 J Hum Ecol,40(3): 239-246 (2012)

Analysis of Electricity and Biomass Usage in Southern Africa

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KEYWORDS Energy Sector. Energy Consumption. Wood Fuel Harvesting. Environmental Threats

ABSTRACT Increasing use of electricity by rural households in southern Africa should in theory lead to a corresponding decrease in the role of biomass as a major source of energy for heating and cooking. The purpose of this paper is to report an investigation using secondary energy consumption statistics of the impact of electricity access on the consumption of biomass in the rural areas of these countries. The analysis involved computing moving mean household electricity and biomass consumption levels for the period 2000-2010 in order to identify trends. The resulting trends were then analyzed for individual countries and for the region as a whole. The results indicate a respectable but variable increase in household usage of electricity from thermal stations, national power grids and private generators between countries. This increase, however, has not been matched by a parallel decline in household consumption of biomass in the region. The findings have immediate policy and planning implications for the energy sector because the heavy reliance on biomass poses a direct threat to the environment at large and to human health in particular.

1. INTRODUCTION

Electricity consumption in the Southern Africa region indicates significant improvements in access (SADC 2004) but clear variations between individual countries and between urban and rural areas. These countries- South Africa, Botswana, Zimbabwe, Malawi, Namibia, Zambia, Mauritius, Madagascar and Mozambique, form part of the larger economic group, the Southern Africa Economic Community (SADC). Current statistics on power generation, transmission and consumption (RSA 2003) indicate an impressive increase in access, especially in South Africa, Namibia and Botswana in the last ten years. Parallel statistics on the structure of energy consumption at household level indicates striking patterns (CIA 2010**)** about the relative position of electricity and biomass usage. Research on energy consumption (IEA 2002, 2004, 2008a, 2008b**)** consistently indicates that in the countryside, the dominance of biomass energy consumption remains unchallenged (DME 2001) and that even in urban areas and the peri-urban fringe, alternative sources of energy for cooking and heating undermine the desire of governments to eliminate dependence on biomass.

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The state of biomass potential for the region is reported in DME (2001), ESKOM (2001), SADC (2001) and Von Maltitz and Brent (2008). In Table1, total energy demand for biomass at 26% in 2030 will still be the second most significant after electricity. Biomass use on a significant scale will persist across the region so long as the rural population component in individual countries remains high. Total energy demand by fuel for the five selected countries in the period 2005-2030 indicate 39% in 2005 dropping to 26% in 2030 for biomass. In the same period, electricity an increase of from 22% to 30% in the same period (Merven et al 2009). Biomass as an energy source will still account for 26% in 2030, the second highest after electricity. In countries where the rural component of the population remains high, the dependence on biomass will persist.

In terms of total estimated biomass fuel supply of 11.2 million tons in South Africa (Damm and Triebel 2008), the relative position of the various sources showed the following: cleared alien invasive species (3%), processed waste (9%), commercial plantations (9%) and natural woodlands (60%) a pattern that is reproduced in Zambia, Malawi and Mozambique. The breakdown of biomass sources indicates that natural woodland is the most dominant energy source from biomass. This is literally true for all countries in the study area with Mozambique, Malawi and Zambia containing massive reserves due to climatic conditions and the nature of farming

practice. The highest biomass potential in South Africa is concentrated in the eastern rim of the country while the arid and semi-arid south western region scores very poorly, a condition that spreads to the southern part of Botswana, Angola and much of Namibia. These are the same areas which instead score the highest potential for solar energy development.

In South Africa, the residential sector energy consumption reported by the Department of Minerals and Energy DME (2002) indicates that Limpopo,KwaZulu-Natal KZN, and Eastern Cape EC score 50%+ of household energy dependence on biomass while North West and Mpumalanga, score 40%+.in the range 40-50%. These scores were calculated based on response on household energy consumption during the national census for 2001 (Statistics South Africa 2001). A more recent estimate pegs the total annual fuel wood consumption in South African households at 11.2 million tons which is equivalent to190, 400 TJ terajoules or 52,889 GWh gigawatt hours (DME 2006). This represents approximately 40% of the total energy consumption in South African households. Compared to a series of local studies in different parts of South Africa, (Aitken 2007) it appears that 4.5 tons per annum per household is a better estimate for fuel-wood consumption in South Africa. The purpose of this paper is to report an investigation using secondary energy consumption statistics for southern Africa, aimed at assessing the relative state of electricity and biomass consumption in a selected number of countries in this region.

