REBUBLIC OF BOTSWANA
Ministry of Minerals, Energy and Water Affairs
Energy Affairs Division

Fuelwood use patterns and future strategies in urban Botswana

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TENDER NO: TB 10/1/10/99-2000

FINAL REPORT

JUNE 2001

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Introduction

This document is a report on a project established under the tender called for by the Government of the Republic of Botswana on Fuelwood Survey in Urban Areas Study numbered TB 10/1/10/99-2000. The tender called for a study to be conducted to determine the actual fuelwood consumption patterns in six selected urban areas, investigate the influence of socio-economic development over the last decade on fuelwood use and design long-term strategies to reduce fuelwood consumption.

The overall project objective was that this study would contribute to making fuelwood consumption in urban areas of Botswana sustainable. The immediate project objectives were that:

a) actual fuelwood consumption patterns in urban areas of Botswana would be established

b) influence of socio-economic development on fuelwood use patterns over the last decade ten would be investigated

c) strategies toward sustainable fuelwood consumption would be designed

d) reliable and updated fuelwood information source for projections and planning would be established.

Survey and analytical methodology

The study focused on six selected urban areas namely Gaborone, Lobatse, Palapye, Molepolole, Mochudi, and Kanye, which have been highlighted on the map on page *xxi* in this report. The main methods used were field surveys using pre-structured and pre-tested questionnaires, literature review, consultations with stakeholders, observations, data analysis and energy modelling. The study started in August 2000 and the survey data was collected in September and October 2000.

The research information on the households was collected using structured questionnaire while information on fuelwood/fuels dealers and use in institutions was collected through unstructured questionnaires. At the end of the survey a total of 794 households, 51 public institutions and 55 fuel dealers had been interviewed.

The survey data was captured and analysed using the Microsoft Access software, which was capable of handling all the numerous data sets investigated in the household questionnaire in one database. 3 different databases were established: one for the household data, another for the fuel dealers and the other for the institutions.

To provide a socio-economic basis of comparison with existing data, the household data was classified into four income groups according to the 1993/94 Household Income and Expenditure Survey (HIES). The 1993/94 income levels (below P750, P750-P1500, P1500-P4000 and above P4000) were then escalated to 2000 levels using cost of living indices (COLI) published by the Central Statistics Office as shown in the table below:

Income group	*1993/94 HH income limits*	*Escalation to Sept 2000*	*Sept 2000 estimated limits (including transfers beyond tax)*
1	Under P750	P1279.379	Under P1500
2	Under P2000	P3411.678	Under P4000
3	Under P4000	P6823.356	Under P8000
4	Above P4000	P6823.356	Above P8000

In analysing energy use information, annual consumption figures are based on per capita estimations since household sizes are not always the same in different places. In all analysis there is distinction made between consumption *by only users* and that *by all* the population.

For an accurate estimation of national urban fuelwood demand there was a need for a representation of urban areas rich in fuelwood resources like Francistown, Selebi-Phikwe and Maun. Thus where possible efforts have been made to estimate what the national mean values would be if the Francistown study on fuelwood flow paths (White 1999) were included in the estimations. In doing so, the sample size of the Francistown study was adjusted according to the population proportions of the other towns. It must be pointed out that, apart from estimates for fuelwood use patterns, it was impossible to include the Francistown study in the use patterns of other fuels since that study's data was specifically for fuelwood users alone.

In the estimation of annual per capita energy demand, an assumption was made that there are 8 summer months and 4 winter months. It was also assumed that, in winter, on average households were using about one and half times the energy they use in summer.

In the modelling of fuelwood projections, Francistown and Selebi-Phikwe have been used to represent the wood-rich areas. These two towns are so big that if relevant assumptions for them were not incorporated into the modelling the impact could be substantial. The LEAP2000 software was used for the modelling of the demand projections but since the software was still at its final stages of development, the modelling encountered a few bugs. Thus alternative modelling has been done in Excel spreadsheet.

Key findings

Trend of income distribution

The study assessed the income distribution trend over the period between 1993 and 2000. During 1993/94, over 50% of urban households in Botswana were in the lower income group with incomes not more than the 1994 P750. Comparing similar income groupings for the year 2000 with that of 1993/94 shows remarkable improvement in household income distribution in urban Botswana. Whilst the lowest income group has reduced from 51% to 42%, the second and third income groups have increased substantially.

The analysis indicates that Botswana is making significant progress towards becoming a middle-income country. This has obviously improved households' affordability of and access to energy services. This significant progress in household incomes is reflective of the general increase in GDP growth per capita since the early nineties.

A closer look at the household income levels at the individual urban centres studied shows a big difference between the income distributions of the towns and the villages. In the towns (Gaborone and Lobatse) the percentage of households in the lowest income group is as low as about 30% whilst in the case of the villages (Kanye, Mochudi, Molepolole and Palapye) the lowest income group constitutes about 50% or more. Molepolole seems to be worst off in terms of household income with over 60% of the households in the lowest income group.

Overview of energy use

About 76% of all the 794 households surveyed were using gas for various end-uses, especially cooking. Comparing current gas use to estimates from the 1996 Botswana Energy Master Plan (BEMP), which was largely based on data collected a decade ago, shows a dramatic increase in urban gas use from 45%. This gives an indication of the effectiveness of the provision of appropriate enabling environment for marketing gas throughout the urban areas of the country, and this has resulted in a huge switch to gas usage despite the fact that there has been about 37% increment in urbanisation over a decade.

Paraffin and electricity come next in terms of extent of use amongst urban households with about 54% and 50% of households respectively. However, comparison with BEMP 96 shows that the dependence of paraffin use has decreased from 70% whilst the use of electricity has almost doubled from 24%. This could be attributed to the improvement in income distribution that has enabled households to switch from less convenient energy sources to more convenient sources.

Although the extent of fuelwood use has decreased, this has not been that significant compared with the shifts between the fuels above. The extent of fuelwood dependence amongst urban households has decreased from the BEMP 96 estimates of 55% to about 43% of all the households surveyed.

Surprisingly coal does not feature at all as an important fuel in urban households. Although the Expanded Coal Utilisation Project has been promoted as a means of reducing over-dependence on fuelwood, urban households' dependence on coal has remained merely under 1%.

The level of electrification of government institutions is impressive. Electricity is the most widely used fuel amongst government institutions, being used mainly for lighting and space heating. Although about 90% of all the government institutions surveyed are electrified, the use of electricity for cooking is very limited especially amongst the Primary and Community Junior Secondary Schools (CJSS).

Fuelwood is the second most widely used fuel amongst public institutions. Almost 80% of all the institutions use fuelwood in the survey and the most prominent are the Primary Schools, all of which use this source of energy. This is followed by the CJSS (88%), Prisons (75%) and the Senior Secondary Schools (SSS) (67%) respectively but the other type of institutions do not use fuelwood at all. Gas (LPG) is the third most widely used energy source with about a half of the institutions surveyed using it. Solar electricity also features as an energy source used only by schools. Half of the SSS surveyed use solar energy, about 20% of the CJSS also use it as well as one out of the 12 Primary Schools surveyed.

Unlike the households where the promotion of coal use has been unsuccessful, there is some indication of success amongst the public institutions with about a third of the institutions surveyed using coal. Over 40% of the CJSS and the Primary Schools use coal, a quarter of the Prisons also use it as well as one of the 2 two Hospitals surveyed. All the 6 SSS, the 2 Clinics and the one Teachers' College surveyed do not use coal at all.

Energy use variation with income

The analysis clearly shows that, in general, just as electrification depends on household income levels, *electricity* has largely become the *energy source of the rich* with its use increasing from 24% at the lowest income level to 88% at highest income level. *Gas* is mainly *the fuel for all* income levels. Urban gas use is as high as 68% even at the lowest income level but there is some switching to electricity at the higher income levels. *Paraffin* and *fuelwood* are mainly *fuels of the poor*, although some extensive use of fuelwood occurs amongst the highest income level households. Paraffin is more pronounced as a fuel of the poor than fuelwood since its use amongst the lowest income households is as high as 78% but reduces to a mere 14% amongst the highest income group. Fuelwood is used by 60% of the lowest income group but this reduces to the lowest level of 30% in the third income group. Candle use seems to occur at all income levels ranging from 25% at the second income level to 42% in the highest income group, which may suggest that its use goes beyond energy (lighting) purposes to decorative and entertainment purposes. Charcoal is predominantly a fuel of an insignificant number of wealthy households, car batteries are used by a small minority at all income levels and dry cell batteries are mainly used by poorer households.

The intensity of energy use

The analysis shows that the average monthly consumption of electricity by user households of about 626 kWh is quite high compared to South African households in general. This may be due to the additional space cooling requirement in terms of air conditioners and fans in Botswana, which is very limited in South Africa due to a relatively cooler climate except in the northern part of the country. Another reason could be that electricity connection costs until recently have been such that only richer households are able to connect to electricity, which is largely not the case in South Africa due to the policy of *mass electrification* after the democratic elections in 1994. Electricity is not only used more extensively in the urban Botswana towns than the villages but also more intensively in the towns than the villages. Whilst the electricity consumption amongst village households ranges between 234 and 406 kWh, consumption in town households is above 600 kWh. This is due to the more sophisticated lifestyle in the towns with more modern appliances.

The electricity consumption in Palapye (406 kWh) stands way above that in the other villages. This seems to have been an influence of the different metering systems. Whilst almost all the households surveyed in the towns were all using credit meters, it is only Palapye which was using credit meters amongst the villages rather than pre-paid meters. This seems to suggest that the use of the credit metering has contributed to excessive use of electricity whilst the use of pre-paid meters has resulted in the cautious use of the utility. In addition, the credit meter systems may be older, and therefore consumption could also be higher due to longer experience with electrification, which lends itself to the ownership of more appliances. However, there is a report that the Botswana Power Corporation (BPC) employees in Palapye are given some free electricity credit units every month and that might have influenced their higher consumption.

In the case of gas there is not much variation of the intensity of use between the various urban centres studied. Although the towns have the highest consumption, the difference between the lowest and highest monthly consumption levels is very small (12.16 –15.72 kg). This seems to suggest that gas use in urban Botswana is becoming saturated. It is also an indication that there is a minimum requirement for a household irrespective of the income level. The monthly average consumption for households using gas is about 14.6 kg but when this is spread over the whole urban population the consumption is about 11.10 kg.

Although paraffin is used extensively amongst urban households (over 50%), in terms of intensity of use it is not that significant amongst user households. Whilst in South Africa monthly consumption of paraffin is about 25 litres/month or more amongst user households (mainly low-income households), the average amongst urban Batswana user households is about 7.83 litres.

Fuelwood use is not only less extensive in the towns than the villages but also less intensive. Fuelwood consumption is lower in Gaborone (104 kg/month) than in Lobatse (140 kg/month) due to probably better access to more convenient fuels in Gaborone than in Lobatse. Monthly fuelwood consumption is not much different amongst the villages (200 – 238kg). Molepolole has the lowest consumption amongst the villages probably due to dwindling fuelwood resources whilst Palapye has the highest due to its location almost in the north-eastern region of the country where it is richer in fuelwood resources. On average 186 kg of fuelwood is used monthly per user household in this study, which translates into an annual household consumption of about 2.6 tonnes of fuelwood. If the north-eastern towns richer in fuelwood resources like Francistown and Selebi-Phikwe are taken into account, the monthly average consumption comes to about 212 kg. If this is further spread over all households (both users and non-users) then the monthly consumption becomes 102 kg per household.

Costs of household energy use

In general, the higher expenditure proportion pattern in the non-electrified households at the lower income levels indicates that there is significant financial saving for connected households (i.e. 'consumer surplus' as a result of electrification). Possibly more importantly, it indicates that the use of electricity at the lower income levels to meet energy needs generally results in lesser expenditure for households.

The cost of gas use to households does not seem to have any specific variation with income both in the towns and in the villages. This shows that the level of gas consumption is not dependent on income levels but rather on more tangible factors like household size.

A comparison of energy expenditure as a proportion of household income in urban towns and villages reveals little difference between the two settlement types for most energy sources. The only significant exception is electricity in which case the average monthly expenditure by village households is about 40% percent of the average by town households.

The observation that the lowest income households are comparatively spending very high proportion of their income (20%) on energy needs is a serious one when one considers the fact that about 42% of the households are in the lowest income group. Furthermore, most of these lowest income households are still largely dependent on fuelwood as a principal source of energy and therefore they should be the main target for any fuelwood reduction measures.

Energy end uses

One of the most significant trends observed in the household energy end-use patterns over the past few decades is the rise of the use of gas as a preferred cooking fuel. In both urban towns and urban villages, there is a marked increase in gas use as the main household cooking fuel from the mid-eighties to the present. In towns, gas, paraffin and fuelwood were all used by similar proportions of households as the main cooking fuel in the mid-1980's, but in the last decade gas use has risen to a point where over three-quarters of households use it as the main cooking fuel, accompanied by a drop in the use of paraffin and fuelwood use for this purpose. According to the survey data in this study, fuelwood use for cooking has diminished from 35% in the mid-eighties to about 2% in the towns surveyed. Adjusting this with data from fuelwood-rich area like Francistown raises fuelwood cooking in towns to about 9%.

In urban villages, fuelwood use as the main cooking fuel has declined from being used by almost 90% of households in 1985 to being used by only one third of households. In its place gas use has risen from about 10% to almost 60% as the main cooking fuel.

In urban towns, electrical lighting has risen from being the main lighting energy source in just over 20% of households in 1985, to over 60% of households in 2000. Linked with this is a decrease in the use of paraffin – which was the most widely used lighting source in urban towns until recent years. Paraffin use as the main lighting source, which increased to almost 60% by 1993/94, has now reduced to about 40%. Candle use for lighting was also significant in the mid-eighties, but this appears to have declined steadily to the point where it is almost insignificant.

In urban villages paraffin use has also decreased as the most widely used lighting source (about 80%) to just over 60%. This also appears to be linked to increased levels of electrification which has resulted into the rise in the use of electricity as the main lighting source from under 10% in the mid-eighties to about 30% in 2000. It is interesting to note that candle use for lighting has never been significant in Botswana urban-villages, even as far back as in 1985.

There are multiple fuel use trends prevalent in households reflecting the transition in energy use patterns. The survey undertaken in this project indicates that 30% of households use a secondary cooking fuel in addition to their primary choice. In general, this phenomenon is more prevalent in the villages, especially Kanye, than in the towns due to lack of access to more convenient fuels. For those who use fuelwood primarily for cooking and also use secondary fuels, 56% of these households use paraffin as the secondary fuel, and 44% use gas. This indicates that 44% are already exposed to gas use and may already have the infrastructure for gas use. Furthermore, it is noteworthy that, of households who cook with gas primarily but who also have a secondary cooking fuel, 61% use fuelwood for this purpose. In the case of those who cook mainly with electricity, gas or paraffin is the backup fuel but no fuelwood is used.

Perceptions about fuel use

<u>Gas cooking</u>

The study shows that the main motivations for gas use for cooking are the cheapness of the fuel, the easy use of the fuel and the easy access to the fuel. It is surprising that the fastness and cleanliness of use did not feature prominently here. This probably shows the extent to which urban dwellers have shifted in their thinking concerning the usual myth that, the use of gas is not safe, to the convenience of gas use.

<u>Solar cookers and solar water heaters</u>

About a third of the households expressed the willingness to use solar cookers, and about a half of the households would like to use solar water heaters (SWHs). However, analysis of the data on the 9% of households using SWHs does not indicate significant energy savings. This is probably because the solar water heaters are very expensive and are usually found in government houses and in higher income households. In spite of the big support SWHs have enjoyed from the Botswana Government, SWHs have had maintenance problems and have not caught on to the general public. Furthermore, there are no financing schemes in place for ordinary households to obtain SWHs. Also, water heating is only partially accountable for fuelwood use, with cooking and other functions of wood fires probably being more important functions. Thus, any promotion of SWHs should specifically target the poor in order to make any meaningful impact on fuelwood use reduction.

<u>Efficient cookstoves</u>

There is evidence in literature that wood-saving stoves have been tried in Botswana since the mid-eighties but traces of these stoves in this study were extremely scanty. Improved fuelwood stoves are usually expensive compared with their energy savings and this might be the reason why this strategy has not been sustainable. However, this study shows that there is a lot of willingness (40-60%) to use these stoves.

<u>Fuelwood cooking</u>

Although only about 2% of the town households are mainly using fuelwood for cooking, almost a third of the urban town households would actually like to cook with fuelwood. In the villages, about a third of the households are currently using fuelwood as the main cooking fuel but about two-thirds of the households actually like cooking with the fuel. This indicates some tendency of reverting to fuelwood use depending on its availability and pricing.

Fuel switching from fuelwood
The study shows that there is significant willingness of households to switch from the use of fuelwood for cooking to other fuels. About 41% of the 43% urban households using fuelwood are willing to switch to other fuels with majority being in the villages. Whilst about two-thirds of all willing households would like to switch to gas, about a quarter would like to switch to electricity. Similar proportions of fuelwood users in both towns and villages would like to switch to electricity for cooking. However, village households prefer switching to gas most (over 70%) since access to electricity is limited. In the electrified households, similar proportions of fuelwood users would like to switch to either electricity or gas. In the non-electrified households about 70% of fuelwood users are willing to switch to gas whilst about 19% would like to switch to electricity.

Future fuelwood demand projections
One striking observation was that the national urban residential fuelwood demand seems to have been over projected in the past. Whilst the 1996/97 Energy Statistics Bulletin estimated urban residential fuelwood demand of 279 kilotonnes, the current study found this to be only 196 kilotonnes. The current annual fuelwood demand by institutions was estimated by this study as about 71 kilotonnes and all the strategies seem to result in fuelwood reduction in the institutions. The total of urban residential and institutions fuelwood demand was estimated as about 267 kilotonnes per annum.

Conclusions
In terms of the Terms of Reference of this study it can be concluded that the project objectives have been adequately addressed. This has been done in terms of establishing current household energy use patterns, the main socio-economic drivers of fuelwood/energy use and the energy burden on households, future strategies and fuelwood demand projections, and established database with current energy use patterns. The energy use patterns have been extensively discussed under the key findings.

Impact of socio-economic development on fuelwood use

The impact of socio-economic development on fuelwood use has been addressed in this study by examining the improvement in the economic situation of households based on income distribution. This study has shown that Botswana has made significant progress in improving income distribution amongst urban households, which has consequently resulted in higher affordability of and access to energy services more convenient than fuelwood use. The improvement in income distribution has enabled urban households to switch from less convenient fuels like fuelwood, paraffin and candles to mostly liquefied petroleum gas and to a less extent to electricity.

Socio-economic drivers of household energy use
- One key driver of household fuelwood use is poverty.
- The cheapness of fuelwood compared with other energy sources is another major driving factor for fuelwood use in the urban areas. This driver is much stronger in the urban towns.
- The social attachment to fuelwood use is a key driver of why households are unwilling to switch to other energy sources, especially in the urban villages.
- For about 50% of fuelwood users, lack of access to other fuels like electricity and gas is the main driving factor for using fuelwood. For gas, lack of access was expressed in terms of unaffordable cost of gas cylinders and appliance acquisition.
- In electrified households, the main driver for using fuelwood is the financial difficulties in acquiring appliances. Other drivers are the unreliability of electricity supply and the high cost of electricity.
- The main reason why about a third of the households expressed likeness for cooking with solar stoves and about half expressed likeness for solar water heating is the fact that the energy source is free and as such the households could make some savings out of it.
- The main motivation for using electricity for cooking by urban households is its ease of use more than anything else.

- The main motivations for most households using gas for cooking are the comparatively cheapness of the fuel (compared with electricity), the easy use of the fuel and the easy access to the fuel (easier than electricity).

Energy burden

Energy expenditure seems to be more burdensome for households using fuelwood than those that are not using fuelwood. The burden is greater on the lower income households than higher income households and that the gap narrows with increase in income. This is another indication of energy poverty amongst fuelwood users.

The monthly expenditure on fuelwood is quite a significant portion of the household energy budget in lower income households. In the lowest income group (where most of the fuelwood users belong) this expenditure constitutes more than half the energy budget. In higher income households the fuelwood portion of the energy budget is smaller.

In the case of the public institutions, the study shows that whilst the energy budgets of SSS and CJSS are mainly borne by the Ministry of Education, that of the Primary Schools is largely borne by the parents themselves. The pupils are sometimes asked to bring firewood to school. The energy burden on Primary Schools is far greater than that of other institutions. It is therefore not surprising that the Primary Schools are very much dependent on fuelwood.

Future strategies and fuelwood demand projections

The study has shown that there are a number of future strategies that could make some significant impacts on the dependence on fuelwood use. These are poverty alleviation, fuel switching from fuelwood to gas, appropriate financial mechanisms to enhance electrification, promotion of efficient fuelwood cookstoves, promotion of solar water heaters and cookers, and the promotion of coal stoves in public institutions. On the fuelwood supply-side, improved availability of fuelwood resources in urban neighbourhood should be the strategy instead of dependence on rural areas of supply. Of all the strategies, fuel switching from fuelwood to gas seemed the most plausible as there is a lot of goodwill out there amongst households already.

The fuelwood projections in this study indicate that, in order to promote sustainable fuelwood use by households, the main thrust of government should be around promoting affordable and accessible use of gas in all areas. This involves addressing barriers to gas use by poorer households in particular, such as access cost (gas cylinder purchase or deposit), appliance cost, availability (transporting heavy gas bottles can be difficult), gas price, and possibly remaining perceptions around its safe use. Promoting the establishment of a more extensive chain of smaller gas dealers at the community level may be appropriate, although depot safety concerns will need to be kept in mind.

Updated fuelwood information source

This study provides an updated information source on urban household energy use in a database with special emphasis on fuelwood. The wealth of information collected in the database is far beyond the analysed data in this report since only the data required for the Terms of Reference was analysed. The EAD database has been reviewed and it has been realised that the data content is purely aggregate information and thus any useful linkage with the data collected in this study will have to be at the aggregate level. The aggregated information in this report, especially the fuelwood demand projections will be useful for that purpose. The survey data has been organised and analysed in three data sets in Microsoft Access. The main database is on households, and the other two are on institutions and fuelwood/energy dealers.

Recommendations

Since the monthly expenditure on fuelwood amongst the lowest income households is quite substantial, the policy implication would be that this amount could contribute to paying for other energy options that are more convenient like gas or electricity. Some education would help in making this realisation clear to households when alternative energy options are offered to them.

The extent to which urban dwellers have shifted in their thinking concerning the usual myth that, the use of gas is unsafe, to the convenience of gas use is very encouraging. There is a need to strengthen such realisation if more households are to switch from fuelwood to gas. Currently, the abundance of gas dealers has improved distribution of the fuel and the free home delivery of gas by dealers is another incentive. Furthermore, housing developments have now started incorporating gas outlets in housing designs whilst provision for electric cookers are sometimes not even considered. These key factors that have contributed to the extensive use of gas should be encouraged.

In spite of the fact that there is significant progress made in implementing policies addressing gas affordability and access, about a third of gas users are dissatisfied largely due to gas unavailability. This is mainly in the villages. There is a need to strengthen strategies of affordability and improved access for sustaining the cheapness of gas in order to encourage its continued use. Whilst the price and appliance acquisition were mentioned as other reasons, it is clear from this project that the issue of gas unavailability needs to be addressed as a matter of priority in order to boost the reliability of gas use. It seems that this will make positive impact on the livelihood of many households since about 70% of urban households use gas for cooking.

The lower levels of electricity consumption in the villages should be taken into account in electrification planning in order to realise the targeted uptake. Electricity connection alone is not enough for improving energy access unless it is coupled with the appropriate financial mechanisms for wiring and appliance ownership. It is only when electricity demand is stimulated in this way that it would lead to significant impact on the reduction of fuelwood use. Since electricity generally appears to be amongst the preferred energy sources, it seems safe to deduce that households that can easily access electricity would do so. Therefore factors such as affordability of connection and appliance acquisition, and proximity of the grid are where strategies need to focus to promote the use of electricity.

It must be noted that the willingness of households to switch to either coal or paraffin is not significant (not more than 5% of fuelwood users). This is worth noting in relation to the strategy to promote household coal use.

In the promotion of solar water heating and cooking, it must be clear from the onset that environmental savings do not matter much to households and that what matters most is the cost savings. It is therefore important to create the necessary awareness concerning the cost implications and the features of solar cooking so that their preference for solar would be based on realistic reasoning. When the switch of households to these solar technologies are based on realistic reasoning then it could be certain that the fuelwood savings involved would be sustainable. Furthermore, the promotion of these solar technologies should specifically target the poor with the appropriate incentives in order to make any meaningful impact on fuelwood use reduction.

Solar cookers can be relatively cheap and a pilot project to assess the willingness to pay for them in practice as well as the cultural and social acceptability of this cooking technology is worth exploring. RIIC's work in this regard could be a natural starting point. However, as with fuel efficient stoves, many such programmes have been attempted in the past with little real impact on fuelwood use patterns of households, and thus one should proceed cautiously based on proper analysis of these attempts.

Initiatives on wood-saving stoves in other parts of Southern Africa have resulted in disappointing results regarding fuelwood saving in spite of carefully implemented long-term programmes. However, since this study shows that there is a lot of willingness to use these stoves, it may be worthwhile to implement a pilot fuel efficient stove programme as a job creation tool, but previous efforts in this regard will need to be evaluated in more detail first.

To make the government directive stopping all government institutions from using fuelwood effective, the government would have to support the institutions with their energy budget and in the provision of appropriate functioning kitchens.

To ensure that urban households are not solely dependent on rural areas for their fuelwood supply, and also to reduce the environmental burden on both the rural and urban areas, government would have to embark on an effective urban forestry renewal programme.

The current EAD energy database in Lotus software has gone obsolete in terms of data and software design. It would require a thorough review of all databases available and the necessity to link them in order to assess what software platform would be more suitable for the design. Consideration should also be made of all external databases in other Government departments that may be necessary to be linked to the EAD database. However, whatever software platform is chosen for the database design, it would have to be adaptable to a wider scope of versatile current and potential future softwares in order to allow easy import from and export to the database. For example, the

Microsoft Office software packages are currently easy to import from and export to one another and it would be easy to link a Microsoft Access database platform to other data formats.

In terms of exploring other issues in the household energy use database of this study that were not analysed, the questionnaires in the Appendices 3-5 of this report would help to identify which questions could have been explored further in the analysis.

When Francistown, where fuelwood is used extensively, is considered in the national urban picture, the estimation of fuelwood use amongst households rises from 43% to about 48%. This 5% increment in the extent of fuelwood use by the inclusion of Francistown data is very significant and points to the need for quality and reliable data. Thus, there is a need for an appropriate sampling frame in the estimation of the national fuelwood demand. Assuming an urban population of about 800 000 and an annual per capita fuelwood consumption of about 200 kg, a 5% decrease in the extent of fuelwood use would be equivalent to a reduction of 8 000 tonnes of fuelwood in fuelwood demand estimation.

Proposed plan of actions

The following are some suggested actions that can be taken to implement the strategies outlined in this study towards sustainable use of fuelwood in urban Botswana. The actions are grouped under each strategy and the strategies are listed according to decreasing order of higher priority.

It must be cautioned though that the full development of action plans is beyond the scope of this study. The action plans mentioned here in this study are basically preliminary ideas evolving out of the information gathered in this study without complete consideration of all other aspects necessary for a better strategy design. For a good plan of actions, there is a need for active deliberations by all stakeholders concerning the information available and also a proper assessment of the environment of the stakeholders in order to direct the actions towards desired and achievable results. A well-facilitated action plan workshop could be useful for this. This could involve the assessment of capabilities of stakeholders, training and institutional needs, the resources necessary for carrying out each action, the nature of services required, categories of target groups, the time requirements (short-, medium- or long-term), constraints, evaluation of the proposed actions and the identification of new ones, and so on. Thus, the action plans suggested in this study should only be taken as a starting point and a guide and not an end in itself since stakeholders know their environment better and their participation is critical if the implementation is to be effective.

Fuel switching from fuelwood to gas

Clearly the switching from fuelwood to gas emerged in the scenario testing as the strategy that would make the greatest impact on the reduction of fuelwood use both in urban households and government institutions. The survey showed that this is a strategy that is already on course with the provision of appropriate enabling environment for marketing gas throughout the urban areas of the country. Thus, the need for government intervention is currently very limited. However, the following suggested actions would be worth considering:

1. Continuous awareness campaign would be required to ensure increase in the intensity of gas use in households. This should not only be limited to cooking but other end-uses as well.
2. Some investigation must be conducted into why there is so much partial switch from fuelwood and efforts must be made to remove or lessen all identified barriers including cultural attachment to wood fires. This may require some education to change mindsets.
3. It is important to establish what other means of acquisition of gas cylinders would be affordable by poorer households.
4. Households and government institutions should be supported financially in their purchase of gas appliances.
5. More effort should be made in the adoption of housing designs that would ensure the safe use of gas in the households and government institutions through the provision gas outlets.
6. Government should support the private sector in promoting the establishment of a more extensive chain of smaller gas dealers at the community level especially in the villages.

7. Periodic discussions with the oil companies, appliance manufacturers and distributors would also be useful in initiating new actions and strengthening already existing ones that would enhance fuelwood switch to gas.

Improving fuelwood availability in urban neighbourhood

This strategy seeks to curtail the dependence on rural areas for urban fuelwood supply by exploring actions that could improve fuelwood availability within the vicinity of the urban areas. The following actions could be useful:

1. The Ministry of Agriculture and the EAD should explore the possibility of facilitating the establishment of urban community woodlots using local authorities and NGOs.
2. All educational institutions should be encouraged to undertake some tree planting programmes.
3. General awareness campaigns would be helpful in sensitizing the urban population on the importance of tree planting.
4. Educational institutions should explore how to integrate forestry and energy issues in school curricula.
5. The Ministry of Agriculture, the EAD, and the forestry-related NGOs like the Botswana Forestry Association should be supported to provide the necessary technical, logistical and institutional assistance in all sustainable fuelwood supply efforts.
6. Efforts should be made by the EAD to organise all fuelwood dealers into a responsible association in order to get them involved in the activities concerning the sustainable supply of fuelwood.

Electrification

1. There must be periodic review of the modalities of payment of the electricity connection cost in order to make it affordable to poorer households.
2. There must be stimulation of the demand of electricity amongst households and government institutions. This can be done by negotiating appropriate financial mechanisms for appliance purchase with the relevant financial institutions and business organisations.
3. Maintenance support system must be in place in order to ensure that electrical appliances already purchased are continuously in good working order. This action offers local entrepreneurs an opportunity for job creation in terms of electrical appliance repair shops.
4. Government would have to explore the possibility of poverty tariff to widen access of electricity to poorer households.
5. Electrification should also be accompanied by effective and safe wiring of households in order to make sufficient impact on the livelihood of people. The electric utility could be sensitized to support this with training and creation of electrical wiring businesses.

Efficient cookstoves

With all the cautions raised in this study concerning this strategy, the following suggested actions need to be considered:

1. Attempts must be made to evaluate the causes of failure in previous attempts in disseminating efficient cookstoves in Botswana and Southern Africa.
2. There must be practical testing of new and current efficient cookstoves to ascertain the level of fuelwood savings that can be achieved in order to assess the relevance of their promotion. BoTeC and RIIC innovative stove designs would be useful in this testing.
3. The specifications of the approved efficient cookstove/s are then used to market it/them widely through public and school awareness campaigns and demonstration programmes.
4. A demand assessment of the stove/s should be carried out to verify the viability of manufacturing the stove/s. The marketing and demand assessment should not be limited to Botswana alone but should be broadened to include other Southern African countries since a wider market would ensure its easy viability.
5. The efficient cookstoves design should explore potential job creation opportunities.

6. Government institutions like schools, clinics and hospitals could be used as promotion and demonstration centres for the approved efficient cookstoves by starting to use the stoves in their kitchens.

Solar cookers and solar water heaters

Almost all the actions involved in the efficienct cookstoves strategy are worth exploring under this strategy. In addition, the following actions could also facilitate the shift to solar cookers and solar water heaters:

1. The energy savings impacts of all solar water heaters in both government and private buildings must be assessed. This would inform government about the next direction of effective promotion of the technology.
2. A pilot project should be conducted to assess the willingness to pay for solar cookers and their cultural and social acceptability. RIIC's work in this regard could be very useful.
3. An investigation should be carried into how to target the design and marketing of solar water heaters towards poorer households. What incentives would make them attractive and what level of financial support would be required?
4. Efforts must be made to ensure that there is adequate maintenance support system available.

Promoting coal stove kitchens in government institutions

1. Government must facilite the availability of coal by supporting the establishment of coal depots in all the urban centres.
2. Clean coal technologies must be pursued in order to increase the fuel efficiency and improve product quality, and these would be mainly physical coal cleaning processes.

Improving paraffin distribution in low-income communities

The main action required in this strategy involves efforts to improve paraffin distribution network at the community level. This action seeks to respond to the needs of those households who use paraffin as secondary fuel for cooking. Thus the impact on the reduction of fuelwood use is not expected to be substantial but it would all the same benefit almost half of the urban population in their lighting needs.

Poverty alleviation

The listing of poverty alleviation here as the last one of the strategies should not be inferred in any way as the least priority in the sustainable use of fuelwood. In fact, as mentioned earlier on, fuelwood dependence is strongly linked to poverty as shown clearly by this study and thus the economic empowerment of households and government institutions is critical in order to reduce fuelwood dependence. This strategy is listed here last because it does not fall in the direct domain of activities of the Ministry of Minerals, Energy and Water Affairs (MMEWA) but rather, other government departments are more responsible for dealing with it. However, MMEWA could undertake the following actions to support the poverty alleviation drive:

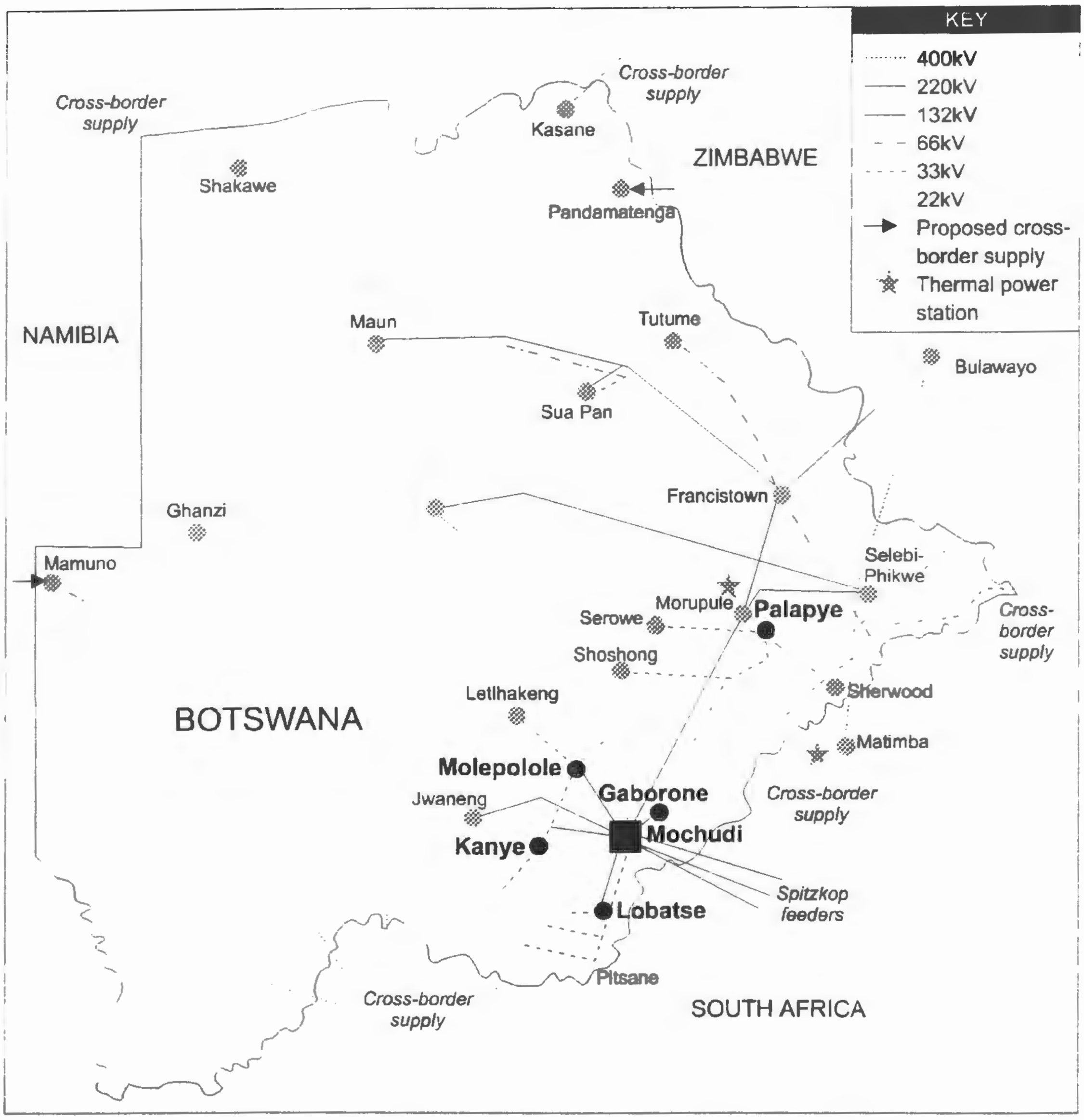
1. It is important for the EAD to articulate to the responsible government departments and institutions the seriousness of the impact of poverty on the use of fuelwood and the environmental concerns. A small documentation presenting the facts of the matter could be useful for such awareness creation.
2. There must be a conscious effort to investigate all energy policies and private energy services in order to identify areas where poverty alleviation measures could be integrated. All sections of the EAD could be asked to undertake this task periodically and the results collated together as a MMEWA policy document on poverty alleviation. This should aim at things that can be done to assist the poor and vulnerable communities as well as government institutions in order to benefit adequately from such policies and services.
3. A special effort should be made to target women concerning poverty alleviation. This study makes it clear how female-headed households form the majority of poorer households. The provision of energy services should therefore explore ways of supporting income-generating activities of women. This task should not be left on the shoulders of government alone but the private sector should also be drawn in.

Acknowledgements

The Project Team is sincerely grateful to all those who have contributed in diverse ways in making this study a useful resource to the people of Botswana. First and foremost, we are thankful to the Botswana Government for funding this project. We feel very indebted to all those who opened up their homes, their institutions and their energy businesses to us and offered to provide us with all manner of information we required. To you, we say a big thank you. There are many others who have contributed to the success of the project and we are thankful to you all. Specifically, we would like to express our sincere gratitude to the following:

- Energy Affairs Division staff especially Mr Michael Utke, Mr Sam Bok and Mr Boiki Mabowe for all the technical and logistical support to the Project Team.
- The Reference Group for all their advice and guidance.
- Ms Boitumelo Motoma, Ms Gertrude Joseph, Ms Maggie Seroke, and Mr Lemogang Mphato for all their dedication as enumerators in gathering quality information for the Botswana Government.
- Mr Pule Monamodi (EDG) and Mr Dominic Moses (FAB) as fieldwork supervisors whose invaluable contribution is evidenced in the quality of information in this report.
- Ms Nthabiseng Mohlakoana (EDRC) and Mr Pule Monamodi for all their patience and enthusiasm in capturing the data and helping with the analysis.
- Kedibonye, Hilda and all the FAB staff for all their warmness and support to the Project Team.
- Dr Peter Zhou of EECG for all the useful thoughts we shared about the project.

National electricity grid of Botswana



Drawn from the Botswana Power Corporation Annual Report 1998

Abreviations and acronyms used

BEMP	Botswana Energy Master Plan
BHC	Botswana Housing Corporation
BoTeC	Botswana Technology Centre
BPC	Botswana Power Corporation
HH	Households
NDP	Botswana National Development Plan
COLI	Cost of living index (indices)
CSO	Central Statistics Office
EAD	Energy Affairs Division
MMEWA	Ministry of Minerals, Energy and Water Affairs
MFDP	Ministry of Finance and Development Planning
ECUP	Expanded Coal Utilisation Project
GAB	Gaborone
MOC	Mochudi
LOB	Lobatse
PALA	Palapye
KAN	Kanye
MOLE	Molepolole
ESMAP	Energy Sector Management Assistance Programme
HIES	Household income expenditure study
RECS	Rural Electrification Collective Scheme
SHHA	Self-Help Housing Agency
SWH	Solar water heater
RIIC	Rural Industrial and Innovations Centre

1. Introduction

This document is a report on a project established under the tender called for by the Government of the Republic of Botswana on Fuelwood Survey in Urban Areas Study numbered TB 10/1/10/99-2000. The tender called for a study to be conducted to determine the actual fuelwood consumption patterns in six selected urban areas, investigate the influence of socio-economic development over the last decade on fuelwood use and design long-term strategies to reduce fuelwood consumption.

The study focused on six urban areas namely Gaborone, Lobatse, Palapye, Molepolole, Mochudi, and Kanye, which have been highlighted on the map on page *xxi* in this report. The main methods used were field surveys using pre-structured and pre-tested questionnaires, literature review, consultations with stakeholders, observations, data analysis and energy modelling. Enumerators were drawn from Botswana in order to add value to the outputs through their familiarity with local environment and players. The study started in August 2000 and the survey data was collected in September and October 2000.

1.1 Problem analysis

The main problems identified in the urban fuelwood situation in Botswana were that:

1. The fast rate of urbanisation has put considerable stress on the existing fuelwood resource and there is lack of knowledge about the current fuelwood use patterns and their environmental impacts on the woodlands surrounding urban and peri-urban areas.
2. The increasing unavailability of fuelwood has a potential negative impact on low-income urban households who do not have the means to either switch to other fuels or collect fuelwood beyond walking distance.
3. There is some evidence of all manners of perceptions and behaviours about fuelwood and energy use in general, which have led to the continuous dependence on fuelwood and its recent scarcity thereof. Fuelwood collection distance has been on the increase and it is also evidenced that urban fuelwood use is linked to the fuelwood deprivation in the rural areas. The extent of these evidences needs to be established and there is a need to test the willingness of household to switch to other fuels.
4. That urban household energy needs were assessed a decade ago and the existing database is obsolete for making any fuelwood projections.

1.2 Project objectives

The overall project objective was that this study would contribute to making fuelwood consumption in urban areas of Botswana sustainable.

The immediate project objectives for addressing the problems summarised in Section 1.1 above were that:

1. Actual fuelwood consumption patterns in urban areas of Botswana would be established.
2. Influence of socio-economic development on fuelwood use patterns over the last decade ten would be investigated.
3. Strategies toward sustainable fuelwood consumption would be designed.
4. Reliable and updated fuelwood information source for projections and planning would be established.

1.3 Project outputs

The outputs resulting from the immediate objectives outlined in Section 1.2 would be that:

1 Fuelwood consumption patterns are reported.

2 Impacts on fuelwood consumption by socio-economic development are analysed and reported.

3 Projections of fuelwood use and strategies to reduce fuelwood consumption are designed and documented.

4 Database specific to data gathered by project is prepared.

1.4 Project personnel

This project was undertaken by a consortium comprising Energy and Development Research Centre (EDRC), Energy and Development Group (EDG) and Forestry Association of Botswana (FAB). EDRC was the leader of this consortium.

The core team members in the consortium were Yaw Afrane-Okese (EDRC), Mark Borchers (EDG), and Lesego Motoma (FAB) and Njeri Wamukonya (EDRC).

Other people working on the project included four enumerators who were recruited locally, and Mr Pule, a researcher from EDG and Mr Dominic Moses of FAB. The enumerators were Ms Boitumelo Motoma, Ms Gertrude Joseph, Ms Maggie Seroke, and Mr Lemogang Mphato.

1.5 Overall project approach

The project team was in consultation with relevant stakeholders in undertaking the surveys. Apart from the three scheduled Reference Group meetings, the project team held meetings with the Energy Affairs Division (EAD) of the Ministry of Minerals, Energy and Water Affairs and sometimes provided them with written progress report on certain issues where necessary. An EAD personnel, Mr Boiki Mabowe, partook in the survey of one of the study areas. It is believed that the consultative approach has enhanced the progress of the project enormously. A reconnaissance survey was also undertaken in all the study areas in order to guide the enumerators in their sampling on the field.

1.6 Linkage between the Urban and Rural Studies

This Urban Study has stayed in touch with the concurrent Rural Energy Study on project management levels. This is to facilitate the necessary synthesis of information gathered from the two studies. It will help create a complete national picture of the fuelwood situation.

1.7 Survey data sets

The EAD database has been reviewed and it has been realised that the data content is purely aggregate information and thus any useful linkage with the data collected in this study will have to be at the aggregate level. The aggregated information in this report, especially the fuelwood demand projections will be useful for that purpose. The survey data has been organised in three data sets in Microsoft Access. The main database is on households, and the other two are on institutions and fuelwood/energy dealers.

The current EAD energy database in Lotus software has gone obsolete in terms of data and software design. It would require a thorough review of all databases available and the necessity to link them in order to assess what software platform would be more suitable for the design. Consideration should also be made of all external databases in other Government departments that may be necessary to be linked to the EAD database. However, whatever software platform is chosen for the database design, it would have to be adaptable to a wider scope of versatile current and potential future softwares in order to allow easy import from and export to the database. For example, the Microsoft Office software packages are currently easy to import from and export to one another and it would be easy to link a Microsoft Access database platform to other data formats.

2. Literature review

2.1 Natural features of Botswana

Botswana is a landlocked country with a featureless to gently undulating topography. Over 80% of the country's land surface is covered by the sandveld land system, of which the Kalahari Desert is a part (Kgathi et al 1994). The Kalahari is not a true desert but has a vegetation typical of the low savannah. The remaining 20% of the land surface, in the south-eastern, eastern and north-eastern parts of the country, hosts the hardveld land system. This has sandy loam and loamy sand soils which support arable agriculture, and is relatively densely populated.

The climate is semi-arid with variable rainfall over the whole country, and most of the rain falls in scattered showers with extremely uneven distribution. The pattern of rainfall greatly influences the type of vegetation in Botswana. In the north where rainfall is generally high vegetation consists of dry deciduous forests. However, in many parts of Botswana where rainfall is in the medium range (350-550mm), vegetation is mainly in the form of tree savannah. In the western part of the country, in the Kalahari Desert where there are poor soils and low rainfall (less than 350mm), the vegetation is mainly a shrub savannah.

