7-2003

Household's Consumption Pattern and Demand for Energy in Urban Ethiopia

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By: Samuel Faye Gamtessa*

Abstract

This study looks into the energy demand and consumption pattern of households in selected urban areas. The analysis indicates that the use of traditional fuels dominates households' consumption pattern. However, the extent of the dominance varies across cities/towns and across income groups. A multivariate analysis of the consumption pattern reveals that the probability of consuming traditional fuels in general declines with increase in income and prices of the traditional fuels where as it increases with the increase in the prices of the modern fuels. The probability of consuming modern fuels increases with increase in income and prices of the traditional fuels and declines with an increase in modern fuel prices.

CLAD estimation of demand functions using micro data indicates that demand for all forms of energy are price elastic. Cross price relations indicate that kerosene is a substitute for both charcoal and firewood, where as electricity is a substitute for all the three. Charcoal and firewood are complements. The result that electricity is a substitute for all forms of energy gives indication that the long-run option in ensuring energy transition is to harness the huge hydro-electric generation potential of the country. All the energy sources considered were found to have income elasticities very close to one owing to the fact that energy consumption is a necessity. The other point to note is that household size has been identified as one important variable that increases demand for all forms of energy.

Owing to the fact that the consumption pattern in Addis Ababa is substantially different from others, this effect is captured by a dummy variable and the estimated coefficients indicate that the use of traditional fuels increases with the probability of being outside Addis Ababa where as the opposite holds for the use of modern fuel, emphasizing the impact of the level of urbanization on energy consumption pattern.

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I. Introduction

Consumption of traditional fuels has negative environmental, economic and health impacts. That is, increased use of firewood and charcoal leads to deforestation, leading to ecological imbalance, and increased use of agricultural residues and animal dung deprives the land of essential nutrients that are necessary for soil fertility. Furthermore, smoke from the use of fuel wood and dung for cooking contributes to acute respiratory infections. This latter problem, i.e., in door air pollution is worse in poor countries where households' houses are not equipped with separate living and cooking places.

Nonetheless, almost 2 billion people are dependent on biomass fuel and all of these are in low-income countries (Anderson, 1996). Meanwhile, many African countries adopted structural adjustment programs since early 1980s, which has raised the costs of using modern fuels due to price deregulations and exchange rate depreciations. World Bank (1989) shows that the annual growth rates in modern energy consumption have been on the decrease in Sub-Saharan Africa; the annual growth rate decreased from 7 percent between 1965 and 1970, to 2.2 percent between 1980 and 1987. This has direct implication for greater reliance on the traditional sources of energy despite the countries' interest to insure energy transition. As a result, fuel wood gathering is one of the major contributory factors to deforestation, which is already claiming about 10 Million hectares of forest each year in the developing world (World Bank, 1984). This excessive deforestation has resulted in fuel wood crises in many countries and hence agricultural residue and animal dung are being substituted for fuel wood. But, this reduces the availability of valuable soil nutrients and hence reduces soil fertility, contributing to slowdown in agricultural production (Lopez, 1997).

Being one of the poorest countries of the world, Ethiopia's experience is not an exception. The mainstay of the country is agriculture, which accounts for about 50% of GDP, 90% of exports and 85% of employment. The country has experienced heavy dependence on traditional energy consumption, with all the negative repercussions associated with it. The energy balance of the country as of 1995/96 reveals that total energy consumption in Ethiopia was estimated at 723 peta joules or about 50 million tones of wood equivalent and is characterized by high dependence on biomass fuels. The contribution of wood fuel alone was about 77 percent of the final consumption and agricultural residue and dung accounted for about 16 percent which means that the share of traditional fuels in the national energy consumption was above 90 percent. Modern energy (petroleum fuel and electricity) accounted only for about 5.5% of total energy consumption, the share of petroleum being about 4.8% and that of Electricity being 0.7%. Sectoral breakdown (table 1) reveals that about 90 percent of the overall energy consumption of the country is that of households out of which the share of urban households is only 6 %. Rural households almost entirely rely on the traditional fuels where as the share of modern fuels in urban households' consumption was about 20 percent. Thus, the extent of dependence on traditional fuels is very high.