Objectives

The first objective is to provide a brief overview of biomass energy resources and the second one is to present statistics on electricity and biomass usage for the period 2000-2030. The third objective is to generate scenarios on the future biomass consumption, given parallel developments in other energy resources while the fourth is to advise on long term implications for planning in the energy sector.

METHODS

The purpose of this paper is to report an investigation using secondary energy consumption statistics for southern Africa, aimed at assessing the relative state of electricity and biomass consumption in a selected number of countries in this region. The first objective is to provide a brief overview of biomass energy resources and the second one is to present statistics on electricity and biomass usage for the period 2000-2030. The third objective is to generate scenarios on the future biomass consumption, given parallel developments in other energy resources while the fourth is to advise on long term implications for planning in the energy sector. This section on objectives has been moved to end of Introduction. The study is largely based on the analysis of documents on the energy sector and the accompanying statistics. Secondary statistics on the energy sector in the five individual countries were extracted from IEA sources for the period 2000-2010. These sources cover energy generation, transmission, installation capacity and relative performance for each energy type. From individual countries comparable statistics on household energy consumption is retrieved from official government publications. From these two data sources, the resulting data sets are subjected to computations of frequencies and trends to generate growth profiles for individual countries and for the region as a whole. Secondly, thereafter, household statistics for individual countries are analyzed using frequency distributions trend surface to generate rates of change per period. A comparison of performance in the context of electricity and biomass is generated through correlation analysis and appropriate graphics. In terms of structure, part three deals with an overview of biomass energy resources and part four presents statistics on electricity and biomass. In part five, the results and discussion are presented in terms of the objectives of the study while the paper rounds up with a conclusion and recommendations in part six.

Overview of Biomass Energy Resources

Power generation statistics from IEA (2008a) consistently indicate increasing energy output but a mismatch between its demand and supply has in recent years led to serious power shortage problems, and rationing through load shedding schemes (NER 2009) indicating problems of long term energy planning and limited investments in the energy sector. Increasing urbanisation has also exerted pressure on energy de-

mand, which is outstripping generation capacity (Alaci 2010). Research effort on the structure of household energy consumption is reported in Kambewa and Chiwaula (2010) for Malawi while work on energy policy and planning in the whole of the southern African region appears in (Karekezi et al 2006). But limited research effort has been put on tracing changes in the relative position of energy from biomass, compared to electricity in individual countries. One problem besetting this type of data collection revolves around cost and accessibility constraints (Ruhiiga 2011a) such that emphasis remains on urban areas and documented consumption data (DME 2010).

In South Africa, the majority of the rural population is poor and depends on low cost biomass fuels and particularly fuel wood for everyday heating and cooking activities. What are almost non-existent in current literature are the distortions on access dynamics (DBSA 1999) that arise out of unplanned rural settlement (Ruhiiga 2011a). Initiatives to improve the sustainable use of biomass energy resources and to mitigate the associated negative effects such as pollution and health problems will therefore remain relevant and important (Damm and Triebel 2008) although the focus of these initiatives may have to be changed. Electrification is an important driver for rural households to move up the energy ladder from fuel wood and other biomass to intermediate energy sources and modern energy (AFREPREN 2004). Relatively little is known about the sustainability of present patterns of fuel wood usage and extraction (Davidson and Wrinkler 2003), and further research in this regard would be valuable (Damm and Triebel 2008). Any future fuel wood initiative should also take note of and incorporate the learning from the Biomass Initiative (DME 1992), which sought to improve the fuel wood supply through community forestry and afforestation pilot projects.