2.2 Socio-economic context of urban areas of Botswana

Although the average population density of Botswana is very low by international standards (currently about 2.7 people per square kilometre), most of the population is concentrated in the towns and villages of the eastern part of the country where the soils are relatively fertile to support the limited, largely subsistence arable agriculture. An estimated 80% of the 1991 total population of 1.33 million lived within 100km of the Francistown – Gaborone railway line traversing the eastern part of the country (EDG 1996). Concentration of population results in strong local demand for fuelwood and pressure on woodland resources.

Although Botswana is sparsely populated, Sekhwela reported in 1994 that the population is one of the fastest growing in Africa, growing at a rate of 3.5% annually (1994). The Botswana Energy Master Plan (BEMP) (EDG 1996) estimated the urbanisation rate at 8% per annum and this fast rate of urbanisation has been putting considerable stress on the existing fuelwood resources. Although in sub-Saharan African terms the population can be considered well-off, in world terms the median income level is relatively low. There is a concern that increasing unavailability of fuelwood is mainly going to affect low-income households who do not have the means to switch to other fuels nor to collect fuelwood beyond walking distance.

2.3 Urban-towns and urban-villages

The current total Botswana population has been projected as about 1.65 million in 2000. According to the Central Statistics Office (CSO), urban areas in Botswana are defined as all settlements on state land and those on tribal land with a population of 5 000 or more persons with at least 75% of labour force in non-agricultural occupations (subsistence farming) and those on stateland (CSO 1997: 17). The percentage of people living in urban areas in Botswana rose from 9.6 in 1971 to 18.3 in 1981 and 45.7 in 1991. Estimations from population projections put the current urban population percentage in 2000 at about 50 as a result of a growth of about 37% in a decade.

The main urban centres in Botswana in 1971 were Francistown, Lobatse and Gaborone. The oldest of these is Francistown, which over the years grew in size and developed urban characteristics. At the time of the 1971 census, Gaborone has just been established, hence the sharp rise in population from under 18 000 in 1971 to nearly 60 000 in 1981. Apart from Gaborone, four other towns built after independence in 1966 were Selebi-Phikwe, Orapa, Jwaneng and Sowa. The first three towns were settled between 1971 and 1981, so the largest extent in the increase in urban population growth between 1971 and 1981 was due to the creation of new urban areas. These seven urban centres which have clear characteristics of planned settlements and infrastructure with established urban administrative structures are referred to as *urban-towns* or simply *towns* in this report.

Kasane and Ghanzi are settlements on state land that got qualified as urban settlements in 1991 on a basis of population size and labour force proportion in non-agricultural occupations. In accordance with the above definition of urban settlement, the following settlements were in 1991 classified as urban settlements on tribal land: Kanye, Moshupa, Tlokweng, Ramotswa, Molepolole, Gabane, Mogoditshane, Thamaga, Mochudi, Palapye, Serowe, Mahalapye, Bobonong, Letlhakane, Tutume, Tonota and Maun. Tlokweng and Palapye already had these characteristics by 1981. All these 19 settlements that qualified to be urban mainly on the basis of population size and labour force proportions are referred to as *urban-villages* or simply as *villages* in this report.

The largest urban centre, Gaborone, currently has a projected population of 203 017 and together with the other six urban-towns make up about 52% of the urban population (CSO 1997: 52-54). This leaves the villages with a percentage of 48.

2.4 Household access to energy services in urban Botswana

According to the 1996 Final Report of the Botswana Energy Master Plan (BEMP), the majority of Botswana households used fuelwood and paraffin as the main fuels. Although the BEMP reported no evidence of widespread energy poverty as such in Botswana, cases of fuelwood shortages were reporeted to be increasing (EDG 1996). According to the BEMP database, about 55% of the urban households used fuelwood but the rural households were even more dependent on fuelwood with about 90% using fuelwood for energy purposes (EDG 1996). 70% of urban households used paraffin while 45% used liquefied petroleum gas (LPG). About 10% of all households in Botswana had access to electricity, about 24% urban and 3% rural. Analysis of electricity usage patterns from the 1996 BEMP indicates low average (200 kWh/month) per household, with electricity generally not contributing much to the thermal loads of cooking and water heating. It must be noted that this household energy access profile found in widely published literature is largely based on data projections collected in the BEMP energy database over a decade ago and it urgently requires an update in order to make further projections and planning relevant.

The BEMP Summary report (1993) indicates that there were only few small (60Wp) photovoltaic (PV) household systems installed in the country. However, Botswana has amongst the highest solar radiation levels in the world and therefore renewable energy resource holds particular promise for application in the country. On the other hand, the low population density is an obstacle, and the distribution of technical support for renewable technologies needs attention alongside any technical considerations.

2.5 Fuelwood use in urban areas of Botswana

Biomass energy is mainly consumed in the form of fuelwood in Botswana. Charcoal is not produced, as it is in most developing countries (Kgathi et al 1994). In terms of quantities consumed, fuelwood has remained the dominant fuel in Botswana for some time, accounting for about 57% of national energy consumption in 1991. More recent energy balances in 1996/1997 and 1997/98 show that fuelwood contributes about 35% and 32% respectively to the Primary Energy Supply (EAD 2000a: 3). The residential sector dominates energy consumption in Botswana with a share of about 44% of the Final Energy Demand in 1997/98. According to the Botswana National Development Plan 7 (NDP 7), fuelwood dominated energy consumption in urban households in terms of quantities, accounting for about 81% demand in 1991 (ESMAP 1991). The 1996/97 Energy Statistics Bulletin shows that the fuelwood contribution to the urban household energy demand had been reduced to 78%. In terms of the actual annual urban household fuelwood consumption, the Energy Statistics Bulletin of the Energy Affairs Division estimates are 270 kilotonnes (4316 TJ) for 1995/96 and 279 kilotonnes (4462 TJ) for 1996/97.

These figures show how important fuelwood is to the urban households. It is widely reported that the main use of fuelwood in the household has been for cooking. Other uses of fuelwood reported in literature include space heating, water heating, baking, lighting (direct and indirect), roasting, ironing and brewing. In most cases, candles and paraffin are reported as the main sources of lighting. Fuelwood is also reported to be used in the government, industrial and commercial sectors.

Due to space heating in winter there is substantial seasonal variation in fuelwood consumption. Fuelwood harvesting is generally regarded to have a major contribution to deforestation. Some researchers have refuted this (e.g. Sekhwela 1994) and have rather found fuelwood impact to be minimal since it salvages otherwise wasted wood from agricultural clearing, dead branch remains from cut wood and dead wood generally for immediate use in fires. The recently completed study on "Fuelwood and Woody Biomass Assessment around Mochudi and Bobonong" confirms the exaggeration of fuelwood use contribution to deforestation (NRP 2000). However, many traders in fuelwood are widely viewed to have a rather different pattern of fuelwood cutting, which is the same as other wood harvesting for other purposes like construction. The cutting of live trees and the continuous increase in fuelwood collection distances have become a great concern. Many of the Energy Statistics Bulletins refer to fuelwood as basically "free" in the rural areas (Energy Statistics 1995/96, 1996/97, 97/98). The use of fuelwood in urban areas is also alleged to be having negative impacts on rural areas as in most cases these areas serve as collection zones for urban centres and often deprive the rural poor of their only source of energy.

According to Kgathi & Mlotshwa (1994), research findings show that most preferred fuelwood species like *Combretum imberbe* have become over-exploited in the south-eastern Botswana. In the North-East District, *Colophospernum mopane* not only tends to dominate the vegetation, but it is also preferred (ERL 1985, Opiro 1996).

2.6 Promotion of coal use in Botswana

Through a bilateral technical co-operation between the Government of Botswana and Federal Republic of Germany the Expanded Coal Utilisation Project (ECUP) was established in 1987 (EAD 1998: 6). The overall goal of the ECUP was to contribute to the preservation of the natural vegetation by using coal instead of fuelwood where viable and to reduce dependence on imported fuels. The promotion of coal was targeted at the industrial, government institutions and households. Some marked success has been reported in the former two sectors but there have been problems of uptake in the household sector ranging from unavailability of coal, unavailability and affordability of appropriate equipment, price of coal, etc. To address these problems the commercial wing of the project was privatised at the beginning of 1998 and the Government has equipped the central coal depots in Francistown and Gaborone with offices and rail links to enable reliable delivery and enhance better handling of coal. These coal depots have been leased to coal dealers at a concessionary rate and the ECUP was finally closed down on 31 January 1998 (EAD 2000a: 6).

A coal beneficiation study carried out in 1997 showed that prior washing of Morupule coal in a plant could improve the quality and reduce pollution. A follow-up study on market assessment of the product established that there is a market potential of 40 000 tonnes of washed coal (MFDP 2000: 122). However, from economic point of view, the plant is not currently viable because the coal product would cost P100/tonne compared with the current market price of P79.75/tonne.

2.7 Household access to electricity

The network extension plan of the Botswana Power Corporation (BPC) will continue for the remaining part of the NDP 8. The plan aims at extending reticulation networks within already electrified villages in order to improve uptake. Under the project "Extension of Distribution Network in 14 Selected Villages" which was completed in October 1998, the following villages were covered: Kanye, Ramotswa, Tlokweng, Molepolole, Thamaga, Tonota, Serowe, Palapye, Mochudi, Mogoditshane, Moshupa, Bobonong, Mmadinare and Mahalapye (EAD 2000a:6).

In order to accelerate rural electrification, the government has decided to electrify 72 villages. The project started in September 1999 and is expected to be complete in October 2001. At the end of 2000, a total number of twenty-four (24) villages were electrified and the remainder will be electrified by October 2001. The total number of villages connected to date is 145 (Hlambelo 2000).

With the exception of the Rural Electrification Collective Scheme (RECS)[1], 100% upfront payments were required prior to October 1995 for any electricity network extensions necessary to connect customers' installations (BPC 1998). From October 1995 to March 2000, upfront payment was reduced from 100% to 25% with repayments between twelve (12) and forty-eight (48) months for individuals. For RECS customers, upfront payment was reduced from 40% to 10% and the ten (10) year repayment period maintained. In April 2000, government approved the reduction of down-payments from 10% to 5% and the remainder paid back in 15 years with interests shown below:

[1] RECS is available to rural customers forming a collective group of 4 or more customers in making agreement for electricity connection (BPC nd). RECS does not cater for house wiring costs.

Pay period	**Below 35 kW**	**Pay period**	**Above 35 kW**
18 months	Interest free	12 months	Interest free
60 months	Prime rate – 0.5%	60 months	Prime rate – 0.25%
180 months	Prime rate	180 months	Prime rate

2.8 Energy use in government institutions

The negative environmental impact of unsustainable utilisation of fuelwood led to the issue of a directive from the Office of the President in 1995 to all government institutions to use alternative sources of fuel such as coal (EAD 2000b). In response to the directive the Energy Affairs Division (EAD) has conducted a number of studies to monitor the situation. The initial study carried out during late 1996 covered a sample of government institutions in Gaborone, Lobatse and Ramotswa (EAD 1996). In 1998, the EAD and Morupule Colliery jointly extended the study to Mahalapye, Palapye, Francistown, Kasane and Kang (Leipego A & Lloyd P 1999). The EAD followed the above two studies with another study in Gaborone in 2000 (EAD 2000b).

The 2000 study revealed that most government institutions in Gaborone no longer use fuelwood, rather they have switched to other sources of energy like electricity, coal and liquefied petroleum gas (LPG) or use fuelwood in combination with any of these alternative sources. Out of the 57 institutions interviewed 22 did not use fuelwood at all. Only 4 institutions were found to be using fuelwood alone. 3 were using both fuelwood and coal while 6 use both fuelwood and electricity. The remaining institutions were using other sources of fuel LPG and electricity. The report concluded that there has been a positive response to the government directive in curbing the excessive use of fuelwood to the detriment of the environment. Institutions like the Botswana Defence Force, the Botswana Police and the Botswana Prisons and Rehabilitation Services have all issued instructions to forbid fuelwood use but it is the enforcement that require monitoring.

The 1999 study estimated a total annual consumption of fuelwood by schools to be 63 000 tonnes. Based on estimations by Tietema et al (1988) for schools and clinics in Dukwe, Sekhwela (1994: 70) estimated the total national annual consumption of fuelwood by the then 572 schools and 153 clinics to be 142 428 and 71 757 tonnes respectively.

2.9 Fuelwood flow paths in Francistown

The Energy Affairs Division (EAD) commissioned a study in 1999 to find out how much fuelwood is used in Francistown, by whom, where it comes from, the means by which it reaches the consumer and at what cost (White 1999). A total of 241 households and 30 traders were surveyed in summer (ending of February and beginning of March). The report on the study does not indicate any seasonal variation in energy consumption patterns and energy use patterns are reported for only fuelwood users.

The report concludes that firewood is the major source of energy to most households in Francistown. According to the report, about 77% of Francistown households used firewood and about 30% described fuelwood as their main fuel. It can be deduced from the figures in the report that the main end uses of fuelwood in the household are water heating (59%) and cooking (29%) and that space heating with fuelwood is insignificant (4%).

The study also concluded that institutional use of firewood in Francistown is of no practical significance since institutions consume only less than 1.2% (500 tonnes) of the total fuelwood consumption in Francistown. The only public institutions still using substantial quantities of fuelwood are the primary and community junior secondary schools.

In terms of consumption, the study reported a mean annual consumption of 3.1 tonnes per household or 558 kg per person (or *per capita*). This leads to a total consumption of 41 903 tonnes of fuelwood a year. Deductions from these figures and the Francistown population show that the *per capita* consumption reported is based on fuelwood users only and not the total population. These consumption figures need to be compared with mean annual household consumption rates given by

ERL (1985) as 3.2 tonnes in rural areas and Kgathi & Mlotshwa (1997) and Sekhwela (2000) as 1.9 tonnes in peri-urban zones. It is usually not made clear when these figures are quoted in literature whether the consumption figures refer to fuelwood users only or all the households. It must be also mentioned that the Francistown study does not make considerations for seasonal variation in annual fuelwood consumption.

2.10 Energy policy goals and measures

The Botswana Government has made significant attempts to integrate energy matters into its wider development planning. Apart from ensuring economic efficiency in energy production, importation and use, the energy policy goals and measures enshrined in the Botswana Energy Master Plan (BEMP) (EDG 1996) also seek to reduce the economic, environmental and social costs associated with the use of fuelwood. However, the BEMP does not have good up-to-date information base for an important energy source like biomass. A comprehensive information on fuelwood use and supply is required for evaluating and monitoring the effectiveness of the policy measures outlined in the Energy Master Plan. The NDP 8 asserts that the "energy ladder" theory has fallen by the wayside and that households behave rationally by typically employing a combination of energy forms depending on cost and application (MFDP 1997). To meet adequate needs of households, the NDP 8 aims to:

- Ensure adequate supplies of fuelwood;
- Use technologies that will reduce the cost of electricity;
- Ensure the availability of appropriate energy services to meet household needs and promote rational least cost choices;
- Develop EAD energy policy formulation capacity in respect of household energy needs; and;
- Provide appropriate services to inform households of cost effective options in order to promote rational least-cost choices.

2.11 Findings of the "Study on Fuelwood / Woody Biomass Assessment around Mochudi and Bobonong"

Some of the important findings of the study in Mochudi and Bobonong (NRP 2000) useful for this study are that:

- Fuelwood remains an important source of energy for households in Mochudi and Bobonong. For majority of poor households in Bobonong, fuelwood is the only source of energy. Even households who own gas/electric cookers and have other sources of lighting and heating use fuelwood to save on gas and electricity.
- During the winter, the demand for fuelwood is higher as it is used for heating and keeping households warm.
- According to fuelwood collectors, no live trees were cut down for fuelwood and that this is something that is understood by the community in Bobonong. Live trees are only cut for use as building poles.
- Fuelwood represents an important source of income for a significant number of people in the Bobonong area. Men who own donkey carts collect fuelwood while their female counterparts sell it.
- Fuelwood also has an important cultural significance, as it is required when there are large cultural gatherings such as funerals and weddings.
- Fuelwood is taken exclusively to mean "firewood" since its derivatives like charcoal, and other potential fuel sources like dry sorghum stalks and cattle dung do not really feature in Botswana as fuel sources.

2.12 Linkage between this project and other work on fuelwood use

This project on fuelwood survey in urban and peri-urban areas is linked to other studies on fuelwood use and supply in Botswana. One of these studies is the recently completed study on Fuelwood Inventory and Monitoring Programme (FIMP) (NRP 2000) which was initiated with the "Study on Fuelwood / Woody Biomass Assessment around Mochudi and Bobonong". On the demand side, this urban fuelwood survey project could be supplemented with information from the current parallel study on Rural Energy Needs and Requirements by establishing useful relationships with the urban and rural fuelwood use. A synthesis of the rural and this urban study would help create a national picture of the fuelwood demand situation.

Besides current fuelwood studies, there is extensive literature on fuelwood use and supply whose review has been useful in informing this project. Some of the useful pieces of literature are *Environmental Impact on Woody Biomass Utilisation in Botswana* by Sekhwela (1994) and *Biomass in Botswana* by Kgathi et al (1994) in Energy and Coal in Africa. The Bibliography of the BEMP Final Report 1996 and the Publications Lists of the National Institute of Development Research and Documentation (NIR) have also been a very useful source of information. Other sources of information have been studies and surveys on fuelwood conducted by institutions like the Forestry Association of Botswana (FAB), the Energy Affairs Division and NIR. The Francistown Study on Fuelwood Flow Paths (White 1999) and the 1991 ESMAP Urban Household Energy Study have also been very useful to this study.

3. Survey methodology and observations

The research information was collected using questionnaire surveys. The household information was collected using structured questionnaire while information on fuelwood/fuels dealers and use in institutions was collected through unstructured questionnaires. The study required energy use data collection from 6 study sites namely: Gaborone, Lobatse, Mochudi, Molepolole, Kanye and Palapye. At the end of the survey a total of 794 households, 51 public institutions and 55 fuel dealers had been interviewed.

3.1 Study sites selection

The 6 urban areas under study represented the current scenario of Botswana urban areas. As discussed in Section 2.3, there are two types of these urban settlements. The first type consists of the real *urban-towns*. These were started as towns from the planning phase. The towns have town councils as the administrative body. The plots are in streets and have numbers. The towns are also characterised by Botswana Housing Corporation (BHC) as the major developer. Gaborone and Lobatse fall into this category. Allocation of plots in these town clusters has different housing cost types, which translate into the socio-economic levels.

The other type is that of *villages* that have grown so big that their populations do not qualify them to be rural any more. Kanye, Mochudi, Molepolole and Palapye fall into this category. The set up is that of the main Kgotla and wards. Unlike the other towns, there is no distinction in plot allocation according to housing type cost. These towns are usually the administrative headquarters of their districts. The government and council have built houses for their employees and these are normally the only rented houses.

The study sites were selected by the project Client based on the severity of fuelwood scarcity. According to Millington et al (1988: 55-57), low productivity levels and low standing biomass are typical of large areas of the following districts of Botswana: Barolong, Ghanzi, Kgalagadi, Kgatleng, Kweneng, Ngwaketse and the South-East. Of these districts the following are either highly populated, or have large towns (shown in parenthesis): Kgatleng (Mochudi), Kweneng (Molepolole), Ngwaktse (Kanye) and South-East (Gaborone and Lobatse). Thus these 5 urban centres were included in the study sites.

In addition, the following large towns, which are all in Central District and have populations larger than 10 000, are situated in biomass classes with localised supply problems: Mahalapye, Serowe and Selebi-Phikwe. Palapye falls into this category and was thus included in the study. In this study Selebi-Phikwe has been assumed to have a high percentage of households using fuelwood like Francistown because there is a lot of literature pointing to that fact.

According to Millington et al (1988), only 2 Batswana towns are in biomass classes with less severe problems namely: Francistown and Maun. A study on fuelwood flow paths had already been commissioned at Francistown in 1999.

Thus the study sites comprise Gaborone and Lobatse, which constitute the *towns*, and Mochudi, Molepolole, Kanye and Palapye, which constitute the *villages*. The 6 study sites selected were all close to the south-eastern border as shown on the map on page *xxi* in this report.

3.2 Sampling approach

The household sampling methodology for the project was driven mainly by three factors: 1) limitations of project resources, 2) improvement in representation by cluster/stratified sampling and 3) probability theory.

1) Project resources

The project budget estimated 90 enumerator-days for the whole survey. This number excludes the days for the questionnaire piloting and training since questionnaires used in those exercises were not accurate enough to be included in the study. A conservative assumption of 7 questionnaires per each enumerator-day limited the study to an estimated planned total sample size of 630 households for all the six urban centres included in the study. However, as enumerators gained more experience with the questionnaire during the survey, project resources were stretched to achieve a higher total of 794 households.

2) Cluster/stratification
Taking cognisance of the fact that the estimated total sample size is far small (less than 1%) compared with an estimated total population of about 380 976 (i.e. about 76 125 households) in all six study sites, elements of cluster sampling and stratification were used to improve the representation of samples with similar characteristics. The first level of clustering constituted the 6 different urban centres and the second level was the type of dwellings households were living in. It was assumed that the value of dwelling type or housing cost was, to a large extent, related to the income levels of households (although this was not true in all cases as revealed in the analysis done) and thus the dwelling type clusters were used as proxies for the stratification. It may be argued that household types are, to some extent, determinants of specific energy use characteristics, which are also largely influenced by income levels. 5 different strata of dwelling types or housing costs were identified for the total sample as: 1) Very High Cost, 2) High Cost, 3) Medium Cost, 4) Low Cost and 5) Very Low Cost. As expected, not all of these household types were found at all the study sites and in some cases there was a need for combinations of household types to reflect the proportions available.

3) Probability theory
The third consideration in the sampling methodology was based on probability theory. Results from a sample survey are used to estimate results for the population from which the sample is drawn. Probability theory can be used as a guide for estimating how accurate the sample sizes are likely to be. In the same way, probability theory can be used as a guide to deciding how large the sample size should be, in order to reach acceptable levels of accuracy or confidence when generalising from the sample results to the population. This statistical approach to determining suitable sample sizes requires certain assumptions to be made. For this reason, it only serves as a guide, and is usually combined with further judgements, and consideration of practical logistics and resources available, before choosing a sample size for a given project.

According to this theory, the statistical accuracy of the sample results will depend mainly on two factors, (1) the size of the sample, (2) the amount of variance or heterogeneity in what is being measured. If the variance is low, then the required sample size (to achieve a given confidence interval) is less than if the variance is high. It is noteworthy that the representivity of a sample usually does not depend much on what percentage of the total research population is sampled. This only becomes a significant factor if that percentage is quite high (e.g. 50% or more) whereas in cases where the sample constitutes smaller percentage of the research population, this percentage factor is of minor importance, and it is the absolute number of units in the sample, not the percentage, which dominates the calculations.

The variance in what is being measured is usually not known in advance. In a questionnaire survey, it will also vary from question to question. With this in mind, one possible approach is to start off by considering a simplified "worst case" scenario, and examine the sample sizes required to achieve selected levels of accuracy and confidence in this scenario. Judgements can then be made about how to improve upon that worst case and what reasonable reductions in sample size can be made.

The simplified "worst case" can be outlined as follows: (a) Sampling method: simple probability sample (simple random sample); (b) Type of survey question: two-category response (e.g. Yes/No); (c) Maximum variance: when 50% of the population answer one way, and 50% the other way. On these assumptions it is possible to work out what sample size would be needed to achieve selected confidence intervals.

3.3 Sampling design

3.3.1 Households

Survey timing
The household survey was conducted in September and October 2000. Thus the winter months had ended resulting in less fuelwood requirement for house heating purposes. Consequently, fuelwood was not available at the household level for weighing in most cases as households were only purchasing or gathering fuelwood for daily needs unlike in winter when they might have piled it for longer period of time.

Proportional representation of sampling

a. Household types
Household types were determined based on socio-economic levels. In Gaborone and Lobatse five categories of households were established based on the housing types prevailing. The housing types reflect their value/costs that could also be linked to the household income levels. The types identified were Very High Cost, High Cost, Medium Cost, Low Cost, Very Low Cost/ SHHA (Self-Help Housing Agency) housing. These were further divided into three robust groups in the case of Lobatse viz., Very High Cost, Medium/ High Cost, and Low/ Very Low Cost/ SHHA. The combinations of the higher income household types in Lobatse were to compensate for relative abundance of low and very low-income groups in that town as compared to Gaborone.

In the remaining towns it would be difficult to come up with 5 groups because of the mixed distribution of housing structures. The housing types were divided into two main groups of rented housing, and the normal village (town) residential. The rented housing encompassed Botswana Housing Corporation (BHC) housing where applicable, government and council housing. Government housing extended to schools. The other type of housing was difficult to separate into cost levels. Therefore, these were recorded during interviews by way of noting the type of house built and any indicators of socio-economic levels.

b. Proportions
Based on the population projections for the year 2000 provided by the Central Statistics Office, a population ratio was used to establish proportional representation of samples across the towns (refer to Table 3.1). However, this ratio would mean that the integrity of the samples in terms of statistical significance would be ignored. For statistical significance in general, each selected household type would have a sample size of about 33, but not less than 25. This was based on calculations from normal distribution tables. Thus, the proportions calculated from the towns based on their total populations would not suffice for statistical significance. To correct this situation a deliberate step was taken to balance out the proportions to at least 33 households per house type. This was applied to the 5 smaller towns first so that the remainder could be allocated to the larger Gaborone to compensate for proportional representation. However, this did not warrant large sample sizes for house types with few households. This was especially the case in the smaller towns where the BHC/ Council/ Government houses were very few compared to the normal town residential houses (ratio of about 1:6).

Town	*2000 population projection*	*Proportion to the total population*	*Number of household types*	*Sample size (households) estimation*	*Corrected proportions*	*Actual households sampled*
Gaborone	213017	55.91	5	266	42.22	305
Lobatse	32075	8.42	3	100	15.87	124
Kanye	36877	9.68	2	66	10.48	90
Mochudi	30671	8.05	2	66	10.48	88
Molepolole	47094	12.36	2	66	10.48	95
Palapye	21242	5.58	2	66	10.48	92
Total	380 976	100		630	100	794

Table 3.1: Population and households sampling of study areas

Determining the sample

a. Gaborone
The detailed plot map of Gaborone was obtained from the Surveys and Lands Division of the ministry of Lands and Housing. The different housing types were deduced from the plot size, with increase in plot size denoting increase in cost of housing type. In Gaborone although interspersed, the housing types could be identified in the different parts of the town. Prior knowledge of the Gaborone set-up facilitated sampling of the SHHA whose plot size do not differ from the BHC low cost housing.

Samples in each housing type were taken at approximately 50 household intervals. Samples were not taken on strict stratified basis. There was flexibility in that if the fiftieth household was not available to respond to the questionnaire a neighbouring household was interviewed instead. Some problems were encountered especially in the Very high cost housing of city centre where the homeowners were not available to be interviewed during the day. A strategy that seemed to work was that questionnaires were left so that they could be collected from homeowners at a later time. On collection of the questionnaire the enumerators sought for clarification of any issue omitted

At the end of the survey the total number of households done in Gaborone was 305.

b. Lobatse
Planning of the sampling for Lobatse was a challenge because the maps obtained from Surveys and Lands Department were very scanty and had very little informative data. For instance, the street names were not marked on the maps. A reconnaissance survey was done at Lobatse and a sketch map drawn during the trip. Unlike Gaborone, Lobatse had a very high incidence of low to very low/ SHHA housing types.

Samples in each housing type were taken at approximately 50 household intervals. Again, samples were not taken on strict stratified basis. There was flexibility in that if the fiftieth household was not available to respond to the questionnaire a neighbouring household was interviewed instead. At the end of the survey a total number of 124 households was done at Lobatse.

c. Molepolole, Mochudi, Palapye, Kanye
The maps used for planning the samples for Mochudi, Molepolole and Palapye were obtained from the Botswana Power Corporation and Central Statistics Office (CSO). The one sheet from CSO showed the number of households in the different parts of the respective village. Six sheets of the BPC maps at a scale of 1:5000 covered the whole of Molepolole. Three sheets covered Mochudi and four sheets covered Palapye.

It was difficult to get a comprehensive map from both BPC and CSO on Kanye. A very small copy of Kanye map was obtained from the Department of Towns and Regional Planning. A visit to the site also facilitated the sampling exercise.

The total number of households covered at Molepolole was 95, 88 at Mochudi, 90 at Kanye, and 92 at Palapye. The whole survey took 2 months to be completed and at the end of the survey a total of 794 households had been covered as shown in Table 3.1. This total sample constitutes just over 1% of the universe. The table also shows that over 40 sampled households were surveyed for each dwelling type at each study area.

Fuelwood weighing
Fuelwood was weighed both at the household and dealer levels. The households were requested to put together the amount of fuelwood they would use for a full day's cooking. The pile was then weighed and the species name recorded. At the dealers' sites the different units of fuelwood piles were identified and weighed. In total fuelwood was weighed in 39 households.

3.3.2 Fuels distribution chains

Main distributors
Distribution chains for all fuels used in the households were established through interviews with main distributors and dealers. The main distributors for the different fuel sources included Morupule Colliery for coal, domestic gas distributors, BP for paraffin and domestic gas, Botswana Power Corporation for electricity, Solar Power and Solar Hart for solar power. A particular attention was paid to fuelwood distributors but the main harvesters for fuelwood were identified as located in the rural areas outside the study areas.

Besides fuelwood, most of the main distributors have their headquarters in Gaborone. Therefore, they were interviewed during the survey in Gaborone. Ideally the main distributors supply the dealers at Gaborone suburbs and in the other urban centres.

Dealers

The next level of distributors comprised dealers. This group comprised of wholesalers, supermarkets, depots (including filling stations) and fuelwood traders. A deliberate bias was made to sample dealers in different energy sources in a given area to achieve quality information as opposed to quantity. The dealers in each area were covered during the household survey of the particular area. Refer to Chapter 10 for details on fuelwood dealers.

At the beginning of the survey in Gaborone, tuck shops (*dimausu*) were considered but after realising that they had no variety of information, they were left out even in the other urban areas in this study. Fuelwood traders were either firewood gatherers or dealers.

3.3.3 Institutions

Institutions included in the survey comprised schools (primary, junior and secondary schools), teacher training colleges, prisons, hospitals and clinics and the Headquarters of the Botswana Defence Force (BDF). Refer to Chapter 10 for details.

3.4 Observations during the survey

3.4.1 Households

Gaborone and Lobatse

In Gaborone, households using fuelwood did not have piles of fuelwood at home because summer had started. In Lobatse most households that were using fuelwood for cooking bought daily portions. Therefore, it was not easy to find fuelwood piles in the households. In the absence of piles of fuelwood, households were asked to describe the volume of fuelwood consumed and these quantities were tracked at the dealers' sites.

Molepolole, Mochudi, Kanye and Palapye

In all these places except Mochudi people preferred to buy fuelwood daily for cooking. Mochudi was different because relatively more households were found with piles of fuelwood.

Fuelwood weighing

Fuelwood was weighed in each household where a pile was found. More samples were weighed in Mochudi than in any of the other places under study. In cases where fuelwood was bought on a daily basis from a dealer, the pile for daily usage was weighed.

3.4.2 Perceptions on Botswana Coal

Of all the areas surveyed, households and even institutions do not like the idea of switching to coal for their energy needs. The major concern is that Botswana coal is not of good quality and when burned it causes a lot of smoke thus leading to respiratory illnesses. Other concern raised is the shortage of coal distribution in Botswana. So far there is only two coal distributors identified in all the urban areas of Botswana surveyed and these are both based in Gaborone. Therefore households and institutions argued that it would be of no benefit to switch to coal if it were not being made available in their respective areas. To encourage coal switching in urban Botswana the quality of coal would have to be improved, the price would have to be relatively cheaper and the commodity would have to be made easily available.

Coal stoves

While interviewing dealers at Palapye, a general dealer was identified who was selling coal stoves. Apparently this was one of the newly designed coal stoves of Morupule Colliery which the company is currently promoting to try and educate people about its use and also to encourage them to switch to coal. It is a 3-burner stove with a chimney, and it is only designed to use coal. The stove is approximately 0.7m high from the ground, and it costs only P200. Coal stoves generally seem to be expensive compared with the Morupule Colliery's stove. In Gaborone some dealers were identified selling coal stoves for about P500. Such high prices of coal stoves could be a barrier to the use of coal. The Palapye general dealer made it known that once households have shown interests in buying the stove the business would be extended to the sale of coal itself to improve the availability.

4. Analytical methodology

The survey data was captured and analysed using the Microsoft Access software, which was capable of handling all the numerous data sets investigated in the household questionnaire in one database. 3 different databases were established: one for the household data, another for the fuel dealers and the other for the institutions.

4.1 Basis of analysis

To provide a socio-economic basis of comparison with existing data, the household data was classified into four income groups according to the 1993/94 Household Income and Expenditure Survey (HIES) (CSO 1995). The 1993/94 income levels (below P750, P750-P1500, P1500-P4000 and above P4000) were then escalated to 2000 levels using cost of living indices (COLI) published by the Central Statistics Office (1999: 51-52) shown in Table 4.1 below:

Date	*Cost of living index (COLI): all items*
Nov-91	100
Mar-94	135.5
Sep-98	199.8
Sep-99	214.9

Table 4-1: Cost of living indices for all items from Nov 1991 to Sep 1999

COLI figures for 2000 were not available at the time of the study. The following assumptions were made in estimating income groupings equivalent to the 1993/94 HIES:

1. That the percentage change in COLI between September 1999 and September 2000 is the same as that between September 1998 and September 1999.
2. That the average COLI for the 1993/94 HIES was that for March 1994 (i.e. that for the middle of first 10 months of the 15-month study which occurred between November 1993 and January 1995. It was assumed that most of the data collection would occur within the first 10 months).
3. That the 1993/94 income groupings were based on disposable income and as such the required income transfers had to be added in order to get equivalent levels for this study incomes which included transfers. P129.5 was assumed as the average income transfer from 1994 P750 household income.

Income group	*1993/94 HH income limits*	*Escalation to Sept 2000*	*Sept 2000 estimated limits (including transfers beyond tax)*
1	Under P750	P1279.379	Under P1500
2	Under P2000	P3411.678	Under P4000
3	Under P4000	P6823.356	Under P8000
4	Above P4000	P6823.356	Above P8000

Table 4-2: Equivalent income groups of the 1993/94 HIES for this study
Source: (CSO 1999: 121)

From Table 4.1, percentage change of COLI from September 1998 to September 1999 is given as:

$$(214.9 - 199.8)/199.8 = 0.075576$$

Thus the COLI for September 2000 (i.e. the time of the study survey) is estimated as:

$$(1+0.075576)*214.9 = 231.1412$$

Now, from the September 2000 COLI and the above assumptions the equivalent income groupings of the 1993/94 HIES for this study were estimated as the September 2000 in Table 4.2 including income transfers.

The household income was estimated by adding all the monthly incomes of the household members as well as incomes from remittances, livestock sales and pensions. All the data was then grouped by their household monthly income according to the groupings in Table 4.2.

4.2 Energy use data analysis

In analysing energy use information, annual consumption figures are based on per capita estimations since household sizes are not always the same in different places. In all analysis there is distinction made between consumption *by only users* and that *by all* the population.

For an accurate estimation of national urban fuelwood demand there was a need for a representation of urban areas rich in fuelwood resources like Francistown, Selebi-Phikwe and Maun. Thus where possible efforts have been made to estimate what the national mean values would be if the Francistown study on fuelwood flow paths (White 1999) were included in the estimations. In doing so, the sample size of the Francistown study was adjusted according to the population proportions of the other towns. It must be pointed out that apart from estimates for fuelwood use patterns it was impossible to include the Francistown study in the use patterns of other fuels since that study's data was specifically for fuelwood users alone.

In the estimation of annual per capita energy demand, an assumption was made that there are 8 summer months and 4 winter months. It was also assumed that, in winter, on average households were using about one and half times the energy they use in summer[2].

In the modelling of fuelwood projections in Chapter 11, Francistown and Selebi-Phikwe have been used to represent the wood-rich areas. These two towns are so big that if relevant assumptions for them were not incorporated into the modelling the impact could be substantial. The LEAP2000 software was used for the modelling of the demand projections but since the software was still at its final stage of development, the modelling encountered a few bugs. Thus alternative modelling has been done in Excel spreadsheet.

4.3 Accuracy and sources of error

4.3.1 Age group of respondents

Figure 4.1 below shows that over 90% of the respondents to the household questionnaire were above 18 years, which is an indication of maturity of the responses. Furthermore, with the exception of Kanye, over 70% of the respondents in all the other urban centres were in their active age (i.e. between 18 and 50 years) and this is an indication of confidence in the responses or the likelihood that most of the respondents knew what they were responding to. In Kanye about 40% of the respondents were above 50 years.

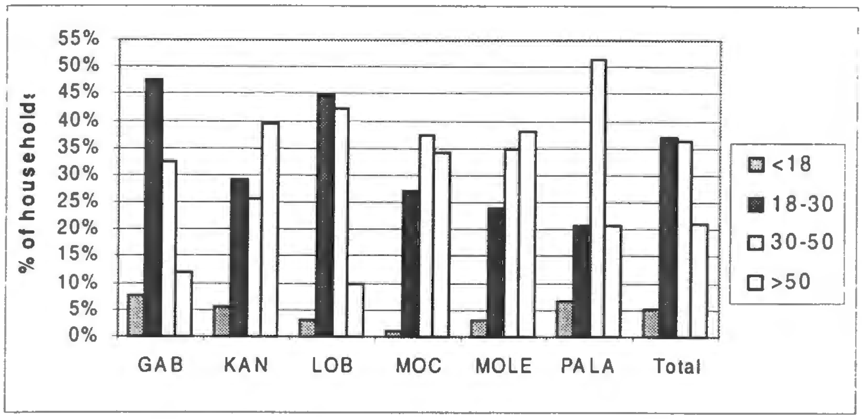


Figure 4-1: Age group of respondents

2 This was based on the average of responses from households.

4.3.2 Gender of respondents

It can be seen from Figure 4.2 below that amongst all the income groups of households that were surveyed female respondents dominated. In fact, in almost 75% of all households surveyed the respondents were female. This could be either a source of error or accuracy depending on gender perceptions prevailing. Since females are mostly the direct end-users of energy in most African homes, there could be a likelihood that they are passionate about energy issues and would thus respond to questions about energy use in a passionate manner. However, if fuelwood issues have become overburdening to females then there could also be the likelihood of exaggerating the severity of the issues.

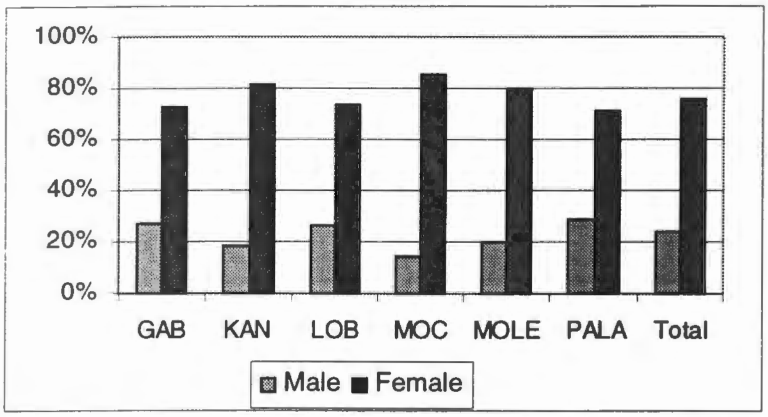


Figure 4-2: Gender bias in sampled household respondents

4.3.3 Income and expenditure

Like in many social surveys, the estimation of household income and expenditure could be one main source of error in this analysis. First, households are generally reluctant to reveal the income of household members and one cannot be so sure whether all the names of household members working have been mentioned. To make this easy for households, ranges of income were offered to respondents to select from and the averages of the ranges selected were taken as the incomes. This could seriously influence the estimation of average household incomes.

Second, incomes from informal sources were poorly recalled or accounted for by respondents. Pension, remittances and livestock sales and their frequencies were not easily recalled and this could easily lead to underestimation of incomes.

Third, some household expenditure items might have been missed in some particular households since not all issues might have been envisaged by the questionnaire. In addition, frequency of certain expenditures was not easily estimated. For example, many respondents could not estimate housing bond monthly instalments since they were not the household heads who might have engaged in the loan agreement with the bank. In most cases respondents could, however, provide the total amount of the loan owed. With some knowledge about the banking system in Botswana rough estimates of these instalments were calculated for inclusion in the household expenditure.

4.3.4 Electricity expenditure

For some households living in the lofty houses of big companies like BMC, the electricity bill was included in the monthly housing rent and this led to underestimation of energy expenditure and it also creates an impression of lower level of electricity use. However, these companies do not usually allow electricity use for thermal purposes like cooking and heating and therefore the error is not that huge. With some information from these companies it could be possible to come out with some rough idea for estimating the actual electricity consumption and expenditure in these households.

4.3.5 Fuelwood measurement

In most cases it was not possible to find piles of fuelwood in the house to weigh in order to establish consumption levels. The measuring of the weights of daily consumption is important as it helps to verify estimated quantification of fuelwood use by households. Repeated weighing of consumed fuelwood over a number of days could also help in establishing more reliable average consumption and reduce the errors in once- off estimations. With no fuelwood available to weigh in the homes, efforts were made to identify quantities mentioned by households at the dealers' sites and linkages were established between their weights and the quantities mentioned in the households. This could be obvious source of errors in the estimation of household fuelwood consumption.

4.3.6 Poor timing of survey

Since the timing of the study was after winter it was realised that most households had reduced their fuelwood consumption because they did not need it for house warming or water heating in some cases. Thus the extrapolation of data collected during this study over the whole year would obviously be a source of error since the indicators are mainly summer conditions and assumptions would have to be made. This could be a major source of error when aggregating fuelwood demand and making projections for the whole urban sector. The study would have been better off if it had been resourced to capture seasonal variation.

4.3.7 Proportions of urban towns and villages

Calculations from projected population figures for 2000 result in urban towns/ villages ratio of 52:48. For the populations of the sampled areas the ratio is 53:47 and that for the study sample is 54: 46 (see Table 3.1). Although these figures are fairly close, the differences could be sources of error in the estimation of the national urban fuelwood demand.

4.3.8 Lack of adequate representation of urban areas rich fuelwood resources

Since the six study sites did not include urban areas rich in fuelwood resources like Francistown and Selebi-Phikwe, assumptions have been made for such areas based on the study by White (1999) so as to create a national picture of the fuelwood situation. Such assumptions could be sources of error in the estimation of fuelwood consumption and projections.

5. Characteristics of households in sampled urban centres

This Chapter provides the necessary background information on the sampled households in this study. The analyses in the chapter sketch the socio-economic bases of the households upon which energy use analysis should be examined. Reference to this discussion is useful in understanding the energy use analysis.

5.1 Gender and migration of household decision-makers

Decision-makers in the household are usually the household heads. The gender of the household heads and their presence could influence decisions made concerning energy use and appliance acquisition in the home. Policies would have to be targeting these decision-makers in order to be effective and therefore it is worth knowing who constitute these household heads in the urban areas.

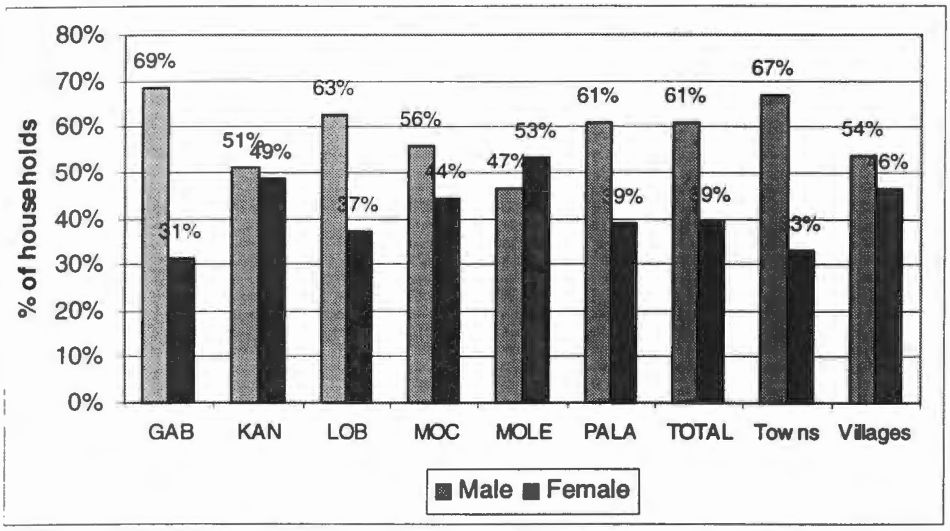


Figure 5-1: Gender of household heads in urban centres studied

Unlike the domination of female-headed households in Namibia (60% or more) due to migrant labour (Afrane-Okese 1999) only about 39% of the urban Batswana households studied were female-headed households (see Figure 5.1). As shown in Figure 5.1, in general, the dominance of male-headed households over female-headed households is more pronounced in the towns (67%: 33%) than in the villages (54%: 46%). The 1993/94 HIES estimated the male-/female-headed households ratio in urban towns to be 64%: 36% (CSO 1996: 51) which shows the same male-headed households dominance. However, the same HIES estimated the national village male-/female- headed households' ratio to be 45%: 55%, which is opposite to the estimates of this study. It is not clear what is the reason for the big difference in the two estimates. This could be due to differences in the definitions of the two studies or indeed a shift in household decision making. In terms of the individual urban centres, it is only Molepolole where female-headed households were in the majority.

Figure 5.2 shows that, in general, migration of household heads from their original urban areas is about 10%. The village households in Molepolole and Kanye have relatively higher household heads migration of 15% and 20% respectively probably because they have less proximity to industrialised centres unlike Mochudi (close to Gaborone) and Palapye (close to Morupule Colliery and Power Station). In fact, Figure 5.4 shows better income distributions in Mochudi and Palapye than Kanye and Molepolole.