This phenomenon has had serious repercussions for the ecological imbalance and agricultural activities in general. For instance, a forecast by CESEN (1986) indicates that the fraction of 'weredas' with critical deforestation would rise from 58.7% in 1984 to 75.7% in year 2005.

According to some estimates, the proportion of land under forest cover has declined to less than 3% (EFAP, 1993). Despite these all, consumption of biomass fuel has been increasing at average annual increment of 2.5% over the last two decades (Mekonnen, 2000).

The excessive deforestation, which led to the depletion of tree stock, caused what is known as the household energy crisis in Ethiopia. The cost of firewood increased, thus, challenging the already staggering living condition. For instance, the cost of firewood in Addis Ababa has increased from US$9 to US$ 90 per tone between 1973 and 1983 and claimed up to 20% of household income (World Bank, 1984: iv). This crisis led to consumption shift towards animal dung and crop residue as household fuels. World Bank (1984) notes that although there is strong cultural preference in Ethiopia to use fire wood and charcoal for cooking, this preference had been affected by the scarcity of wood and hence, people started using dung and crop residue which accounted for over half of the total households' energy use (World Bank, 1984: 4). Increased burning of dung and crop residue, however, deprives the soil of important nutrients and hence reduces soil fertility. This means, agriculture, which is the mainstay of the economy, is negatively affected by the existing consumption pattern. It is estimated that nutrient loss and soil erosion result in forgone agricultural production of close to 600,000 tons of grain per year and this is equivalent to 90 percent of Ethiopia's food deficit in 1993 (World Bank, 1995). The loss of soil fertility and land degradation leads to financial loss of about 2% of GDP in Ethiopia (EFAP, 1993). World Bank (1984) estimate shows that the growing diversion of natural fertilizers in dung and crop residues to household fireplaces reduced crop yields by more than one million tones of grain a year. This problem is one of the major problems affecting the future of Ethiopia and hence should stand as the nations' top priorities to be considered by policy makers. As is stated in World Bank (1984: ii);

> *"the most important issue in the future of Ethiopia is the supply of fuels, the related massive deforestation, and the resultant and insidious depletion of agricultural resources on which so much economic activity depends."*

However, the extent of agro-forestry practices has remained at very unsatisfactory levels in relation with the extent of the problem. Furthermore, supply of the alternative source of energy, i.e., the modern sources of energy, has remained at a low level. By the year 2000, only 13% of the total population got access to electricity, despite the country's immense hydroelectric generation potential. Supply and distribution of petroleum fuel has been influenced by several factors such as foreign exchange availability; transport problems; accessibility, and affordability. Fuel imports generally claim above 42 percent of the export earnings of the country exerting significant strain on the balance of payments. Thus, there is significant constraint on the supply side. Furthermore, the inefficient way the people use energy did not change much, i.e., most people use open fire to cook their food without any heat insulating mechanisms and use clay pots as opposed to aluminum pots that are more fuel efficient. Thus, there is no any indication of significant measures to arrest the problem.

The Federal Democratic Republic of Ethiopia has clearly put in its Energy policy document (1994) that it envisages for transforming the energy consumption pattern from the traditional to modern fuel and energy conservation in all types of uses. It has also stressed rational development and exploitation of indigenous energy sources such as hydroelectric powers, and natural gas. It also stresses affordability.

Furthermore, because of the overall macroeconomic policy direction towards a market oriented economy, a flexible exchange rate and price deregulation were implemented leading to continuous increases in prices of petroleum fuels and electricity tariff, although kerosene and electricity prices are still being subsidized. Kerosene price that was Birr 0.66 in September 1992 reached Birr 2.00 currently in Addis Ababa. The prices are higher as we move out side Addis since price is varied owing to differences in transportation costs. Average electricity tariff for residential use increased from Br 0.1399 to Birr 0.3897 during the same period.

Needles to say, the increase in prices of modern energy would however act against the government's declared objective of bringing about energy transition. The affordability issue is quite crucial given the very low income of the people. For instance Bereket et al (2001) indicated that electricity consumption is highly unaffordable for urban households in Ethiopia.