The White Paper on Renewable Energy identified biomass, together with solar, wind, hydro, tidal and other sources, as an important form of renewable energy (DME 2003). About 9% of SA's energy mix is renewable energy, with fuel wood being very prominent, particularly in the rural household sector. Natural woodlands constitute the primary source of fuel wood is from the woodland biome that covers an estimated 42 million hectares or 34% of South Africa of which 11% is partially transformed and 10% totally transformed to agricultural production. Natural woodlands constitute the primary source of fuel wood. These cover an estimated 42 million hectares or 3.4% of South Africa. Out of this, at least 11% is partially transformed while 10% is totally transformed to agricultural production. Approximately one quarter of the woodland biome is zoned as communal land, and over 70% of the former homelands are in the woodland biome. The range of values that resulted from studies on the annual harvestable production of dead wood and sustainable utilization of woody vegetation (Shackleton et al. 1999) lie between 80 kg to 590 kg per hectare per year.

Commercial plantations cover approximately 1.35 million hectares of South Africa, mainly in the moister areas (where precipitation exceeds 800 mm per annum) Over 80% of them are located in only three provinces, namely Mpumalanga (40%), KwaZulu-Natal (39%) and the Eastern Cape (11%). These plantations produce an estimated 20 million tons of wood fuel annually, for commercial production and a further estimated one million tons of fuel wood originate from commercial plantations (Dam and Triebel 2008). Indigenous forests constitute the smallest biome in South Africa, covering approximately 350 000 hectares. A very small area of the plantation resource is managed as woodlots for local consumption, under the nominal control of tribal authorities and local government. Some 75% of households in villages, townships and peri-urban settlements plant trees in their homesteads, with 40% being indigenous trees used for shade and medicinal or spiritual purposes, 40% exotic fruit bearing species and the remainder are exotic trees used for construction and fuel wood. Based on an industry log intake of 5 million tons, the waste output could easily range up to 0.5 million tons (Damm and Triebel 2008).

Statistics on Electricity and Biomass

From Table 1, it can be noted that there are major differences in the rate of electrification within Southern Africa itself with Mauritius and South Africa at the top of the group scoring 99% and 75.5% respectively. At the extreme opposite end of the scale is Malawi at 9% and Mozambique at 11.7% These sharp differences in access raise questions about the best way to address rural electrification (Ruhiiga 2011b).

Table 1: Electricity access in SADC and Africa in 2009

	[#] % Electrification rate	*[*]Without electricity in millions*	*[*]Electricity consumption (MW.h/yr)*	*[*]Average power per capita(WPP)*
Botswana	45.4	1.1	2 602 000	168.0
Malawi	9.0	13.5	1 299 000	11.5
Mauritius	99.4	0.0	2 068 000	189.0
Mozambique	11.7	20.2	9 127 000	52.6
South Africa	75.5	12.5	241 400 000	581.0
Zambia	18.8	10.5	8 655 000	84.6
Zimbabwe	41.5	7.3	12 270 000	108.0
Namibia	34			
Sub-Sahara Africa	30.5	585. 2	-	-
North Africa	99.0	1.6	-	
Africa	41.9	586.8	-	

Source: [*]CIA World Fact Book 2010
[#*] IEA World Energy Outlook 2010. http;//www.iea.org/weo/development_index.asp, pp. 23,25.Where $, WPP is consumption of electricity in watts per person.

Table 2: Electricity projections for rural and urban areas in selected countries

Country	*% access 2008(1)*	*2008 urban with Access(1)*	*2008 rural with access (1)*	*Urban pop. as a % 2006(2)*	*Estimate of urban pop. % in 2030*
Botswana	45	68	12	58	65
Malawi	09	25	4	33	39
Mauritius	99	100	99	42	44
Mozambique	12	21	6	35	42
Namibia	34	70	13	36	41
South Africa	75	88	55	60	64
Zambia	19	47	3	35	37
Zimbabwe	42	79	19	36	41

Source: IEA (2008a) and UNDP, 2009
UNDP and WHO, 2009, p. 81

Note that electricity access in column 3 is in terms of the number of households while population without access is a subset of the actual population.

In Table 2, the difference between urban and rural access is very significant. Only in Mauritius has this gap been completely eliminated. With the exception of Mauritius, only South Africa registers a rural access rate of over 50% while Zambia registers the lowest rural access followed by Malawi**.** Projections of the urban population component by 2030 (UN-Habitat 2010; Parnell and Walawege 2011) indicate that only Botswana and South Africa will have passed the 50% mark showing that the rest of these countries will still support the majority of the population in the rural countryside.