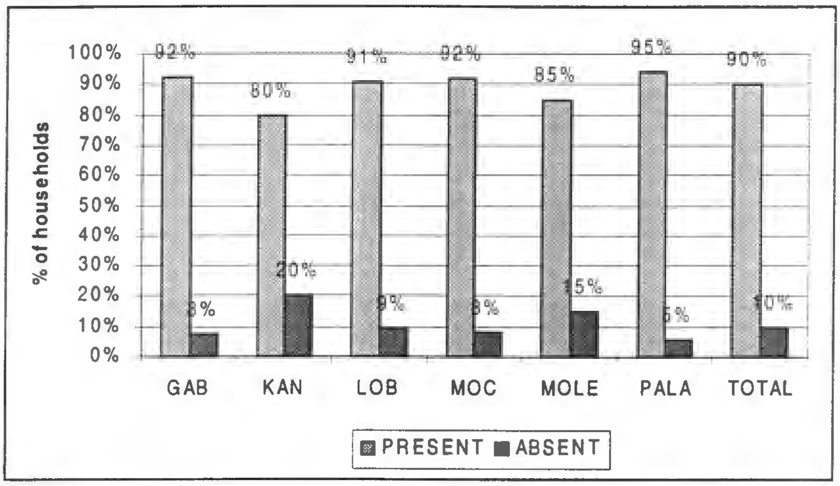


Figure 5-2: Percentage of household heads present and absent

5.2 Income distribution

Trend of income distribution

The household incomes of this study were grouped according to the income groupings of the 1993/94 HIES study, taking into consideration inflation over the period (see Chapter 4). The purpose of this was to study the income trend over the period. During 1993/94, over 50% of urban households in Botswana were in the lower income group (see Figure 5.3) with incomes not more than the 1994 P750. Comparing similar income groupings for the year 2000 with that of 1993/94 in Figure 5.3 shows remarkable improvement in household income distribution in urban Botswana. Whilst the lowest income group has reduced from 51% to 42%, the second and third income groups have increased substantially.

This figure illustrates that Botswana is making significant progress towards becoming a middle-income country. This will obviously improve households' affordability of and access to energy services. This significant progress in household incomes is reflective of the general increase in GDP growth since 1992/93 to about 8.3% in 1997/98. Figure 5.4 also shows substantial growth in GDP per capita since the early nineties.

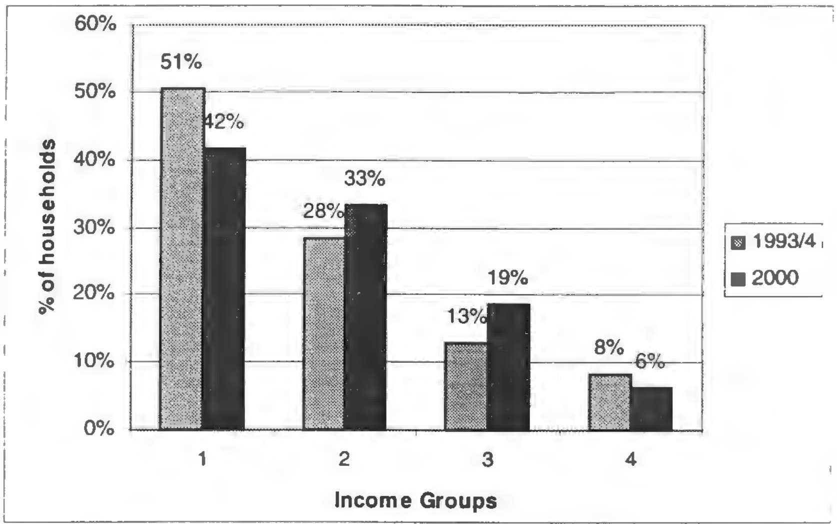


Figure 5-3: Urban income distribution trend, 1993/4 –2000
Source: CSO 1999: 121, CSO 1995, Survey results

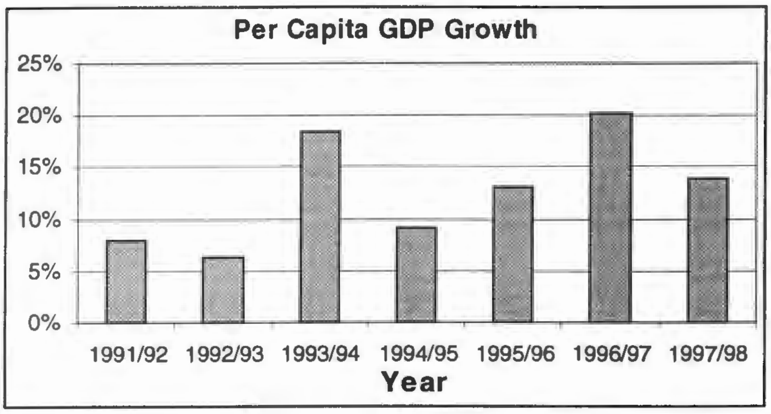


Figure 5-4: Percentage growth of per capita GDP since the early nineties

Income distribution and levels of urbanisation
A closer look at the household income levels at the individual urban centres studied (see Figure 5.5) shows a big difference between the income distributions of the towns and the villages. In the towns (Gaborone and Lobatse) the percentage of households in the lowest income group is as low as about 30% whilst in the case of the villages (Kanye, Mochudi, Molepolole and Palapye) the lowest income group constitutes about 50% or more. Molepolole seems to be worst off in terms of household income with over 60% of the households in the lowest income group. It explains why it has a relatively high migration of the household heads. Further, this shows possible lower accessibility and affordability to energy services in the villages than in the towns. This could also indicate insufficient provision of income generating activities in the villages that could perpetuate migration from the villages to the towns.

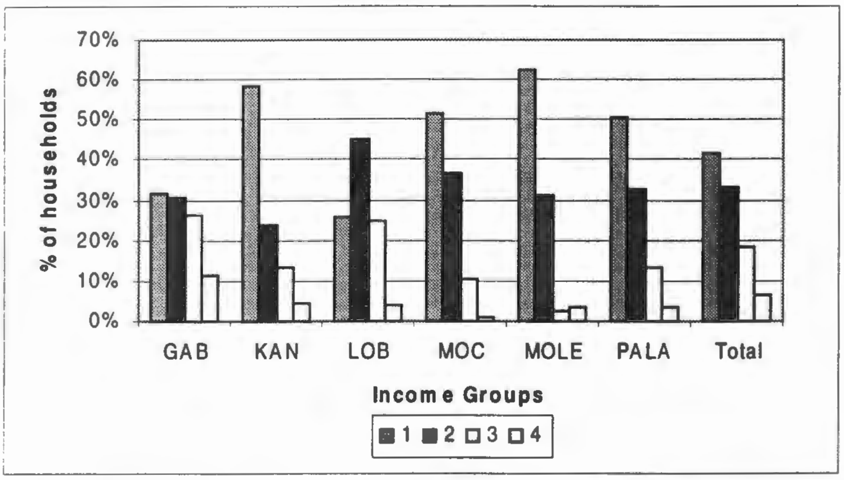


Figure 5-5: Income distribution in urban centres studied

Gender perspective of income distribution
Although Figure 5.1 shows that female-headed households are in the minority in urban Botswana, Figure 5.6 shows that majority of these female-headed households are amongst the poorest in urban Botswana. About two-thirds of the female-headed households are in the lowest income group whilst only about a third of the male-headed households are in this group.

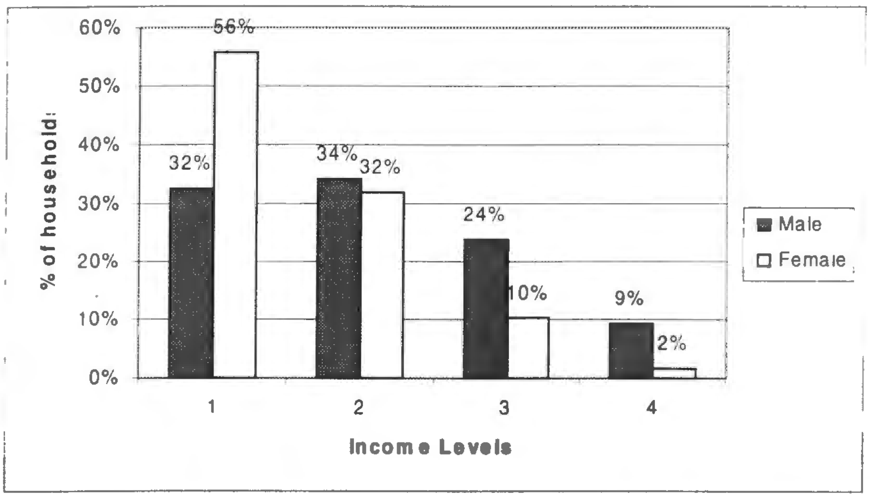


Figure 5-6: Income distribution amongst male- and female-headed households

This is an indication of serious gender inequalities with the consequent negative effect on the purchasing power of energy services by these female-headed households. It is clear from this that it would be useful for energy policies targeting poorer households to also target female-headed households since they constitute the majority of decision-makers in the poorest income group.

5.3 Household size

The number of people in a household (household size) will influence the per capita consumption of energy of the household. It is therefore useful to understand what the average and distribution of household sizes of the different categories of household to be analysed. The 1993/4 HIES estimated the average urban household size as 3.56 and the urban village household size as 4.84 (CSO 1995: 42). These estimations were lower than what was estimated in this study as shown in the Table 5.1 below. The difference could be because the HIES study might have tracked down and excluded visitors or non-permanent household members whilst this study did not track down visitors.

Town	*Average HH Size*
GAB	5.06
KAN	6.29
LOB	5.41
MOC	5.93
MOLE	5.43
PALA	5.74

Table 5-1: Average household size for sampled urban centres

As can be seen from the table above and Figure 5.7, the urban town households generally have lower household sizes than the village households. This is illustrated in the graph by the fact that the town households are more drawn towards the smaller sizes end of the graph whilst the village households are drawn towards the larger household sizes end. Thus a town household with the same monthly energy consumption as a village household is likely to have a higher per capita energy consumption than the village household. Kanye has the highest average household size followed by Mochudi.

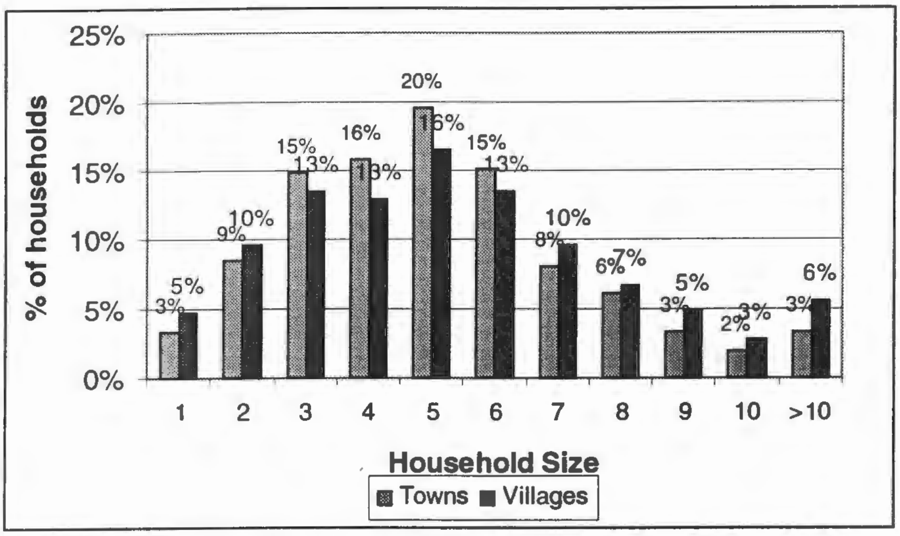


Figure 5-7: Household size distribution amongst towns and villages

In terms of the distribution of the household size it is shown in Figure 5.8 that Kanye has the largest median household size followed by Palapye and Mochudi. This is determined by locating the household size of the fiftieth percentile.

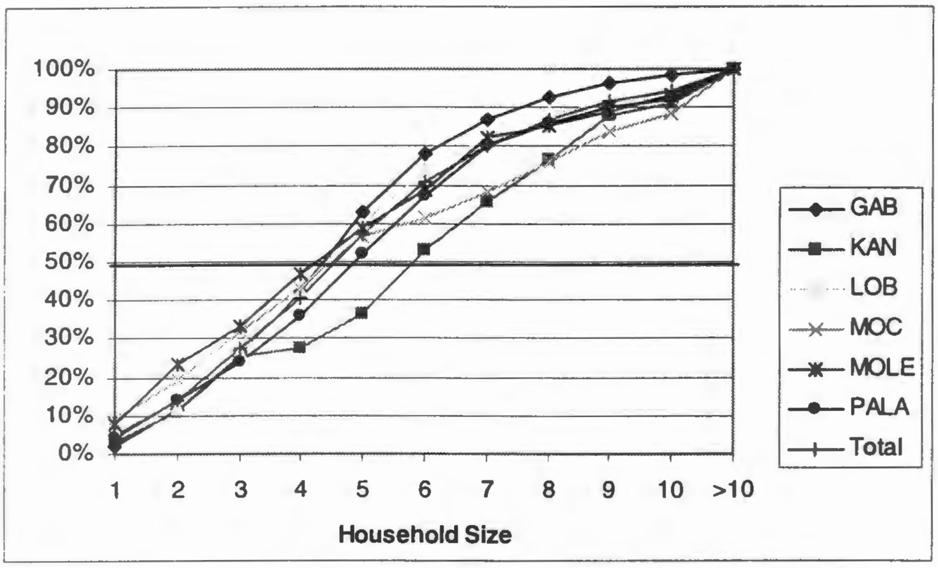


Figure 5-8: Cumulative percentage of household size in study areas

5.4 Educational levels of household heads

The highest level of formal education obtained by the household head could influence the energy decision making at home. Figure 5.9 shows the difference between the highest educational levels of town and village household heads. The figure shows that whilst the highest educational level of almost half of the village household heads is below the junior secondary school (JSS), only about a quarter of town household heads their highest educational level below JSS. Figure 5.10 also shows that female-heads are worse off in terms of formal education than male-household heads. Whilst 56% of male-headed households have educational qualification beyond JSS, only 37% female-headed households have educational qualification beyond JSS. These differences in educational qualifications will influence the job opportunities for the household heads and consequently impact on their income, which could be a major driver in energy decision making.

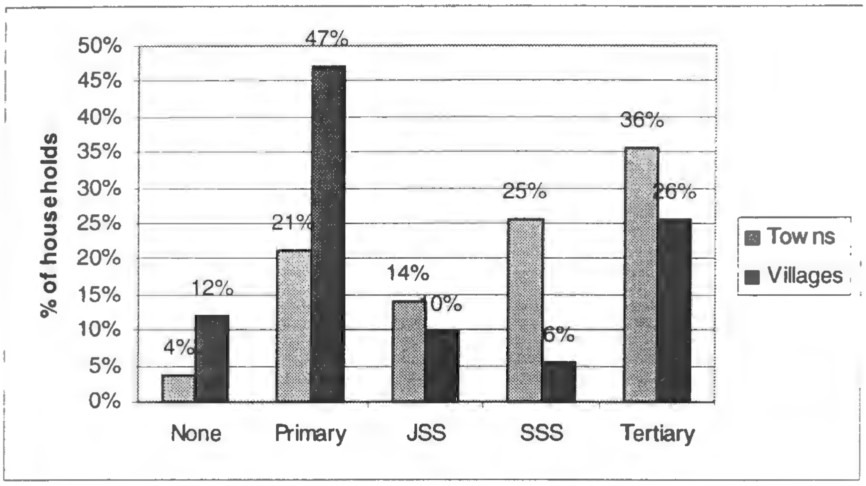


Figure 5-9: Highest educational levels of household heads in towns and villages

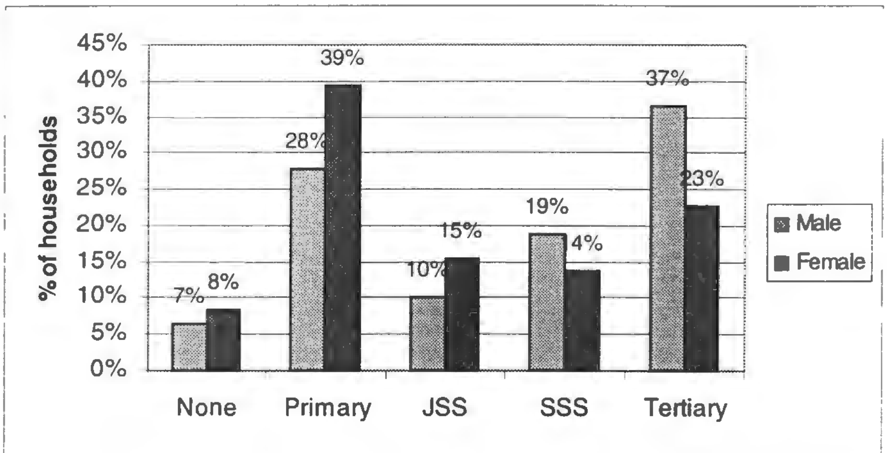


Figure 5-10: Highest educational levels household heads: male and female

6. General overview of household energy use

This chapter discusses the analysis of the extent of use of various energy sources in different categories of households, the intensity of use of these fuels (i.e. consumption patterns) and the expenditure on these fuels by households. It explores the impacts of urbanisation (i.e. urban-towns and urban-villages differences), income distribution, electrification and the variation between the different urban centres on patterns of household energy use, consumption and expenditure. It further assesses the socio-economic impacts of energy use by looking at what percentage of household income goes into energy use.

6.1 Levels of electrification

Before discussing the use of various energy sources in urban households, it is useful to analyse the levels of electrification in order to provide the context within which energy sources are used. This also helps to identify the impacts of electrification on the use of other fuels.

6.1.1 Sampled urban centres

Figure 6.1 shows the level of electrification amongst households in all the six sampled urban centres. The urban-towns Gaborone and Lobatse have high electrification levels of 67% and 65% respectively. In the villages, however, the percentage of households electrified is much lower. About a third or more of the households in Mochudi, Molepolole and Palapye are electrified (36%, 34% and 32% respectively) but Kanye has a lower level of electrification (17%).

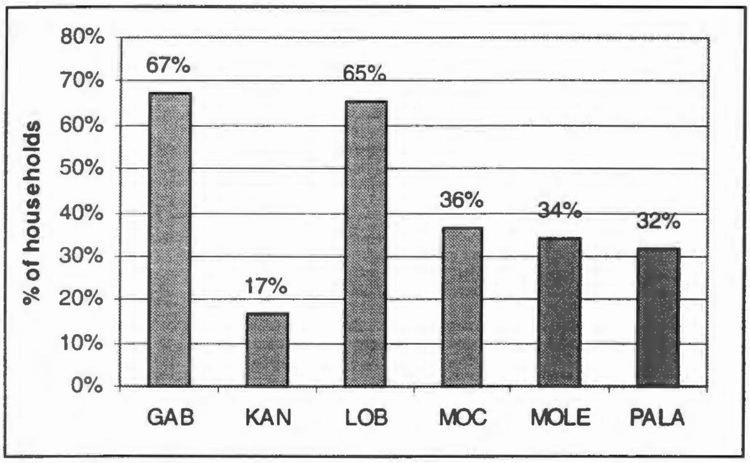


Figure 6-1: Levels of electrification in sampled urban centres

6.1.2 Gender-related aspects on electrification

Figure 6.2 shows the influence of the gender of the household heads on the levels of electrification in all the study areas. Apart from Mochudi, there are higher levels of electrification amongst male-headed households than female-headed households indicating some sense of gender influence on electrification. For all the 794 sampled households electrification levels amongst male-headed households is about 55% whilst that of female-headed households is about 44%. However, a closer look at the data reveals that this might not necessarily be gender influence alone since female-headed households have generally lower levels of income (see Chapter 5). Nevertheless, in Mochudi, female-headed households have lower income levels but this has not influenced the levels of electrification negatively. There could be other factors for this.

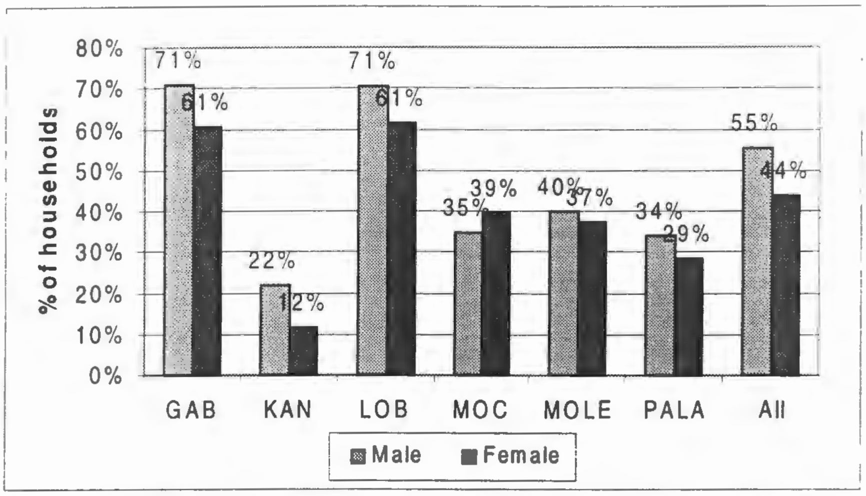


Figure 6-2: Levels of electrification amongst male- and female-headed households

6.1.3 Variation of levels of electrification with household income

Figure 6.3 depits the impacts of income on access to electrification in urban Botswana. The figure shows that almost half of the urban Batswana households are electrified but the access to electrification largely depends on the income levels of the households. Although Zhou (1999: 116) concludes that the policy of reducing downpayments of electrification from 40% to 10% has paid off with larger numbers of consumers connecting to electricity, this seems to be favouring higher income households. Zhou (ibid) further states that the downpayments and the house wiring costs are still prohibitive to rural households but this could be the same situation urban lower-income households are facing. Electrification levels amongst the lowest income households is about 24% whilst at the highest income level it is about 88%.

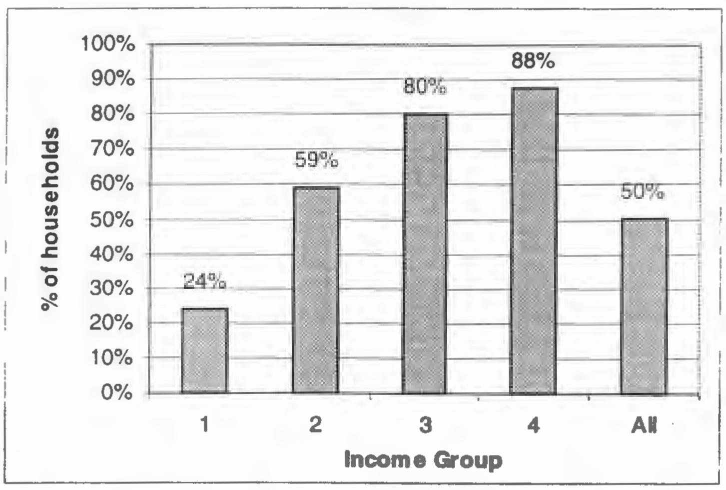


Figure 6-3: Variation of levels of electrification with household income

6.1.4 Electrification levels in towns and villages

Figure 6.4 shows that the influence of household income on levels of electrification is mainly in the towns but in the villages it is only limited to the lowest income group. However, income is still a source of concern in the villages since over 50% of households are in the lowest income group (see Chapter 5).

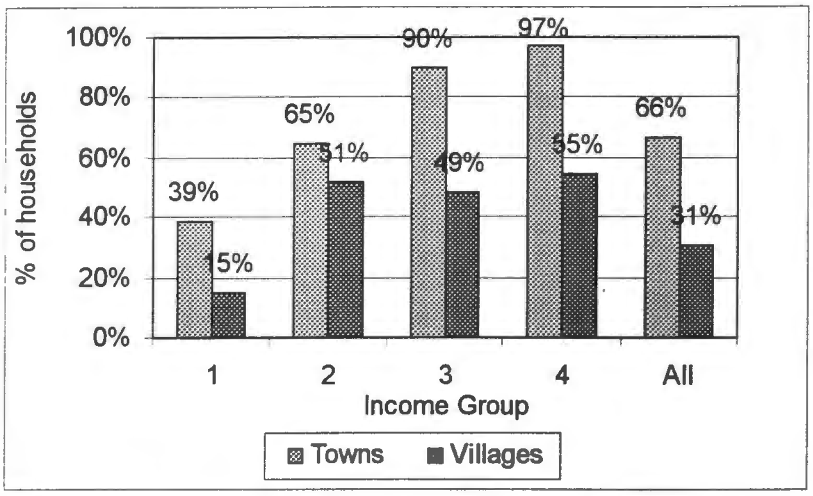


Figure 6-4: Electrification levels in towns and villages

6.2 Extent of fuel use in the households

6.2.1 National urban situation

Figure 6.5 gives a general overview of the extent of use of various fuels in the households sampled in Gaborone, Lobatse, Kanye, Mochudi, Molepolole and Palapye. Taking the sampled urban centres as a close representation of the urban households sector, the use of liquefied petroleum gas (*simply called gas in this report)* is the most widespread amongst urban households. About 76% of all the 794 households surveyed were using gas for various end-uses, especially cooking (refer to Chapter 7). Comparing current gas use to estimates from the BEMP 96 (Zhou et al 1999:25), which was largely based on data collected a decade ago, shows a dramatic increase in urban gas use from 45%. This gives an indication of the effectiveness of the provision of appropriate enabling environment for marketing gas throughout the urban areas of the country, which has resulted in an increase of about 69% in gas usage, despite the fact that there has been about 37% increment in urbanisation over a decade.

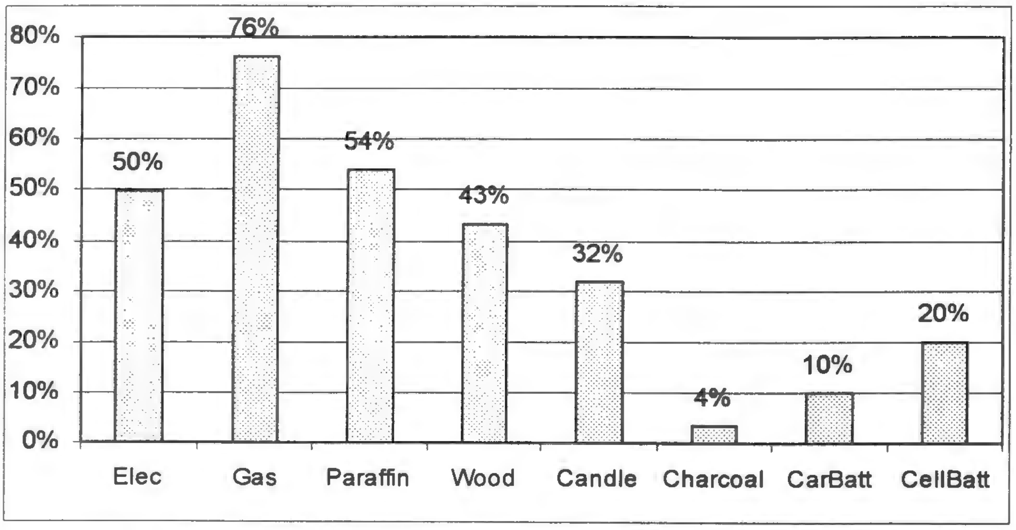


Figure 6-5: Percentage of households using particular energy sources in all urban centres surveyed

Paraffin and electricity come next in terms of extent of use amongst urban households with about 54% and 50% of households respectively. However, comparison with BEMP 96 shows that the dependence of paraffin use has decreased from 70% whilst the use of electricity has almost doubled from 24%. This could be attributed to the improvement in income distribution (Section 5.2) which has enabled households to switch from less convenient energy sources to more convenient sources.

Although the extent of fuelwood use has decreased, this has not been that significant compared with the shifts between the fuels above. The extent of fuelwood dependence amongst urban households has decreased from the BEMP 96 estimates of 55% to about 43% (Figure 6.1) of all the households surveyed. However, these figures do not in any way indicate how intensive these fuels are used in the households.

It is striking to note that candle use amongst urban households has gone up from the BEMP 96 estimate of 19% to about 32%. The reasons for this increase could be explored by looking further at the end-uses of the fuels (Chapter 7). Other energy sources of lesser significance amongst households are dry cell batteries (20%), car batteries (10%) and charcoal (4%). The expenditure on these fuels, the specific end-uses and the intensity of use would indicate how important these fuels are to the livelihood of households.

Surprisingly coal does not feature at all as an important fuel in urban households. In spite of the Expanded Coal Utilisation Project (ECUP) sponsored bilaterally by the Governments of Botswana and Germany since 1987 (EAD 1998) with the household sector as one of its main targets, only 6 out of the 794 households surveyed indicated some use of coal in the home. These few households were in Gaborone, Lobatse and Palapye. Although the ECUP has been promoted as a means of reducing over-dependence on fuelwood, urban households' dependence on coal has remained merely under 1%. The privatisation of the commercial wing of the ECUP since the beginning of 1998 to alleviate the unavailability problem of coal has also not yet resulted in a meaningful uptake since the central coal depots at Gaborone and Palapye are within the urban centres studied.

It must be mentioned that the above energy use pattern is not a complete picture of the national urban situation since it does not include data from more extensive fuelwood use places like Francistown and Maun (see Section 3.1). According to a recent study in Francistown, fuelwood is used in about 77% of all households, although only about 29% of the households use fuelwood for cooking (White 1999: 8-10). The 1991 Census (CSO 1994: 39) showed that Selebi-Phikwe is an important fuelwood use town with about 40% of households using fuelwood for cooking. Although there is no sufficient literature that point to sustained use fuelwood in some of these places, lack of representation of one of these fuelwood-using towns in a national sample may create an incomplete picture. Every effort was made to include Francistown data from the study by White (1999) but, unfortunately, the study provides data on only fuelwood users and as such only data on fuelwood users could be incorporated into this study. Adjusting the national urban fuelwood use with the higher fuelwood use in Francistown brings the national urban fuelwood use to about 48% households instead of 43%, which is a decrease of about 13% since 1991 instead of over 20%.

The 5% increment in the extent of fuelwood use by the inclusion of Francistown data is very significant and points to the need for quality and reliable data. There is also a need for an appropriate sampling frame in the estimation of the national fuelwood demand. Assuming an urban population of about 800 000 and an annual per capita fuelwood consumption of about 200 kg, a 5% decrease in the extent of fuelwood use would be equivalent to a reduction of 8 000 tonnes of wood in fuelwood demand estimation.

6.2.2 Levels of urbanisation: towns and villages

Having given an overview of the national urban fuel use, a closer look at different levels of urbanisation shows some differences of fuel use due to access to fuels and socio-economic differences. Figure 6.6 shows the differences between towns and villages excluding more fuelwood using areas like Francistown and Selebi-Phikwe. It is clear from this figure that gas and electricity are the main fuels used in towns whilst the use of paraffin, fuelwood and gas are the most widespread amongst village households. The use of gas and electricity in the surveyed town households is as high as 85% and 66% respectively. In the villages, however, about 74%, 72%, and 68% of the households use paraffin, fuelwood and gas respectively.

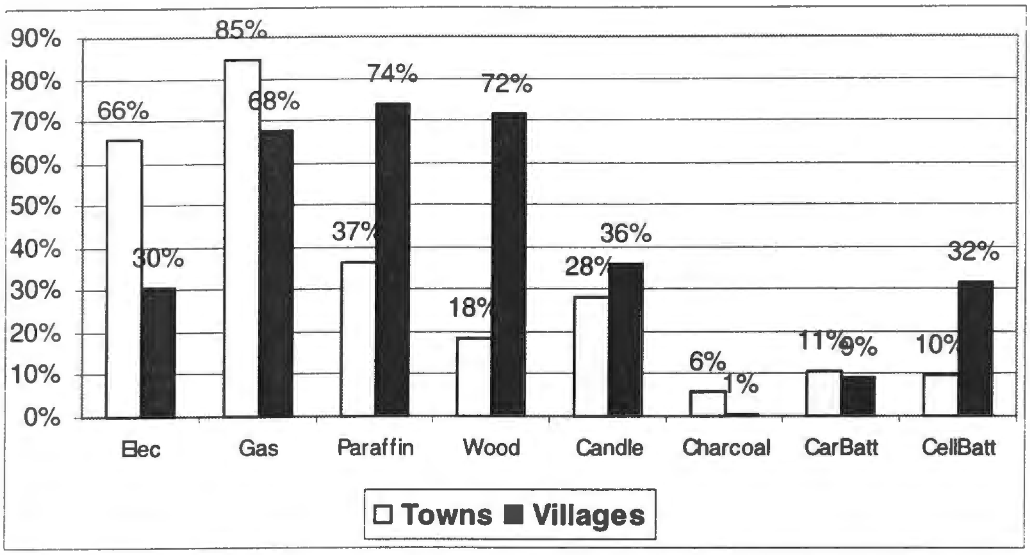


Figure 6-6: Percentage of households using particular fuels in town and village households

The second most widely used fuels amongst town households are paraffin (37%), candles (28%) and fuelwood (18%) whilst amongst village households electricity (30%), candles (36%) and dry cell batteries (32%) are the second most widely used sources of energy. Almost all the charcoal use occurs in the towns whilst car battery use is almost the same in towns and villages.

For the same reason given in the preceding section, data on a fuelwood-using area like Francistown could not be included in Figure 6.2. If the Francistown data (White 1999) on fuelwood use is included in the analysis the percentage of households using fuelwood in towns becomes 32% instead of 18%. A 14% increment is quite significant and this is due to Francistown being in the north-eastern *mopane* region. This again points to the need for appropriate sampled areas in the estimation of the national fuelwood demand.

6.2.3 Impacts of household income

Figure 6.7 gives an overview of urban energy use variation with household income in all 794 sampled households. The figure clearly shows that, in general, just as electrification depends on household income levels, *electricity* has largely become the *energy source of the rich* with its use increasing from 24% at the lowest income level to 88% at highest income level. *Gas* is mainly *the fuel for all* income levels. Urban gas use is as high as 68% even at the lowest income level but there is some switching to electricity at the higher income levels. *Paraffin* and *fuelwood* are mainly *fuels of the poor*, although some extensive use of fuelwood occurs amongst the highest income level households. How intensive fuelwood is used by these higher income households (Section 6.3), and the purposes for which they are used (Chapter 7) would determine how important the fuel is actually to them. Paraffin is more pronounced as a fuel of the poor than fuelwood since its use amongst the lowest income households is as high as 78% but reduces to a mere 14% amongst the highest income group. Fuelwood is used by 60% of the lowest income group but this reduces to the lowest level of 30% in the third income group. Candle use seems to occur at all income levels ranging from 25% at the second income level to 42% in the highest income group, which may suggest that its use goes beyond energy (lighting) purposes to decorative, entertainment and shoe polishing purposes. Charcoal is predominantly a fuel of an insignificant number of wealthy households, car batteries are used by a small minority at all income levels and dry cell batteries are mainly used by poorer households.

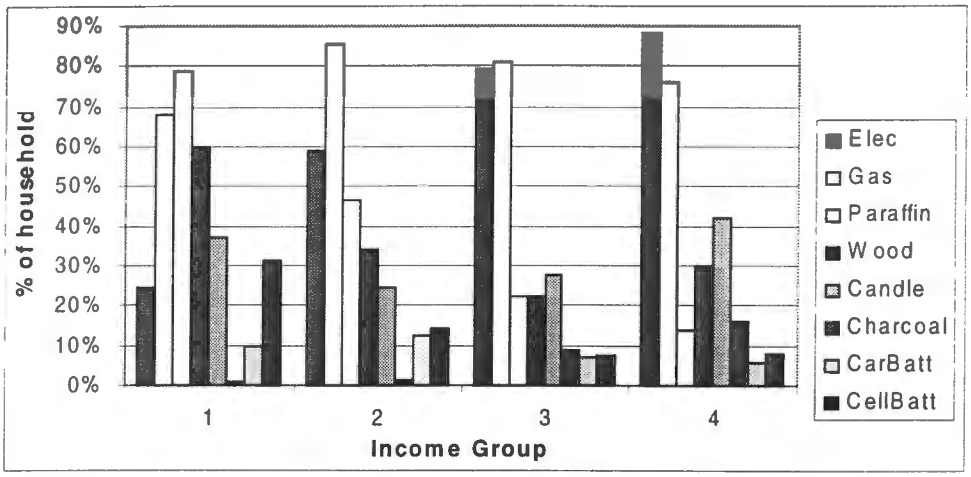


Figure 6-7: Overall energy use variation with household income

Comparison of energy use variation with household income in towns with that in villages shows that the switch towards electricity use in the higher income levels is more pronounced in the towns than in villages due to availability of electricity (see Figure 6.8 and 6.9). It is interesting to note that gas use is popular at all income levels even in the villages with more than half of the lowest income group in the villages using gas. Unlike the sharp decline in paraffin use with rise in income levels that can be seen in the towns, the use of paraffin remains as high as almost 50% or above at all income levels in villages. In fact at the village lowest income level (which constitutes about 56% of the sampled village households), almost 90% of the households use paraffin. This situation is mainly due to lack of access to electricity in the villages as compared to the towns.

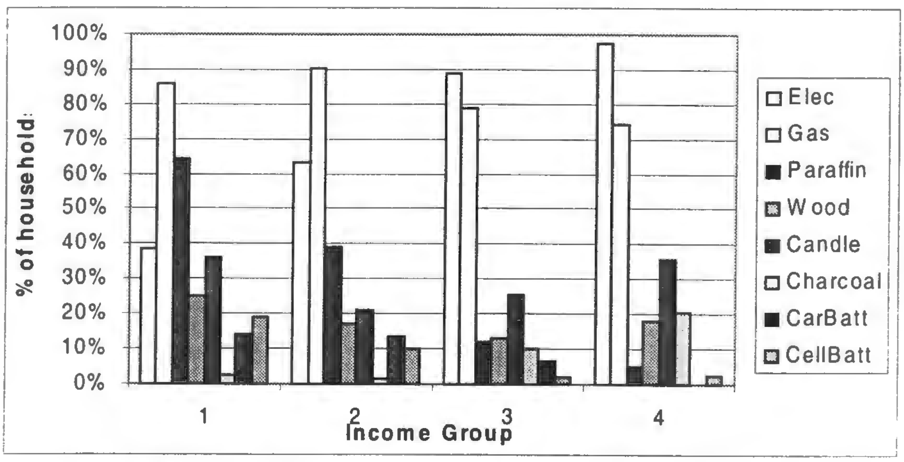


Figure 6-8: Energy use variation with household income in urban-towns

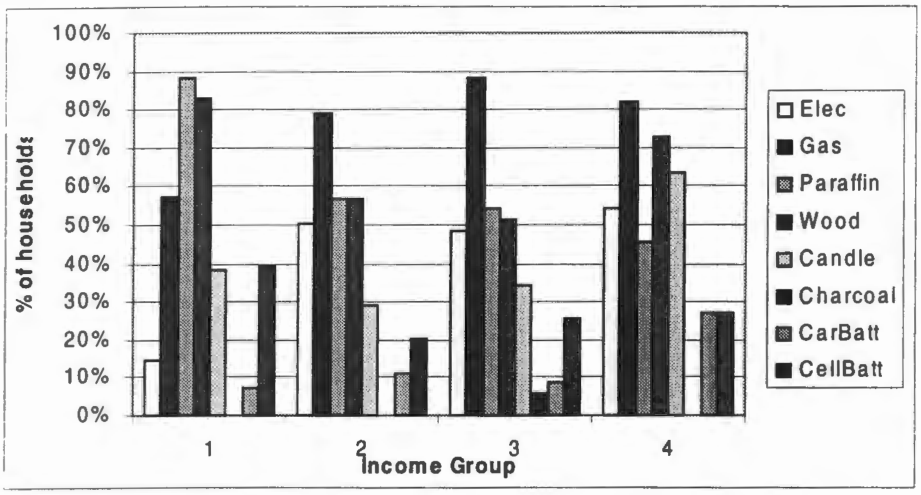


Figure 6-9: Energy use variation with household income in urban-villages

The variation between towns and villages for fuelwood use is similar to the paraffin situation except that in the case of fuelwood a higher percentage of the highest income households use fuelwood due to affordabality and better access to the resource. In the village lowest income level group, fuelwood use is over 80% but again the importance of this depends on the intensity of use and the end uses.

6.2.4 Impacts of electrification

Electrification seems to have influenced households in shifting from the so-called traditional and transitional fuels to modern energy sources like electricity and gas (see Figure 6.10). Although the use of gas amongst non-electrified households is quite high (66%), a large number of these households still depend on more inconvenient sources of energy like paraffin (96%), fuelwood (65%), candles (44%) and dry cell batteries (38%). It is interesting to note how low the use of fuelwood is in electrified households (20%) but it has to be remembered that most of the electrified households are in the urban-towns, and have higher incomes.

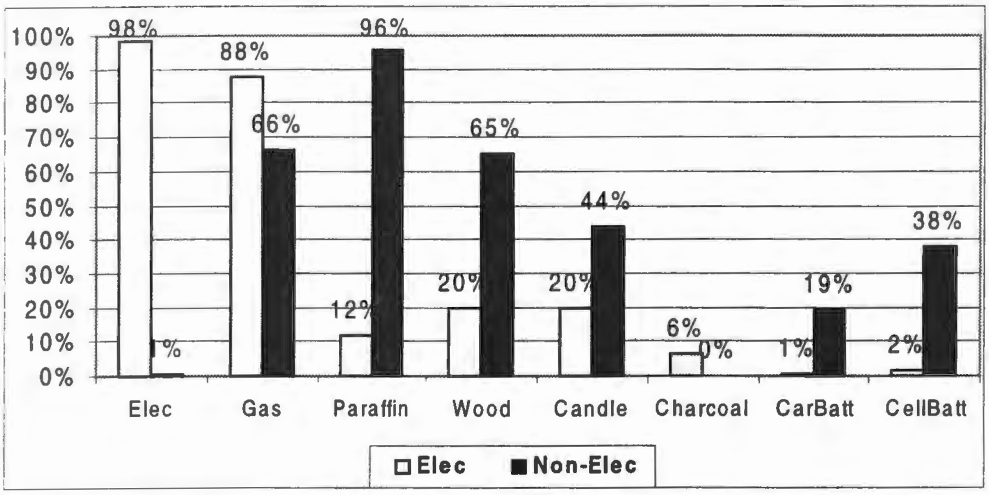


Figure 6-10: Percentage of households using energy source in electrified and non-electrified households

6.2.5 Household energy sources in study areas

The energy use patterns in the actual urban centres studied are provided in Figure 6.11. This figure depicts that paraffin and fuelwood are more dominant in the households of Kanye (80% or more) than all the other villages. This is mainly due to the low levels of electrification in Kanye (see Figure 6.2) compared with the other villages. It is interesting to note how close the levels of use of these two fuels amongst village households are which indicates that they share common determinants. In Mochudi, Molepolole and Palapye the use of paraffin and fuelwood is about 70%.

The energy use patterns of Gaborone and Lobatse are very similar with higher levels of gas and electricity use and lower levels of use of other fuels. Fuelwood use in the two towns does not exceed 20% of the households. Candle use, which is above 20%, does not vary much in all the study areas. Dry cell batteries use, which is almost the same in all the villages, is quite significant (about 30-40%) but less significant (10%) in both towns studied. However, car battery use is insignificant in all towns and villages.

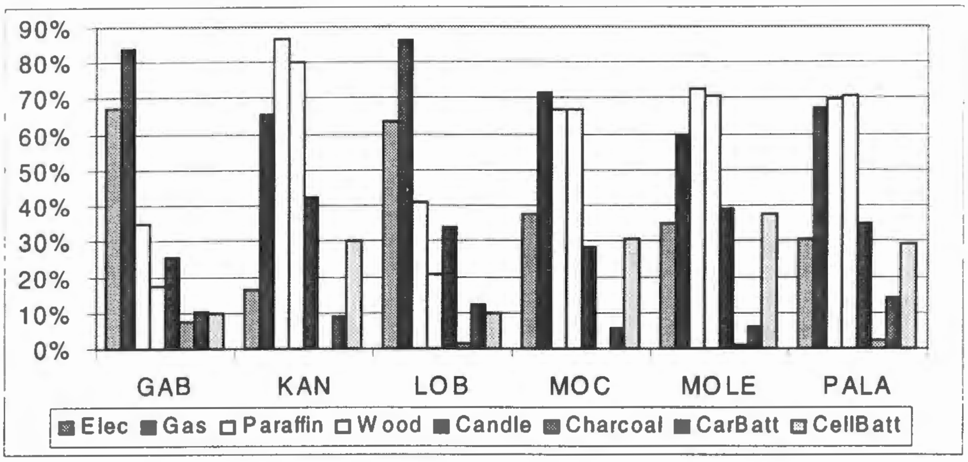


Figure 6-11: Percentage of households using energy source in study areas

6.3 Intensity of fuel use in the households: consumption patterns

The following section discusses how intensely the various energy sources are used in different categories of households. The consumption patterns would indicate two important things:

1. The level of households' dependence on a particular energy source.
2. The impact of households' energy use on national resources.