The attempt to influence the existing consumption patterns requires identification of those factors significantly contributing to the exiting situation, and the possible options through which one can influence them. To this effect, identification of the factors governing the current energy consumption patterns will be helpful to show the appropriate target variables in the attempt to influence the exiting patterns and hence bring about the envisaged transition. Knowledge about the various factors underlying the existing consumption pattern helps policy makers to prescribe measures that will strengthen the conditions that encourage use of modern fuels while opting for measures that will weaken reliance on traditional fuels. Furthermore, knowledge of basic income and price elasticities could be crucial for the purpose of planning and forecasting energy demand and in assessing the effects of energy related policies such as subsidies, taxes and energy conservation measures. In general, formulation and implementation of energy related policy requires detailed knowledge of the existing consumption pattern, substitution possibilities among the various household energy sources and the responsiveness of household energy demand to changes in prices, income, etc.

Studies on household energy demand in urban Ethiopia was carried out by CESEN (1986), Asmerom (1991) and Bereket et al (2001). But there are several gaps that need to be filled in order to enrich the literature. For instance, CESEN (1986) provides estimation of end-use demand functions, which implies that the results can not be used as direct policy inputs. Asmerom (1991) result is based on an inherently flawed method and the results are not in harmony with the existing use pattern. Bereket et al (2001) is relatively a better one in terms coverage of the various types of energy sources and the functional form used. However, the study uses Tobit estimation technique whose reliability is highly dependent on absence of heteroskedasticity and non-normality, both of which are almost always existent. Furthermore, the method used in estimating cost of energy seems to be unrealistic. Thus, in line with the limited number of empirical literature and the methodological problems they exhibited this paper will have significant contribution in that it adopts appropriate and recent estimation techniques and used appropriate and data admissible models. Thus, this study will significantly contribute to the existing literature. The paper gives up to date information on the existing energy consumption pattern in major towns/cities. The focus on the major towns, although guided by availability of data, will be very interesting since energy transition should first take place in such major towns/cities.

The rest of the paper is organized as follows. The next section presents the description of the consumption pattern, and analyzes the underlying factors of the pattern. Demand for household energy is analyzed in section three. Section four concludes the paper by presenting summary of results and concluding remarks.

2. Household Energy Consumption Pattern in Urban Ethiopia

2.1. Descriptive Analysis

The urban socio-economic survey conducted by the Department Economics of Addis Ababa University in the year 2000 covers seven towns and cities; namely: Addis Ababa, Awassa, Bahir Dar, Dessie, Dire Dawa, Jima, and Mekele. The sample size is 1,500 households, with an average household size of six. The overall sample size of the survey is considered in this study so that only households with missing essential information are excluded. Therefore, about one thousand four hundred fifty one (1,451) households are covered in this study out of which eight hundred sixty two (862) were from Addis Ababa. The sample sizes in other towns/cities are 76 in Awassa, 95 in Bahir Dar, 100 in Dessie, 125 in Dire Dawa, 96 in Jima and 97 in Mekele. ANOVA analysis shows that mean equality hypothesis across the cities/towns is rejected for all the variables of our interest, i.e., household size, average household overall and energy expenditure, expenditure shares of all energy forms, and prices of the fuel groups except electricity.

Information about households' consumption of the traditional energy forms is compiled based on local measurement units that are variable across the different towns and to some extent across households. Quantity data is computed by dividing households' value of expenditure on a particular form of energy by price per unit of measurement. For instance, quantity in terms of firewood consumed in 'chinet' is computed by dividing the households' expenditure by price per 'chinet', which is assumed to be fairly uniform within a city/town. However, comparison based on these quantity data across the cities/towns may not be feasible since 'chinet' is not a standard measurement unit, which represents uniform amount across all the cities/towns. As a result, the discussion is based on expenditure share and the proportion of households that consumed the energy source, regardless of the amount consumed. Furthermore, the analysis uses expenditure as a proxy of household income because of three reasons. First, in examining the energy pattern of households, budget shares of individual sources of energy are computed using expenditure as a base. Second, expenditure data appears to be more reliable due to the possible under-reporting by the households, and the errors that might be committed while pooling all the possible sources of individual household incomes together due to the diversity in the sources of income. Third, in demand analysis, it is expenditure rather than income, which is the appropriate variable for analyzing the effect of income. Fourth, data on households' expenditure captures monthly, quarterly and annual information. Thus, it is the most reliable data for information on expenditure groups since monthly information could be obtained from the annual or quarterly data for greater accuracy Accordingly, expenditure on all the energy categories except for the ones grouped under "others" for which expenditure data is not provided are computed from the annual data for energy expenditure categorized under "non-food" group. The approach is a standard approach followed by several other studies such as Hossier and Kipondya (1993) for Tanzania, Alam et al (1998) for India and Bereket et al (2001) for Ethiopia.