Countries with relatively high rural electrification scores are likely to register lower values for biomass usage. The opposite applies in Malawi, Mozambique and Zambia which score in the 80-90% range in terms of dependence on biomass energy. Given urbanisation projections for 2030 (Alaci 2010; UN-Habitat 2010), this has direct implications for changes in income per capita, population up-grade from primary to secondary energy sources and the progressive reduction in biomass consumption.

RESULTS AND DISCUSSION

Overview of Biomass Energy Resources

From available data, it is not possible at this point in time to precisely provide a reliable score other than estimates for the size of biomass resources in each of the countries in the region. Data on total biomass energy potential for South Africa is already outdated and such data does not exist for other countries. While studies of energy consumption has put 4.5 metric tons per annum as fuel wood consumption in South Africa, similar estimates do not exist for the other countries in the region. This limits assessment of the biomass energy sub-sector in the region and the potential for comparison across these countries.

Statistics on Electricity and Biomass Usage for the Period 2000-2030

Certain salient features can be derived from existing statistics presented in Tables 1 and 2. These show some characteristics about the position of biomass in the energy mix of the countries covered in this study. Data on the rate of electrification, expressed as a percent (%) per country merely captures household access to grid electricity (Table 2). It does not show the percentage of households that depend completely on biomass. Indeed, given the practice at household level of using an energy mix across different categories, it is difficult to compute the relative use of biomass compared to electricity. In cases where there is practically no electricity, as shown by the % of households without electricity, this presents additional problems of interpretation. It is necessary to consider the use of liquefied petroleum gas(LPG) gas and paraffin as energy sources making it difficult to generate a reliable computation of biomass consumption. But national statistics in Table 2 indicates energy consumption at the disaggregated national level. This provides a fair estimate of the status quo in the region as of 2006. Projections in the context of increasing rural electrification indicate that by the end of 2010, the biomass percentage (%) was lower-especially in Namibia, South Africa and Zimbabwe given their massive electrification schemes in the period 2007-2010 (DME 2010; SADC 2010).

Scenarios on the Future of Biomass Consumption

Projections in (DME 2010; SADC 2010) indicate a slow but steady reduction in the use of biomass across the entire region. This change will be driven by two parallel developments; an improvement in standards of living of the majority of rural people and large scale rural electrification (Rugumayo 2010; World Bank 2008) similar to what has occurred in South Africa since 1995. A drastic reduction in biomass consumption (EUEI PDF 2006) is unlikely because of several constraints. Low income per capita scores for many countries in the region mean that a significant percent of the population will not afford to convert to electricity in the near future. Pricing biomass beyond the reach of the majority of rural people – as a way of forcing a radical shift to electricity use is not feasible given the low level of private ownership of biomass resources in the area and the potential discontent that would arise if the state was to pass restrictive legislation against biomass harvesting.

State policy has not been forth right in encouraging the uptake of renewable energy technologies RET's (Tsikata and Sebitosi 2010; Karekezi S 2002a) especially in the rural countryside. Such technologies include solar power, wind power and off-grid stand-alone mini hydro-power units (Ruhiiga 2011b; Phuangpornpitak and Kumar 2007**;** Karekezi and Kithyoma 2002; Liu and Hu 2010; Wamukonya 2007; Klunne 2011). A number of studies show that using biomass for electricity generation is 80% more efficient than transforming the biomass into biofuels (Fisher 2011). Such a development would increase energy efficiency, reduce dependence on biomass and encourage an upgrade to higher levels of electricity. Merven et al. (2010) report that the spread of renewable energy technology in the region has been handicapped by a lack of a legal and institutional framework-save for South Africa. Activities within RET are limited by lack of resources, poor and inappropriate policies and constraints in accessing financial resources to invest into grid extensions to rural areas. Nevertheless, investment into off–grid renewable electricity (Klunne 2011) can be viable if it is made attractive by opening it to independent power producers (IPPs). The fragmented nature of RET programmes within the region makes them unattractive to domestic and foreign investors (RSA 2003; Dam and Triebel 2008). The practice by governments of subsidizing conventional energy development at the expense of renewable energy sources has had serious adverse effects on the potential for expanding RETs (Tsikata and Sebitosi 2010). The upfront costs for renewable energy devices are presently beyond the reach of communities for which they are intended and this has an impact on the adoption of these technologies. There is a general lack of participation in energy markets by consumers, lack of awareness of RET's and lack of information on suppliers and resource availability (Damm and Triebel 2008). Improved information dissemination strategies can enable consumers make informed energy choices. There is a general lack of expertise in RET's in the sub-region and this is recognized as a major weakness within SADC (SADC