The section covers energy consumption patterns with respect to the study areas, the differences between household income variation in towns and villages, and the differences between household income variation in electrified and non-electrified households. The data is presented in the form of monthly and annual household consumption, and also in the form of monthly and annual per capita consumption patterns. The data in this section is presented in tables rather than graphical formats due to differences in units of consumption. The discussion is limited to the main energy sources in the household namely, electricity, gas, paraffin, fuelwood and candles. *All the analysis in the tables in this section is based on only the number of households that were actually using the specific fuels.*

6.3.1 Overall user households consumption patterns

Annual and monthly consumptions of household energy sources are shown in Table 6.1. The table shows that the average monthly consumption of electricity by user households of about 626 kWh is quite high compared to South African households in general. This may be due to the additional space cooling requirement in terms of air conditioners and fans in Botswana, which is very limited in South Africa due to a cooler climate except in the northern part of the country. Another reason could be that electricity connection costs until recently have been such that only richer households are able to connect to electricity, which is largely not the case in South Africa due to the policy of *mass electrification*[3] after the democratic elections in 1994. Thus electricity use in Botswana is largely limited to higher income households who can afford higher consumption levels. When this consumption is spread over all households including the 50% non-electricity users (see Figure 6.5) then the average monthly household consumption for urban Botswana becomes 313 kWh. Electricity is not only used more extensively in the towns than the villages but also more intensively in the towns than the villages. Whilst the electricity consumption amongst village households ranges

[3] Mass electrification meant that all households in the priority list of electrification are electrified.

between 234 and 406 kWh, consumption in town households is above 600 kWh. This is due to the more sophisticated lifestyle in the towns with more modern appliances. It is noteworthy that Kanye with the least percentage of households electrified also has the least consumption level. This gives the impression that places with longer time of electricity connection seem to have higher consumption levels. Credit metering, which is often found at older places of electricity connection, seems to influence kWh consumption a lot. Furthermore, older places usually have more appliances available locally, which potentially promotes consumption.

	kWh	*kg*	*litres*	*kg*	*packets*	*Kg*	*charges*	*litres*
Town	**Elec**	**Gas**	**Paraffin**	**Fuelwood**	**Candle**	**Charcoal**	**CarBatt**	**Petrol**
GAB	807	15.72	11.24	104	2.02	7.26	3.27	7.67
KAN	234	12.16	8.63	202	1.73		1.50	
LOB	603	14.64	5.82	140	1.80	5.00	1.27	30.00
MOC	252	14.19	9.88	202	2.30		1.80	
MOLE	294	13.87	3.79	200	1.50	3.00	1.00	
PALA	406	13.38	4.49	238	1.40	5.00	1.67	3.50
Ave (monthly)	626	14.6	7.83	186	1.83	6.66	2.23	12.86
Ave (annual)	8758	204.47	109.62	2604	25.55	93.17	31.15	180

Table 6-1: Monthly and annual household fuel consumption in study urban centres

It is also clear from the table that electricity consumption in Palapye (406 kWh) stands way above that in the other villages. This seems to have been an influence of the different metering systems. Whilst almost all the households surveyed in the towns were all using credit meters, it is only Palapye which was using credit meters amongst the villages rather than pre-paid meters. Only one out of the 92 households sampled in Palapye indicated the use of pre-paid meter. This seems to suggest that the use of the credit metering has contributed to excessive use of electricity whilst the use of pre-paid meters has resulted in the cautious use of the utility. In addition, the credit meter systems may be older, and therefore consumption could also be higher due to longer experience with electrification, which lends itself to the ownership of more appliances. However, there is a report that BPC employees staying in Palapye are given some free electricity credit units every month and that might have influenced the higher consumption in Palapye.

In the case of gas there is not much variation of the intensity of use between the various urban centres studied. Although the towns have the highest consumption, the difference between the lowest and highest consumption levels is very small (12.16 –15.72 kg). This seems to suggest that gas use in urban Botswana is becoming saturated. It is also an indication that there is a minimum requirement for a household irrespective of the income level. The monthly average consumption for households using gas is about 14.6 kg but when this is spread over the whole urban population the consumption is about 11.10 kg.

Although Figure 6.5 shows that paraffin is used extensively amongst urban households (over 50%), in terms of intensity of use it is not that significant amongst user households. Whilst in South Africa monthly consumption of paraffin is about 25 litres/month or more amongst user households (mainly low-income households) (Afrane-Okese 1998), the average amongst urban Batswana user households is about 7.83 litres. For all urban households paraffin consumption is about 4.10 litres per month. The intensity of use is more pronounced amongst users in Gaborone, Mochudi and Kanye. It is not strange that the consumption is high in Kanye since it has the lowest number of households electrified and most households would therefore rely mainly on paraffin for lighting (see Section 7).

Fuelwood use is not only less extensive in the towns than the villages but also less intensive. Fuelwood consumption is lower in Gaborone (104 kg/month) than in Lobatse (140 kg/month) due to probably better access to more convenient fuels in Gaborone than in Lobatse. Monthly fuelwood consumption is not much different amongst the villages (200 – 238). Molepolole has the lowest consumption amongst the villages probably due to dwindling fuelwood resources whilst Palapye has the highest due to its location almost in the north-eastern region of the country where it is richer in fuelwood resources. Sekhwela (1994: 100-101) estimates household fuelwood consumption in

Molepolole as 201.5 kg per month and Kgathi (1994) estimates the same consumption rate of 201.5 kg in Khakhea.

It was shown in Figure 6.5 that about a third of urban households use candles but Table 6.1 shows that it is not intensively used in all the urban centres studied. The average consumption in all cases was about 1.5 to just over 2 packets a month. Candles are basically used as a backup lighting fuel (see Section 7).

	kWh	*kg*	*litres*	*kg*	*packets*	*kg*	*charges*	*litres*
Town	**Elec**	**Gas**	**Paraffin**	**Fuelwood**	**Candle**	**Charcoal**	**CarBatt**	**Petrol**
GAB	205	3.38	2.43	20.54	0.44	2.07	0.61	2.00
KAN	89	2.54	1.63	32.12	0.33		0.22	
LOB	142	2.97	1.65	25.87	0.36	1.25	0.17	2.50
MOC	79	3.17	2.09	34.05	0.48		0.42	
MOLE	129	4.61	0.88	36.81	0.34	1.42	0.16	
PALA	120	3.15	0.91	41.71	0.34	2.50	0.22	0.83
Ave (Mon)	165	3.29	1.70	32.88	0.39	2.00	0.39	1.81
Ave(Annual)	2310	46.06	23.80	460	5.44	28.01	5.51	25.30

Table 6-2: Monthly and annual per capita fuel consumption in study urban centres

Amongst the insignificant number of households using charcoal very small quantities are used per month. Thus it is concluded that charcoal does not play a major role in basic energy services in urban Botswana.

It is interesting to note in Table 6.2 how differences in household sizes in the various urban centres have influenced the per capita consumption of the different energy sources when compared with the household consumption. For example, Kanye and Mochudi have very low monthly per capita consumption of electricity (89 kWh and 79 kWh respectively) due to their higher household sizes. Although Palapye has the highest household consumption of electricity amongst the villages, in terms of per capita consumption Molepolole has the highest (129 kWh).

For all fuelwood users in this study, the average monthly per capita consumption is about 32.88 kg. According to ERL (1985), a survey in urban towns and villages like Gaborone, Lobatse, Selebi-Phikwe, Molepolole, Palapye and Serowe gave a range of estimates of about 0.3 to 1.1 kg per day per capita. However, it is not clear whether this is consumption by users alone or the whole sample of urban households. Gay and Zietlow (1985) also observed that fuelwood consumption in the urban towns is much lower than in the large villages and this study confirms that.

In terms of annual per capita consumption of fuelwood, this study's estimate is about 0.46 tonne for households using fuelwood. According to Sekhwela (1985) the long-term ESMAP studies (1991) estimated the annual urban household fuelwood consumption to be about 0.44 tonne per capita but it does not make clear whether this is for only fuelwood users. A critical look at the ESMAP documents suggests that this was for all urban households (users and non-users). If the Francistown annual per capita consumption of 0.558 tonne for user households is used for other fuelwood-rich areas like Selebi-Phikwe in calculating the national urban user average, then the per capita consumption becomes 0.489 tonne. This reduces to about 0.235 tonne when spread over all households irrespective of users or non-users.

6.3.2 Energy consumption variation between towns and villages

Table 6.3 clearly shows that, apart from fuelwood, town dwellers use other energy sources more intensively than the village dwellers. One energy source that stands out in this regard is electricity. This is largely due to improved access to more convenient energy sources and higher income levels in towns than in villages. The table shows that most of the high electricity consumption shown in Table 6.1 comes from the town dwellers. In fact, the average monthly electricity consumption in the village households of about 299 kWh is below 40% of the average of the town dwellers (754 kWh). This is where the challenge lies in electrification of smaller villages and rural areas where long grid extensions are required, and with consumption levels so low that paying back the connection costs is slow, presuming that there is a big part of capital recovery in the tariff. The burden of wiring village households also contributes to the low consumption levels.

		kWh	*kg*	*litres*	*kg*	*packets*	*Kg*	*charges*	*litres*
	IncGrp	**Elec**	**Gas**	**Paraffin**	**Fuelwood**	**Candle**	**Charcoal**	**CarBatt**	**Petrol**
Towns	1	449	16.20	8.48	181	2.68	13.33	2.59	18
	2	555	15.38	10.53	122	1.64	5.00	3.12	16
	3	922	14.12	11.46	61	1.46	6.09	2.33	
	4	1172	15.00	5.00	59	1.14	6.88		
Total		754.11	15.40	9.49	116	1.94	7.08	2.73	16.6
Villages	1	192	11.99	6.95	191	1.92		1.38	
	2	282	14.36	7.16	211	1.45	3.00	1.91	
	3	413	13.83	7.05	303	1.77	5.00	1.33	
	4	666	20.68	4.20	104	1.00		1.00	
Total		298.96	13.41	6.80	210	1.71	4.00	1.53	3.5

Table 6-3: Monthly energy consumption variation with income in towns and villages

The table also shows that, although paraffin is more widely used amongst village households than town households (see Figure 6.6), the intensity of use is much higher in the towns than in the villages. This is due to higher affordability in towns. Although the average use of gas in the villages is lower than in towns, the difference is insignificant when compared with the difference in the case of electricity. This is a real case where improved accessibility has over-ridden the barrier of affordability. Fuelwood consumption per month of about 210 kg in the village household users is much higher than the 116 kg of town users since the village dwellers have limited access to other fuels.

6.3.3 Energy consumption variation with income

Examination of the energy consumption at different income levels in Table 6.3 establishes that electricity is indeed an energy source of the rich with consumption rising as income increases both in towns and villages. Zhou (1994: 15-16) reported monthly electricity consumption of 770 kWh for the highest income group in a study in Gaborone, Kanye and Goodhope. 450-770 kWh was estimated for the middle income group and 150 kWh was estimated for the lowest income group in the same study. Although these levels of consumption are lower than the estimations for this study, they show a similar variation of electricity consumption with income. It must also be noted that note the current study is 6 years after the Zhou study (1994) and hence it is not surprising that the estimates for this study are higher when the improvement in income distribution is taken into consideration.

In the case of fuelwood, the intensity of use decreases with income in towns whilst it generally increases with income in the villages. However, at the highest income level in the villages households use less fuelwood since they tend to shift to higher consumption of gas and electricity.

The intensity of gas use does not seem to have any specific variation with income both in the towns and in the villages. It illustrates that the level of gas consumption is not dependent on income levels but rather on more tangible factors like household size. It is only in the highest income group in the villages that income seems to be influencing households to use more gas especially where households are not connected to electricity.

The intensity of candle use in the towns decreases with income due to increased access to electricity but there is no distinct variation of candle use intensity with income in the villages. Paraffin use intensity increases with income in the towns, but at the highest income level, households decrease their consumption by shifting to other fuels. In villages there does not seem to be any clear variation with income.

6.3.4 Energy consumption variation in electrified and non-electrified households

Table 6.4 shows that, even though electrification has not contributed much towards changing fuelwood cooking patterns (see Chapter 7), it has contributed towards the reduction in the intensity of use of fuelwood, paraffin, gas and candles. Electricity replaces candles as main lighting source and fuelwood and paraffin seem largely used as backup fuels for space and water heating with less intensity of use in electrified households.

		kWh	*kg*	*litres*	*kg*	*packets*	*kg*	*charges*	*litres*
Connect	**IncGrp**	**Elec**	**Gas**	**Paraffin**	**Fuelwood**	**Candle**	**Charcoal**	**CarBatt**	**Petrol**
Elec	1	355.24	14.89	5.88	199	0.94	13.33		
	2	449.33	14.15	4.50	138	1.01	5.00	1	
	3	843.33	13.72	5.67	132	1.24	5.92		20.00
	4	1110.51	15.56	3.00	52	1.13	6.88	1.00	
Total	Elec	626.19	14.43	5.48	142	1.10	6.93	1.00	
Non-Elec	1		13.64	7.57	188	2.37		2.07	17.50
	2		16.51	9.73	216	1.86	5.00	2.70	13.25
	3		15.32	9.58	318	2.06		2.00	
	4		23.00	5.00	201	1.00		1.00	2.00
Total	Non-elec		14.86	8.11	201	2.15	5.00	2.28	12.85

Table 6-4: Monthly household energy consumption variation with income in electrified and non-electrified households

The income variation with energy consumption in electrified and non-electrified households is similar to that in towns and villages respectively in most cases. The main difference is that in the non-electrified households the intensity of fuelwood use at the highest income level still remains significantly high (201 kg). This is mainly due to lack access to electricity and the ability to afford to buy fuelwood or a better access to fuelwood due to higher income.

6.3.5 Per capita energy consumption

The total household demand for each energy source can be estimated from the analysed data in Table 6.5 showing both the monthly and annual per capita consumption of the various energy sources. It must be mentioned that the annual per capita consumption figures are calculated based on the assumption that there are 8 summer and 4 winter months.[4]

		kWh	*kg*	*litres*	*kg*	*packets*	*kg*	*charges*	*litres*
		Elec	**Gas**	**Paraffin**	**Fuelwood**	**Candle**	**Charcoal**	**Carbatt**	**Petrol**
Monthly	*Towns*	188	3.26	2.18	22	0.41	2.01	0.49	2.20
	Villages	105	3.34	1.40	36	0.37	1.96	0.25	0.83
	Elec	165	3.52	1.28	28	0.30	2.09	0.13	
	Non-Elec		2.99	1.75	42	0.43	1.25	0.40	1.81
Annual	*Towns*	2637	46	30	312	6	28	7	31
	Villages	1465	47	20	505	5	27	2	12
	Elec	2312	49	18	390	4	29	2	0.00
	Non-Elec	0	42	25	593	6	18	6	25

Table 6-5: Annual and monthly per capita consumption of energy sources in towns and villages, and in electrified and non-electrified households

Although electrified households use less gas than non-electrified ones on the average, in terms of per capita consumption it is interesting to note that the consumption by electrified households is higher

[4] On average most households indicated that their winter energy requirement is about one-and-a-half times their summer consumption. Since the data for this study was collected only in summer, the winter rise in consumption was included in the annual per capita calculations.

than non-electrified households. This is mainly due to the fact that the household sizes of the electrified households that largely occur in the towns are in general lower than those of the non-electrified households that largely occur in the villages. It must be mentioned that the figures in Table 6.5 do not include towns like Francistown and Selebi-Phikwe in the north-eastern region of the country where it is rich in biomass resources. The figures are also based on households using the energy sources.

6.3.6 Energy consumption of households cooking with different fuels

It is interesting to investigate the intensity of energy use in households cooking with a particular main energy source and a secondary energy source. This helps to understand the implications of fuel substitution on total energy demand and it helps to explore what substitutions are likely or possible. Tables 6.6 and 6.7 estimate the monthly and annual per capita energy consumption by households using specific energy sources as the main and secondary fuels.

Both tables show that where fuelwood is used as the main cooking fuel, electricity is not used at all in the town households. Since in electrified households electricity is used for at least lighting, this is an indication that in the town electrified households fuelwood is not used as a main cooking fuel. However, in the electrified village households, fuelwood can sometimes be the main cooking fuel. Where fuelwood is the main cooking fuel the annual per capita consumption of fuelwood is above 0.5 tonne. It also shows that in the case where fuelwood is the main cooking fuel in the towns, gas is used most intensively (over 53 kg per capita per annum) due to lack of access to electricity. Another clear observation is that where electricity is used as the main cooking fuel with gas as the secondary fuel, households do not use either paraffin or fuelwood at all both in towns and villages. Where gas is used as the main cooking fuel with electricity as the secondary cooking fuel paraffin is not used at all in both towns and villages.

	kWh	*kg*	*litres*	*Kg*	*packets*	*kg*
	Elec	**Gas**	**Paraffin**	**Fuelwood**	**Candles**	**Charcoal**
HH with fuelwood as main cooking fuel						
Towns		3.80	0.90	13	0.27	
Villages	19.99	1.72	1.15	42	0.34	
Main Elec & Sec Gas Cooking						
Towns	262	2.95			0.21	
Villages	119	2.50			0.25	
Main Fuelwood & Sec Gas Cooking						
Towns		3.80	1.00	14		
Villages	24.05	1.48	1.11	37	0.24	
Main Gas & Sec Fuelwood Cooking						
Towns	121.91	3.47	1.08	17	0.30	0.33
Villages	27.95	2.39	1.42	29	0.33	
Main Gas & Sec Elec Cooking						
Towns	209.11	2.80		12	0.18	1.05
Villages	121.19	3.21		16	0.25	

Table 6-6: Monthly per capita energy consumption of households cooking with a main and/or a secondary fuel

	kWh	*kg*	*litres*	*kg*	*packets*	*kg*
	Elec	**Gas**	**Paraffin**	**Fuelwood**	**Candles**	**Charcoal**
HH with fuelwood as main cooking fuel						
Towns	0	53.20	12.67	184	3.74	0.00
Villages	280	24.12	16.12	588	4.82	0.00
Main Elec & Sec Gas Cooking						
Towns	3668	41.28	0.00	0.00	2.92	
Villages	1666	35.00	0.00	0.00	3.50	
Main Fuelwood & Sec Gas Cooking						
Towns	0	53.20	14.00	200	0.00	0.00
Villages	337	20.76	15.53	518	3.31	0.00
Main Gas & Sec Fuelwood Cooking						
Towns	1707	48.55	15.16	231	4.23	4.67
Villages	391	33.53	19.88	410	4.56	0.00
Main Gas & Sec Elec Cooking						
Towns	2928	39.22	0.00	166	2.57	14.75
Villages	1697	44.96	0.00	217	3.50	0.00

Table 6-7: Annual per capita energy consumption of households cooking with a main and/or a secondary fuel

6.4 Cost of fuel use in the households

This section discusses the extent to which energy is a burden to households by looking at the patterns of costs of individual energy sources and the total energy expenditure of households. It explores the variations between the difference urban centres, electrified and non-electrified households, urban towns and villages, and different income levels. The discussion is limited to the energy sources used extensively and intensively. *It must be noted that all expenditures on energy sources discussed here are those by only households that use the fuels and not those of the whole urban population. Furthermore, only cash or monetary expenditures have been taken into account*

6.4.1 Expenditure on individual fuels

Overview

Figure 6.12 depicts that the energy sources that are of significant costs to households are electricity, fuelwood and gas. Although petrol seems to have significant cost, insignificant number of households use it. It is clear from the figure that whilst the average monthly expenditure on fuelwood (P63) is just a little above that of gas (P57), the average monthly expenditure on electricity (P163) is way above that of all other energy services.

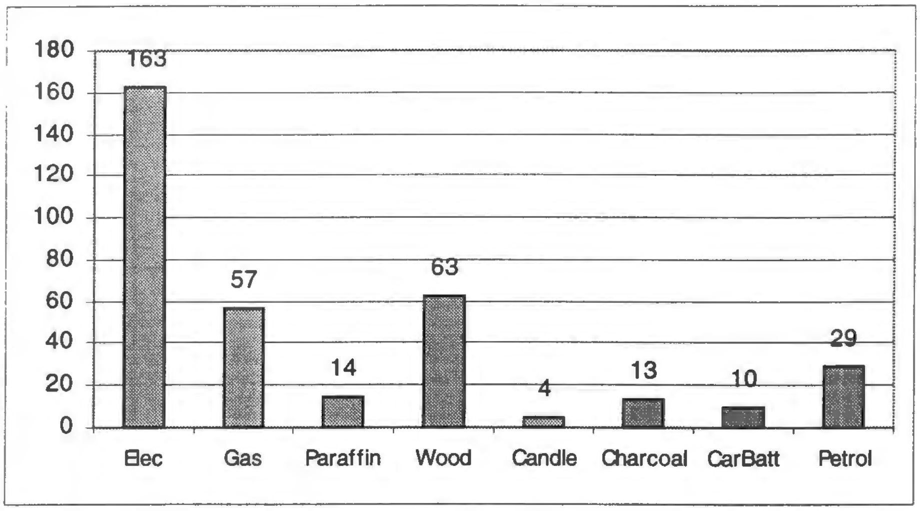


Figure 6-12: Average monthly expenditure (P) on energy sources by users in all study areas

Sampled urban centres
Expenditure in the Botswana Pula (P) amongst different individual urban centres covered in the study is shown in Figure 6.13. It is noteworthy that expense on gas and fuelwood is relatively constant amongst the settlements, but electricity expenditure varies significantly. Just like the consumption levels in Table 6.1, Palapye has the highest expenditure on electricity amongst the village households, which might be due to its credit metering system. The metering system in the other villages is mainly the pre-paid system. Under the credit system consumers pay a fixed basic amount in addition to energy consumption costs, and households usually have no control on consumption. Whilst the average monthly expenditure on gas and fuelwood (just over P50) are not very different in most urban centres, expenditure on fuelwood is significantly higher than gas in Lobatse and Mochudi.

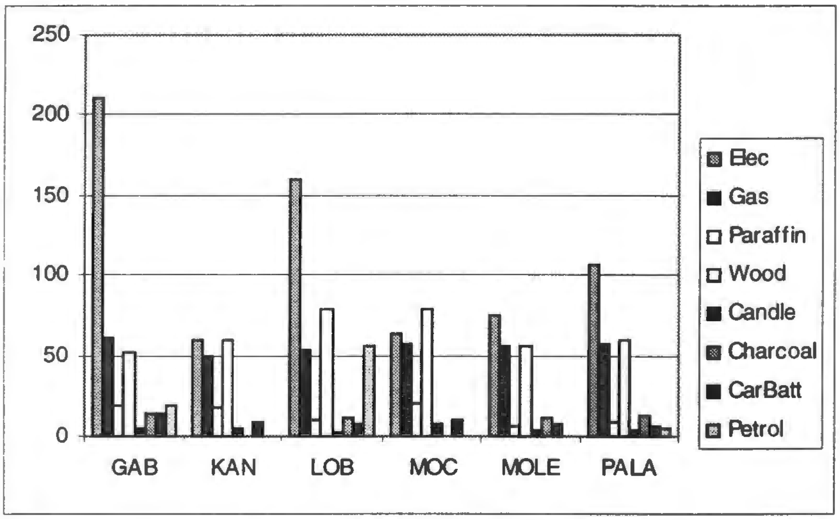


Figure 6-13: Average monthly expenditure (P) on energy sources by users in individual study areas

Urban towns and villages
A comparison of energy expenditure as a proportion of household income in urban towns and villages reveals little difference between the two settlement types for most energy sources (see Figure 6.14). The only significant exception is electricity in which case the average monthly expenditure by village households is about 40% percent of the average by town households. These lower levels of electricity consumption in the villages should be taken into account in electrification planning in order to realise the targeted cost recovery. Electricity connection alone is not enough for improving energy access unless it is coupled with the appropriate financial mechanisms for wiring and appliance ownership.

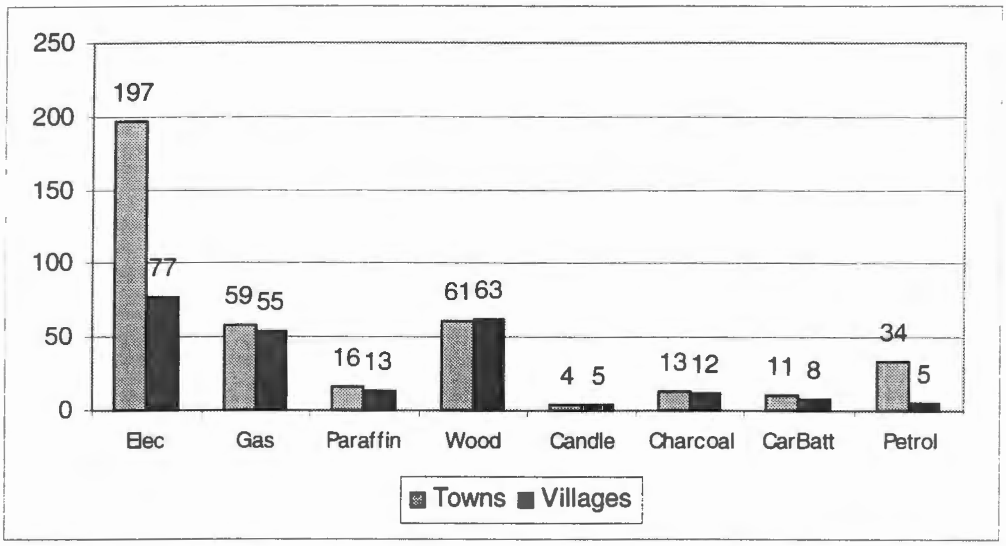


Figure 6-14: Average monthly expenditure (P) on energy sources by users in towns and villages

Electrified and non-electrified households

Although expenditures on gas, paraffin, fuelwood and candles in non-electrified households are slightly higher than those in electrified households, the higher expenditure on electricity in electrified households obviously makes electrified households incur more energy expenses than non-electrified households.

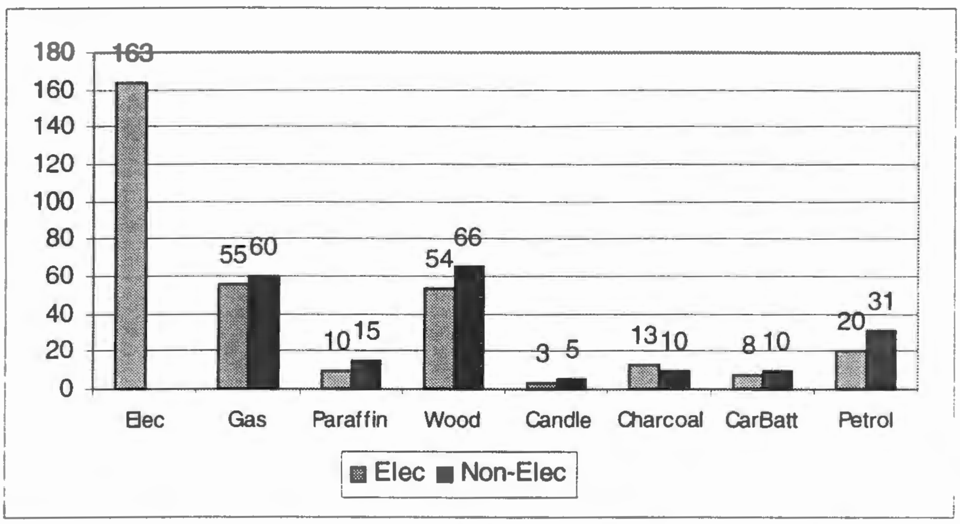


Figure 6-15: Average monthly expenditure (P) on energy sources by users in electrified and non-electrified households

Energy expenditure variation with income: electrified and non-electrified households

Looking at different expenditure characteristics in electrified households (Figure 6.16), it can be seen that electricity expenditure clearly increases with income in both towns and villages, although it is significantly lower in urban villages. This goes to show that electricity is not only more widely used amongst the richer households, but that the richer households also spend more on electricity. Gas expenditure is remarkably constant amongst income groups in both electrified and non-electrified households, except for the highest income group in non-electrified households, where it increases noticeably (see Figure 6.17).

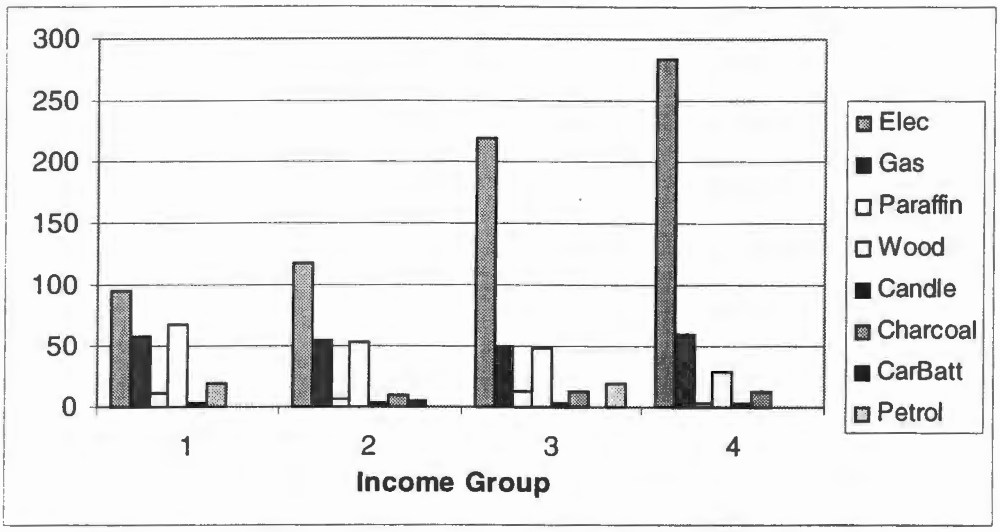


Figure 6-16: Variation of user average monthly expenditure (P) on energy sources with income in electrified households

Expenditure on fuelwood in electrified households decreases slightly with increasing income, indicating a shift to other preferred options, particularly electricity. In non-electrified households, fuelwood expenditure is significant in the first three income groups (above P60), although it reduces in the highest income group where, again, there are other preferred alternatives that are available and affordable to these households. The fact that low income non-electrified households spend as much on fuelwood as higher income households may indicate that they are forced to purchase fuelwood rather than it being freely available for collection, otherwise it is likely that they would reduce the burden of high energy expenditure by increased collection.

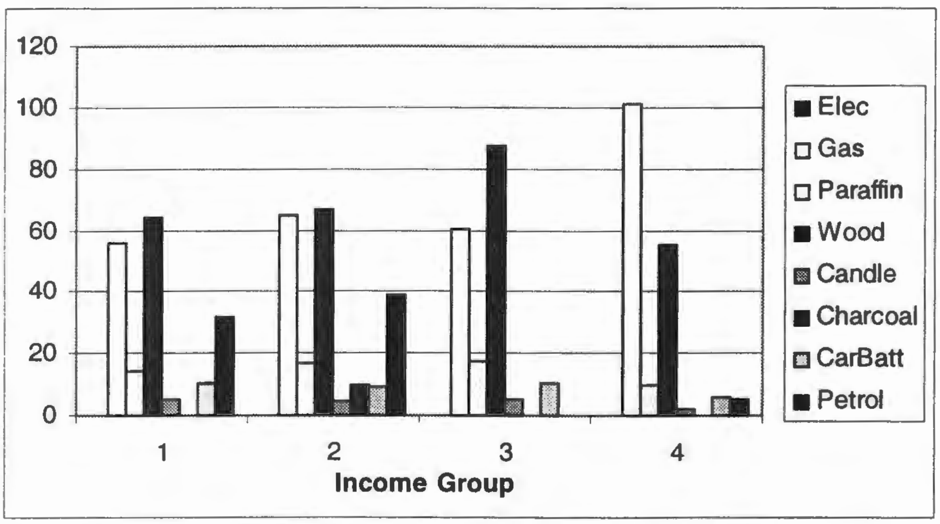


Figure 6-17: Variation of user average monthly expenditure (P) on energy sources with income in non-electrified households

6.4.2 Total energy expenditure

Electrification and total energy expenditure

Figure 6.18 illustrates how electrification influences the total monthly cost of energy to urban households. The non-electrified households spend far less on energy compared to the electrified households. In fact, the lowest income group of electrified households spends more on energy than the higher income groups of non-electrified households. Whilst most of the energy expenditure in non-electrified households is spent on fuelwood and gas, a greater portion of the energy budget in electrified households is spent on electricity (as shown in Figures 6.15 and 6.16). The figure also shows how income influences the energy expenditure in electrified households. The richer the electrified households the more they are able to purchase appliances and consume more electricity.

In the non-electrified households, however, the richer the households the easier they are able to access cheaper sources of energy like fuelwood and other energy sources like gas; thus in the end their total energy expenditure does not rise much at higher income levels.

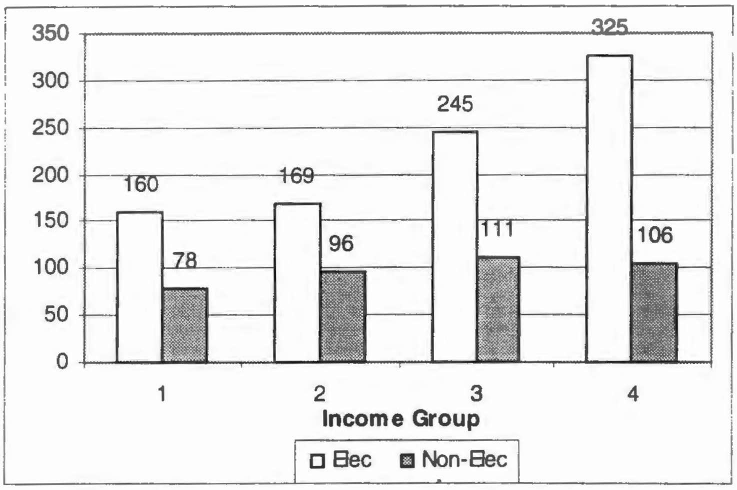


Figure 6-18: Variation of total monthly household energy expenditure with income

Energy burden of low-income households

As shown in Figure 6.19, energy expenditure in the lowest income households is around 20% of household income. This represents a significant burden for such households, and is a common situation in developing countries. The issue is even more pertinent if one considers the fact that about 42% of the urban population are in the lowest income group (see Section 5.2). It can be seen that this proportion is much higher than for the higher income groups, where energy expenditure typically is no more than 5% of household income. The indication is that there is a certain minimum energy requirement that households have for cooking and other uses, and thus poorer households are effectively forced to spend such high proportions of their scarce financial resources on meeting this minimum requirement than are other income groups. From a policy perspective this is important because specific attention to ensuring adequate and affordable energy sources for lower income households is likely to be required to promote their continued welfare.

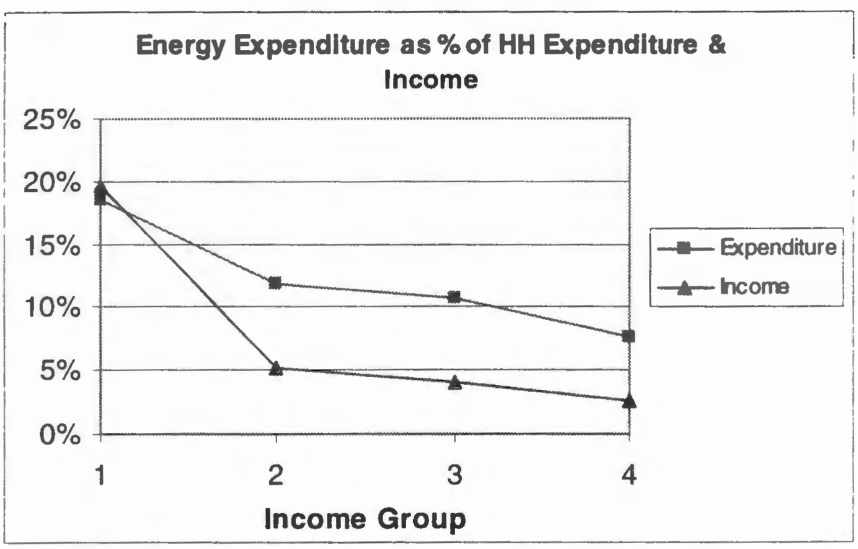


Figure 6-19: Total monthly energy expenditure as a percentage of total monthly household expenditure and income in all study areas

Urban towns and villages

The percentage of the total household budget spent on energy indicates how burdensome energy use is to households. Figure 6.20 shows that at the lower income levels energy use seems to be more burdensome for village households than town households. The energy burden differences between town and village households narrow in the middle-income groups. However, the contrary occurs in the highest income group where village households seem to have better access to cheaper source of energy in the form of fuelwood.

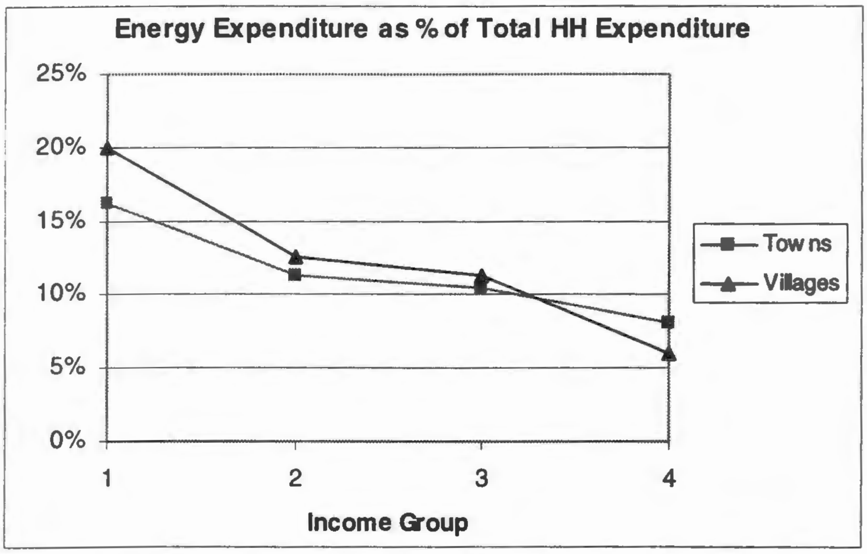


Figure 6-20: Total monthly energy expenditure as a percentage of total monthly household expenditure in towns and villages

Electrified and non-electrified households

Figure 6.21 shows that the proportions of household expenditure for meeting energy needs in non-electrified households are higher than those in electrified households at the lower income levels. This is an indication that energy use is more burdensome at the lower income levels for non-electrified households than electrified ones. However, in the highest income group, the electrified households tend to spend more on energy than in the non-electrified households. This could be because such households can afford luxury spending, and electricity lends itself more to such spending than other energy sources (e.g. for microwave ovens, large colour TV sets etc). This is also due to the high cost of electricity since most high-income households are using electricity and electricity expenditure is higher than all the other energy services (see Figure 6.15).

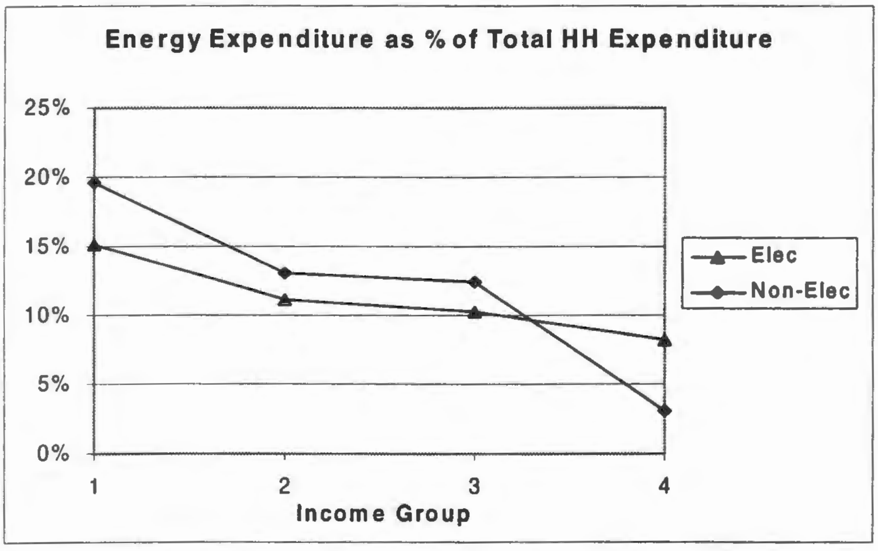


Figure 6-21: Total monthly energy expenditure as a percentage of total monthly household expenditure in electrified and non-electrified households

In general, however. the higher expenditure proportion pattern in the non-electrified households at the lower income levels indicates that there is significant financial saving for connected households (i.e. 'consumer surplus' as a result of electrification). Possibly more importantly, it indicates that the use of electricity at the lower income levels to meet energy needs generally results in lesser expenditure for households. Since electricity generally appears to be amongst the preferred energy sources, it seems safe to deduce that households that can easily access electricity would do so. Therefore factors such as affordability of connection and appliance acquisition, and proximity of the grid are where strategies need to focus to promote the use of electricity.

In general, the analysis of expenditure on energy by households supports the trends mentioned earlier – that households move away from dependence on fuelwood where they can afford to and where other viable options are available (such as electricity). Equally important, however, is the observation that lower income households are spending a very high proportion of their income on energy needs, and that many of them are also still largely dependent on fuelwood as a principal energy source.

7. Household energy end-use patterns

7.1 General cooking and lighting trends from 1985 to 2000

7.1.1 Main cooking fuel trends

One of the most significant trends observed in household energy use over the past few decades is the rise of the use of gas as a preferred main cooking fuel. In both urban towns and urban villages, there is a marked increase in gas use as the main household cooking fuel from the mid-eighties to the present. In towns, gas, paraffin and fuelwood were all used by similar proportions of households as the main cooking fuel in the mid-1980's, but in the last decade gas use has risen to a point where over three-quarters of households use it for cooking, accompanied by a drop in the use of paraffin and fuelwood use for this purpose (see Figure 7.1). According to the survey data in this study, fuelwood use for cooking has diminished from 35% in the mid-eighties to about 2% in the towns surveyed. This transition has been particularly strong in Gaborone, but is also clear in Lobatse. Cooking mainly using electricity shows only a marginal increase over this period in towns.

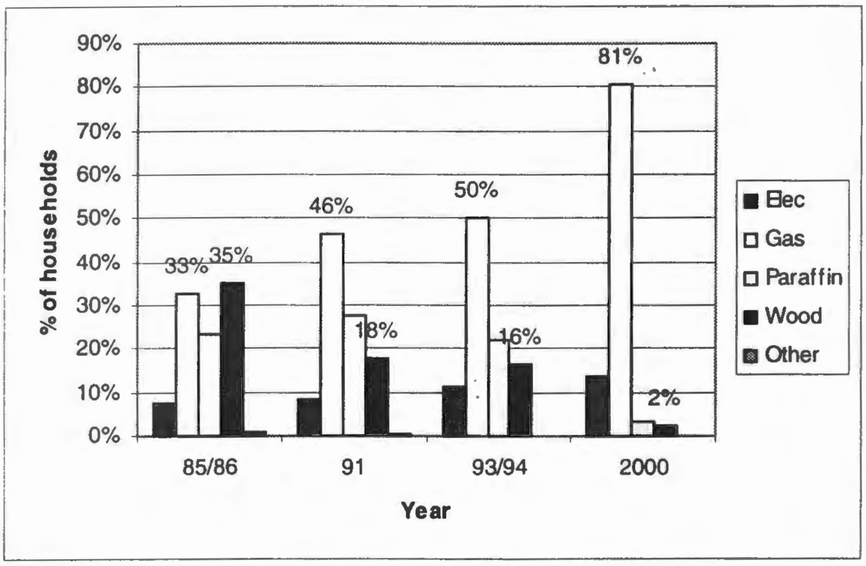


Figure 7-1: Main cooking fuel use trends in urban towns, 1985-2000
Source: CSO 1999: 121, CSO 1995, and Current survey results

It must be mentioned that the 2000 data in Figure 7.1 does not include coverage of the north-eastern towns like Francistown and Selebi-Phikwe where, due to richer resources in biomass, fuelwood cooking is more popular. According to White (1999:10), 71 out of the 241 households surveyed in Francistown were using fuelwood for cooking, which translates into 29%. Including such data in this study raises the national urban fuelwood cooking to about 9%. Cooking with other fuels could not be adjusted with the Francistown data since a closer look at the data provided on end uses shows that the study was only referring to fuelwood users.

In urban villages fuelwood use as the main cooking fuel has declined from being used by almost 90% of households in 1985 to being used by only one third of households. In its place, gas use has risen from about 10% to almost 60% as the main cooking fuel (see Figure 7.2). Electricity use for cooking has remained insignificant since the mid-eighties despite the fact that electrification levels have risen to about a third of the households in three of the four urban villages studied. Later in this chapter some of the determinants involved in this shift towards cooking with gas are explored.

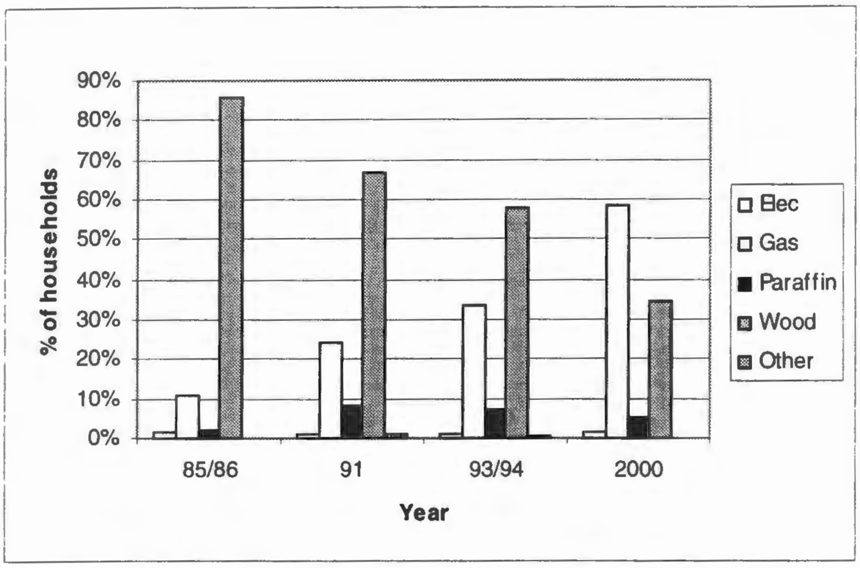


Figure 7-2: Main cooking fuel trends in urban villages, 1985-2000
Source: CSO 1999: 121, CSO 1995, and Current survey results

7.1.2 Main lighting trends

The trends in lighting use since the mid-eighties show a clear decrease in non-electric lighting options, most probably linked with the increasing availability of electricity. In urban towns, electrical lighting has risen from being the main lighting energy source in just over 20% of households in 1985, to over 60% of households in 2000 (see Figure 7.3). This is largely as a result of the increased focus on household electrification in urban areas. Linked with this is a decrease in the use of paraffin – which was the most widely used lighting source in urban towns until recent years (see Figure 7.3). Paraffin use as the main lighting source, which increased to almost 60% by 1993/94, has now reduced to about 40%. Candle use was also significant in the mid-eighties, but this appears to have declined steadily to the point where it is almost insignificant. This confirms the fact that most of the 28% of urban town households using candles (see Figure 6.6) do not actually use them as main lighting source but rather as a backup lighting source or for decoration and entertainment purposes.