Table 1: Summary of the Sample by Cities/Towns and Energy group

	Number of Households Consuming:										Total No. hhs.
City	Fire wood	charcoal	Dung cake	twigs & branch	Leaves	Crop Residue	Kero	LPG	Electri -city	others	
Addis	395	541	89	45	56	11	726	26	819	14	862
Awassa	61	60	8	3	0	20	55	0	72	1	76
Bahir Dar	81	85	30	2	4	1	15	0	85	0	95
Dessie	74	57	6	8	4	0	63	0	92	0	100
Dire Dawa	80	79	1	3	0	0	91	1	107	0	125
Jima	79	87	2	0	1	0	17	0	92	0	96
Mekele	64	77	10	1	3	0	63	0	80	0	97
Total	834	986	146	62	68	32	1030	27	1347	15	1451

Source: Department of Economics, Addis Ababa University

'Injera' baking is the major component of household energy requirement in Ethiopia. Over 50 percent of the overall households' energy consumption is for 'injera' baking (World Bank, 1984). Specifically, urban households use electricity and fire wood in most cases and leaves, animal dung, crop residue and twigs and branches in some cases; i.e., it is only kerosene that is not needed for this purpose. Electricity is required for several other purposes, lighting being the most important use of electricity in urban areas, where as firewood is mostly required for baking only, particularly in Addis Ababa. Since 'injera' is baked in almost every household, the fact that few proportion of the households considered consume firewood, dung, crop residue, leaves, and twigs and branches mean that electricity is taking care of the task of baking 'injera'. This is true given a widespread distribution of electricity 'mtad'[1] in recent past. Furthermore, widespread use of firewood and electricity together may mean that electricity is not being used for baking 'injera' since they may afford to use electricity only for lighting. This is the feature observed in all towns other than Addis Ababa. Where as the proportion of households consuming electricity in other towns is not substantially different from that of Addis Ababa, the difference in terms of firewood is significant. Bereket et.al (2001) indicates that electricity cost is unaffordable for most households.

Electricity is the largest in terms of the proportion of households consuming it in all cities/towns except in Bahir Dar where the ratio is the same for both charcoal and electricity. The largest ratio of households not consuming electricity is observed in Mekele (17 %). The small standard deviation of the proportions indicates that the consumption pattern is similar in all cities/towns in terms of electricity. Significant variation is observed in terms of all others, that of kerosene being very big. This has been due to very small proportions observed in Jima and Bahir Dar towns. Exclusion of these two towns reduces the standard deviation from 28 to 9 indicating that consumption pattern among the cities/ towns except the two is comparable also in terms of

[1] 'Mtad' is a clay-made circular pan used for baking 'injera'

kerosene. The measure of variation in consumption patterns in terms of charcoal and firewood indicates also that there is significant variation among the cities/towns.

Furthermore, the ratio of households consuming electricity is the highest followed by kerosene, charcoal and firewood at aggregate level. However, city/town specific observation reveals that this ranking does not hold in all the cities/towns. For instance, firewood is the second widely used energy source whose use is the second most in Awassa and Dessie where as charcoal takes the position of kerosene in Mekele and Jima. Kerosene, which is the second most widely used in general is the fourth in Awassa, Bahir Dar, and Jima.

Table 2: Ratio of households consuming a particular energy source (%)

City	Charcoal	Fire wood	Kerosene	Electricity	Others
Addis Ababa	63	46	84	95	26
Awassa	79	80	72	95	13
Bahir Dar	90	85	16	90	35
Dessie	57	74	63	92	14
Dire Dawa	63	64	73	86	3
Jima	91	82	18	96	3
Mekele	79	66	65	83	8
Average	**68**	**57**	**71**	**93**	**20**
St. Dev.	**14**	**14**	**28**	**5**	**12**

Source: Ibid

The number of households consuming dung cakes, leaves, crop residue, twigs and braches and LPG are very small. Taking them all together, only 20 percent of the households consume them. Thus, while they individually account for very small proportion, their share as a group is not insignificant. In terms of the number of households consuming a particular energy source, electricity is the leader followed by kerosene, charcoal, and firewood, in that order. Thus, the use of modern fuels is widespread, conforming to the salient feature of energy consumption pattern in urban centers.

