0.6059	0.6745
energy exp	0.6654	1	0.9474	0.9636
end use energy	0.6059	0.9474	1	0.949
access-adj-useful	0.6745	0.9636	0.949	1
house value	0.7648	0.5832	0.5171	0.6114
education	0.5725	0.3643	0.3116	0.3695
rooms	0.6379	0.547	0.4952	0.576
sanitation	0.6043	0.4804	0.4118	0.5186
infrastructure	0.402	0.3283	0.27	0.3975
ownership	0.082	0.1664	0.1731	0.1683
house type	0.4399	0.3401	0.2726	0.3863
belongings	0.6961	0.5331	0.4829	0.5509

Figure 9b: Poverty variables compared with expenditure and three energy poverty measures for rural areas.

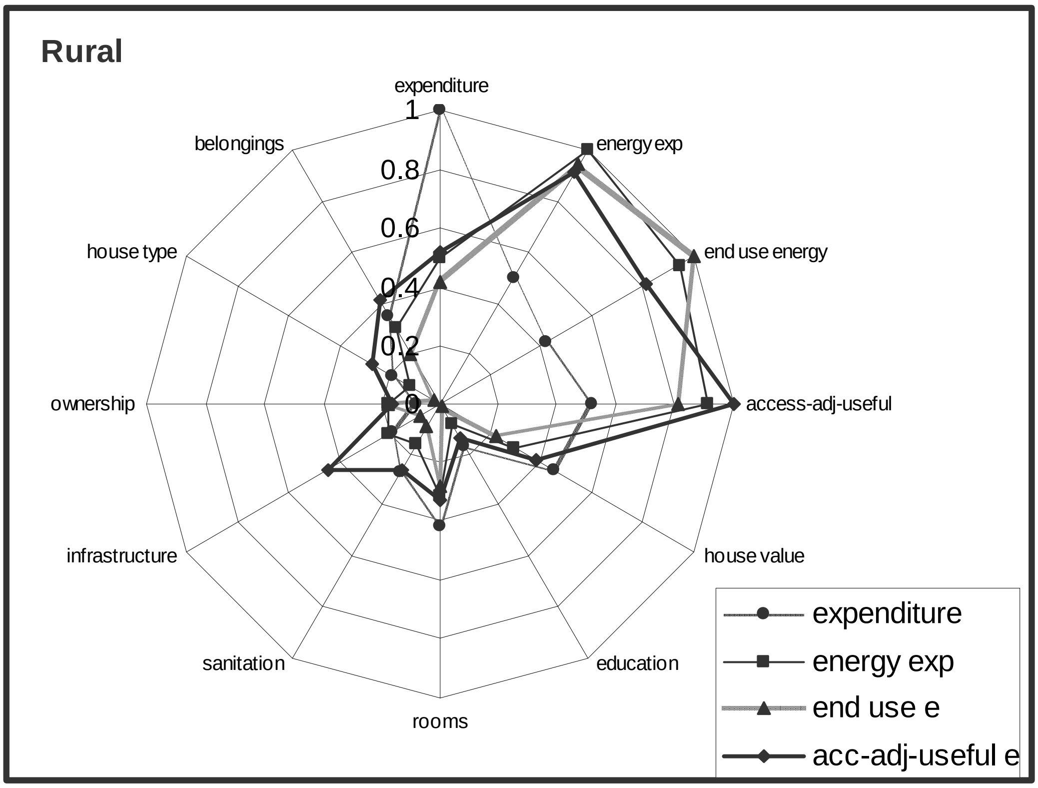

Figure 3b: Correlation coefficients for rural based SA sampled households

	expenditure	energy exp	end use	acc-adj-useful
expenditure	1	0.4998	0.4151	0.5192
energy exp	0.4998	1	0.9385	0.9139
end use energy	0.4151	0.9385	1	0.8064
access-adj-useful	0.5192	0.9139	0.8064	1
house value	0.4482	0.2946	0.221	0.3716
education	0.1608	0.0746	0.01	0.1394
rooms	0.4146	0.3122	0.2794	0.3233
sanitation	0.2628	0.1591	0.09	0.2557
infrastructure	0.1886	0.2034	0.0845	0.4398
ownership	0.0808	0.1752	0.1795	0.1649
house type	0.1929	0.1133	0.0272	0.267
belongings	0.345	0.297	0.1953	0.409

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