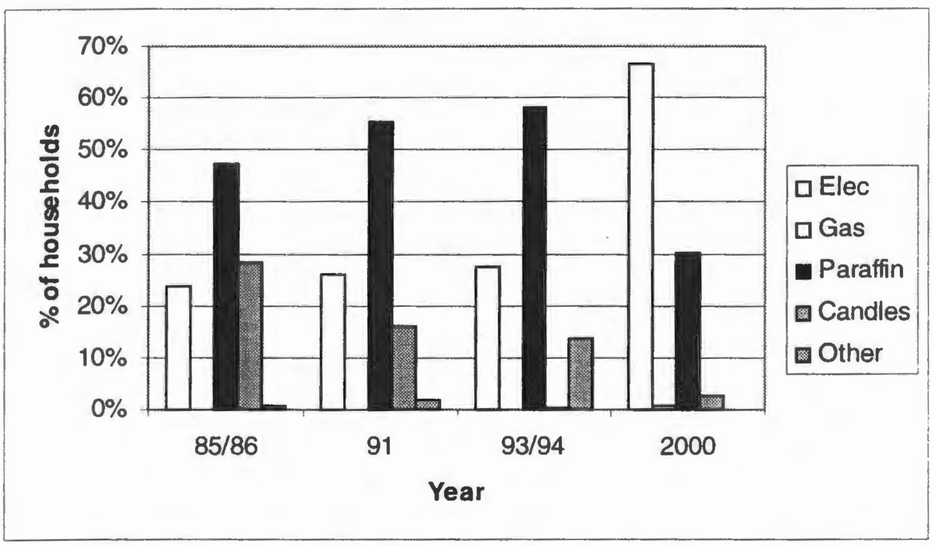


Figure 7-3: Main lighting source trends in urban towns, 1985-2000
Source: CSO 1999: 121, CSO 1995, and Current survey results

In urban villages paraffin use has also decreased as the most widely used lighting source (about 80%) to just over 60% (see Figure 7.4). This also appears to be linked to increased levels of electrification which has resulted into the rise in the use of electricity as the main lighting source from under 10% in the mid-eighties to about 30% in 2000. It is interesting that candle use has never been significant in villages, even as far back as in 1985. This is remarkable when compared with the neighbouring South Africa where candle use for lighting in urban townships was about 60% or more before the democratic dispensation in 1994 (Afrane-Okese 1998: 120).

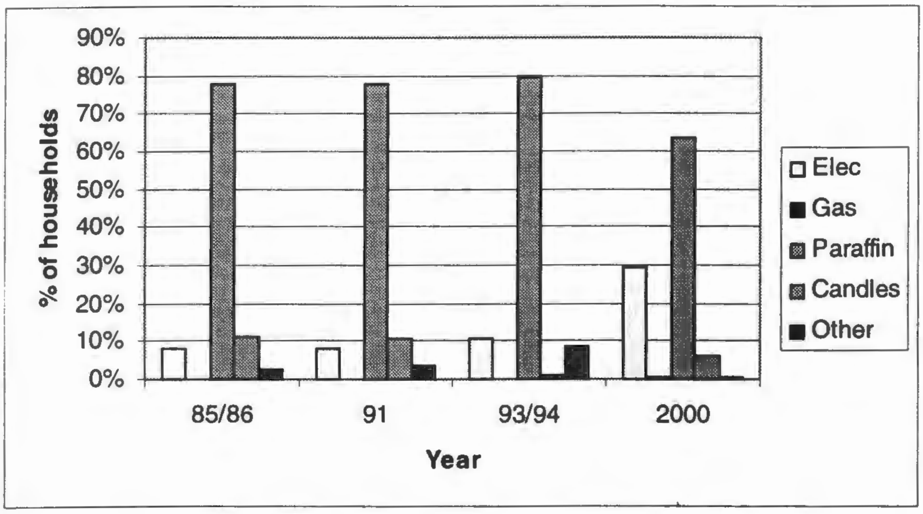


Figure 7-4: Lighting source trends in urban villages, 1985-2000
Source: CSO 1999: 121, CSO 1995, and Current survey results

7.2 Cooking patterns

7.2.1 Urban towns and villages

Although gas is used more in urban towns than in urban villages, it is still clearly the dominant main energy source for cooking in all urban areas covered by this project (70%) (see Figure 7.5), and, as has been illustrated in the previous section, its adoption is increasing fast. Whilst data from this study estimates fuelwood cooking in all the urban areas studied to be 17%, the inclusion of the Francistown data increases the all urban average to about 20% of households.

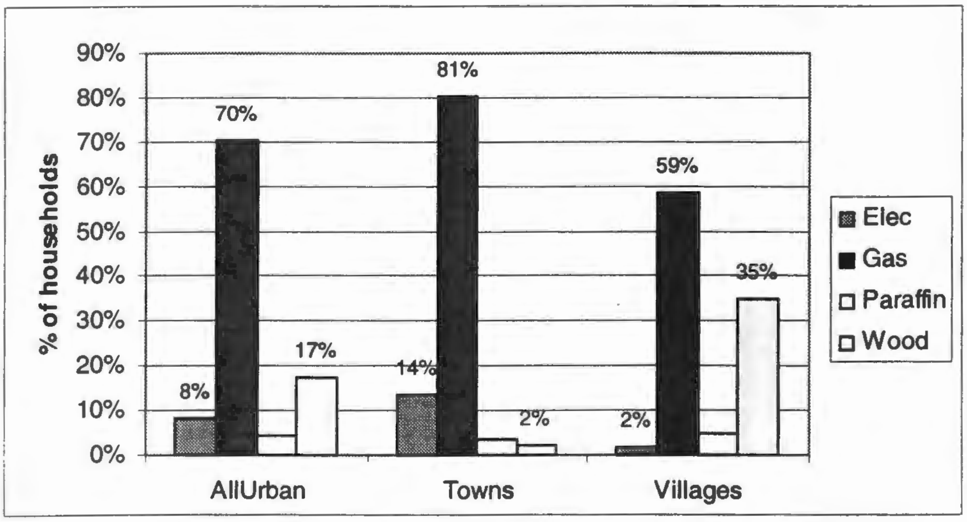


Figure 7-5: Main cooking fuels - all urban areas

7.2.2 Income variation with cooking fuels

The use of gas for cooking is high amongst all income groups, although two other cooking energy use characteristics are notably relevant to income levels. Firstly, in the lowest income village households, fuelwood is used as the primary cooking fuel by roughly as many households as cook with gas (above 45% of households – see Figure 7.6). This is significant from a policy perspective when one considers the fact that over 50% of village households are in the lowest income group.

This indicates that many poorer households are probably still reliant on fuelwood for cooking, which they often buy or gather themselves at little financial cost.

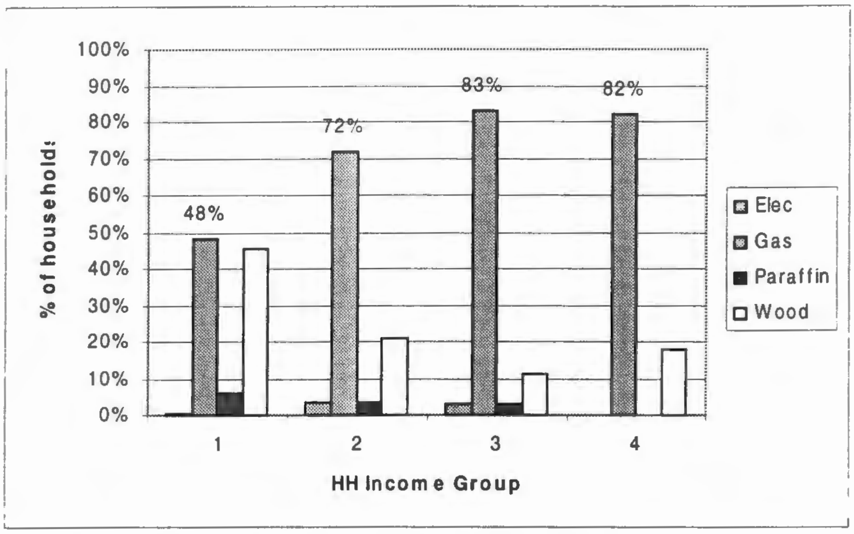


Figure 7-6: Cooking fuel variation with income - urban villages

Secondly, there is a tendency for more higher income town households to cook with electricity, although gas is still used by the majority for this purpose (Figure 7.7).

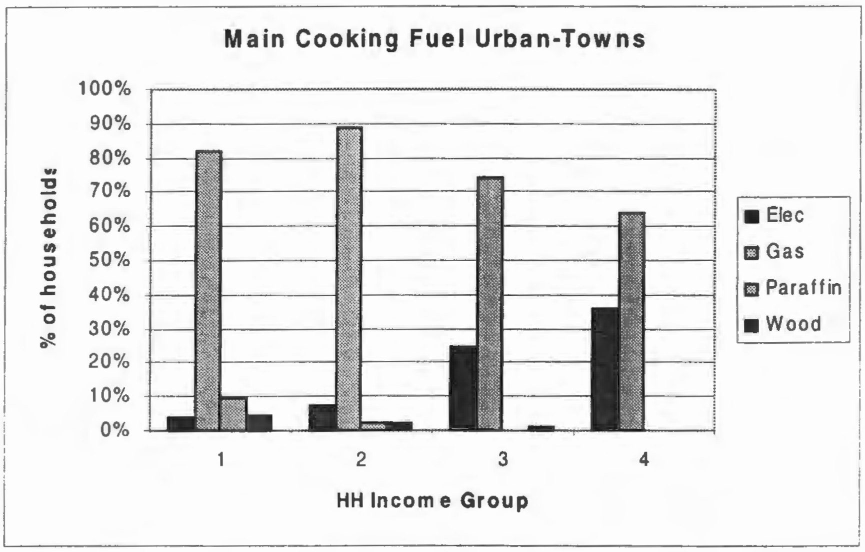


Figure 7-7: Cooking fuel variation with income - urban towns

7.3 Lighting patterns

As illustrated in Figure 7.8, electricity is the dominant lighting energy source in towns, while paraffin use is prevalent in urban villages. This is linked to the accessibility (i.e. availability and affordability) of electrification in these areas.

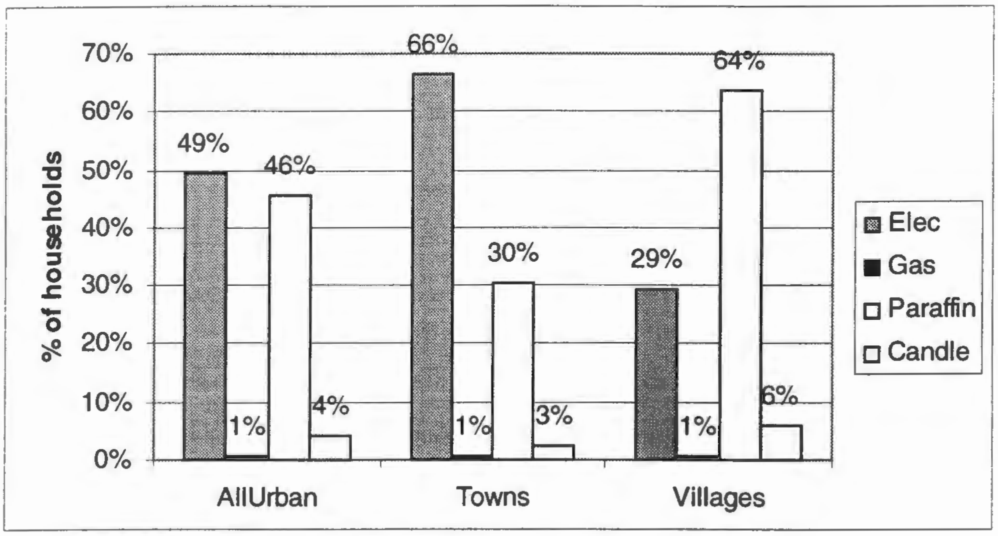


Figure 7-8: Main lighting fuels

There is a strong correlation between electricity use for lighting and income level, while paraffin use for lighting decreases concomitantly (Figure 7.9). Paraffin use for lighting is more pronounced in villages than towns in the same income groups, probably due to the lower levels of electrification in villages. In all areas and in all income groups, candles are the main secondary lighting source.

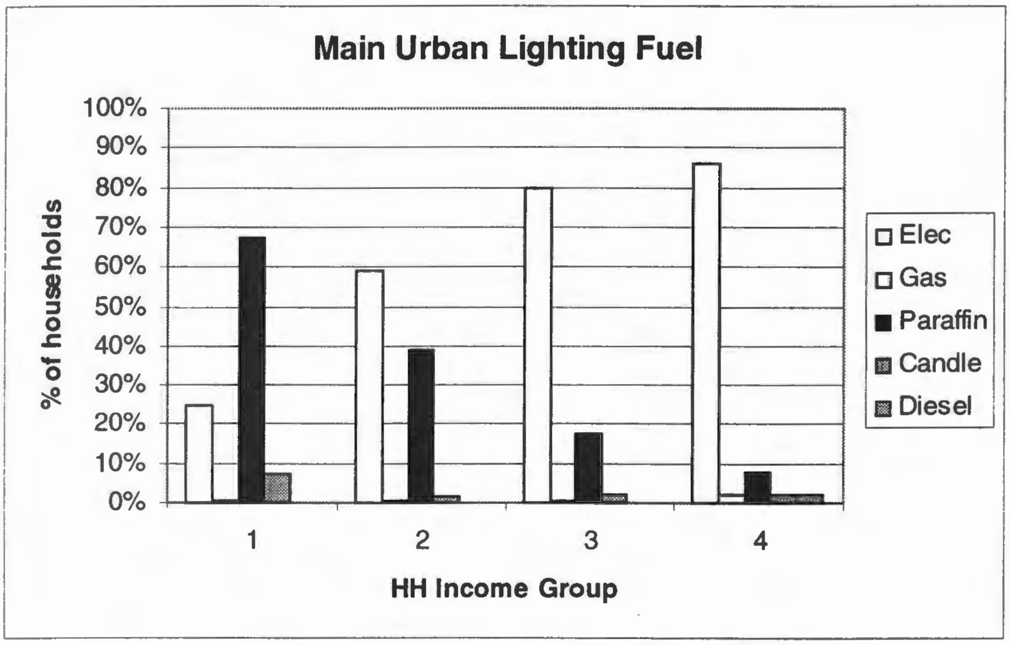


Figure 7-9: Main lighting fuels for different income levels

7.4 Water heating

Over the total study area, approximately one third of households use gas as the main water heating energy source, and one third use fuelwood, while 19% use electricity (see Figure 7.10). There is more extensive use of fuelwood for water heating in the villages (58%) than in the towns (9%). If the data for this study is adjusted with the Francistown fuelwood water heating data (59%) (White 1999) the estimate for the fuelwood water heating in towns becomes 21% and that for the whole urban Botswana becomes 36%. In towns gas is used for water heating (40%) more than electricity (30%).

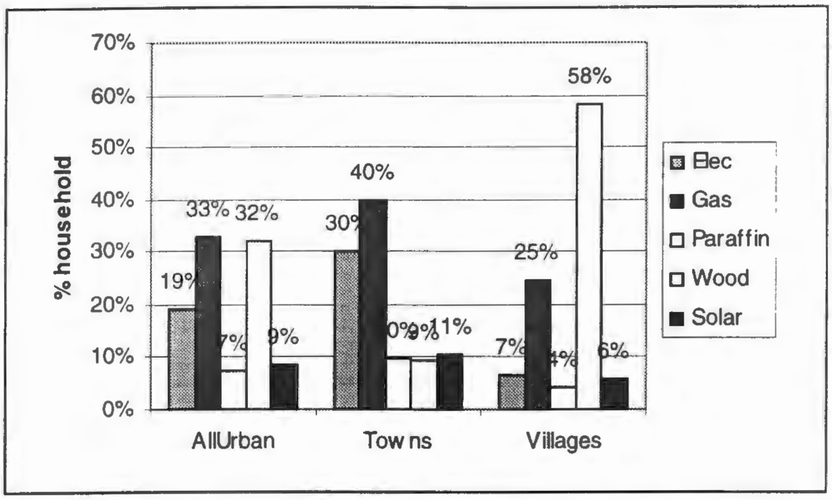


Figure 7-10: Main water heating fuels in towns, villages and all urban Botswana

Gas is used by all income groups for water heating to a similar degree, while fuelwood is more widely used by lower income groups and electricity by higher income groups (see Figure 7.11). Paraffin use does not exceed 11% in all income groups.

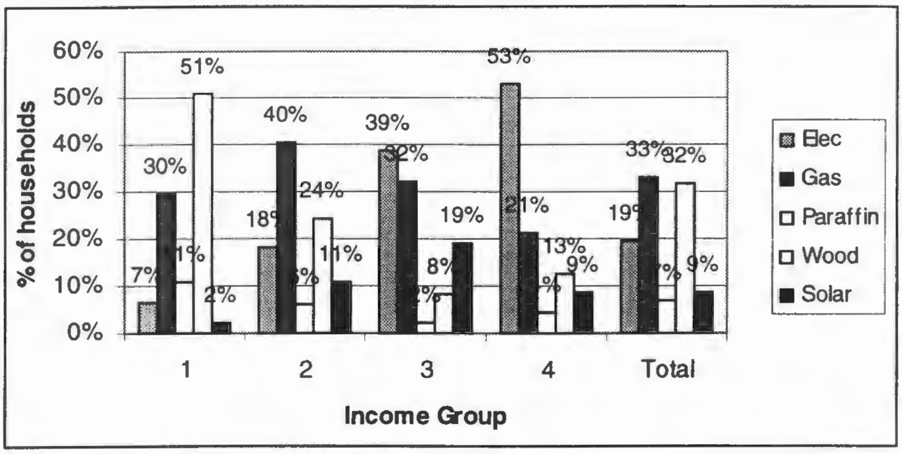


Figure 7-11: Main water heating fuels for different income levels

If one looks into the geographic breakdown of the sample, however, it can be seen that fuelwood is used by the majority of households as a main water heating fuel in all settlements except Gaborone and Lobatse – the two most urbanised settlements (see Figure 7.12). This stresses the importance of fuelwood as a water heating energy source, which is not apparent on looking at the aggregated sample data. It is, however, significant that 71% of households who use fuelwood mainly for water heating, use gas as a secondary water heating source. They will thus already have the basic infrastructure for using gas.

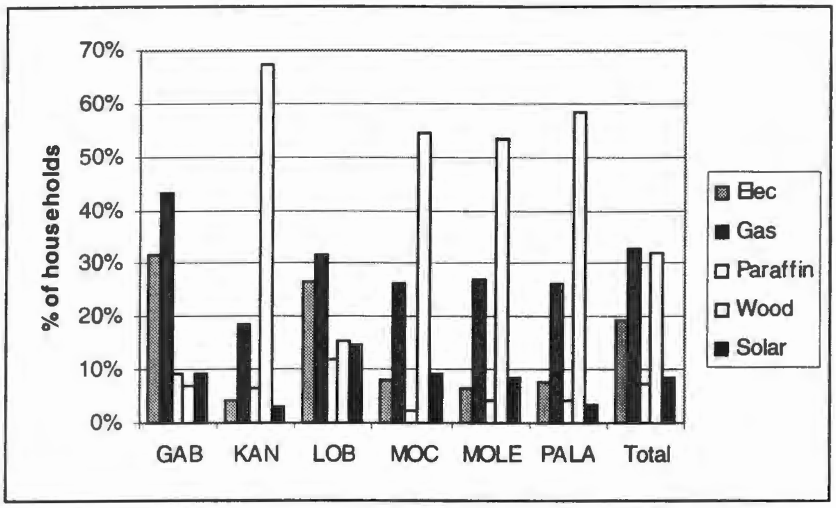


Figure 7-12: Water heating sources at surveyed urban centres

About 9% of the total sample use solar water heaters and these are mainly middle income households in Lobatse, Gaborone, Mochudi and Molepolole.

7.5 Space heating

As illustrated in Figure 7.13, over the entire sample, about a quarter of all households use electricity for space heating, and another quarter use fuelwood. Gas and paraffin are little used for this purpose. In the towns electricity is used by just over a third of the households whilst in the villages it is used for space heating only by 13%. Almost half of the sampled village households use fuelwood for space heating but in the towns fuelwood use is only about 5%. In Francistown fuelwood use for space heating is also insignificant (4%) (White 1999).

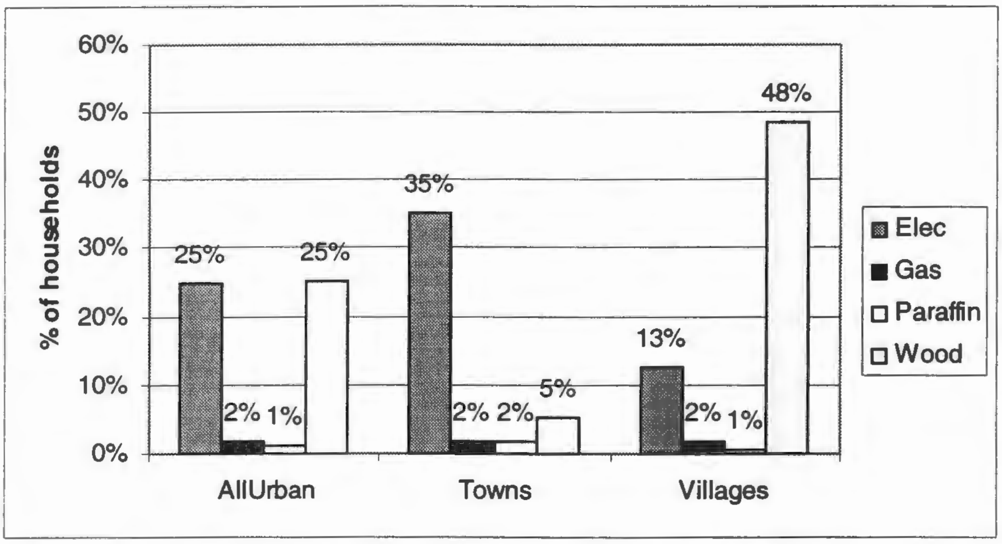


Figure 7-13: Main space heating fuels in towns, villages and all urban Botswana

There is a very distinct correlation between income level and space heating energy source, with almost two-third of the highest income households using electricity for this purpose (see Figure 7.14) (over 80% of households in income groups 3 and 4 are electrified). Fuelwood use for space heating decreases with income and over 40% of the lowest income households using fuelwood. The figure shows that only about half of the urban households make provision for space heating.

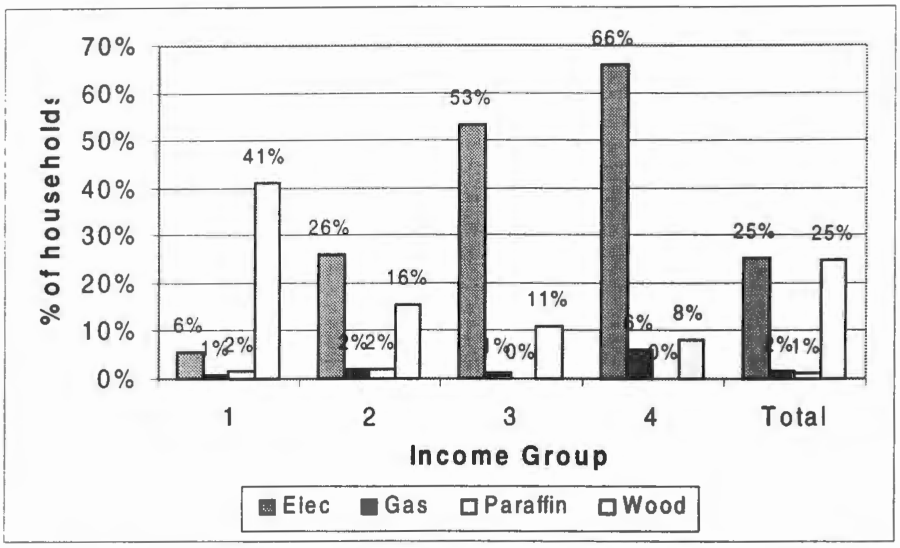


Figure 7-14: Main space heating fuels for different income levels

7.6 Refrigeration

Over the entire project coverage, about half of all households were found to own refrigerators. At least about three-quarters of these refrigerators are electrically powered (see Figure 7.15) at all the urban centres studied. The level of refrigeration ownership is heavily influenced by the prevalence of fridges in Gaborone, where 69% of households own refrigerators. However, in other settlements, including Lobatse, refrigerator owners are in the minority, or even rare - in Lobatse 26% own fridges (in spite of relatively high electrification levels), while in Kanye, the study area with the lowest electrification levels, only 5% have these appliances.

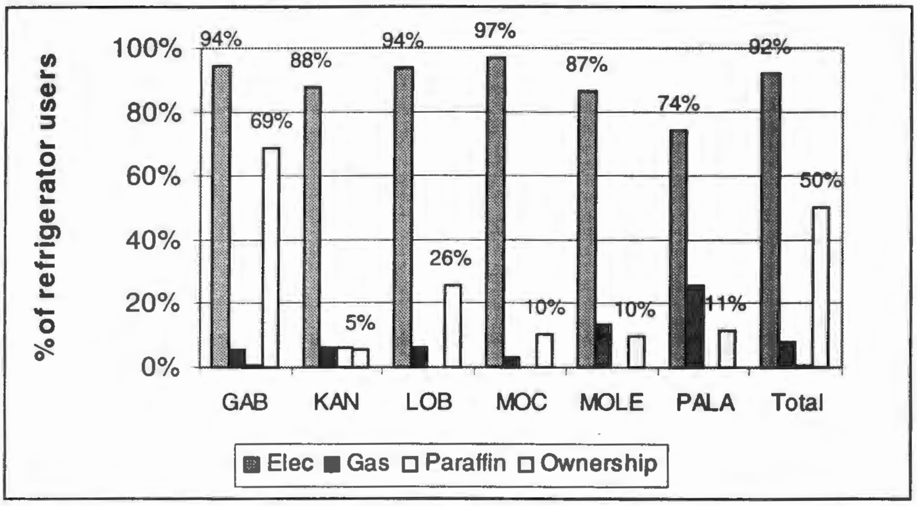


Figure 7-15: Energy sources for the refrigerators owned at study areas

Some lower income households used gas as a refrigeration energy source, and some few paraffin fridges were found in Kanye. Refrigerator ownership appears to be influenced by two main factors – income level of the household (fridges are expensive) and electricity availability – since electrical fridges are more common and often considered more convenient than the gas or even paraffin alternatives. The greater proportion of fridges found in higher income households and extensively electrified urban towns is therefore not surprising.

7.7 Other end uses

7.7.1 Ironing

Electricity is relatively widely used for ironing, particularly in higher income households, while lower income households use gas or fuelwood more (see Figure 7.16). However, income level is unlikely to be the sole determinant of ironing fuel – electricity availability is also a key factor, and this is not always directly linked to household income (electricity is more readily available in the urban town settlements than in the urban villages).

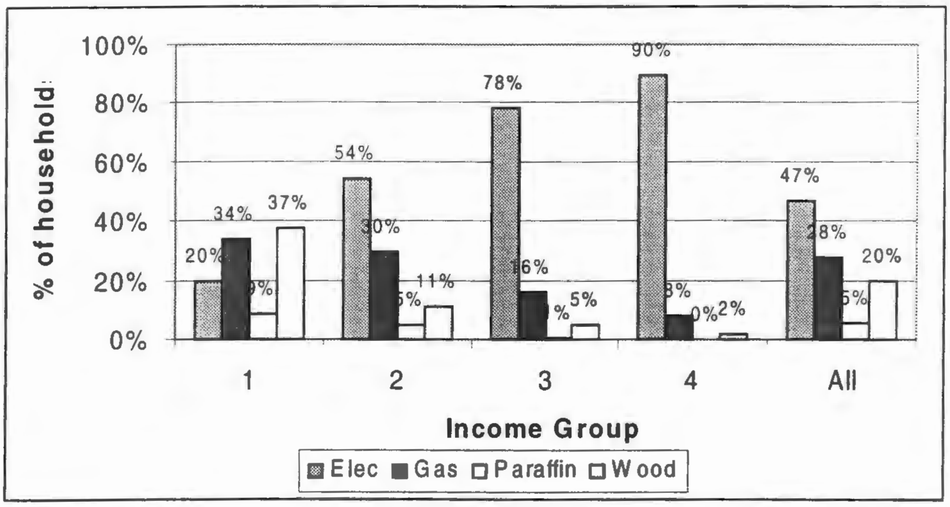


Figure 7-16: Main energy sources for ironing at different income levels

7.7.2 Television, radio, fan

Ownership of televisions (TVs, radios and fans is illustrated in Figure 7.17. The ownership pattern shown correlates with electrification levels in the different settlements. The figure shows that about 29%, 49% and 75% of all the households have space cooling service (fans), televisions and radios respectively.

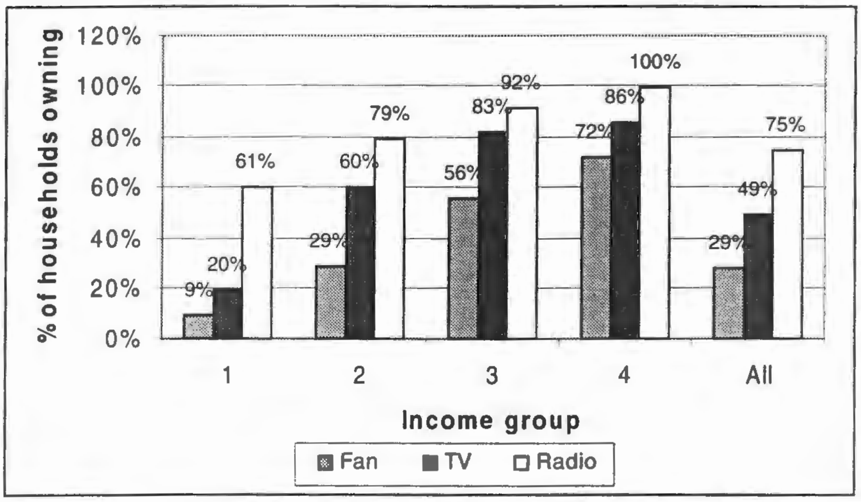


Figure 7-17: Appliance ownership at different income levels

8. Socio-economic issues of household fuelwood use

8.1 Extent of fuelwood gathering and buying

In the urban areas fuelwood is not generally "basically free" as it is often referred to. Figure 8.1 shows that, out of the 43%[5] of the urban households using fuelwood, about a half of them buy all the fuelwood they use whilst about 40% gather all the fuelwood they use. For the other 10%, they buy about 40% of their fuelwood and gather the rest themselves. It is interesting to note that it is only in Kanye where fuelwood gathering is more dominant than buying. This may be due to the fact that Kanye is the least electrified (see Section 6.11) and thus has the highest percentage of fuelwood users (Figure 8.1), and probably has a better proximity to fuelwood resources. Looking at the other areas, fuelwood buying is more pronounced in Molepolole than the rest, reaching over 65% of the households.

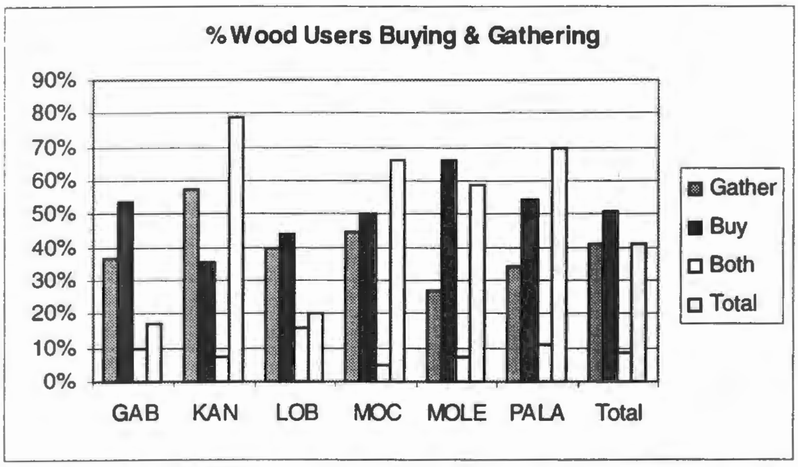


Figure 8-1: Percentage of fuelwood-using households buying or gathering fuelwood

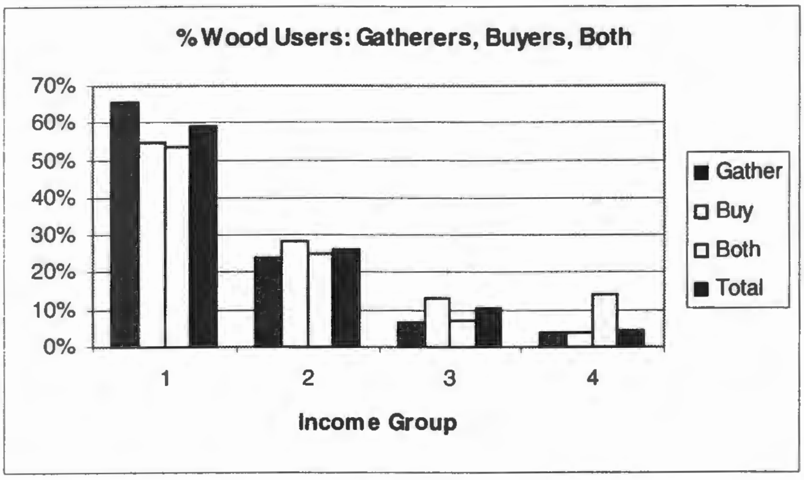


Figure 8-2: Percentage of fuelwood-using households buying or gathering fuelwood at different income levels

In terms of income variation with fuelwood gathering or buying, Figure 8.2 illustrates that both buying and gathering reduces generally at similar proportions with increase in income. The figure makes clear that one main driver of household fuelwood use is poverty.

Figure 8.3 shows the extent of fuelwood gathering and buying in electrified and non-electrified households. In non-electrified households similar proportions of households either buy or gather their fuelwood. In the 20% electrified households using fuelwood (see Figure 6.10), the households

5 The overall percentage of households using fuelwood is depicted here as 41%, which is lower than what is actually the case as depicted in Figure 6.5 (43%). The difference is due to the fact that lower number of households responded to the fuelwood gathering and buying questions.

tend to purchase their fuelwood more than to gather probably because electrified households are more in the higher income groups than non-electrified households.

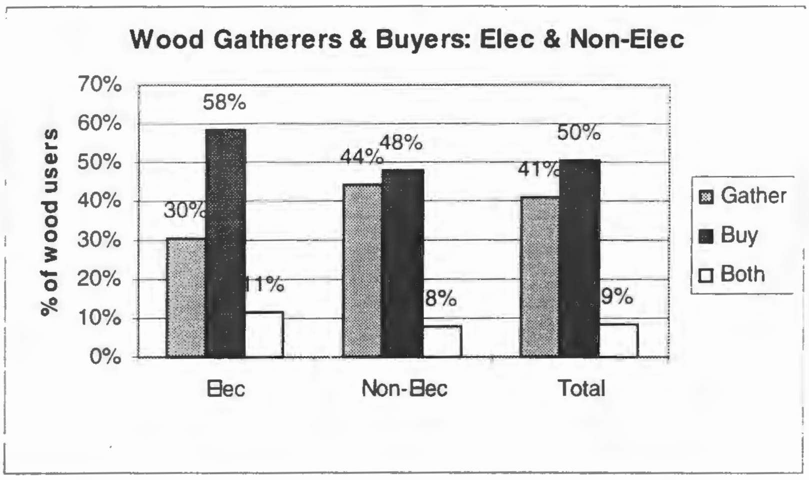


Figure 8-3: Percentage of fuelwood-using households buying or gathering fuelwood in electrified and non-electrified households

8.2 Household members involved in fuelwood gathering

Figure 8.4 clearly shows that fuelwood gathering is not a significant burden on children below 15 years in all the urban centres studied. In over 50% of the households collecting fuelwood, the chore is mainly in the hands of adults above 15 years. The figure also shows that it is not only the wives who are involved in fuelwood collection but also the husbands. In the towns (Gaborone and Lobatse) where fuelwood use is under 20% of households, fuelwood collection seems to be the responsibility of the wives (30-40%) more than the husbands (under 7%). However, in the villages, similar proportions of the wives and husbands are involved in fuelwood gathering. This seems to confirm recent criticisms of the widely published notion that fuelwood collection is mainly a burden on women and children. The survey however failed to ascertain what categories of people (boys or girls, students or workers) constitute the adults above 15 years. This would have helped in assessing properly household production costs[6] due to fuelwood collection.

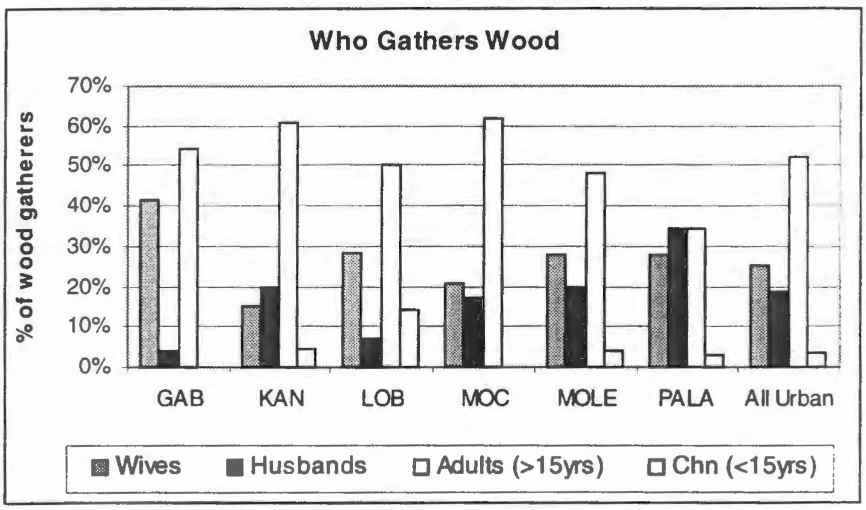


Figure 8-4: Percentage of household members who are fuelwood gatherers

[6] Household production cost refers to the opportunity cost of undertaking a household chore in lieu of an economic activity.

8.3 Characteristics of fuelwood gathering and buying

8.3.1 Gathering of fuelwood

Where households collect their fuelwood and the distances involved usually influence how they transport the fuelwood home. Figure 8.5 shows that the most popular way households take their collected fuelwood home is on foot. Besides this, about a third of the households use vehicles, about 20% use donkey carts and about 10% use wheelbarrows.

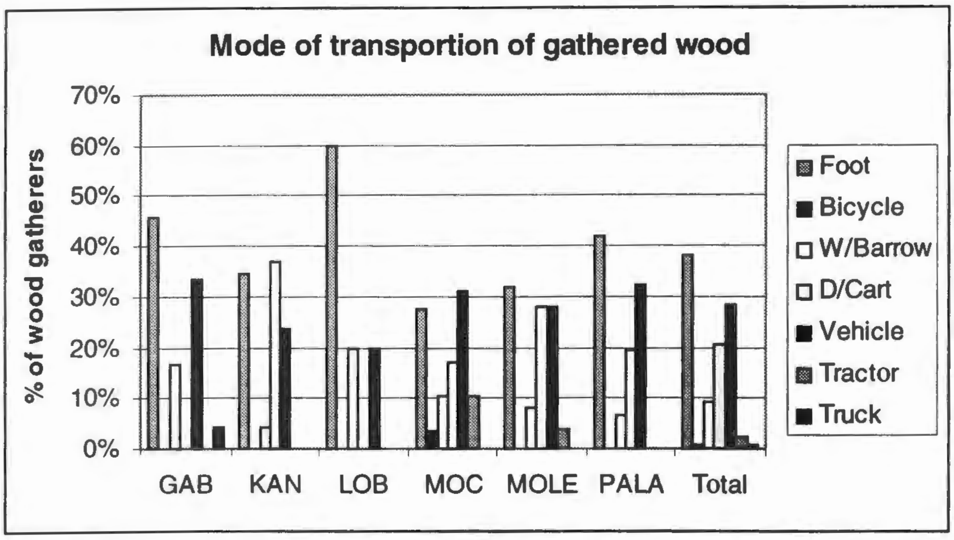


Figure 8-5: Percentage of fuelwood gatherers using specific mode of transportation in gathering fuelwood

The figure further shows that fuelwood gathering on foot was more common in Gaborone, Lobatse and Palapye in which case it exceeded 40%. There was no indication of donkey carts use in Gaborone and Lobatse but this was common in the villages especially at Kanye and Molepolole.

Transport	*Distance (km)*	*WholeTrip Time (hrs)*	*Collection Time (hrs)*
Foot	5.98	3.24	1.35
Wheel Barrow	3.92	3.08	1.65
Donkey Cart	19.24	6.15	2.47
Vehicle	51.13	4.03	1.79
Tractor	98.67	3.67	2.67
Truck	2.00	2.00	1.50

Table 8-1: Modes of transport, distances and hours in fuelwood collection

From Tables 8.1 and 8.2 it can be seen that vehicles and tractors are mostly used for transporting fuelwood from longer distances like the cattle posts, the lands, near farm areas and from the hills. Table 8.1 shows that for distances above 50 km vehicles and tractors are used requiring about 3-4 hours. For medium distances around 20 km donkey carts are used requiring about 6 hours. Shorter distances less than 10 km require the use of wheelbarrows or trucks, or otherwise fuelwood is collected on foot for about 2-3 hours. The unit cost of fuelwood transportation ranges between P0.45 and P2.00 per kilometre. If these costs could be accurately included in the fuelwood cost to the households the monthly household fuelwood expenditure would be higher than reported but this could not be ascertained in the survey.

Where gathered	*Transport*	*Transport cost (P)*	*Distance (km)*	*Unit transport cost (P/km)*
Near farm	Vehicle	20	10	2.00
Near farm	Tractor	130.00	96.00	1.35
Hills	Vehicle	10.00	10.00	1.00
Cattle post	Vehicle	57.14	127.43	0.45
Lands	Vehicle	41.43	48.57	0.85

Table 8-2: Long distance sources of fuelwood and their related transportation costs

8.3.2 Buying of fuelwood

In the case of buying of fuelwood, Figure 8.6 makes it clear that donkey carts use is even more popular in the villages. In the towns fuelwood buying is usually by vehicle or on foot or sometimes by wheelbarrow.

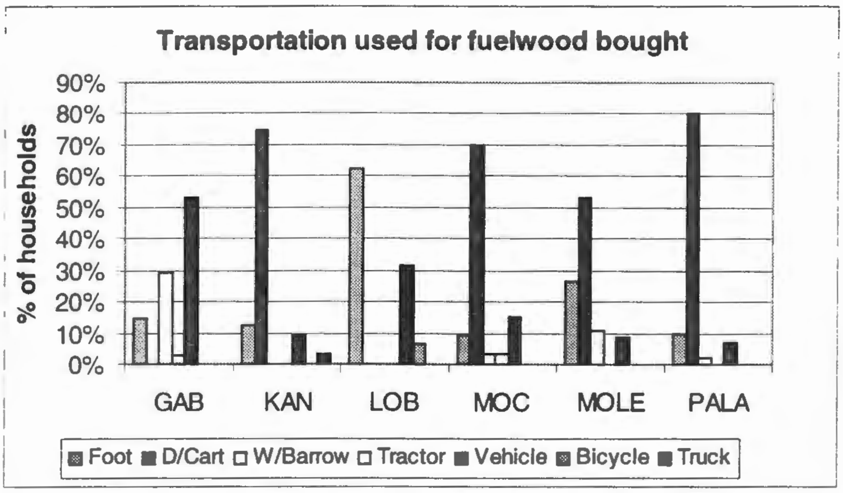


Figure 8-6: Modes of transportation for buying fuelwood

Figure 8.7 shows clearly that village households mostly purchase fuelwood in quantities of donkey carts whilst in the towns fuelwood is purchased in smaller quantities of bundles, bags, headloads, wheel barrows or a few number of sticks.

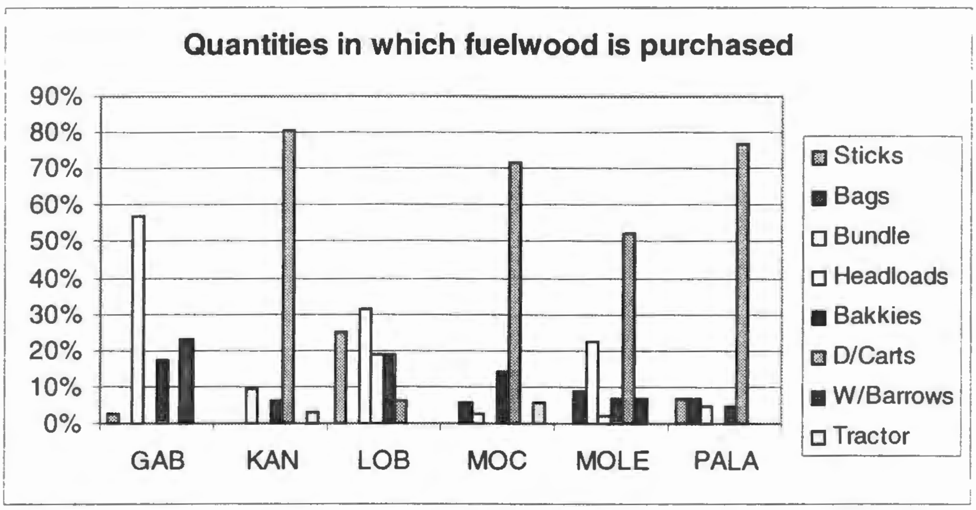


Figure 8-7: Percentage of households buying fuelwood in specified quantities

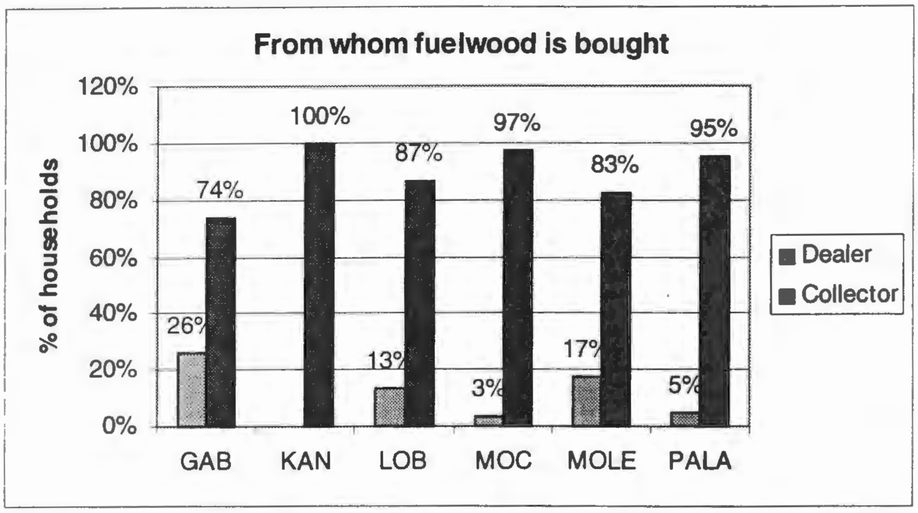


Figure 8-8: Percentage of households buying fuelwood from different fuelwood traders

Figure 8.8 shows that three-quarters or more of the households in all the urban centres purchase their fuelwood from traders who collect the fuelwood themselves.