The data shows that the average overall expenditure is Birr481.30 where as energy expenditure is Birr 59.63 per month, which accounts for about 12.40 percent of the average overall households' expenditure. This is very close to data from CSA (1997) report of the 1995/96 survey that indicates that the average monthly expenditure on energy accounts for 9.24 percent. There have been significant increases in prices of kerosene and electricity tariff since 1995/96 and this may be one of the reasons behind the rise in energy budget. Furthermore, the coverage of the survey is different in that the CSA, 1995/96 survey considers all enumeration area with 2000 or more inhabitants as an urban center. In such small centers, one cannot really make a clear distinction between urban and rural energy consumption patterns. The reason is that there is absence or limited supply of modern energy and easy access to the traditional fuels. Most of the time people living in such small towns collect the fuels themselves instead of purchasing.

Households' preference for a particular energy source is a function of several factors such as familiarity with the energy source, price, access, reliable supply, effectiveness etc. According to the information compiled on households' preference for cooking fuels, price stands out to be the major reason for a particular fuel to be the most preferred fuel. Five hundred thirty three (533) out of one thousand four hundred forty six (1, 446) households attribute their preference to cheapness. Of all factors, price, easy access and effectiveness are the major factors although familiarity is also a major factor. Price is fairly different across the cross sectional unit considered here except for electricity for which uniform price is set through out the country. Access is dissimilar and familiarity and households' perception regarding effectiveness could also vary across the cities.

Table 3: Summary of Households Expenditure

City	Monthly Average Expenditure (in Birr)	Monthly Average Energy Expenditure (in Birr)	Expenditure Share of Energy (%)	Traditional Fuel (%)	Modern Fuel (%)	Average Household Size
Addis Ababa	520	68	12.05	37	63	6
Awassa	716	62	11.5	54	46	7
Bahir Dar	551	49	13.4	60	40	6
Dessie	268	42	23	55	45	4
Dire Dawa	320	49	21	45	55	5
Jima	348	41	13	63	37	6
Mekele	476	45	10.2	57	43	6
Average	481	60	12.5	52	48	6

Source: Department of Economics, Addis Ababa University

Addis Ababa is the leader in terms of average monthly energy expenditure and its share in the overall monthly household budget. The maximum monthly fuel cost is Birr 68.12 whereas the lowest is Br 41 in Jima. Energy expenditure in all cities other than Addis Ababa and Awassa lie between Birr49.40 and Birr 41, where as the figures for Addis Ababa and Awassa are Birr 68.12 and Birr 62.49 respectively.

In terms of expenditure share, Dessie stands out as an outlier with the share being as high as 23 percent, closely followed by Dire Dawa (21 percent). The lowest expenditure share is observed in Mekele, 10.2 percent. This implies that energy budget is significant in urban Ethiopia. In conformity with the general prescription that expenditure share of energy decreases with increases in overall budget (income), the largest expenditure share (23 percent) was observed in Dessie town where the overall average household budget (income) is the least of all (Birr268.50). Furthermore, ranking the towns/cities in terms of expenditure shares of energy tallies with the inverse of the raking in terms average household budget (income) except Mekele, which has the lowest expenditure share where as it stands fourth in terms of average monthly budget (expenditure). This could be due to less widespread use of electricity. Furthermore, it could be due to a relatively better energy conservation culture of the people. World Bank (1983) reports that the traditional baking stove used in Tigray is 25% more energy efficient than the three stone open fire stove used in other parts of the country.