2004; Sebitosi and Pillay 2005). Overall, this state of affairs limits options for developing alternative energy sources. Energy pricing has consistently failed to take stock of affordability issues so that while energy utilities must operate at a profit, there is little evidence of approaches that would maximize electricity use, widen access and cushion cost overheads in the process (Ruhiiga 2011b). What then is the future of biomass use in the region? In predominantly rural areas with high population density and low levels of electrification, continued dependence on biomass will see a steady deterioration in biomass resources through over-harvesting. This has already occurred in much of the former homelands on South Africa. It is occurring in the rest of the region except Namibia and Botswana where low population limits the pressure on the environment. Mauritius is the exception where almost all households already had access to electricity by 2010 (IEA 2010). Malawi still reports the dominance of wood fuel whose potential availability is still higher than current demand (Kambewa and Chiwaula 2010).

Long Term Implications for Planning in the Energy Sector

The long term implications for the energy sector in the region seem to point to the need to actively pursue integrated energy policies that allow for the gradual reduction in biomass dependence and its replacement by modern forms of renewable energy. For this to occur, there has to be concerted anti-poverty programmes across the region to raise standards of living and take the majority of the population out of the vicious cycle of poverty. This position agrees with the work of Brew-Hammond (2010) but is in sharp contrast to those who instead argue for sustainable systems of biomass harvesting (Von Maltitz and Brent 2008; EUEI PDF 2006). Several critical issues should inform current and future energy policies within the Southern Africa region:

- The need to improve standards of living of the masses of the rural poor is urgent so that rural electrification makes it possible to move away from biomass dependence. This calls for aggressive poverty-reduction long term sustained programmes, a position comparable to Brew-Hammond (2010) and Rugumayo (2010) who argue that greater emphasis should be put on using energy to generate income in order to break out of the vicious cycle of low incomes leading to poor access to modern sources of energy.
- The urgent need to support the development of renewable energy technologies as an alternative to the over-reliance on fossil fuels remains an area of concern. This position is also raised in Tsikata and Sebitosi (2010) who report that South Africa has not yet made any serious investments in renewable energy technologies.
- The need to review state energy policies in the sub-region so that there is a concerted effort to integrate energy access as a critical input in the wider context of economic growth. Policy harmonization is currently underway and the outcome of this intervention should go a long way in rationalizing the energy sector. Unfortunately, while SADC countries have issued policy papers about an integrated energy framework, this is not taking in practice.
- The need to commit greater financial resources for the energy sector in Zambia, Malawi and Mozambique is urgent given their currently low levels of electrification. These should create the means to develop electricity distribution infrastructure. Only when these interventions are pushed simultaneously will there be a possibility of a drastic reduction in the dependence on biomass as an increasing percentage of the population move up the energy ladder.

CONCLUSION

The findings of this study indicate major variations in the use of biomass energy in individual countries. It is noted that disaggregation of data on household consumption reveals inadequacies in energy reporting protocols, cumulatively limiting attempts at a comparative analysis. Biomass consumption remains a major component of the energy sector within SADC despite massive rural electrification efforts in Namibia, Botswana, Zimbabwe and South Africa. The state of renewable energy use across the region is characterized by under-development, low levels of development due to a multiplicity of challenges around financing, policy, management skills, institutions and legal frame-

works. Simultaneously, continued reliance on biomass has witnessed a steady deterioration in the biomass potential of the region. In order to ensure an upgrade across these countries from dependence on biomass to secondary energy sources, it is recommended that current energy policies in the region should be aggressively integrated to give top priority to renewable energy sources parallel to poverty reduction. Such an intervention will ensure greater role for energy development as a critical input in the overall economic growth equation.

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