8.4 Perception of fuelwood use

Figure 8.9 shows the results when households were asked whether they use more or less fuelwood as compared with 5-10 years ago. Generally, the perception is that more than 60% of households at all the urban centres are using less fuelwood currently as compared with the past. Amongst fuelwood gatherers the percentage is even higher. Thus, it is very clear that there is sufficient awareness that fuelwood consumption is dwindling. When asked why fuelwood consumption is dwindling, over 75% of the households said it was because it is more difficult to find fuelwood (Figure 8.10) and this response was even stronger amongst lower income groups. It appears that fuelwood use depends on rational decision making in terms of availability of fuelwood resources and access to other fuels.

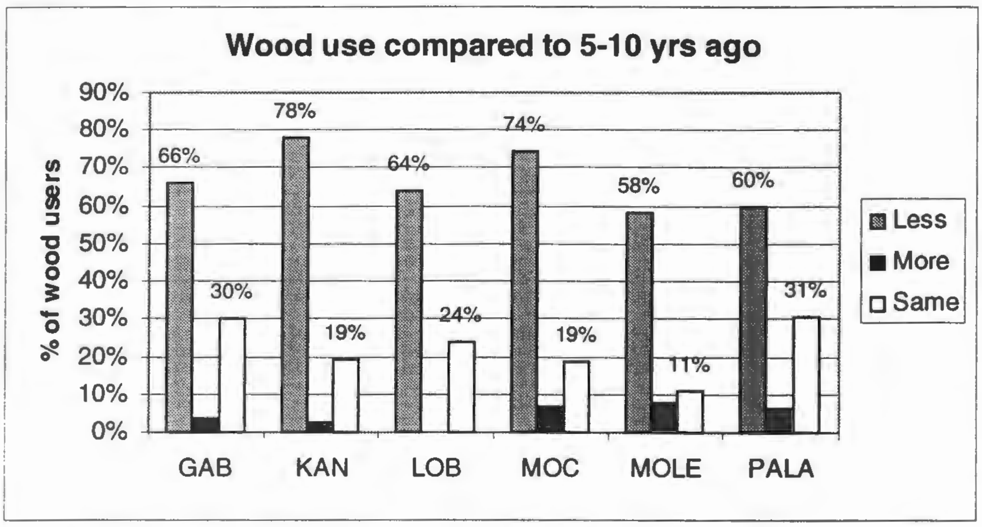


Figure 8-9: Percentage of fuelwood-users using less, more or the same amount of fuelwood compared to 5-10 years ago

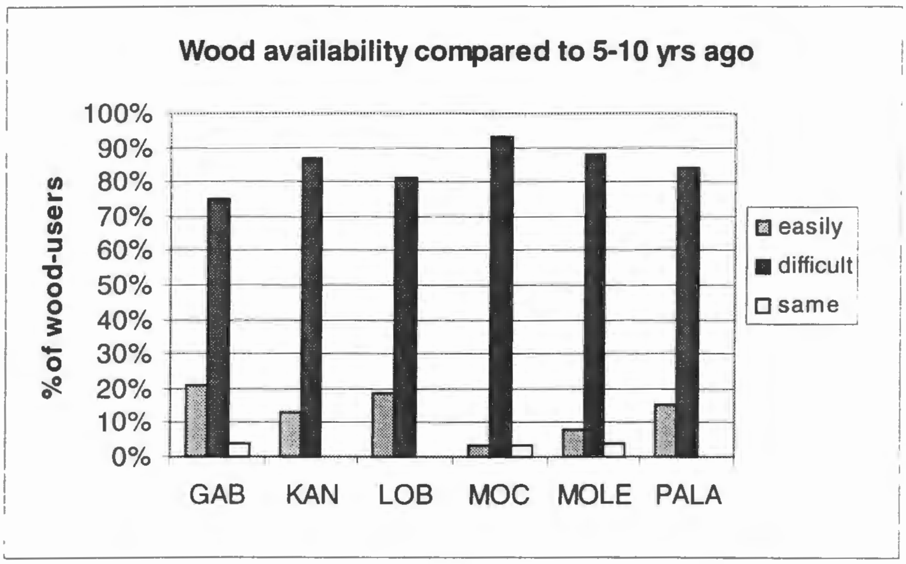


Figure 8-10: Perception of fuelwood availability by fuelwood users

8.5 The energy burden amongst fuelwood users

Energy expenditure seems to be more burdensome for households using fuelwood than those that are not using fuelwood. This is illustrated in Figure 8.11 which depicts that the percentage of household monthly budget spent on energy for fuelwood-using households lies on top of that of other households not using fuelwood. The graph further shows that this burden is greater on the lower income households than higher income households and that the gap narrows with increase in income. This is another indication of energy poverty amongst fuelwood users.

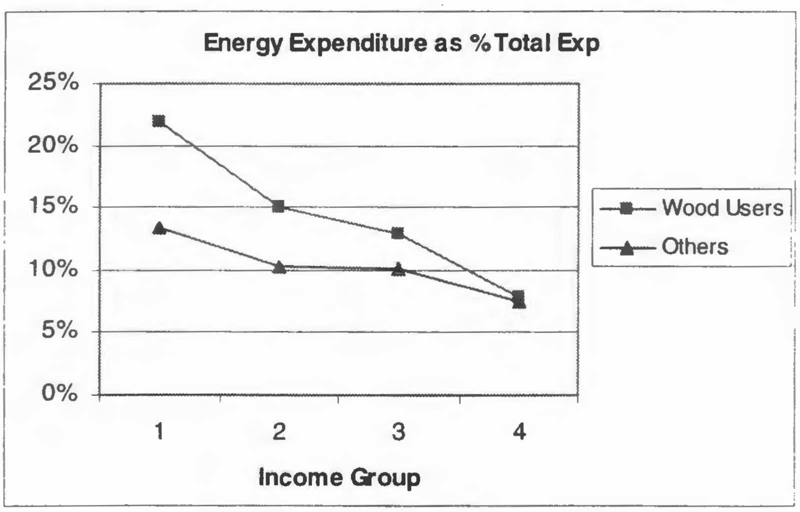


Figure 8-11: Energy expenditure as percentage of total household expenditure for fuelwood users and non-fuelwood users

Figure 8.12 shows that the monthly expenditure on fuelwood is quite a significant portion of the household energy budget in lower income households. In the lowest income group (where most of the fuelwood users belong) this expenditure constitutes more than half the energy budget. The policy implication is that this amount could contribute to paying for other energy options since it is already a substantial portion of the household budget. Some education would help in making this realisation clear to households when alternative energy options are offered to them. In higher income households the fuelwood portion of the energy budget is smaller.

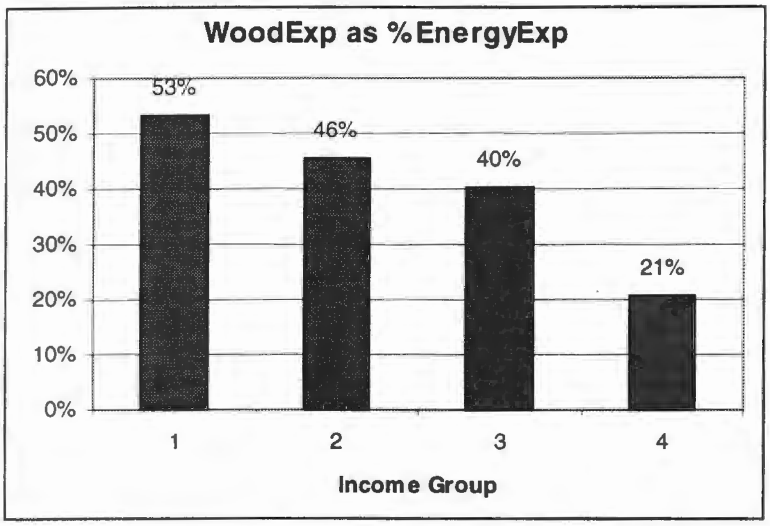


Figure 8-12: Percentage of household energy budget spent on fuelwood at difference income levels

8.6 Preferred and available tree species for fuelwood

When households were asked about the most available and preferred tree species for fuelwood similar names of tree species came up in all areas. However *moologa* was mentioned as one of the easily available species but not as a preferred specie. *Motsweri* also came up as one of the preferred species especially in Gaborone and Lobatse but not as one of the most available species in any of the places.

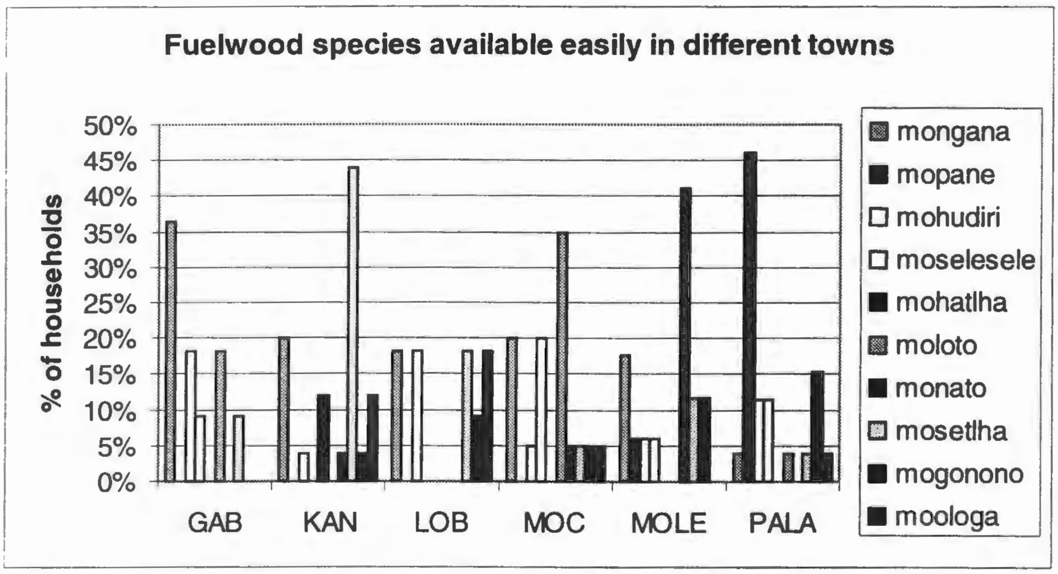


Figure 8-13: Percentage of households perceiving that certain fuelwood species are easily available

The most available specie in Gaborone was mentioned as *mongana*, that in Kanye was mentioned as *mosetlha*, that in Mochudi was mentioned as *moloto*, that in Molepolole was mentioned as *monato*, that in Palapye was mentioned as *mopane*, and in Lobatse all *mongana, mohudri, mosetlha* and *moologa* were all mentioned. In terms of most preferred species, *mongana* was mentioned in almost all the urban centres. In addition to that *mopane, mohudiri* and *motsweri* came up in Gaborone. In Lobatse additional preferred species were mentioned as *mohudiri* and *motsweri.* In Kanye additional preferred species were mentioned as *mohatlha* and *mosetlha*. The additional most preferred species in Mochudi, Molepolole and Palapye were mentioned as *moloto, monato* and *mopane* respectively. Thus, in general, most of the preferred species are still easily available but perhaps the main concerns are that the quantities required are not easily met.

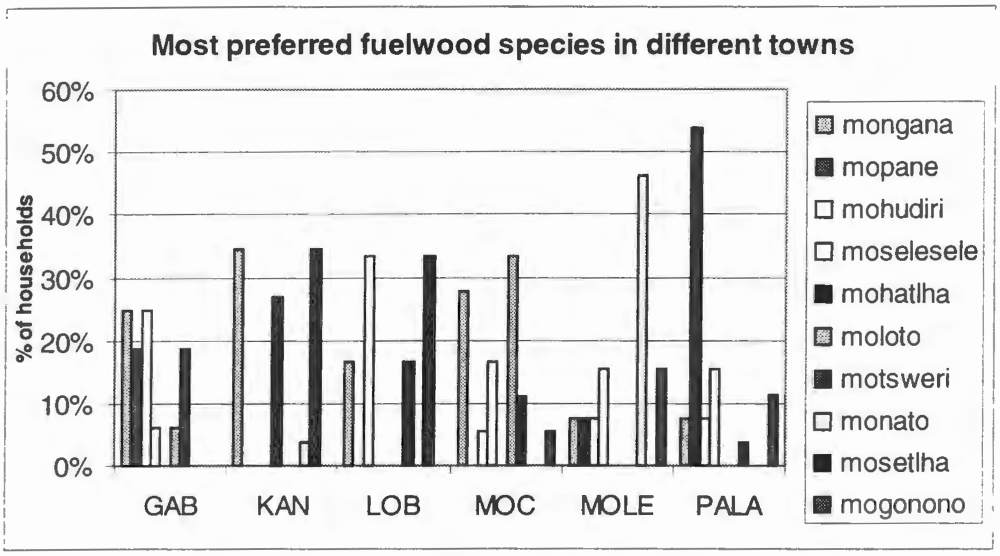


Figure 8-14: Tree species preferred by households for fuelwood

9. Household energy use perceptions

In order to ensure ease of implementation of future energy policy strategies, it is prudent to explore what motivates households in their energy decision making. Thus this chapter analyses what actually are the fuel preferences for cooking, which is one of the main end uses of energy sources, and tries to identify the reasons behind such preferences for each of the main energy sources. The chapter also tests households' willingness to switch from using fuelwood to other energy sources and why they may not be willing to switch to other fuels. The chapter goes on to test the satisfaction with their current cooking fuels and the reasons behind their dissatisfaction. Furthermore, there is analysis on what secondary fuels are used as cooking fuels. This will help to identify what cooking infrastructure already exists in the household or what fuels households are already used to in order decide on what options are more plausible. The chapter also looks at perceptions about a few sustainable measures of fuelwood use like wood-saving stoves and tree planting.

9.1 Perceptions about cooking with different fuels

The analysis of the responses to questions about what energy sources households like using for cooking is very revealing. Comparison between the preferences shown in Figure 9.1 and the actual energy sources used currently in Figures 7.1 and 7.2 is very striking. Although only about 2% of the town households are mainly using fuelwood for cooking, almost a third of the urban town households would actually like to cook with fuelwood. In the villages, about a third of the households are currently using fuelwood as the main cooking fuel but about two-thirds of the households actually like cooking with the fuel. This indicates some tendency of reverting to fuelwood use depending on certain circumstances. In actual fact, about 60% of households using gas as the main fuel rely on fuelwood as a secondary source of cooking fuel (see Figure 9.14). For the use of paraffin, gas and electricity, the likeness for the energy sources in both the towns and the villages is slightly higher than the current level of use as main cooking fuels but the differences are not much.

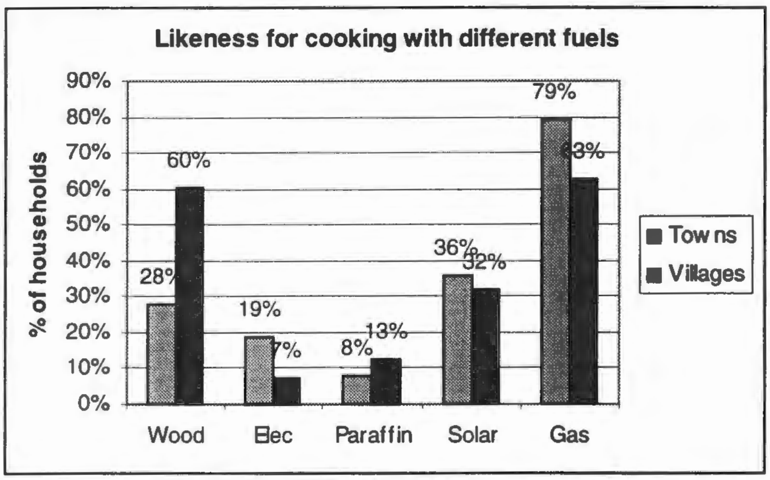


Figure 9-1: Percentage of households liking a particular fuel for cooking

What comes as a surprise is the level of preference for solar cooking. Perhaps not counting cost implications, about a third of the households both in urban towns and urban villages like the idea of solar cooking. With such a significant level of preference for solar cooking, it would be worthwhile exploring this option more vigorously. Perhaps a more plausible option for solar energy is for water heating. Figure 9.2 shows that about half of all the households both in urban towns and urban villages expressed interest in using solar water heaters. Consideration of the actual use of solar energy in urban Botswana shows that existing usage for cooking is insignificant whilst the use of solar water heating amongst the sampled households is already 9% (see Figure 7.10). Thus solar water heaters (SWHs) also appear attractive as a strategy for reducing fuelwood consumption. However, the experience with SWHs is rather mixed and has not become a sustainable industry yet on any substantial scale. In fact, the analysis in this study did not show any appreciable savings in electricity use by SWH users probably due to the fact that most of the SWH users are in Government houses or higher income households which are not very much constrained by energy burden (see Section 11.1).

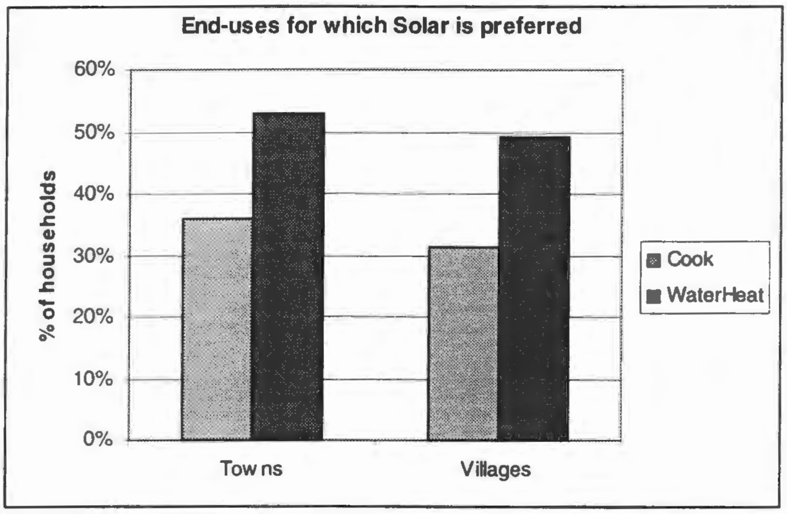


Figure 9-2: Comparison between households' likeness for solar cooking and solar water heating

9.2 Reasons for preferring energy source for cooking

Fuelwood cooking

It is clear in Figure 9.3 that the reason why households like using fuelwood is mainly due to the cheapness of the fuel. As far back as the mid-eighties Gay (1985: 25) also found that about 57% of urban households gave the same reason for preferring to use fuelwood. This is not strange since most of the households using fuelwood are poorer households. The cheapness of fuelwood is a motivation for more households in the towns (over 70%) than for the village households (40%). Thus the price of fuelwood is definitely a clear determining factor in the use of fuelwood, especially in the towns. For the village households, two other significant reasons are the ease of use (20%) and cultural preferences (20%).

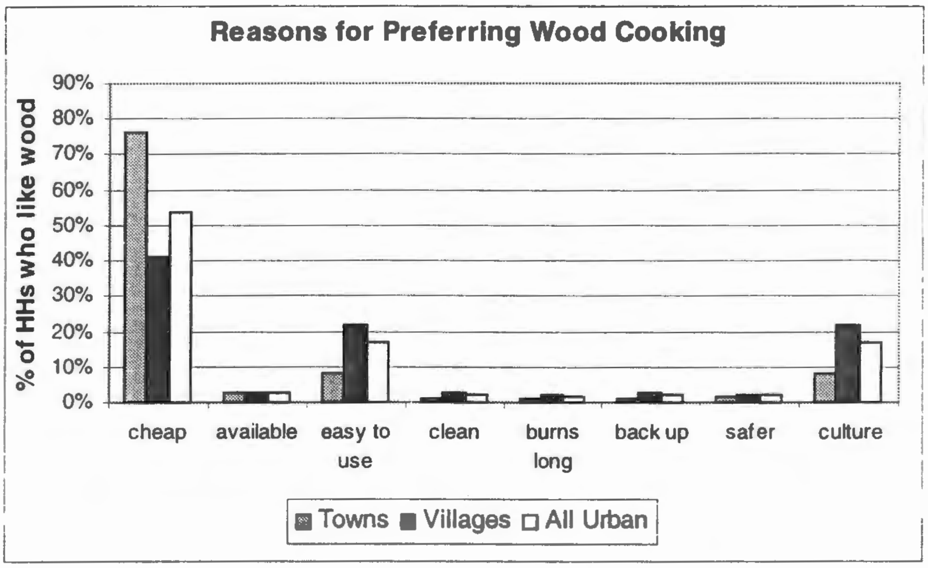


Figure 9-3: Reasons why households like using fuelwood for cooking

Solar cooking

It is interesting to note that the main reason why about a third of the households expressed preference for cooking with solar stoves is the fact that the energy source is free and as such the households could realise some savings out of it. It is clear from Figure 9.4 that this reason was very strong (80%) compared with the advantage of 'saving wood' for environmental reasons. Thus in the promotion of solar cookers it must be clear from the onset that environmental savings do not matter much to households and that what matters most is the cost savings. It is therefore important to create the necessary awareness concerning the cost implications and the features of solar cooking so that their choice of solar would be realistically founded.

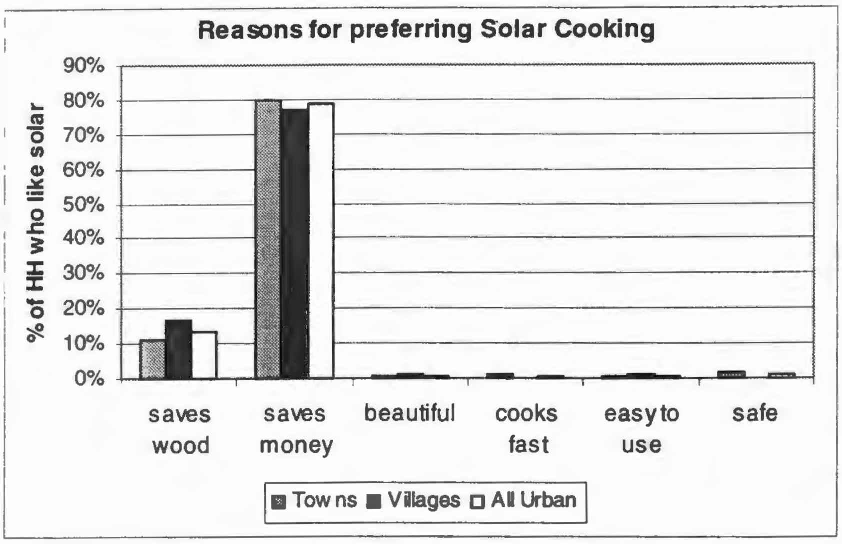


Figure 9-4: Reasons why households would like using solar for cooking

Electric cooking

The main motivation for using electricity for cooking by urban households is its ease of use more than anything else (see Figure 9.5). Similar result came up in the study by Gay in 1985. The marketing of electricity should therefore emphasise this. This reason was stronger amongst the town households than the village households who also saw the cleanliness of electricity use as another major motivation to use it. There seems to be concerns about the cost of electricity, the access to electricity and the acquisition of appliances.

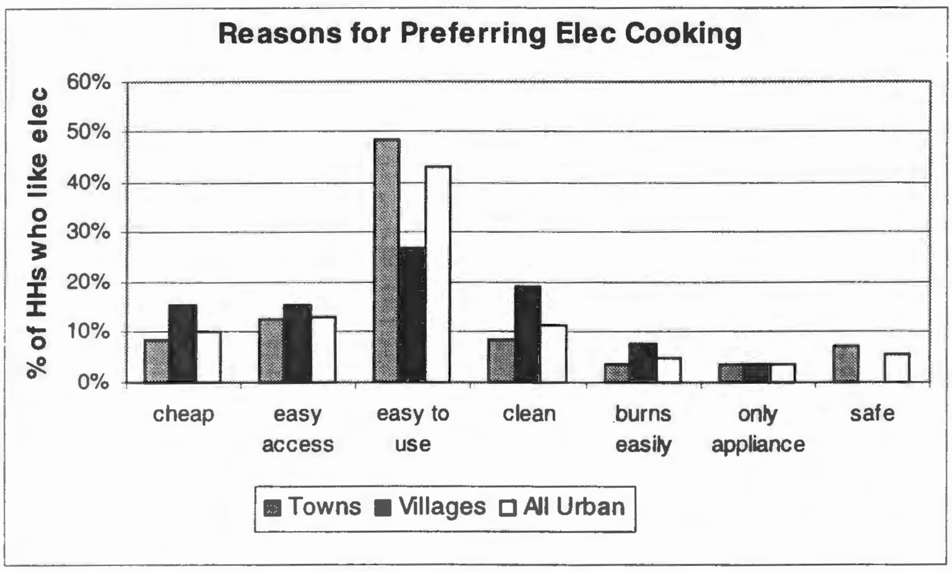


Figure 9-5: Reasons why certain households like using electricity for cooking

Gas cooking

Figure 9.6 shows that the main motivations for gas use for cooking are the cheapness of the fuel, the easy use of the fuel and the easy access to the fuel. It is surprising that the fastness and cleanliness of use did not feature prominently here. In the Gay study (1985) the fastness of use came up strongly but the cheapness of the fuel was not that strong. This probably shows the extent to which urban dwellers have shifted in their thinking concerning the usual myth that the use of gas is not safe to the convenience of gas use. There is a need to strengthen such realisation if more households are to switch from fuelwood to gas. Currently the abundance of gas dealers has improved distribution of the fuel and the free home delivery of gas by dealers is another incentive. The private sector seems to have the conducive environment for marketing gas in urban Botswana. Furthermore, housing developments have now started incorporating gas outlets in housing designs whilst provision for electric cookers are sometimes not even considered. These key factors that have contributed to the extensive use of gas should be encouraged.

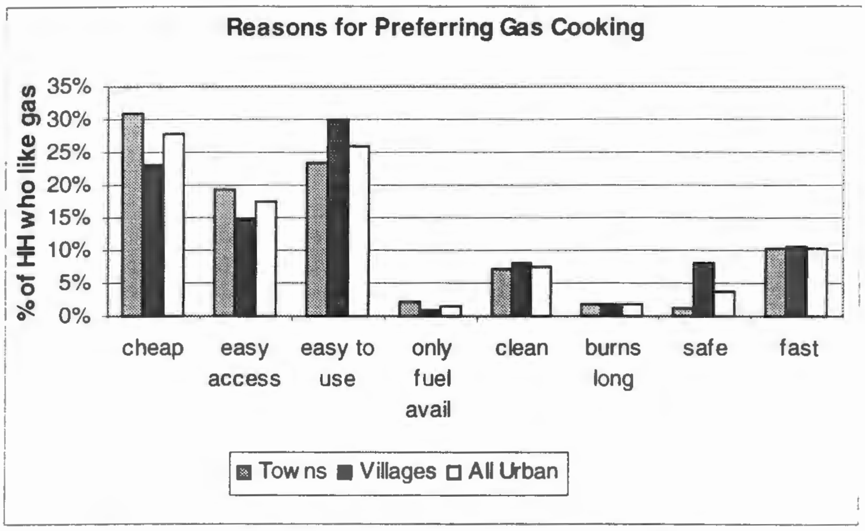


Figure 9-6: Reasons why households like using gas for cooking

9.3 Willingness to switch from fuelwood to other fuels

Figure 9.7 shows significant willingness of households to switch from the use of fuelwood for cooking to other fuels. About 41% of the 43% urban households using fuelwood are willing to switch to other fuels with majority being in the villages. The main fuels they would like to switch to are gas and electricity. Whilst about two-thirds of all willing households would like to switch to gas, about a quarter would like to switch to electricity. Similar proportions of fuelwood users in both towns and villages would like to switch to electricity for cooking. However, village households prefer switching to gas most (over 70%) since access to electricity is limited. It must be noted that the willingness of households to switch to either coal or paraffin is not significant (not more than 5% of fuelwood users). This is worth noting in relation to the strategy to promote household coal use.

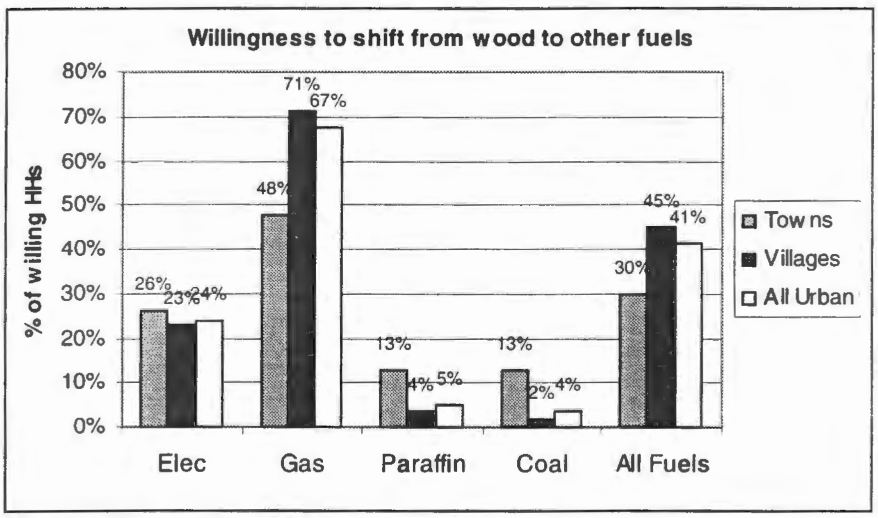


Figure 9-7: Percentage of households willing to switch from fuelwood to other fuels: all urban

In the electrified households similar proportions of fuelwood users would like to switch to either electricity or gas as shown in Figure 9.8. In the non-electrified households about 70% of fuelwood users are willing to switch to gas whilst about 19% would like to switch to electricity.

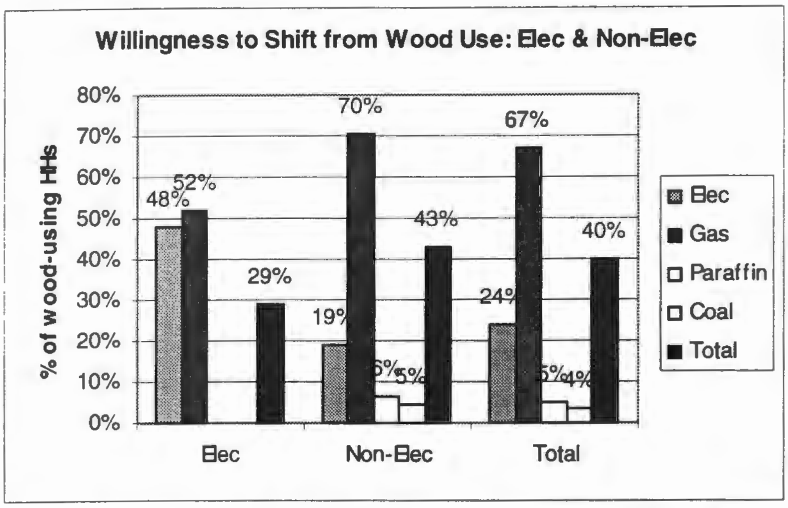


Figure 9-8: Percentage of households willing to switch from fuelwood to other fuels in electrified and non-electrified households

Interestingly, the main reason why some village households are unwilling to switch from fuelwood use to other fuels is not because fuelwood is cheaper but rather because *they are used to it* (see Figure 9.9). Although this cultural attachment came up as one of the major reasons in the towns, the cheapness of the fuel came up much stronger. It seems safe to conclude that cultural values and the comparative higher prices of other energy sources are the main barriers to switching from fuelwood use to other fuels.

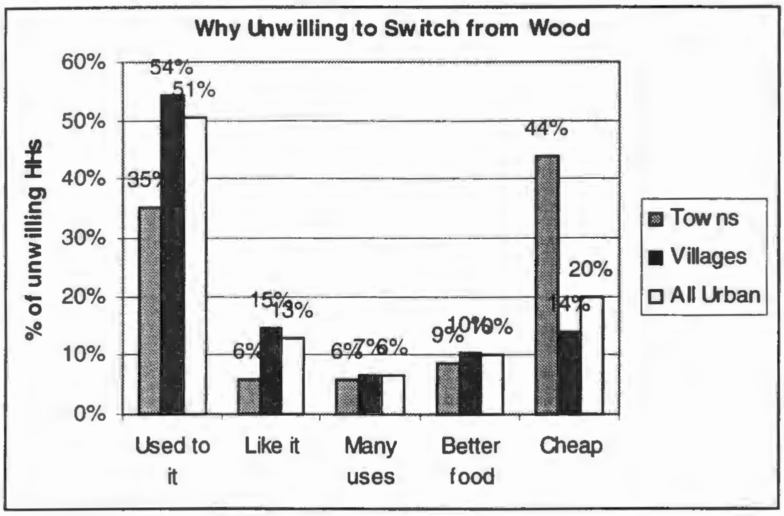


Figure 9-9: Reasons why households are unwilling to switch from fuelwood to other fuels

9.4 Satisfaction with cooking fuel

The level of satisfaction of households concerning their cooking fuel was tested by asking households whether they are cooking with their favourite energy source. Figure 9.10 shows that the level satisfaction is significantly high (about two-thirds of the households). Whilst about half of fuelwood users expressed dissatisfaction, overwhelming majority of electricity users expressed satisfaction. It is revealing to note that about a third of the households using gas are dissatisfied. This must be a great concern since households using gas as their main cooking fuel constitute about 70% of urban households (refer to Figure 7.5).

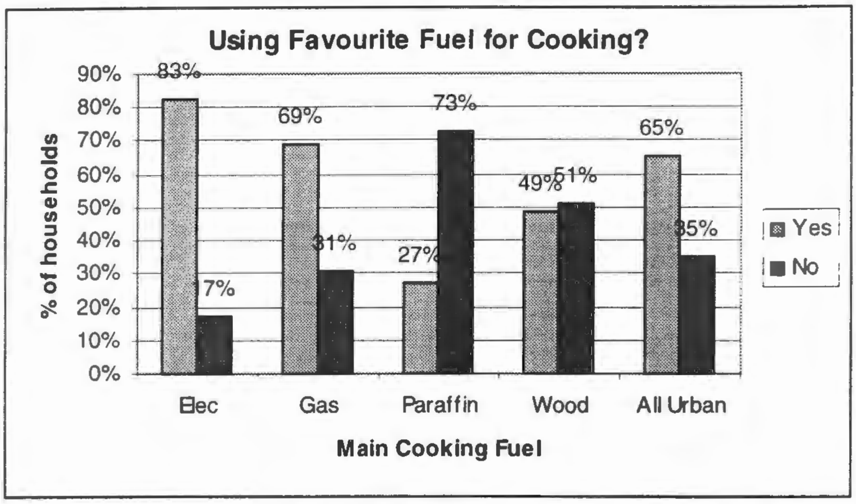


Figure 9-10: Percentage of households using their favourite energy source for cooking

Figure 9.11 shows the reasons behind the dissatisfaction amongst households concerning their cooking fuels. The most reason why a third of the gas using households are dissatisfied is that gas is not always available. Whilst the price and appliance acquisition were mentioned as other reasons, it is clear from the graph that the issue of gas unavailability needs to be addressed as a matter of priority in order to boost the reliability of gas use. It seems that this will make positive impact on the lives of many households.

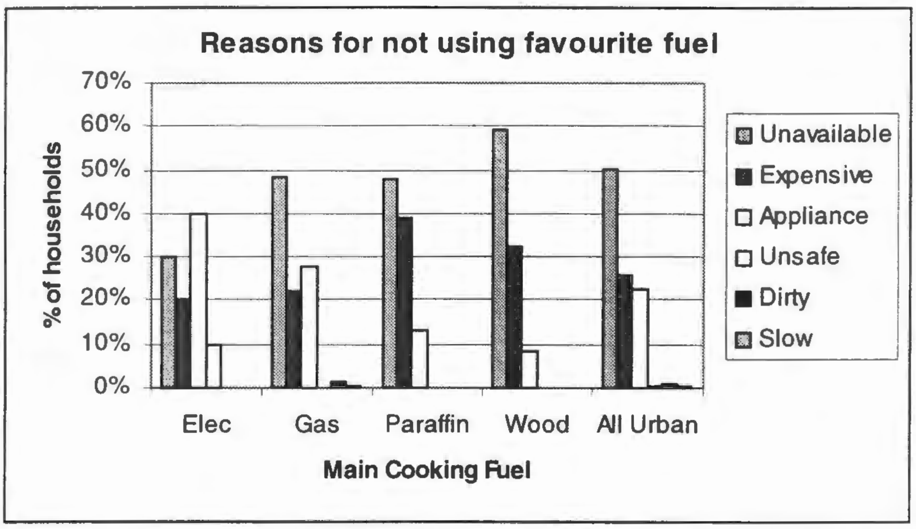


Figure 9-11: Reasons why households are not using their favourite energy source for cooking

For the half of fuelwood cooking households who are dissatisfied with using fuelwood for cooking, the main reason why they are not using the fuel they would prefer is that they do not have access to the fuel. A secondary reason is that other fuels are more expensive.

For the small minority of electricity cooking households who are dissatisfied with cooking electricity, the main reason why they prefer cooking with other fuels is the problem they have in acquiring appliances. Other reasons are that electricity is not always available (i.e. unreliability of supply) and that households find it expensive and, to a lesser extent, unsafe.

9.5 Secondary cooking fuels

It is also useful to look briefly at secondary cooking fuels used by households in order to explore what energy sources households are already exposed to and what cooking equipment they may already have. The survey undertaken in this project indicates that 30% of households use a secondary cooking fuel in addition to their primary choice (see Figure 9.12). In general this phenomenon is more prevalent in the villages, especially Kanye, than in the towns due to lack of access to more convenient fuels.

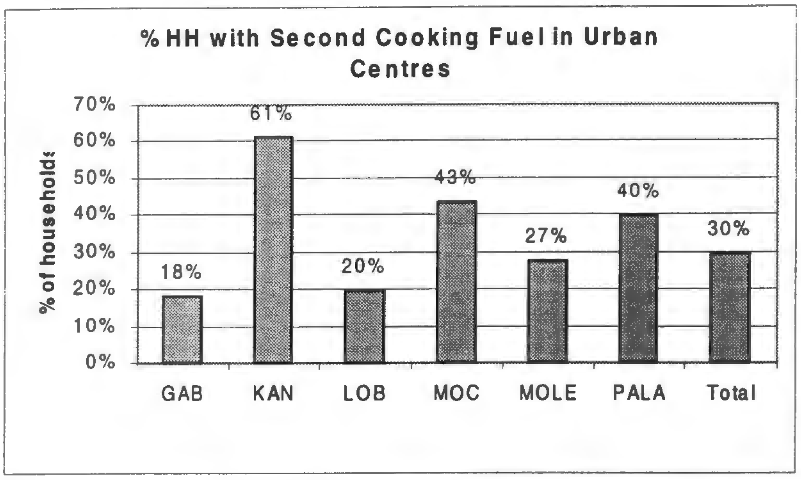


Figure 9-12: Percentage of households using a secondary fuel for cooking

For those who use fuelwood primarily for cooking and also use secondary fuels, 56% of these households use paraffin as the secondary fuel, and 44% use gas (see Figure 9.13). This indicates that 44% are already exposed to gas use and may already have the infrastructure for gas use.

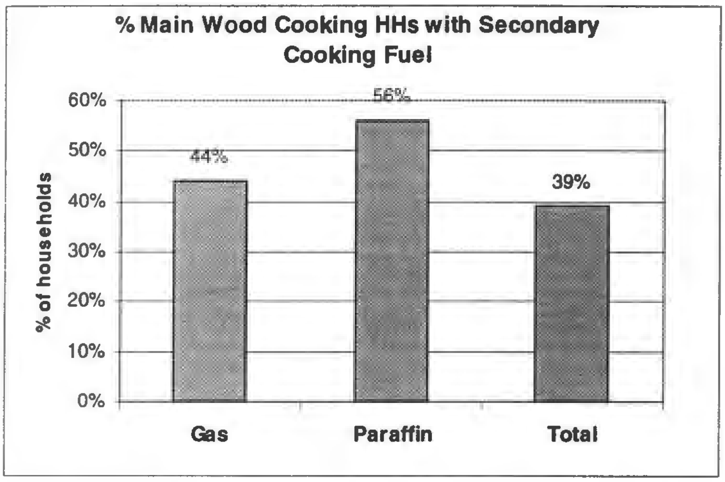


Figure 9-13: Percentage of households whose main cooking fuel is fuelwood that have a secondary cooking fuel

Furthermore, it is noteworthy that, of households who cook with gas primarily but who also have a secondary cooking fuel, 61% use fuelwood for this purpose (see Figure 9.14). These multiple fuel use trends prevalent in households reflect the transition in energy use patterns as observed in Section 7.1.1 where gas use particularly, and to a lesser extent electricity use, is increasing.

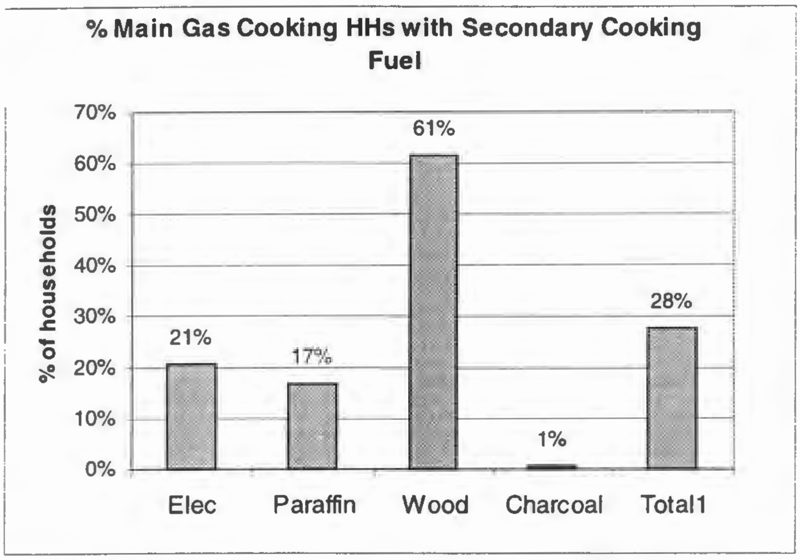


Figure 9-14: Percentage of households with secondary cooking fuels: households with gas as main cooking fuel

It is interesting to note in Figure 9.15 that for households whose main cooking fuel is electricity, only gas or paraffin is used as a secondary fuel but fuelwood is not used at all. Gas seems to be the backup fuel in these households.

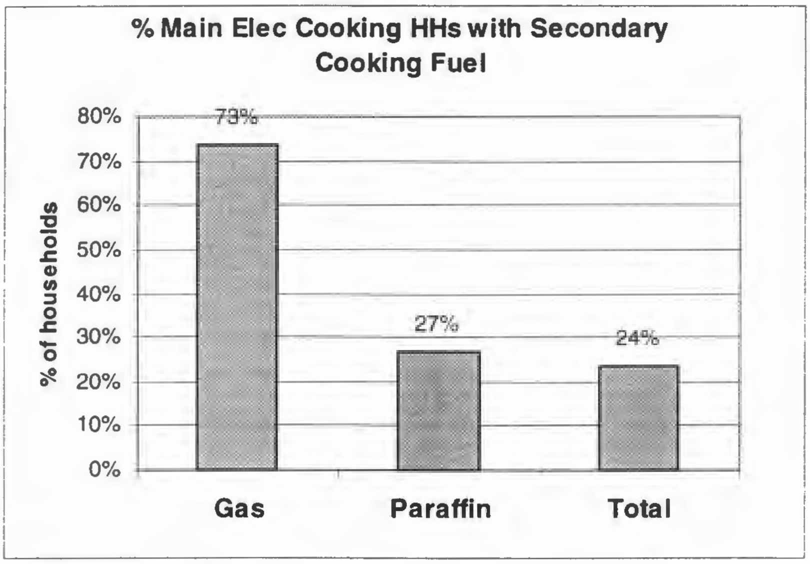


Figure 9-15: Percentage of households with secondary cooking fuels: households with electricity as main cooking fuel

9.6 Perceptions about fuelwood-saving stoves

The study also explored households' perceptions about an energy efficiency measure like the use of fuelwood-saving stoves. This received an impressive response as shown in Figure 9.16. Roughly between 40% and 60% of the households in all the urban areas are aware of fuelwood-saving stoves, and would like to use and buy one. Between 12% and 27% of the households at the different urban centres claim they have used a fuelwood-saving stove before but knowledge about where to buy one is very low, especially in the villages.

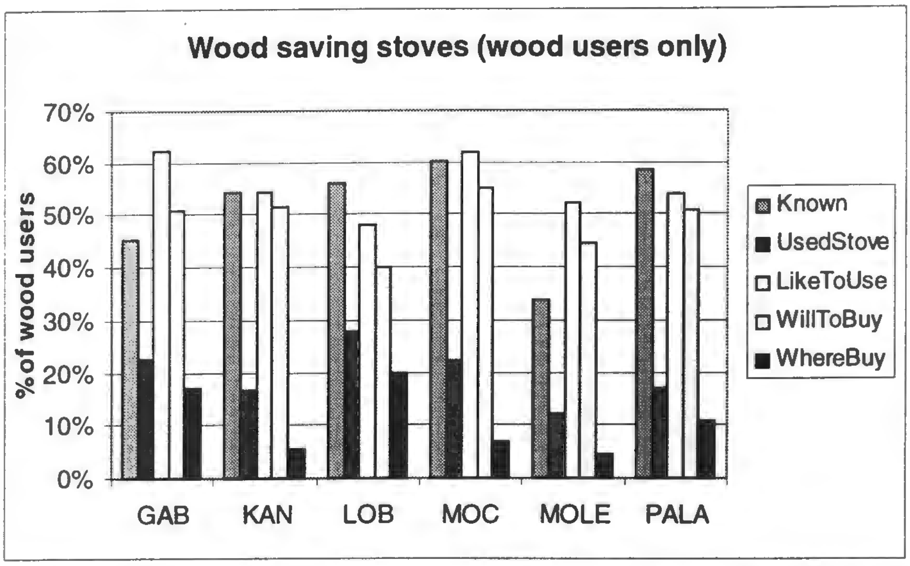


Figure 9-16: Perceptions about fuelwood saving stoves amongst fuelwood using households

9.7 Tree planting awareness

On the supply side of fuelwood, households were tested on their willingness to contribute towards sustainable supply of fuelwood through tree planting and the interesting responses received are analysed in Figure 9.17. Although households' level of involvement in tree planting in their areas is very low, their willingness to be involved and their knowledge about where to obtain tree seedlings are remarkably high. The majority of the households have planted trees in their yards before.