In terms of composition, the share of firewood is 24.4 percent where as that of electricity is 33.8 percent, implying that the two alone account for about 60 percent of the energy budget. The shares of charcoal, kerosene and "others" were 18.8, 14.6 and 8.5 percent, respectively. The modern-traditional distinction shows that electricity and kerosene accounted for 48 percent of the energy budget, the remaining 52 percent being accounted for by traditional fuels. Comparison with the 1995/96 CSA survey confirms the general dominance of the consumption pattern by the traditional fuels. The share of traditional fuels was 60 percent. The fact that use of the traditional energy dominates energy consumption patterns even in the urban areas means that Ethiopia is at the lower edge of the 'energy transition ladder" (Bereket et. al, 2001). The overall pattern that energy expenditure share declines as households budget (income) increases is confirmed from comparison across the cities/towns. Product specific consideration reveals that although the pattern is similar with the general case, the importance of charcoal varies little with income.

The role of household size as one of the factors behind the variation in household expenditure is discerned by the use of per capita energy expenditure. The extent of the variation across the cities almost vanishes when we use per capita data.

It is indicated that electricity is the leader in terms of the proportion of households consuming it and its share in households' energy budget in all cities/towns. This uniform pattern shows greater variation when we concentrate on cooking fuels. In Addis Ababa, kerosene is the major cooking fuel consumed by about 85 percent of the households considered and claims birr15 out of the total birr 68.42 average monthly energy budget (about 22%). This pattern is peculiar with Addis Ababa. In terms of both the proportion of households consuming it and average monthly budget, firewood is the major fuel in all cities/towns other than Addis Ababa.

This could be due to the fact that firewood is used both for cooking and baking in many of the cities/towns; and due to non-reliability of kerosene supply. As a matter of fact, data on households' first preferred fuel indicates that kerosene is the most preferred fuel, the major reason being its effectiveness. On the other hand, firewood is the next most preferred fuel because of its cheapness in most cases. More than fifty percent of the households stated that firewood is their first preference because of its cheapness. Furthermore, a significant number of households believe that it is easy to get firewood and prefer it for its familiarity. Thus, variation in relative price of kerosene and firewood, availability and familiarity with firewood seem to be the major reasons for the variation between Addis Ababa and the rest.

However, per unit price of firewood is not the highest and kerosene price is not the least in Addis Ababa. This implies that variation in consumption pattern is attributable to several factors. The most important factor is income level which governs the extent to which households consume more of a commercial fuel instead of the traditional one.

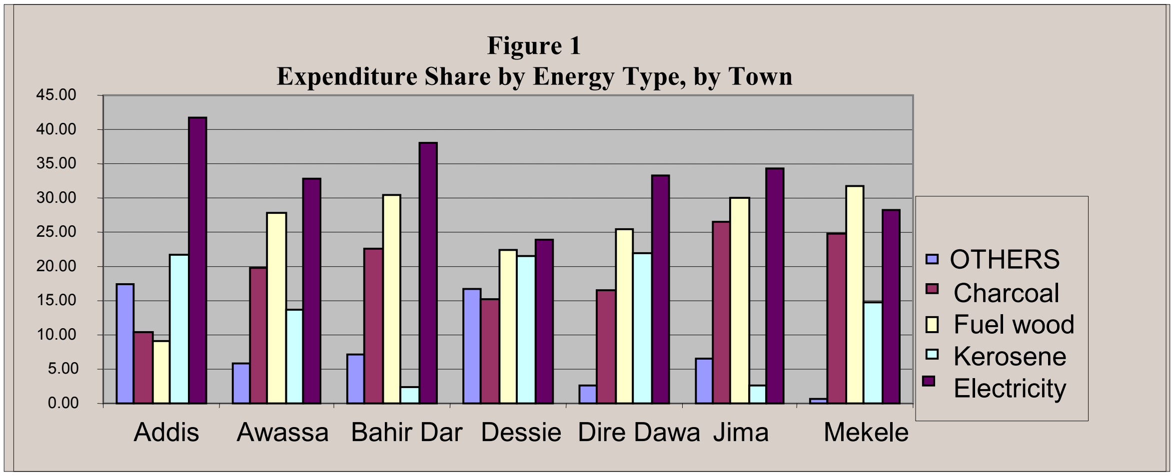

Figure 1
Expenditure Share by Energy Type, by Town

Charcoal stands as the third most important energy source in Awassa, Bahir Dar, Jima and Mekele where as kerosene is the third in the remaining towns except in Addis Ababa where the composite group categorized as "others" is the third. Firewood is the most important fuel in Mekele. The expenditure shares of each individual energy form are very close to each other in Dessie. Although it is difficult to conclude about the significance of energy source without knowledge of the volume consumed based only on its expenditure share on the aggregate level, such comparison gives a rough idea about the variation in its significance across the various cross sectional units.