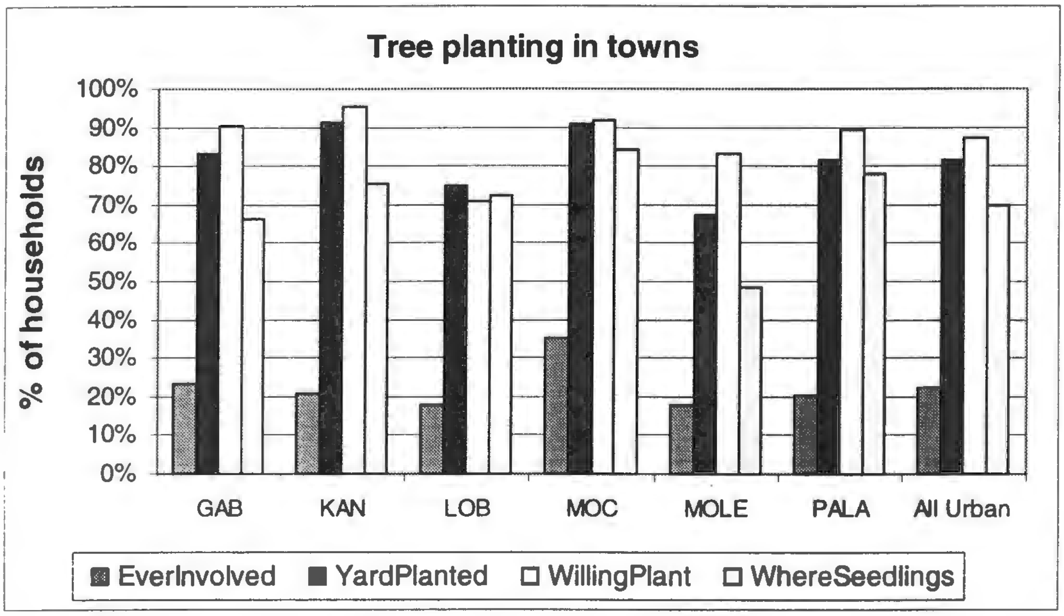


Figure 9-17: Level of tree planting awareness amongst households

10. Fuelwood use in government institutions and fuel dealers

Background information on the use of fuelwood in government institutions has been described in Section 2.8. According to the latest study of institutions in Gaborone (EAD 2000), most government institutions in Gaborone no longer use fuelwood, rather they have switched to other sources of energy like electricity, coal and gas or use fuelwood in combination with any of these alternative sources. The study of government institutions by Leipego & Lloyd (1999) also concluded that institutions like the Botswana Defence Force (BDF), the Botswana Police and the Botswana Prisons and Rehabilitation Services have all issued instructions to forbid fuelwood use, but it is the enforcement that requires monitoring. To monitor the current situation, this study also carried out a survey of public institutions in all the 6 urban areas of the study.

The study also conducted a survey of those selling various fuels in order to identify the characteristics of those who deal in supplying households and public institutions with fuelwood.

10.1 Fuelwood use in government institutions

10.1.1 Coverage of institutions in survey

Since the earlier studies concluded that it is mainly in the schools where fuelwood use is happening, this study's survey focused more on the schools than the other institutions. The numbers of various institutions studied in each urban area have been listed in Table 10.1. The number of each type of institution surveyed mainly depended on the co-operation of the respondents and not necessarily on their statistical significance. In addition, the Community Junior Secondary Schools (CJSS) were intentionally over-sampled compared with the Primary Schools since the use of fuelwood in the Primary Schools was more obvious and further sampling was leading to mere repetitive information.

Town	*Primary School*	*Comm Jnr Sec School*	*Senior Sec School*	*Teachers College*	*Prisons/ BDF*	*Clinics*	*Hospitals*	*Total*
GAB	3	10	2		1 (BDF)	2		17
KAN	2	3	1		1		1	8
LOB	2	2	1		1		1	7
MOC	1	3			1			5
MOLE	2	4	1	1	1			9
PALA	2	2	1					5
Total	12	24	6	1	5	2	2	52

Table 10-1: Types of institutions in different towns surveyed

The EAD study of Gaborone institutions (2000) covered 57 institutions and the Leipego & Lloyd study (1999) covered 36 institutions in Gaborone, Mahalapye, Palapye, Francistown, Kasane and Kang. In all, the current study covered 52 institutions including 12 primary schools, 24 Community Junior Secondary Schools (CJSS), 6 Senior Secondary Schools (SSS), 2 Clinics, 2 Hospitals, 1 Teachers' College, 4 Prisons and the BDF headquarters.

10.1.2 Extent of use of different energy sources

Table 10-2 shows the extent of use of various energy sources in the different types of institutions surveyed. Comparison of the data in this table with that in Table 10.1 is quite revealing in that there is still some extensive use of fuelwood in Primary Schools, CJSS, SSS and the Prisons, although not to the same intensity. A clearer picture of this is presented graphically in Figure 10.1. The other institutions do not use fuelwood at all.

The BDF Headquarters confirmed in an extensive interview that their 52 units across the country have all stopped using fuelwood. Gas is supplied even for military operations outside military camps. However, coal is used at the camps near the Morupule Colliery like Palapye.

Type	*Gas*	*Elec*	*Fuelwood*	*Paraffin*	*Coal*	*Solar*
Primary School	5	8	12	1	5	1
CJSS	17	23	21	2	11	5
SSS	6	6	4	1	0	3
T/ College	1	1	0	0	0	0
Prisons	2	4	3	0	1	0
Clinics	0	2	0	0	0	0
Hospitals	2	2	0	1	1	0
Total	33	46	40	5	18	9

Table 10-2: Number of institutions using different types of energy sources in the survey

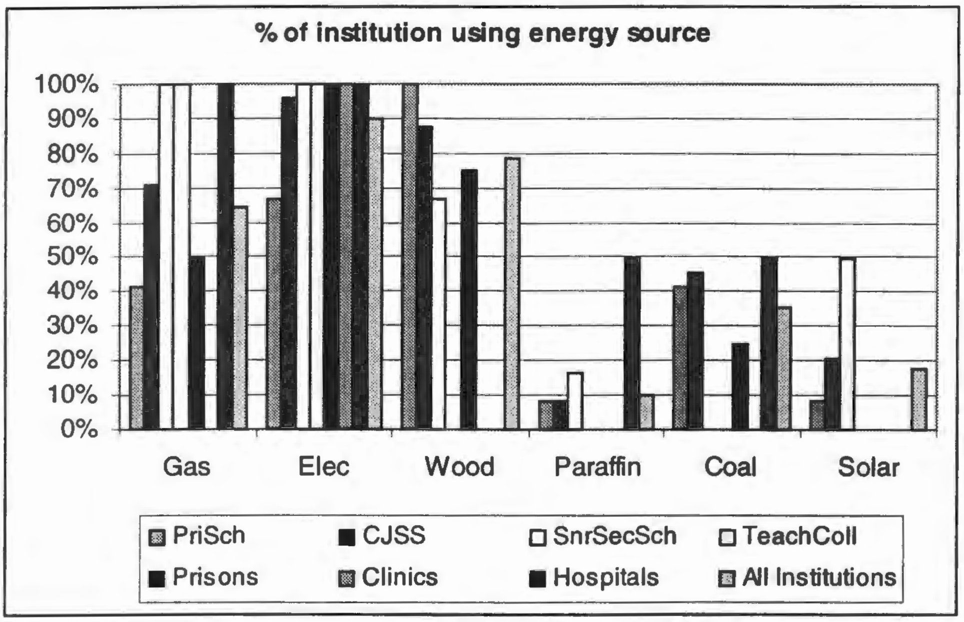


Figure 10-1: Percentage of institutions using energy source

Figure 10.1 creates the impressive picture that about 90% of all the institutions surveyed are electrified. In fact, apart from the 4 out of the 12 Primary Schools and the 1 out of the 24 CJSS that are not electrified, all the other institutions are electrified. Thus the main costs of switching from fuelwood to electricity use for cooking and water heating would probably be the building of electric stove kitchens with the appropriate sizes of kitchens.

Fuelwood is the second most widely used fuel amongst public institutions. Almost 80% of all the institutions use fuelwood in the survey and the most prominent are the Primary Schools, all of which use this source of energy. This is followed by the CJSS (88%), Prisons (75%) and the SSS (67%) respectively. The Teachers' Colleges, the Clinics and the Hospitals do not use fuelwood at all, although their samples are too small for any meaningful generalisation.

Gas (LPG) is the third most widely used energy source with about a half of the institutions surveyed using it. Amongst the institutions surveyed, the Clinics are the only institutions that were not using gas but featured amongst those using electricity.

Unlike the households where the promotion of coal use has been unsuccessful, there is some indication of success amongst the institutions with about a third of the institutions surveyed using coal. Over 40% of the CJSS and the Primary Schools use coal, a quarter of the Prisons also use it as well as one of the 2 two Hospitals surveyed. All the 6 SSS, the 2 Clinics and the one Teachers' College surveyed do not use coal at all.

Solar electricity also features as an energy source used only by schools. Half of the SSS surveyed use solar energy, about 20 of the CJSS also use it as well as one out of the 12 Primary Schools surveyed.

Paraffin use is not popular amongst the institutions, although one of the 2 Hospitals surveyed indicated its use.

10.1.3 Energy end uses

Main cooking energy sources

Figure 10-2 shows the main fuels used for cooking in the different institutions and the percentages of the institutions using those types of fuels. It is clear from this figure that only the Primary Schools and CJSS use fuelwood as their main cooking fuel. This is encouraging in the sense that even if other institutions are using fuelwood as a secondary cooking fuel, there is a likelihood that they would switch to other fuels given the opportunity. Fuelwood use is more prominent amongst Primary Schools than the CJSS, in fact, whilst about three-quarters of the Primary Schools use fuelwood for cooking, the percentage of the CJSS using fuelwood for cooking is just above 50%.

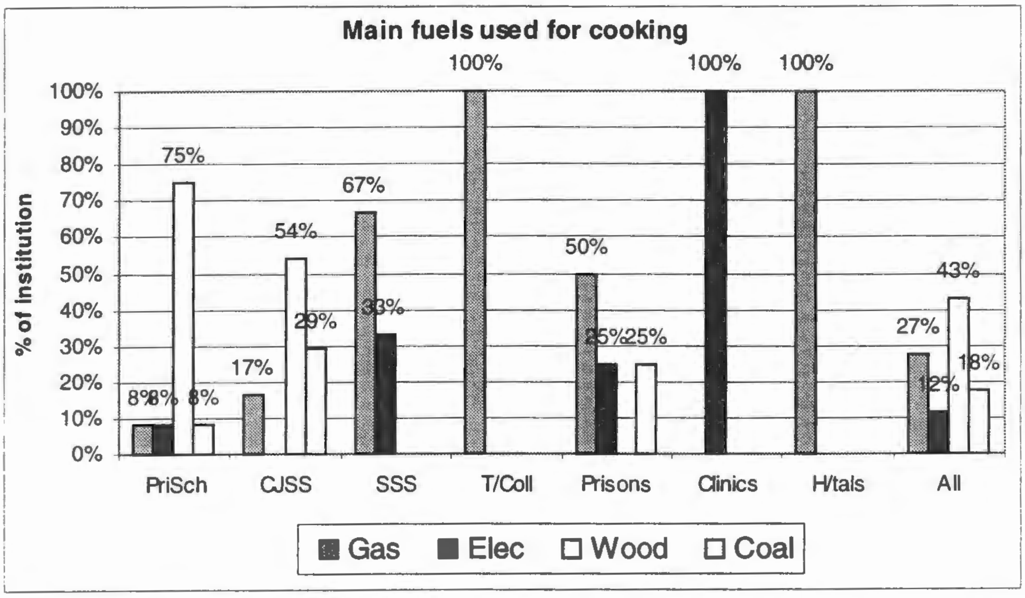


Figure 10-2: Percentage of institutions using specific energy sources for cooking in all urban areas[7]

Only a few Primary Schools (8%) use gas, coal and electricity as their main source of energy for this purpose. While the CJSS do not use electricity at all for their cooking requirements, about 30% of them use coal and about 17% use gas for cooking.

In general the prominence of the energy sources for cooking is in the order of fuelwood (43%), gas (27%), coal (18%) and electricity (12%). The Hospitals, the Prisons, the Teachers' College and the SSS mainly use gas for cooking. The 2 Clinics surveyed used electricity for cooking.

[7] This data refers to only fuels used as main cooking energy source. It does not include secondary sources

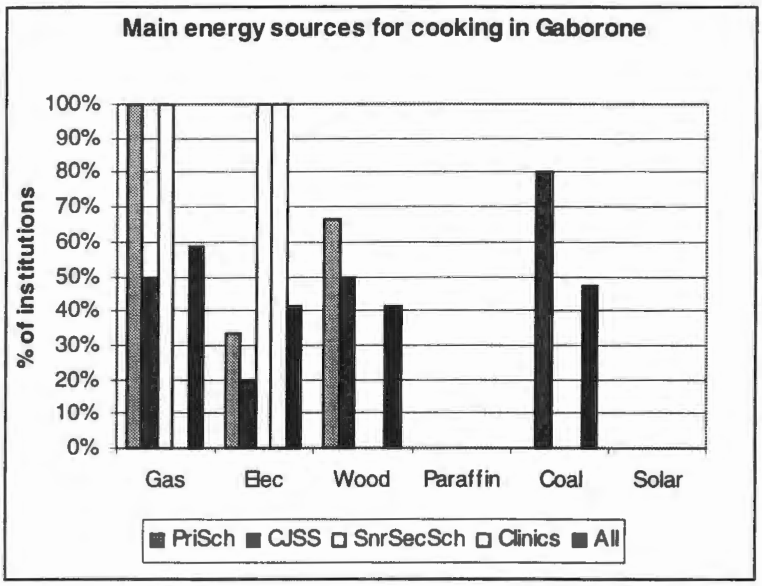


Figure 10-3: Percentage of institutions using specific energy sources for cooking in Gaborone[8]

The Leipego & Lloyd study (1999) did not analyse the energy end uses by institutional types and therefore it is not possible to compare the results of the current study with that. However, it is interesting to compare the energy sources for cooking in Gaborone in a study by EAD (1996) with the current study's analysis of cooking energy sources in Gaborone shown in Figure 10.3. This comparison helps to identify any changes in fuelwood use that have occurred since 1996. The widely use of fuelwood in the Primary Schools for cooking, in spite of the fact that almost all Gaborone Primary Schools are fitted with electricity stoves, is confirmed by Figure 10.3. Two-thirds of the Primary Schools use fuelwood (the 1996 EAD study reported 61%) and a third use electricity. Although Primary Schools sample for Gaborone in the current study is too small to draw any generalisation from it, it still gives an impression that fuelwood use in Primary Schools have not gone down since the government directive in 1995 to reduce fuelwood consumption in government institutions.

The wide use of coal in the CJSS as reported in the 1996 EAD study is confirmed by this study but the estimate is now much higher (about 80% as against 57% in the previous study). In fact, in general, almost half of all the institutions surveyed in Gaborone use coal for cooking, although in varied intensities. The previous study recorded a lower coal use of 13%. While this may be partly due to the fact that more CJSS were sampled in this study, the fact remains that coal use in CJSS has increased significantly from 57% to about 80%. This shows that some progress is being made in the government promotion of coal as a substitute for fuelwood. Coal is mainly being encouraged because it is indigenous to Botswana.

The previous study estimated that there were about 13% other government institutions using fuelwood for cooking besides Primary Schools and CJSS in 1996 but the study shows that fuelwood use for cooking in government institutions in Gaborone only occurs in the Primary Schools and the CJSS. This is an indication of fuel switching in Gaborone. The SSS and the Clinics in Gaborone use either gas or electricity or both.

Water heating energy sources

It is clear from Figure 10.4 that fuelwood is used for water heating by only Primary Schools (80%), CJSS (45%) and the Prisons (67%). The one Teacher's College surveyed use only gas for water heating, the Clinics use only electricity and the hospitals use either electricity or coal. One-half of the SSS use electricity and about a third of them use solar water heaters. Apart from fuelwood, gas, coal and solar water heaters are used in the CJSS in similar proportions.

[8] This data includes secondary energy sources in order to compare with the EAD study (1996) in Gaborone

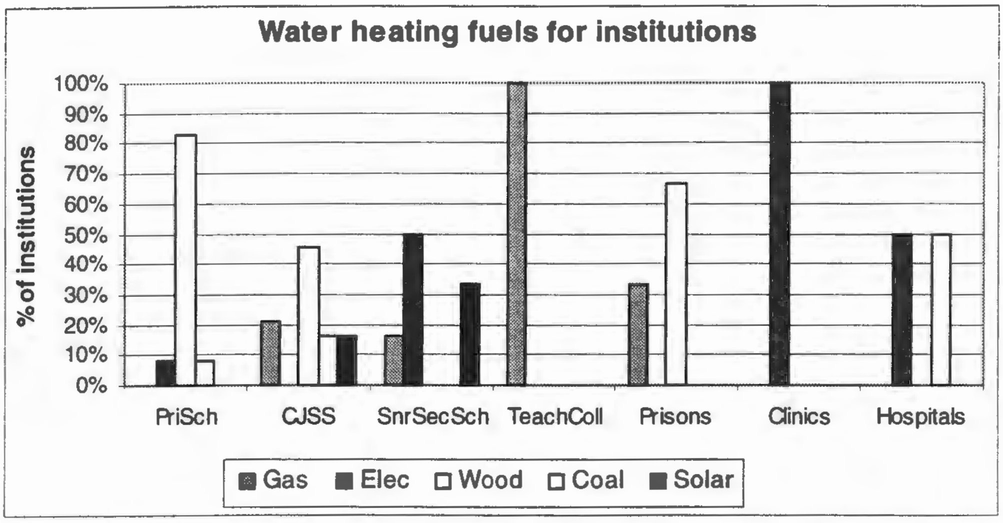


Figure 10-4: Percentage of institutions using specific energy sources for water heating in all urban areas

Space heating energy sources
Space heating in government institutions is mainly by electricity as shown in Figure 10.5. However, half of the Primary Schools still use fuelwood for space heating. Also besides the 70% of the CJSS using electricity for space heating, there is 10% use of gas, fuelwood and coal for space heating.

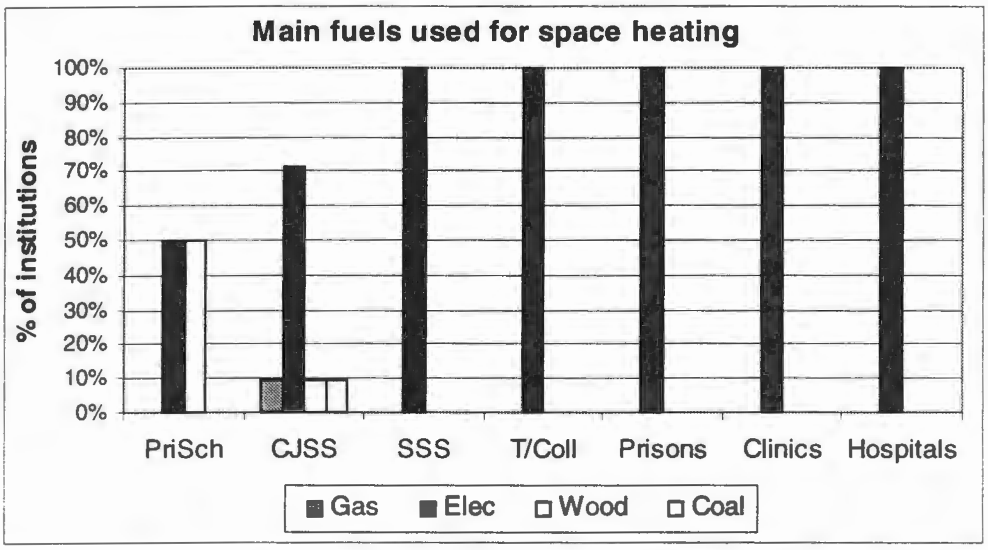


Figure 10-5: Percentage of institutions using specific energy sources for space heating in all urban areas

It must be noted that, in the three end uses discussed in this section, no SSS featured as fuelwood user even though Figure 10.1 shows that two-thirds of SSS use fuelwood. This is an indication that the SSS use fuelwood only as a secondary fuel and not as a primary fuel (see Section 10.1.4).

10.1.4 Fuelwood consumption

The average monthly consumption of fuelwood by the 4 types of institutions that use fuelwood has been analysed in Table 10.3. The annual consumption of the schools was based on the assumption that there are 3 school terms in a year with each consisting of 3 months.

Type of institution	*Mean Monthly Consumption/unit (Tonnes/institution)*[9]	*No. of Institutions*[10]	*% of Institution using fuelwood*	*Mean Total Annual Consumption (Tonnes)*
Primary Schools	6.1	725	100%	39513
Comm Junior Sec Schools	18.3	205	88%	29605
Snr Sec Sch	2	27	67%	324
Prisons	10	21	75%	1418
Total				70859

Table 10-3: Mean monthly and annual consumption of fuelwood in Government institutions

The table confirms that only 4 out of the 7 institutions studied use fuelwood (see Section 10.1.2). Out of the 4 institutions the amount of fuelwood consumed by the SSS is very small compared with the other 3 institutions. The low monthly fuelwood consumption of 2 tonnes by the SSS is a confirmation that fuelwood is only used as secondary energy source as mentioned in the previous section.

It is interesting to note that, although fuelwood use more widespread amongst Primary Schools than the CJSS, the intensity of fuelwood use at the CJSS (18.3 tonnes/month/fuelwood-using CJSS) is about 3 times that of the Primary Schools (6.1 tonnes/month/fuelwood-using Primary School). Figures by Leipego & Lloyd (1999:4) confirm this ratio but in that case the estimates for consumption for both types of schools were a little lower than the estimates in this study.

The total annual consumption fuelwood by the 4 institutions is estimated as about 70 859 tonnes. It must be mentioned that Leipego & Lloyd (1999:4) observed fuelwood use in one of the 2 Clinics studied but this was not the case in this study. Furthermore, both of the 2 Brigades studied by Leipego & Lloyd (1999:4) were all using fuelwood at the consumption rate of 3.5 tonnes/month/each. Now assuming there are a total of 41 Brigades in Botswana, then for a 12-month year operation of the Brigades the annual consumption of fuelwood would be 1722. This brings the total of institutional consumption of fuelwood to about 72 581 tonnes per annum. It must also be mentioned that Leipego & Lloyd (1999:10) estimated annual consumption of fuelwood in schools to be 63 000 tonnes. The estimation for the schools in this study was 69 411 tonnes but this includes the small consumption by the SSS whilst the previous study did not indicate any fuelwood use in the SSS. This indicates that there has not been any reduction in consumption of fuelwood between 1998 and 2000 when the studies were carried out. Rather, there has been a slight increase in consumption. This calls for a need to investigate the implementation of government directive to decrease fuelwood consumption in schools and the focus should be on the Primary Schools and the CJSS.

10.1.5 Responsibility and funding for energy provision

A critical look at what constitutes the energy budgets of the institutions, the source of funding or provision of the energy sources, and the appliances involved would help identify what the real barriers of fuel switching are.

Energy expenditure

Table 10.4 shows the average monthly expenditure by each type of institution on the different types of energy sources. The table shows that it is only in the Primary Schools and the CJSS that fuelwood constitutes a significant portion of the total energy budget. Thus fuelwood expenditure could make a significant contribution to the energy budget in a fuel switch in the Primary Schools and the CJSS.

[9] The mean consumption here is referring to only users of fuelwood and not averaged over all institutions

[10] The sources of the number of government institutions were through personal communication with Mr Boiki Mabowe of the EAD (2001) and Leipego & Lloyd (1999).

Type	*Elec*	*Gas*	*Paraffin*	*Fuelwood*	*Coal*	*Candles*
PriSch	740	100	50	525		300
CJSS	2217	1135		1010	622	
SnrSecSch	11712	3255	43	300		
TeachColl						
Prisons	6250	5676		1000		
Clinics						
Hospitals	6500	5000	500	750	1250	

Table 10-4: Monthly average expenditure (P) on different fuels per institution

Funding for energy budget and appliances

Table 10.5 shows that whilst the energy budgets of the CJSS and the SSS are largely funded by the Ministry of Education, those of the Primary Schools are mainly borne by the pupils' parents. This energy burden on the parents has led to the cheaper option, which, they find as fuelwood. The Ministry of Labour funds the Prisons' energy budget and appliances.

Type	*Institution*	*Parents*	*Ministry of Education*	*Council*	*Ministry of Labour*	*Ministry of Health*	*Total*
PriSch	2	9		1			12
CJSS	6		17				23
SenSecSch	1		5				6
TeachColl	1						1
Prisons	2				2		4
Clinics	2						2
Hospitals	1					1	2
Total	15	9	22	1	2	1	50

Table 10-5: How energy budget is funded at different institutions

The Ministry of Education also provides funding for appliances in most of the SSS and the CJSS but in the case of the Primary Schools only a few are supported. The rest of the Primary Schools receive their funding for appliances from the Council. This leads to disparities in appliance provision at different Primary Schools since your appliances would depend on the financial strength of your Council.

Type	*Institution*	*Ministry of Education*	*Council*	*Ministry of Labour*	*Ministry of Transport*	*Ministry of Health*	*Total*
PriSch		4	6				10
CJSS	3	21					24
SenSecSch		4		1	1		6
TeachColl		1					1
Prisons	2			2			4
Clinics	2						2
Hospitals	1					1	2
Total	8	30	6	3	1	1	49

Table 10-6: How appliances for institutions are funded

In terms of fuelwood provision, Table 10.7 shows that whilst the responsibility of paying for the fuelwood used at the SSS and the CJSS is borne between the Ministry of Education and the institutions themselves, in the case of the Primary Schools the responsibility is mainly borne by the parents. The pupils are sometimes asked to bring firewood to school.

Type	*Institution*	*Parents*	*Ministry of Education*	*Total*
PriSch	1	10		11
CJSS	11		9	20
SenSecSch	2		3	5
Total	14	10	12	36

Table 10-7: Responsibility of paying for fuelwood

In order to assess whether student learning times are affected by the use fuelwood, the institutions were asked who is responsible for supplying them with fuelwood. Table 10.8 shows that the school children are not in anyway involved in the gathering of the fuelwood. Fuelwood is mainly purchased through fuelwood dealers. However, in some Primary Schools parents are involved in the supply of fuelwood.

Type	*Cook*	*Inmates*	*Parents*	*Dealers*	*Manager*	*Total*
PriSch	1		4	6	1	12
CJSS				18	1	19
SenSecSch	1			1	1	3
Prisons		3				3
Total	2	3	4	25	3	37

Table 10-8: Responsibility of gathering fuelwood

Table 10.9 shows the number of institutions who have electric and gas appliances they are not using. The table shows that it is the Primary Schools and the CJSS who are not using the electric or gas appliances they have. The reasons for not using these appliances were mostly that the electricity or gas is expensive and secondly the appliance maintenance is expensive. Some institutions also complained that they have problems with their appliances.

Type	*Elec*	*Gas*
Primary Schools	3	2
CJSS	5	1
Snr Sec Schools	1	0
Teachers' College	1	1
Prisons	1	0
Clinics	0	0
Hospitals	0	1
All Institutions	11	5

Table 10-9: Number of institutions who have electric and gas appliances they are not using

10.1.6 Willingness to stop using fuelwood

It is encouraging to note that about three-quarters of the institutions using fuelwood are willing to switch to other energy sources if their conditions could be improved. It is even more encouraging to note that the level of willingness is highest amongst the Primary Schools who constitute the majority of fuelwood-using institutions.

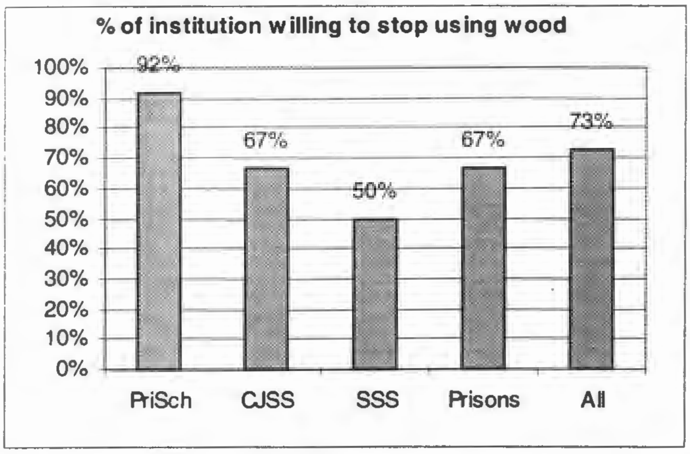


Figure 10-6: Percentage of fuelwood-using institutions willing to stop using fuelwood

Figure 10.7 shows that the main reason why the Primary Schools would like to quit using fuelwood is that it has become too expensive for them. They are also concerned about the impact on the environment and about the fact that it cannot be found in the neighbourhood anymore and it has to be collected from far distances. For the CJSS, the main reason why they would like to quit using fuelwood is that it is difficult to find and secondly the negative environmental impact. For the Prisons, fuelwood collection by their inmates often leads to runaway of inmates and as such they would like to stop collecting fuelwood. Also the Prisons are concerned about the environmental degradation associated with fuelwood collection.

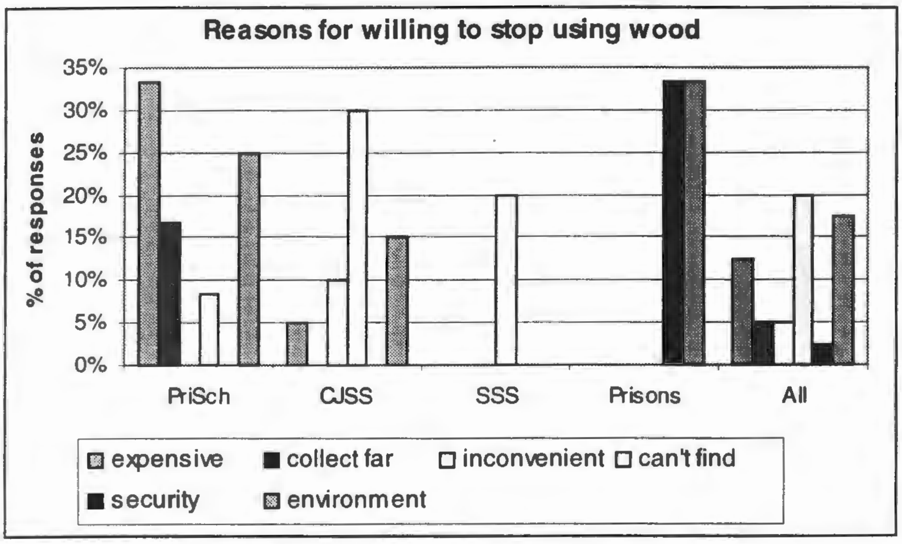


Figure 10-7: Reasons why institutions are willing to stop using fuelwood

Figure 10.8 shows the perceptions of institutions concerning fuelwood-saving stoves. Amongst the institutions which use fuelwood most (the Primary Schools and the CJSS), there is general lack of knowledge about fuelwood-saving stoves but there is high willingness to own one.

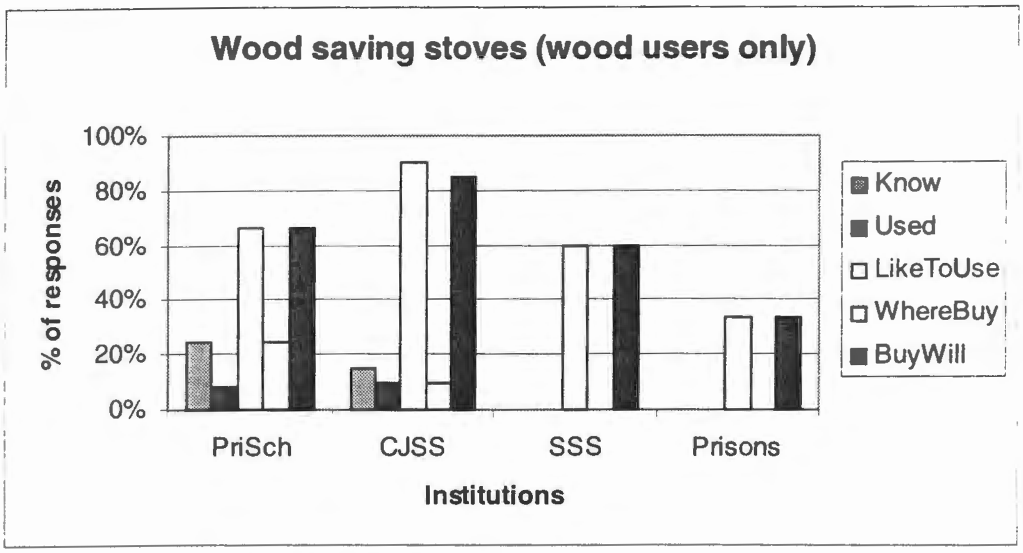


Figure 10-8: Perceptions about fuelwood-saving stoves

10.2 Dealers of energy sources

This section deals with the sale of energy sources with special emphasis on fuelwood.

10.2.1 Coverage of dealers in survey

The different participants involved in the sale of various energy sources were covered in the survey. Table 10.10 gives a coverage of energy dealers in this survey. The scope was wide enough to assess whether fuelwood is sold amongst other energy sources. Out of the 55 dealers interviewed 12 were selling fuelwood alone whilst filling stations, supermarkets and tuck shops were selling fuelwood together with other energy sources as well as other products.

Town	*Gas dealer*	*Fuelwood dealer*	*Filling station*	*Super market*	*General Dealer*	*Wholesaler*	*Tuck shop*	*Total*
GAB		3	4	4	1	2	2	16
KAN		1	2	2	1	1		7
LOB	1	1	1	1		1	3	8
MOC		2		2	3			7
MOL		4	1	2			1	8
PAL	2	1	2	1	2	1		9
Total	3	12	10	12	7	5	6	55

Table 10-10: Types of dealers in different towns surveyed

10.2.2 Fuelwood prices

Table 10.11 summarises the prices of fuelwood from different dealers. It is only from the fuelwood dealers that households can purchase fuelwood in different quantities. It must be remembered that in the urban villages fuelwood is usually purchased in quantities of donkey cart-loads (see Chapter 8) and as such fuelwood dealers are the main suppliers. Average price of fuelwood ranges between P2.60 and P5.00 for 5kg fuelwood depending on who is selling it and where it is being purchased. The table indicates that fuelwood is cheapest when purchased from the fuelwood dealers whose main business is fuelwood marketing.

Type	5kg	2 wheel donkey cart	4 wheel donkey cart	Wheel barrow	Bakkie load	Truck load	Tractor load
Fuelwood trader	2.6	57	90	8	130		250
Filling station	5						
Supermarket	3.3						
Tuck shop	5					500	

Table 10-11: Average cost (P) of fuelwood by different types of dealers

In terms of the different urban centres studied the average price of fuelwood does not vary much as it can be seen from Table 10.12. The price ranges from P2.00 in Palapye to P3.51 in Gaborone for each 5kg of fuelwood. The average prices at the fuelwood dealers were used to compute the weights of the household fuelwood consumption in cases where there was no fuelwood at the household to be weighed. It must be mentioned that the number of fuelwood weighings was limited since the sale of fuelwood was not in abundance as it would have been in the winter. Sixteen weighings were done in total. Thus the accuracy of the fuelwood prices in the table is not very high.

Town	5kg	2 wheel donkey cart	4 wheel donkey cart	Wheel barrow	Bakkie load	Truck load	Tractor load
GAB	3.51		100	8			
KAN	2.04	80					
LOB	3.38				130	500	
MOC	2.12						250
MOL	3.40	45	80				
PAL	2.00						

Table 10-12: Average cost (P) of fuelwood in different towns

10.2.3 Fuelwood customers and sources

The main customers of fuelwood dealers were the households, although there were a couple of them who supplied fuelwood to institutions and a butchery (Table 10.13). The main sources of fuelwood to the dealers in the different urban centres have been identified in Table 10.14. These are Ntsweng for Gaborone, Legonyane for Kanye, Peleng for Lobatse, Marakeng for Mochudi, Makanke and Mantsweng for Molepolole, and Dikabeane for Palapye. Ntseng refers to the Kgale Hills in Gaborone, whilst Peleng is on the eastern side of the main Lobatse mall. Mantsweng refers to the Molepolole Hills whilst Makenke is about 10km before you enter Molepolole village from Gaborone. Dikabeya is about 14km from Palapye to Francistown and Marakeng refers to a shopping complex in Mochudi.

Town	Households	Butcheries	Institutions	Total
GAB	5			5
KAN	1			1
LOB	2		1	3
MOC	2		1	3
MOL	4	1		5
PAL	1			1
Total	15	1	2	18

Table 10-13: Customers of fuelwood dealers in different towns

Town	*Source*
GAB	Ntsweng
KAN	Legonyane
LOB	Peleng
MOC	Morakeng
MOL	Makanke,Mantsweng
PAL	Dikabeya

Table 10-14: Source of fuelwood for dealers

10.2.4 Gas prices

If fuelwood users are to be able to switch to other fuels, then the distribution of those other fuels should be effective to make the prices affordable in all places. Table 10.15 shows that the price of gas at the different urban centres does not vary much. It is interesting to note that the price of gas in Palapye is higher than that in Gaborone only by a few Pula, although the two are separated by over 300km. The closeness of the price of a bulky commodity like gas at all places seems to have contributed to the wide use of gas in the urban areas.

Cylinder weight	*48kg*	*19kg*	*14kg*	*9kg*	*6kg*	*4.5kg*	*3kg*	*1.4kg*
GAB	210	84	62	41				
KAN	207	82	64	46				
LOB	207	81	60	40				
MOC	218	87	64	42				
MOL	214	85	61	40				
PAL	217	87	65	41	30	22.5	15	7

Table 10-15: Average prices of different cylinders of gas

11. Future strategies and fuelwood demand projections

The aim of this chapter is to identify and discuss strategies to promote the sustainable use of fuelwood in Botswana. A strategy, according to Oxford Dictionary, is originally a military word used to describe the movement of all the battle resources including troops and equipment into favourable positions of attack and defence. Thus its use in the policy arena has evolved to comprise the identification of vulnerable areas of socio-economic and environmental concerns and the design of a plan of actions to overcome or lessen the vulnerability. These areas of vulnerability are potential areas of intervention for steering natural or human actions towards sustainability.

This chapter therefore seeks to identify potential areas of intervention for sustainable use of fuelwood in urban Botswana based on the information gathered in this study. These areas of potential intervention are tested in a scenario approach of modelling in order to assess their impacts in terms of fuelwood demand projections. Then the measures of intervention are further developed into action plans.

11.1 Potential areas of intervention and future strategies

The areas of potential intervention in the sustainable use of fuelwood have been drawn from all the information gathered in this study. This includes all the comments of households in Appendix 1 of this report, the analysis of the energy use patterns and the end uses of household energy sources, the socio-economic characteristics of fuelwood use and the perceptions associated with household energy use. The following broad areas of potential interventions clearly emerged. The broad measures of intervention which form the strategies are briefly outlined below and scenarios are developed from each of these broad strategies.

Poverty alleviation

This study makes it abundantly clear that the dependency on fuelwood is largely linked to poverty. Households who cannot afford or access other alternative energy sources have no choice but to cling to fuelwood, in combination with other fuels, for survival. Thus appropriate economic growth that translates into improved income distribution would eventually help ease the problem of fuelwood dependency. Without improved income levels it would be harder for households to switch from fuelwood to other more convenient fuels. In fact, there is even a tendency of reverting to fuelwood cooking since households who would like to use it exceeds the number who are currently using it (see Figures 7.1, 7.2 and 9.1).

Fuel switching from fuelwood to gas

There is a strong willingness amongst households to switch from fuelwood use to other energy sources particularly gas and, to a lesser extent, electricity. There is therefore a need for policies and strategies to capitalise on this goodwill. Chapter 7 makes it clear that gas has successfully made huge in-roads in the households' sector since 1991 and it is imperative to improve its distribution in order to make it more accessible and affordable. Although some households would still continue to use fuelwood where necessary for cooking meals that require a lot of calories, urban lifestyles are changing fast, and coupled with the scarcity of cheaper fuelwood of reasonable quality, many would like to switch either completely or partially to gas. The willingness to switch from fuelwood use is also very high (over 70%) amongst government institutions (see Figure 10.6). This shift seems such a very strong trend in this study that it will need only nominal support. It looks like one of the few energy interventions regarding fuel switching that will actually work in a developing country.

Electrification

It has been shown in this study that electrification is mainly dependent on the income of the household. However, access to electricity broadens the choices of household energy use and influences the extent and intensity of fuelwood use. Since fuelwood users are mainly poor income households, there is a need for strategies to target electrification towards the poor in order to encourage fuel switching from fuelwood. Although many households would not use electricity for cooking, as this study shows, they would use it for other purposes like lighting, space heating, water heating, ironing, etc. The recent reduction in the upfront cost of electrification and the concessionary interest rate for repaying the balance of the connection cost is a step in the right direction. This will facilitate the affordability and accessibility by the poor. However, a further step is necessary if households are to use electricity enough to pay back the electrification investment cost in good time. There is a need for appropriate financial mechanisms for appliance acquisition.

In the case of government institutions, the costs of switching from fuelwood to electricity use for cooking and water heating purposes would be mainly be the building of electric stove kitchens since most of the institutions surveyed are already electrified (Figure 10.1).

Efficient cookstoves

There is evidence in literature that efficient fuelwood stoves use about 25-30% less fuelwood (ESMAP 1991). There is also evidence in literature that wood-saving stoves have been tried in Botswana since the mid-eighties but traces of these stoves in this study were extremely scanty. Improved fuelwood stoves are usually expensive compared with their energy savings and this might be the reason why this strategy has not been sustainable. Also, initiatives in other parts of Southern Africa have resulted in disappointing results regarding fuelwood saving in spite of carefully implemented long-term programmes. However, this study shows that there is a lot of willingness amongst households (40-60%) to use these stoves. The level of willingness amongst the main fuelwood-user institutions like Primary and Senior Secondary Schools is even higher (above 60%, see Figure 10.8). It may be worthwhile to implement a pilot fuelwood efficient stove programme as a job creation tool, but previous efforts in this regard will need to be evaluated in more detail first.

Solar cookers and solar water heaters

Another strategy for consideration is the promotion of solar cookers. About a third of the households expressed the willingness to use solar cookers, and about a half of the households would like to use solar water heaters (SWHs). However, analysis of the data on the 9% of households using solar water heaters did not indicate significant energy savings. In fact, households using SWHs had higher electricity consumption in most cases than those who do not use solar. This is probably because the solar water heaters are very expensive and are usually found in government houses and in higher income households. Comparison amongst the higher income groups showed only some small savings. In spite of the big support SWHs have enjoyed from the Botswana Government, SWHs have had maintenance problems and have not caught on to the general public. Furthermore, there are no financing schemes in place which normal households can use to obtain SWHs. Also, water heating is only partially accountable for fuelwood use, with cooking and other functions of wood fires probably being more important functions. Thus, this study does not find solar water heaters as a strong strategy for reducing fuelwood dependency, unless it is targeted towards the poor who need to shift from fuelwood use. However, solar cookers can be relatively cheap and a pilot project to assess the willingness to pay for them in practice as well as the cultural and social acceptability of this cooking technology is worth exploring. RIIC's work in this regard could be a natural starting point. However, as with fuel efficient stoves, many such programmes have been attempted in the past with little real impact on fuelwood use patterns of households, and thus one should proceed cautiously based on proper analysis of these attempts.

Improving fuelwood availability in urban neighbourhood

On the fuelwood supply-side, this strategy seeks to shift the increasing dependence of urban areas on rural areas for their fuelwood supply to an approach that would seek to increase the fuelwood stock in the urban neighbourhood in the medium- to long-term. The survey shows that there is a lot of interest in the participation of tree planting but what are needed are mobilisation and direction. Thus, with the necessary institutional support urban households and institutions could be mobilised to "grow their own wood" by and large.

Promoting coal stove kitchens in government institutions

Unlike urban households where the promotion of coal use has been unsuccessful, this study shows that there is some indication of success amongst the public institutions with about a third of the institutions surveyed using coal. Over 40% of the CJSS and the Primary Schools use coal, a quarter of the Prisons also use it as well as one of the 2 two Hospitals surveyed. If the environmental concerns of coal use are taken into consideration in the design of this strategy, government could continue to support public institutions in the establishment of coal stove kitchens in order to displace some fuelwood use with coal use. Since Botswana is endowed with large reserves of coal, ways must be found to utilise this resource effectively with minimised carbon dioxide emissions.

Improving paraffin distribution in low-income communities

This strategy is of less priority in terms of the impact on fuelwood use since insignificant number of urban households (about 2%) use paraffin as the main cooking fuel. On the other hand, it is included here because out of the 17% urban households who use fuelwood as their main cooking fuel, 56% also use paraffin as their secondary cooking fuel (Figure 9.13). About three-quarters of those using paraffin for cooking are unhappy with the fuel because it is usually unavailable and expensive (Figures 9.10 and 9.11). Thus the paraffin distribution network at the community level would require some improvement. However, it is doubtful whether this will make any major impact on fuelwood use since insignificant number of fuelwood user-households in the survey (5%) expressed interest to switch from fuelwood to paraffin (Figures 9.7 and 9.8). Although this may not be a strong fuelwood strategy, it would all the same make an impact on households since about 46% of urban households use paraffin as their main lighting fuel (Figure 7.8).

11.2 Fuelwood demand scenarios and assumptions

This section only deals with fuelwood demand-side strategies since information collected in this study is not adequate to model supply-side projections.

11.2.1 Baseline assumptions

The baseline assumptions for the scenarios were as follows (see Appendix 2 for tables):

1. That 10-year planning period is assumed from 2000 to 2010.
2. That households' fuelwood use differs according to income levels and electrification levels. Electrification levels in different income groups in Figure 6.3 are used as categorising households in the survey.
3. That income distribution amongst the sample is as shown in Figure 5.3.
4. That the urban population is growing as projected by CSO (1997).
5. That the urban areas have been categorised into two areas: "*wood-rich*" and "other urban". The wood-rich areas refer to Francistown and Selebi-Phikwe in the north-eastern Botswana where fuelwood is known to be in excess of demand. The other areas are therefore referred to as "*other urban*". These *other urban* areas refer to the data gathered by this study.
6. That the percentage of household using fuelwood in the *wood-rich* areas is assumed to be 77% (White 1999). Those of the 4 income groups in the electrified and non-electrified households in the *other urban* areas can be found in Appendix 2. These percentages of households within a particular income group using specific fuels for the *other urban* areas will remain constant for all scenarios. Rather it is the income distributions of the population that will change according to a particular scenario.
7. That per capita annual fuelwood consumption of fuelwood users in the *wood-rich* areas is assumed to be 558kg (White 1999). Those of the 4 income groups in the electrified and non-electrified households in the *other urban* areas can be found in Appendix 2. All per capita annual fuelwood consumption will remain constant for all scenarios
8. That the fuelwood demand of the institutions is growing at the same rate as population.

11.2.2 Reference scenario: economic growth continues

The Reference Scenario is an optimistic one. It assumes that the current economic prosperity will continue throughout the decade (2000 –2010) and this will result in improved income distribution as shown in Figure 11.1. It is assumed that 5% of households in the lowest income group would have shifted to higher levels of income by the year 2010. The Reference Scenario also assumes that access to electrification throughout the decade would have the same income criteria as in 2000 (i.e. according to Figure 6.3). Calculations from this scenario result in an in increase in electrification from 50% to 52.3%. Thus improved income distribution has empowered more households to have access to electricity. Higher electrification levels are not assumed here since even maintaining the electrification level at 50% with the increased population is a huge challenge. The increase of electrification from 24% in 1991to 50% in 2000 involved the connection of about 36 000 households but maintaining it at 50% from 2000 to 2010 would require the connection of over 50 000 households due to population growth.

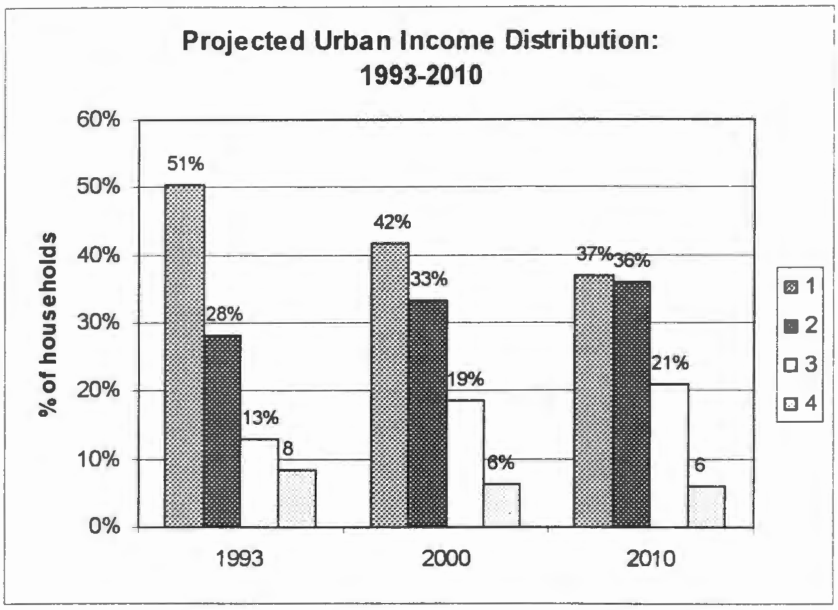


Figure 11-1: Projected distribution of urban households in different income groups for the Reference Scenario: 1993-2010

Under this scenario of economic growth the wood-rich areas would have their fuelwood use reduced from 77% to 70% by the year 2010. The fuelwood demand of the institutions will grow at the population growth rate minus 0.3%.

11.2.3 Stagnation scenario: No more economic growth, stagnant economy

This scenario assumes that there will not be any improvement in the income distribution and that the income criteria for electrification in Figure 6.3 will still apply. This means that electrification will remain at 50%.

Under this scenario of economic stagnation the wood-rich areas would have their fuelwood use remain constant at 77% throughout the decade. The fuelwood demand of the institutions will grow at the population growth.

11.2.4 Electrification scenario: growth and electrification

This scenario retains the economic growth assumptions of the Reference Scenario except:

1. That the electrification level will increase from 50% to 60%.
2. That the wood-rich areas would have their fuelwood use reduced from 77% to 65% by the year 2010.
3. The fuelwood demand of the institutions will grow at the population growth rate minus 0.7%.

11.2.5 Optimistic scenario: growth and higher electrification

This scenario retains the economic growth assumptions of the Reference Scenario except:

1. That the electrification level will increase from 50% to 70%.
2. That the wood-rich areas would have their fuelwood use reduced from 77% to 60% by the year 2010.
3. The fuelwood demand of the institutions will grow at the population growth rate minus 1.0%.

11.2.6 Wood-Gas switch scenario

This scenario retains the economic growth assumptions of the Reference Scenario except:

1. That 29% of fuelwood users in electrified households will switch to gas use and electricity by 2010.

2. That 43% of fuelwood users in non-electrified households will switch to gas use mainly and, to a lesser extent, to electricity by 2010.
3. That the wood-rich areas would have their fuelwood use reduced from 77% to 65% of households by the year 2010.
4. The fuelwood demand of the institutions will grow at the population growth rate minus 1.0%. Some will switch to gas while others switch to coal

The fuelwood-to-gas switch percentages here are derived from the willingness of households to switch expressed in Figure 9.7. It is assumed that the willingness could increase during the decade due to better income levels. Thus it is reasonable to assume that all those willing will make the fuel switch. The distribution of the switches at different income levels in electrified and non-electrified is found in Appendix 2.

11.2.7 Wood-Gas switch & High electrification scenario

This scenario retains all the Wood- Gas Switch Scenario assumptions except:

1. That the electrification level increases from 50% to 60% by 2010.
2. That the wood-rich areas would have their fuelwood use reduced from 77% to 60% by the year 2010.
3. The fuelwood demand of the institutions will grow at the population growth rate minus 1.3%. Some will switch to gas while others switch to coal.

11.2.8 Solar cooker/ Wood-saving stove scenario

This scenario retains the economic growth assumptions of the Reference Scenario except:

1. That there is a 30% penetration of either solar cookers or wood-saving stoves in fuelwood using households by 2010.
2. That the use of a solar cooker or a wood-saving stove saves a household about 25% of fuelwood used by ordinary fuelwood stove.
3. The same penetration and wood-saving rates are assumed for the wood-rich areas and institutions

11.3 Urban fuelwood demand projections

11.3.1 Urban residential fuelwood demand

The above scenarios and the associated assumptions were modelled in the Long-range Energy Alternatives Planning (LEAP) system. The fuelwood demand projections that emerged from the modelling are shown in Figures 11.2 –11.7. One striking observation in Figure 11.2 is that urban residential fuelwood demand seems to have been over projected in the past - whilst the 1996/97 Energy Statistics Bulletin estimated the total urban residential fuelwood demand to be 279 kilotonnes, the current study found this to be only 196 kilotonnes per annum for 2000.

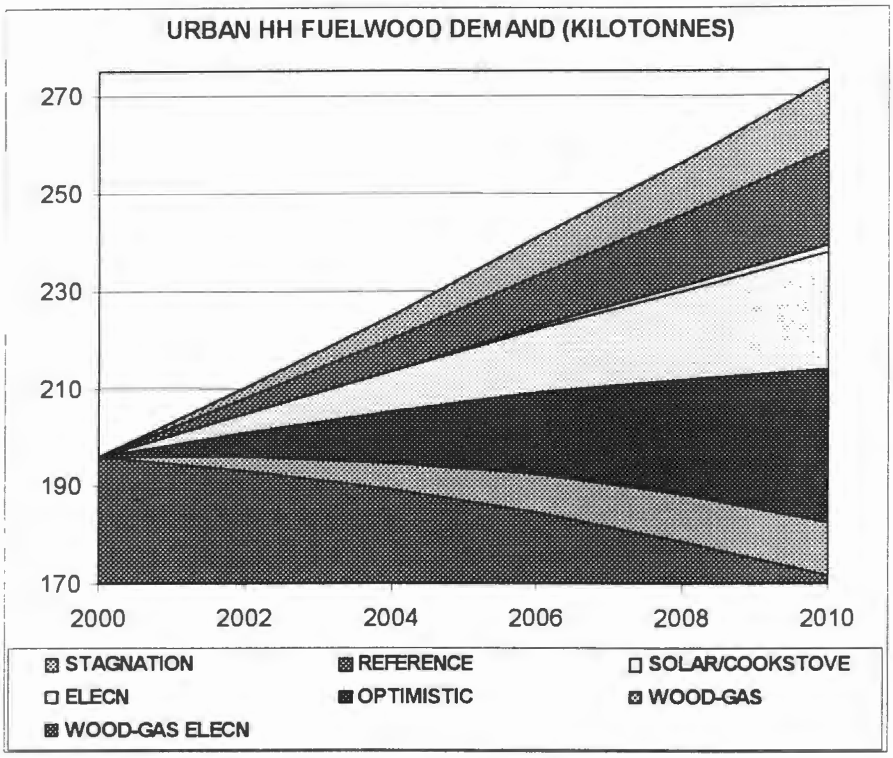


Figure 11-2: Urban residential fuelwood demand projections for different scenarios

Figures 11.2 and 11.3 show that, with a stagnant economy, fuelwood consumption will continue to grow sharply at an average rate of 3.9% to about 273 kilotonnes by 2010. This shows that with a stagnant economy the rate of growth of urban residential fuelwood demand will supersede the national population growth rate. However, with a continuous economic growth (i.e. the Reference Scenario) the demand growth rate could be reduced to 3.2% per annum. There is not much difference between the demand growth rate of the promotion of solar cookers or wood-saving stoves and 60% electrification in a continuos economic growth (about 2.1%). However, 70% electrification in an environment of economic growth (i.e. Optimistic Scenario) will bring the urban residential fuelwood demand growth rate to below 1%. Both figures show that it is only the scenarios involving a fuelwood switch to gas use that result in negative demand growth rates. This is an indication of the potentially powerful impact of fuelwood switch to gas use especially when it is coupled with 60% electrification.

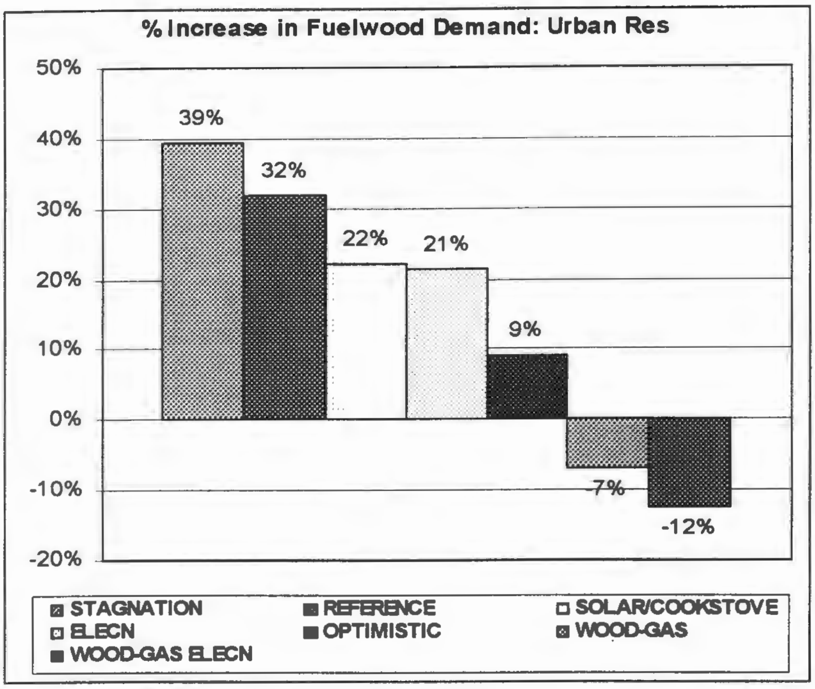


Figure 11-3: Urban residential fuelwood demand growth between 2000 and 2010

11.3.2 Institutional fuelwood demand projections

Figure 11.4 shows that annual institutional fuelwood demand in 2000 is about 71 kilotonnes. Both Figures 11.4 and 11.5 show that, besides the Stagnant Economy Scenario which results in average of about 1.8% growth rate of institutional fuelwood demand per annum, all the other scenarios result in negative growth rate of fuelwood demand. This indicates that the Government directive to reduce fuelwood use in public institutions has already started bearing fruit and, with more aggressive fuelwood switch to gas coupled with about 60% electrification, fuelwood use in public institutions could be reduced to as low as under 20% by 2010.

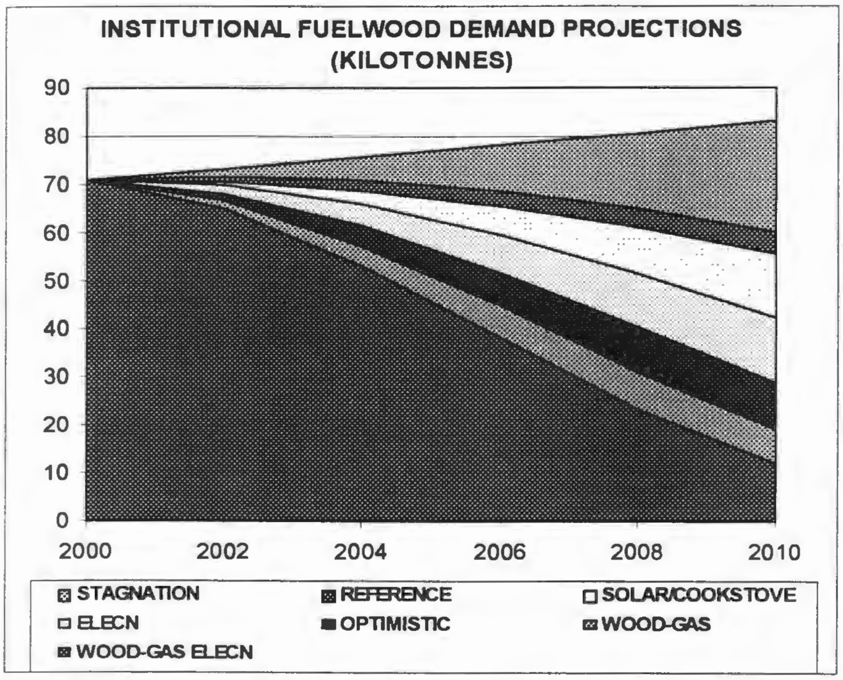


Figure 11-4: Institutional fuelwood demand projections for different scenarios

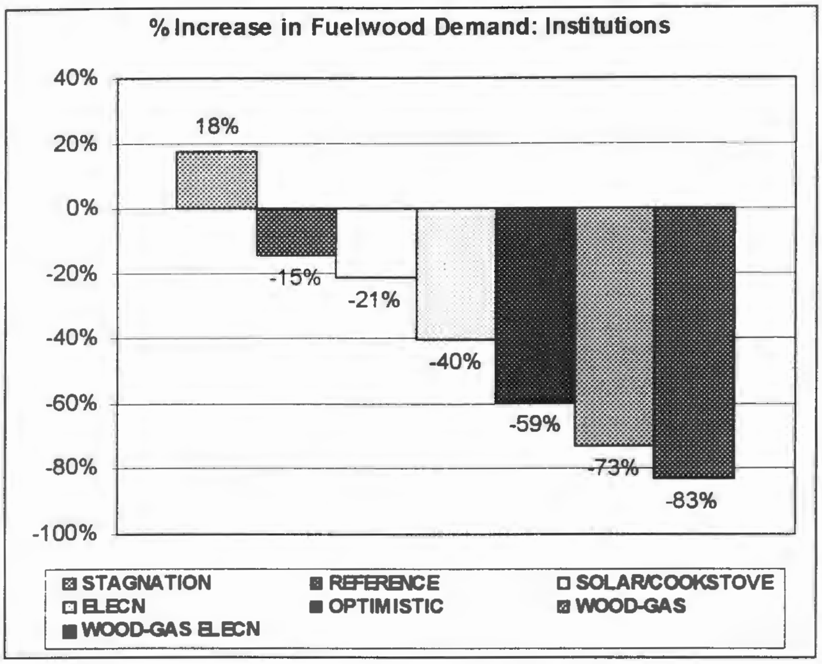


Figure 11-5: Institutional fuelwood demand growth between 2000 and 2010

11.3.3 Total urban fuelwood demand projections

Figure 11.6 shows that the total of urban residential and institutional fuelwood demand is about 267 kilotonnes per annum which is about the projections for the urban residential demand in the current Energy Statistics Bulletins. This is an indication that consumption per capita levels have gone down and the extent of use of fuelwood has also dropped (see Section 6.2.1) due to scarcity of fuelwood and improved economic growth.

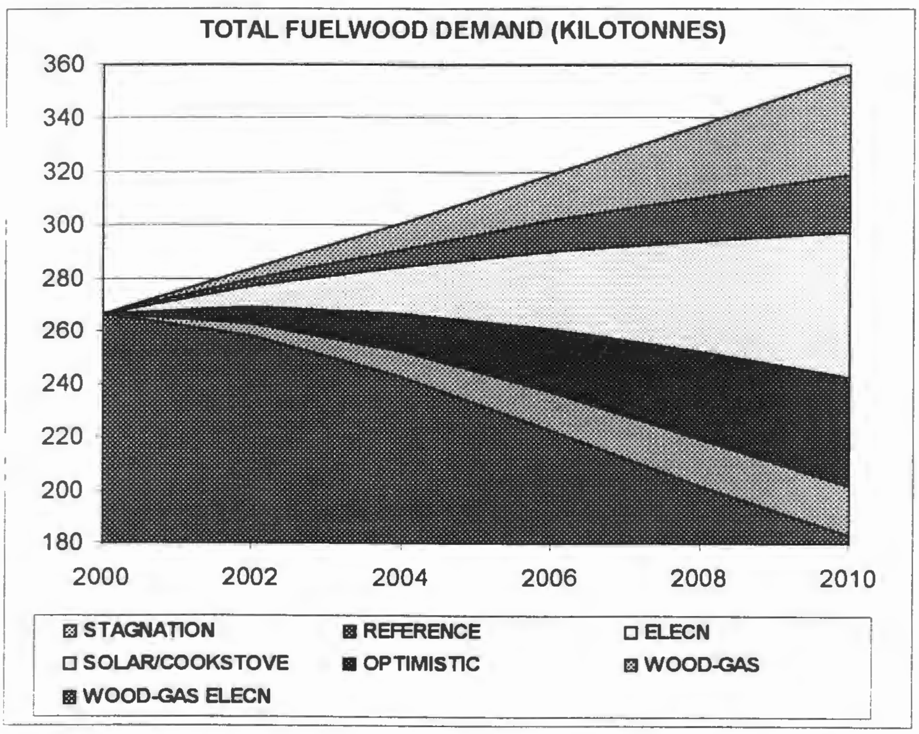


Figure 11-6: Total fuelwood demand projections for different scenarios

Figure 11.7 illustrates that in a Stagnant Economic Growth Scenario the total fuelwood demand will grow at an average rate of 3.4%. However, with a continuous Economic Growth Scenario (Reference Scenario) the average rate of growth of total fuelwood demand will drop to about 2.0%. The figure further shows that, in a continuous economic growth environment, 60% electrification

(Electrification Scenario) and 70% electrification (Optimistic Scenario) could reduce the total fuelwood demand growth rate to 1.1% and 0.5% respectively. Again the Figures 11.6 and 11.7 clearly show that it is the fuelwood to gas use switch that can make a real impact in reducing the dependency on fuelwood.

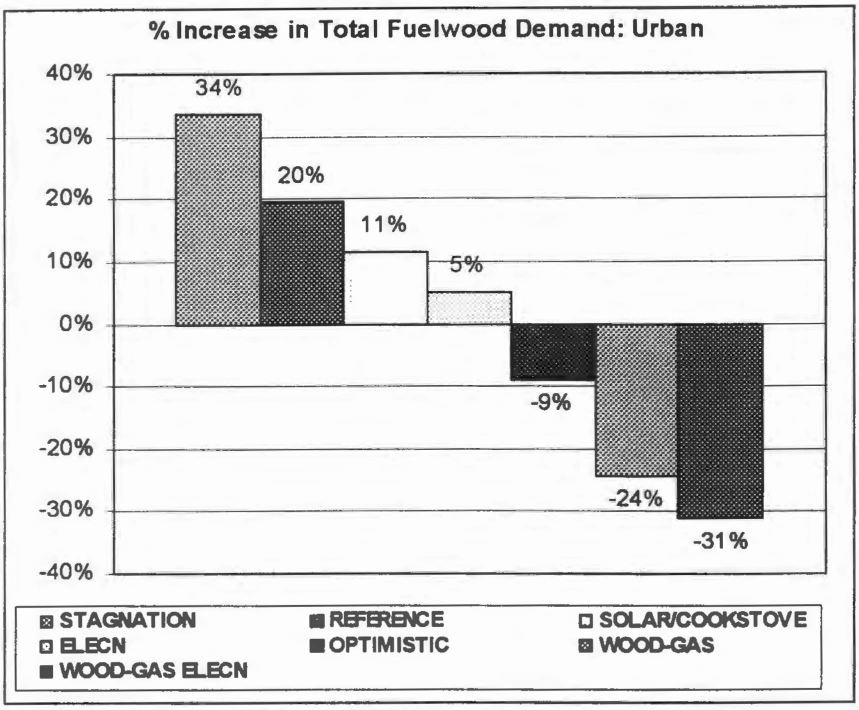


Figure 11-7: Total fuelwood demand growth between 2000 and 2010

11.4 Proposed plan of actions

The above section makes it clear which of the strategies would make significant impact on the reduction of fuelwood consumption. The following section suggests some actions that can be taken to implement the strategies outlined in Section 11.1 both on the fuelwood demand- and supply-sides. The actions are grouped under each strategy and the strategies are listed according to decreasing order of higher priority.

It must be cautioned though that the full development of action plans is beyond the scope of this study. The action plans mentioned here in this study are basically preliminary ideas evolving out of the information gathered in this study without complete consideration of all other aspects necessary for a better strategy design. For a good plan of actions, there is a need for active deliberations by all stakeholders concerning the information available and also a proper assessment of the environment of the stakeholders in order to direct the actions towards desired and achievable results. A well-facilitated action plan workshop could be useful for this. This could involve the assessment of capabilities of stakeholders, training and institutional needs, the resources necessary for carrying out each action, the nature of services required, categories of target groups, the time requirements (short-, medium- or long-term), constraints, evaluation of the proposed actions and the identification of new ones, and so on. Thus, the action plans suggested in this section should only be taken as a starting point and a guide and not an end in itself since stakeholders know their environment better and their participation is critical if the implementation is to be effective.

Fuel switching from fuelwood to gas

Clearly the switching from fuelwood to gas emerged in the scenario testing as the strategy that would make the greatest impact on the reduction of fuelwood use both in urban households and government institutions. The survey showed that this is a strategy that is already on course with the provision of appropriate enabling environment for marketing gas throughout the urban areas of the country. Although some households complained about the high price of gas, market forces seem to have dictated the price to a lower level that is comparable to the price at the coastal areas of South Africa from where the gas is supplied. Price differentials in the urban areas are clearly insignificant, in spite of the distances between them, due to the many corridors of entry into the country's borders from South Africa. Thus, the need for government intervention is currently very limited. However, the following suggested actions would be worth considering:

1. Continuous awareness campaign would be required to ensure increase in the intensity of gas use in households. Although the use of gas amongst urban dwellers is high, about 60% of households that use gas as their main cooking fuel still use fuelwood as their secondary cooking fuel. Now that the myth about the safety of gas seems to have been largely suppressed, the cleanliness, the convenience and all the positive aspects of the fuel should be packaged into convincing campaign tools targeting households and government institutions to convert a large portion of the partial fuelwood switches into complete switches. This should not only be limited to cooking but other end-uses as well.
2. Some investigation must be conducted into why there is so much partial switch from fuelwood and efforts must be made to remove or lessen all identified barriers including cultural attachment to wood fires. This may require some education to change mindsets.
3. It is important to establish what other means of acquisition of gas cylinders would be affordable by poorer households. The practice where households have to own a cylinder in order to be able to purchase gas is a barrier for many poor households. Thus other options of gas cylinder acquisition should be explored. For instance, households could be made to pay a reasonable deposit for the cylinder or the required cost of the cylinder could be spread over a period of time. This should include the afffordability of acquiring more than one cylinder. Households with more than one cylinder in the survey had higher gas consumption levels because they are able to use the gas simultaneously for other purposes besides cooking.
4. Households and government institutions should be supported financially in their purchase of gas appliances. Financial arrangements could be made with shopping centres for households to pay for their appliance purchases over a reasonable period of time at an affordable interest rate. The oil companies could be drawn in to support such innitiatives and community organisations could also be rallying points for such initiatives.
5. More effort should be made in the adoption of housing designs that would ensure the safe use of gas in the households and government institutions. Already this has started happening but the impact could be greater if the government could come out with policies that would sensitize housing development agencies towards gas-friendly housing development. This would require the co-operation of the Housing Department, architects and engineers in general.
6. Government should support the private sector in promoting the establishment of a more extensive chain of smaller gas dealers especially in the villages.
7. Periodic discussions with the oil companies, appliance manufacturers and distributors would also be useful in initiating new actions and strengthening already existing ones that would enhance fuelwood switch to gas.

Improving fuelwood availability in urban neighbourhood

This strategy seeks to curtail the dependence on rural areas for urban fuelwood supply by exploring actions that could improve fuelwood availability within the vicinity of the urban areas. The following actions could be useful:

1. The Ministry of Agriculture and the EAD should explore the possibility of establishing urban community woodlots. These government agents should be facilitators in this but the actual process should be owned by the communities. Local authorities and NGOs could be invited to take leadership roles in this and they could support communities in their acquisition of land for such purposes.
2. All educational institutions should be encouraged to undertake some tree planting programmes. Schools could be offered state or communal lands for establishing school woodlots. An annual competition could be conducted to reward schools that excel in community forestry.
3. General awareness campaigns would be helpful in sensitizing the urban population on the importance of tree planting. The survey indicates that there is a lot of willingness amongst urban dwellers to participate in tree planting and it would therefore be helpful if appropriate campaigns are organised to direct people concerning their individual contribution. Households should be

encouraged to plant trees in their homes, especially fruit trees, and government institutions could also plant trees on their compounds.

4. Educational institutions should explore how to integrate forestry and energy issues in school curricula. The EAD, the Ministry of Agriculture and relevant NGOs could help with the development of the required educational packages for such curricula development.

5. The Ministry of Agriculture, the EAD, and the forestry-related NGOs like the Botswana Forestry Association should be supported to provide the necessary technical, logistical and institutional assistance in all sustainable fuelwood supply efforts. This should include the establishment of tree nurseries, the advice concerning selection of species and the maintenance of natural woodlands and plantations.

6. Efforts should be made by the EAD to organise all fuelwood dealers into a responsible association in order to get them involved in the activities concerning the sustainable supply of fuelwood. In this way, they would be able to report on their activities and also effect some control on fuelwood pricing. This would help to get them to contribute positively in all other efforts and also provide them with the necessary awareness concerning the cutting of live trees.

Electrification

Following from the broad electrification strategy discussed in Section 11.1, the following actions could be effective:

1. There must be periodic review of the modalities of payment of the electricity connection cost in order to make it affordable to poorer households. The upfront cost, the required rate of payment of the rest of the connection cost, and the interest rate for paying the remainder should be made reasonably bearable by poorer households. Proactive measures should be taken to increase the current urban electrification rate of 50% in order to make an impact on the reduction of fuelwood use. This should not only be limited to households but also government institutions, especially primary schools.

2. There must be stimulation of the demand of electricity amongst households and government institutions. This can be done by negotiating appropriate financial mechanisms for appliance purchase with the relevant financial institutions and business organisations. The payment for acquired appliances could be spread over affordable period of time at reasonable interest rates. The connection of households and government institutions to the electricity grid alone would not produce the desired results of switching from fuelwood use to electricity. Currently, only about 14% out of the 66% electrified urban town households use electricity for cooking and about 2% out of the 31% electrified urban village households use electricity for cooking (see Figures 7.1,7.2 and 6.4). Surely the demand could be stimulated further and this would be in the interest of the electric utility since it would eventually lead to increased revenue. Thus, it would be useful to get the utility involved. The survey also indicates that substantial portion of the energy budget of households using fuelwood is spent on the purchase of fuelwood. This amount could be rather used for electricity consumption if the necessary awareness is created to shift the mindset from fuelwood use. Thus some awareness campaign would be necessary for this and the utility could be made to champion it with government institutional support.

3. Maintenance support system must be in place in order to ensure that electrical appliances already purchased are continuously in good working order. This will reduce the frustration of households and institutions that might induce them to revert to fuelwood use. This action offers local entrepreneurs an opportunity for job creation in terms of electrical appliance repair shops.

4. Government would have to explore the possibility of poverty tariff to widen access of electricity to poorer households. This can be done by giving some concessions to households that consume below a certain limit of kWh. This limit should be that which could at least provide basic electricity service to poor households. These kinds of tariffs are currently being tried in the electric and water utilities of South Africa.

5. Electrification should also be accompanied by effective and safe wiring of households in order to make sufficient impact on the livelihood of people. The electric utility could be sensitized to support this with training and creation of electrical wiring businesses.

Efficient cookstoves

With all the cautions raised in Section 11.1 concerning this strategy, the following suggested actions need to be considered:

1. Attempts must be made to evaluate the causes of failure in previous attempts in disseminating efficient cookstoves in Botswana and Southern Africa.
2. There must be practical testing of new and current efficient cookstoves to ascertain the level of fuelwood savings that can be achieved in order to assess the relevance of their promotion. BoTeC and RIIC innovative stove designs would be useful in this testing. The stoves should be tested in selected households and some government institutions. It would be useful for the approved stove/s to be adaptable for the use of other fuels like coal. The possibility of incorporating the social dimension of wood fires in the stove design would be very important.
3. The specifications of the approved efficient cookstove/s are then used to market it/them widely through public and school awareness campaigns and demonstration programmes.
4. A demand assessment of the stove/s should be carried out to verify the viability of manufacturing the stove/s. The marketing and demand assessment should not be limited to Botswana alone but should be broadened to include other Southern African countries since a wider market would ensure its easy viability.
5. The efficient cookstoves design should explore potential job creation opportunities.
6. Government institutions like schools, clinics and hospitals could be used as promotion and demonstration centres for the approved efficient cookstoves by starting to use the stoves in their kitchens.

Solar cookers and solar water heaters

Almost all the actions involved in the efficienct cookstoves strategy are worth exploring under this strategy. In addition, the following actions could also facilitate the shift to solar cookers and solar water heaters:

1. The energy savings impacts of all solar water heaters in both government and private buildings must be assessed. This would inform government about the next direction of effective promotion of the technology.
2. A pilot project should be conducted to assess the willingness to pay for solar cookers and their cultural and social acceptability. RIIC's work in this regard could be very useful.
3. An investigation should be carried into how to target the design and marketing of solar water heaters towards poorer households. What incentives would make them attractive and what level of financial support would be required?
4. Efforts must be made to ensure that there is adequate maintenance support system available.

Promoting coal stove kitchens in government institutions

1. Government must facilite the availability of coal by supporting the establishment of coal depots in all the urban centres.
2. Clean coal technologies must be pursued in order to increase the fuel efficiency and improve product quality, and these would be mainly physical coal cleaning processes.

Improving paraffin distribution in low-income communities

The main action required in this strategy involves efforts to improve paraffin distribution network at the community level. This action seeks to respond to the needs of those households who use paraffin as secondary fuel for cooking. Thus the impact on the reduction of fuelwood use is not expected to be substantial but it would all the same benefit almost half of the urban population in their lighting needs.

Poverty alleviation

The listing of poverty alleviation here as the last one of the strategies should not be inferred in any way as the least priority in the sustainable use of fuelwood. In fact, as mentioned earlier on, fuelwood dependence is strongly linked to poverty as shown clearly by this study and thus the economic empowerment of households and government institutions is critical in order to reduce fuelwood dependence. This strategy is listed here last because it does not fall in the direct domain of activities of the Ministry of Minerals, Energy and Water Affairs (MMEWA) and other government departments are more responsible for dealing with it. However, MMEWA could undertake the following actions to support the poverty alleviation drive:

1. It is important for the EAD to articulate to the responsible government departments and institutions the seriousness of the impact of poverty on the use of fuelwood and the environmental concerns. This will create the necessary awareness amongst government agents mandated to formulate, strengthen and implement policies that will truly ensure poverty alleviation. These government agents could include those responsible for social welfare, employment, finance and economic planning, education, health and also the legislative body. A small documentation presenting the facts of the matter could be useful for such awareness creation.

2. There must be a conscious effort to investigate all energy policies and private energy services in order to identify areas where poverty alleviation measures could be integrated. All sections of the EAD could be asked to undertake this task periodically and the results collated together as a MMEWA policy document on poverty alleviation. This should aim at things that can be done to assist the poor and vulnerable communities as well as government institutions in order to benefit adequately from such policies and services. It could include appropriate targeted subsidies, job creation opportunities in energy policies and service deliveries and supportive acquisition of appliances by households and government institutions.

3. A special effort should be made to target women concerning poverty alleviation. This study makes it clear how female-headed households form the majority of poorer households. The provision of energy services should therefore explore ways of supporting income-generating activities of women. These could start from small-scale home businesses like sewing and knitting, hair saloons, tuck shops, poultry, tourism attractive products, and women could be also encouraged in the new and renewable energy technologies. This task should not be left on the shoulders of government alone but the private sector should also be drawn in. In South Africa, Eskom, which is a parastatal, has been extensively involved in business creation in terms of provision of funding and business advice. Sasol and other petroleum companies have also been supportive of this. It would also require encouraging women education in technical and business disciplines.

12. Conclusions and recommendations

Conclusions

In terms of the Terms of Reference of this study it can be concluded that the project objectives have been adequately addressed. This has been done in terms of establishing current household energy use patterns, the main socio-economic drivers of fuelwood/energy use and the energy burden on households, future strategies and fuelwood demand projections, and established database with current energy use patterns.

Energy use patterns

About 76% of all the 794 households surveyed were using gas for various end-uses, especially cooking. Comparing current gas use to estimates from the 1996 Botswana Energy Master Plan (BEMP), which was largely based on data collected a decade ago, shows a dramatic increase in urban gas use from 45%. This gives an indication of the effectiveness of the provision of appropriate enabling environment for marketing gas throughout the urban areas of the country, and this has resulted in a huge switch to gas usage despite the fact that there has been about 37% increment in urbanisation over a decade.

Paraffin and electricity come next in terms of extent of use amongst urban households with about 54% and 50% of households respectively. However, comparison with BEMP 96 shows that the dependence of paraffin use has decreased from 70% whilst the use of electricity has almost doubled from 24%. This could be attributed to the improvement in income distribution that has enabled households to switch from less convenient energy sources to more convenient sources.

Although the extent of fuelwood use has decreased, this has not been that significant compared with the shifts between the fuels above. The extent of fuelwood dependence amongst urban households has decreased from the BEMP 96 estimates of 55% to about 43% of all the households surveyed.

Surprisingly coal does not feature at all as an important fuel in urban households. Although the Expanded Coal Utilisation Project has been promoted as a means of reducing over-dependence on fuelwood, urban households' dependence on coal has remained merely under 1%.

The level of electrification of government institutions is impressive. Electricity is the most widely used fuel amongst government institutions, being used mainly for lighting and space heating. Although about 90% of all the government institutions surveyed are electrified, the use of electricity for cooking is very limited especially amongst the Primary and Community Junior Secondary Schools (CJSS).

Fuelwood is the second most widely used fuel amongst public institutions. Almost 80% of all the institutions use fuelwood in the survey and the most prominent are the Primary Schools, all of which use this source of energy. This is followed by the CJSS (88%), Prisons (75%) and the Senior Secondary Schools (SSS) (67%) respectively but the other type of institutions do not use fuelwood at all. Gas (LPG) is the third most widely used energy source with about a half of the institutions surveyed using it. Solar electricity also features as an energy source used only by schools. Half of the SSS surveyed use solar energy, about 20% of the CJSS also use it as well as one out of the 12 Primary Schools surveyed.

Unlike the households where the promotion of coal use has been unsuccessful, there is some indication of success amongst the public institutions with about a third of the institutions surveyed using coal. Over 40% of the CJSS and the Primary Schools use coal, a quarter of the Prisons also use it as well as one of the 2 two Hospitals surveyed. All the 6 SSS, the 2 Clinics and the one Teachers' College surveyed do not use coal at all.

Impact of socio-economic development on fuelwood use

The impact of socio-economic development on fuelwood use has been addressed in this study by examining the improvement in the economic situation of households based on income distribution. This study has shown that Botswana has made significant progress in improving income distribution amongst urban households, which has consequently resulted in higher affordability of and access to energy services more convenient than fuelwood use. The improvement in income distribution has enabled urban households to switch from less convenient fuels like fuelwood, paraffin and candles to mostly liquefied petroleum gas and to a less extent to electricity.

Socio-economic drivers of household energy use

- One key driver of household fuelwood use is poverty.
- The cheapness of fuelwood compared with other energy sources is another major driving factor for fuelwood use in the urban areas. This driver is much stronger in the urban towns.
- The social attachment to fuelwood use is a key driver of why households are unwilling to switch to other energy sources, especially in the urban villages.
- For about 50% of fuelwood users, lack of access to other fuels like electricity and gas is the main driving factor for using fuelwood. For gas, lack of access was expressed in terms of unaffordable cost of gas cylinders and appliance acquisition.
- In electrified households, the main driver for using fuelwood is the financial difficulties in acquiring appliances. Other drivers are the unreliability of electricity supply and the high cost of electricity.
- The main reason why about a third of the households expressed likeness for cooking with solar stoves and about half expressed likeness for solar water heating is the fact that the energy source is free and as such the households could make some savings out of it.
- The main motivation for using electricity for cooking by urban households is its ease of use more than anything else.
- The main motivations for most households using gas for cooking are the comparatively cheapness of the fuel (compared with electricity), the easy use of the fuel and the easy access to the fuel (easier than electricity).

Multiple fuel use phenomenon

It is worth noting that fuelwood is widely used in urban households in conjunction with other fuels. Thus, the switch from fuelwood, and the strategies involved, must relate to the use of other fuels for specific end uses. Two important considerations involving fuelwood switch in this study are that:

- About 44% of households using fuelwood as the main cooking fuel are already exposed to gas use and may already have the infrastructure for switching to gas use.
- About 61% of those using gas as the main cooking fuel also use fuelwood as a secondary fuel, which indicates that most of the gas switch has been *partial.*

Energy burden

Energy expenditure seems to be more burdensome for households using fuelwood than those that are not using fuelwood. The burden is greater on the lower income households than higher income households and that the gap narrows with increase in income. This is another indication of energy poverty amongst fuelwood users.

The monthly expenditure on fuelwood is quite a significant portion of the household energy budget in lower income households. In the lowest income group (where most of the fuelwood users belong) this expenditure constitutes more than half the energy budget. In higher income households the fuelwood portion of the energy budget is smaller.

In the case of the public institutions, the study shows that whilst the energy budgets of SSS and CJSS are mainly borne by the Ministry of Education, that of the Primary Schools is largely borne by the parents themselves. The pupils are sometimes asked to bring firewood to school. The energy burden on Primary Schools is far greater than that of other institutions. It is therefore not surprising that the Primary Schools are very much dependent on fuelwood.

Future strategies and fuelwood demand projections

The study has shown that there are a number of future strategies that could make some significant impacts on the dependence on fuelwood use. These are poverty alleviation, fuel switching from fuelwood to gas, appropriate financial mechanisms to enhance electrification, promotion of efficient fuelwood cookstoves, promotion of solar water heaters and cookers, and the promotion of coal stoves in public institutions. On the fuelwood supply-side, improved availability of fuelwood resources in urban neighbourhood should be the strategy instead of dependence on rural areas of supply. Of all the strategies, fuel switching from fuelwood to gas seemed the most plausible as there is a lot of goodwill out there amongst households already.

One striking observation was that the national urban residential fuelwood demand seems to have been over projected in the past. Whilst the 1996/97 Energy Statistics Bulletin estimated urban residential fuelwood demand of 279 kilotonnes, the current study found this to be only 196 kilotonnes. The current annual fuelwood demand by institutions was estimated by this study as about 71 kilotonnes and all the strategies seem to result in fuelwood reduction in the institutions. The total of urban residential and institutions fuelwood demand was estimated as about 267 kilotonnes per annum.

The fuelwood projections in this study indicate that, in order to promote sustainable fuelwood use by households, the main thrust of government should be around promoting affordable and accessible use of gas in all areas. This involves addressing barriers to gas use by poorer households in particular, such as access cost (gas cylinder purchase or deposit), appliance cost, availability (transporting heavy gas bottles can be difficult), gas price, and possibly remaining perceptions around its safe use. Promoting the establishment of a more extensive chain of smaller gas dealers at the community level may be appropriate, although depot safety concerns will need to be kept in mind.

Updated fuelwood information source

This study provides an updated information source on urban household energy use in a database with special emphasis on fuelwood. The wealth of information collected in the database is far beyond the analysed data in this report since only the data required for the Terms of Reference was analysed. The EAD database has been reviewed and it has been realised that the data content is purely aggregate information and thus any useful linkage with the data collected in this study will have to be at the aggregate level. The aggregated information in this report, especially the fuelwood demand projections will be useful for that purpose. The survey data has been organised and analysed in three data sets in Microsoft Access. The main database is on households, and the other two are on institutions and fuelwood/energy dealers.

Recommendations

Since the monthly expenditure on fuelwood amongst the lowest income households is quite substantial, the policy implication would be that this amount could contribute to paying for other energy options that are more convenient like gas or electricity. Some education would help in making this realisation clear to households when alternative energy options are offered to them.

The extent to which urban dwellers have shifted in their thinking concerning the usual myth that, the use of gas is unsafe, to the convenience of gas use is very encouraging. There is a need to strengthen such realisation if more households are to switch from fuelwood to gas. Currently, the abundance of gas dealers has improved distribution of the fuel and the free home delivery of gas by dealers is another incentive. Furthermore, housing developments have now started incorporating gas outlets in housing designs whilst provision for electric cookers are sometimes not even considered. These key factors that have contributed to the extensive use of gas should be encouraged.

In spite of the fact that there is significant progress made in implementing policies addressing gas affordability and access, about a third of gas users are dissatisfied largely due to gas unavailability. This is mainly in the villages. There is a need to strengthen strategies of affordability and improved access for sustaining the cheapness of gas in order to encourage its continued use. Whilst the price and appliance acquisition were mentioned as other reasons, it is clear from this project that the issue of gas unavailability needs to be addressed as a matter of priority in order to boost the reliability of gas use. It seems that this will make positive impact on the livelihood of many households since about 70% of urban households use gas for cooking.

The lower levels of electricity consumption in the villages should be taken into account in electrification planning in order to realise the targeted uptake. Electricity connection alone is not enough for improving energy access unless it is coupled with the appropriate financial mechanisms for wiring and appliance ownership. It is only when electricity demand is stimulated in this way that it would lead to significant impact on the reduction of fuelwood use. Since electricity generally appears to be amongst the preferred energy sources, it seems safe to deduce that households that can easily access electricity would do so. Therefore factors such as affordability of connection and appliance acquisition, and proximity of the grid are where strategies need to focus to promote the use of electricity.

It must be noted that the willingness of households to switch to either coal or paraffin is not significant (not more than 5% of fuelwood users). This is worth noting in relation to the strategy to promote household coal use.

In the promotion of solar water heating and cooking, it must be clear from the onset that environmental savings do not matter much to households and that what matters most is the cost savings. It is therefore important to create the necessary awareness concerning the cost implications and the features of solar cooking so that their preference for solar would be based on realistic reasoning. When the switch of households to these solar technologies are based on realistic reasoning then it could be certain that the fuelwood savings involved would be sustainable. Furthermore, the promotion of these solar technologies should specifically target the poor with the appropriate incentives in order to make any meaningful impact on fuelwood use reduction.

Solar cookers can be relatively cheap and a pilot project to assess the willingness to pay for them in practice as well as the cultural and social acceptability of this cooking technology is worth exploring. RIIC's work in this regard could be a natural starting point. However, as with fuel efficient stoves, many such programmes have been attempted in the past with little real impact on fuelwood use patterns of households, and thus one should proceed cautiously based on proper analysis of these attempts.

Initiatives on wood-saving stoves in other parts of Southern Africa have resulted in disappointing results regarding fuelwood saving in spite of carefully implemented long-term programmes. However, since this study shows that there is a lot of willingness to use these stoves, it may be worthwhile to implement a pilot fuel efficient stove programme as a job creation tool, but previous efforts in this regard will need to be evaluated in more detail first.

To make the government directive stopping all government institutions from using fuelwood effective, the government would have to support the institutions with their energy budget and in the provision of appropriate functioning kitchens.

To ensure that urban households are not solely dependent on rural areas for their fuelwood supply, and also to reduce the environmental burden on both the rural and urban areas, government would have to embark on an effective urban forestry renewal programme.

The current EAD energy database in Lotus software has gone obsolete in terms of data and software design. It would require a thorough review of all databases available and the necessity to link them in order to assess what software platform would be more suitable for the design. Consideration should also be made of all external databases in other Government departments that may be necessary to be linked to the EAD database. However, whatever software platform is chosen for the database design, it would have to be adaptable to a wider scope of versatile current and potential future softwares in order to allow easy import from and export to the database. For example, the Microsoft Office software packages are currently easy to import from and export to one another and it would be easy to link a Microsoft Access database platform to other data formats.

In terms of exploring other issues in the household energy use database of this study that were not analysed, the questionnaires in the Appendices 3-5 of this report would help to identify which questions could have been explored further in the analysis.

When Francistown, where fuelwood is used extensively, is considered in the national urban picture, the estimation of fuelwood use amongst households rises from 43% to about 48%. This 5% increment in the extent of fuelwood use by the inclusion of Francistown data is very significant and points to the need for quality and reliable data. Thus, there is a need for an appropriate sampling frame in the estimation of the national fuelwood demand. Assuming an urban population of about 800 000 and an annual per capita fuelwood consumption of about 200 kg, a 5% decrease in the extent of fuelwood use would be equivalent to a reduction of 8 000 tonnes of fuelwood in fuelwood demand estimation.

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