Classification of households' energy budget into expenditure on modern energy (kerosene and electricity) indicates important variation in household energy consumption pattern across the towns. In particular, the share of modern fuels dominates that of traditional fuels in Addis Ababa and Dire Dawa. Thus, although traditional fuel claims the highest share of households' energy budget, the observation across the towns/cities indicates that this is not applicable in Addis Ababa and Dire Dawa. In some cases, the share of traditional fuels is as high as 63 percent (Jima) indicating the dominance of the traditional fuels in the consumption pattern.

However, the importance of the modern fuel is not systematically related with the variation in average incomes as we may expect. Although Awassa is the leader in terms of average income (expenditure), the importance of the traditional fuels overwhelms the other group. This indicates the importance of fixed location factors in determining households' energy consumption pattern in general. A more reliable explanation may however require grouping households according to levels of income/ expenditure and make comparison for similar groups across the cross sectional units. The following table indicates a neat variation in consumption pattern in relation with variation in income by simply grouping households in to three distinct income groups arbitrarily[2].

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[2] The number of households grouped under high, middle, and low-income groups are 208, 637 and 623, respectively. Location distribution of the groups indicates greater variation across the cities/towns. Most of households categorized under high-income group dwell in Addis Ababa (144 of 208). This may justify the dominance of modern fuel in Addis Ababa.

Table 4: Average Expenditure Share of Energy by Income (Expenditure) Groups

Income group	OTHERS	Charcoal	fuel wood	Kerosene	Electricity	Energy Total
Low (< 300 birr)	3.7	2.3	3.2	3.3	5.0	17.6
Middle (300-800)	1.8	1.9	2.2	2.6	4.9	13.0
High (>800)	1.2	1.2	1.0	1.6	4.4	9.3

Source: Department of Economics, Addis Ababa University

As indicated in the above table, expenditure share of energy is very high in the low-income group (18 percent), followed by the middle income group (13%) and the share in the high-income group is almost half of that of the low-income group (9.3 %). This is in line with the standard situation. It was shown in Bereket, et al (2001) that mean expenditure share of energy consistently decreases with expenditure deciles. Observation through individual fuel indicates that expenditure shares are higher in low-income group, and low in high-income group for all fuel types. However, the expenditure share of electricity and charcoal for all the income groups are very much close to each other. This indicates that their consumption increases with income until income reaches very high level.

Grouping all the fuels in to modern and traditional gives us a pattern which indicates that fuels are necessity and that there is a transition from the traditional fuels to modern fuels in general. That is, as we move from the low to high-income group, expenditure share of traditional fuel decreases from 9 percent to 3 percent. However, it should be noted that the trend for modern fuel is similar in this respect. This observation leads us to the distinction of two important points that are often confusing in the literature: energy transition and energy-income relationship.

Table 5: Expenditure Shares of Modern and Traditional Fuels

Group		Traditional	Modern
High income	Percentage of total Expenditure	3.3	6.06
	Percentage of energy expenditure	36	64
Middle income	Percentage of total Expenditure	5.9	7.6
	Percentage of energy expenditure	42	58
Low income	Percentage of total Expenditure	9	8
	Percentage of energy expenditure	53	47

Source: Ibid

The fact that expenditure share of energy declines as income grows, be it modern or traditional, is associated with the fact that energy is a necessity (less than one income elasticity). Energy transition is related with the fact that households would tend to consume more of modern fuels as their income grows. This point is not reflected from energy-income relationship. Rather, fair judgment requires the breakdown of energy budget into the traditional and modern fuels as we move across the various income groups.

Energy transition has the postulation that the share of modern fuels in households' energy budget increases as we move from low to high-income groups. The energy transition hypothesis is fairly confirmed in urban Ethiopia. In other words, the poverty of the households has something to do with the existing energy consumption pattern. Expenditure share of modern fuels increases from 47 percent to 64 percent while that of the traditional fuel decreases from 53 percent to 36 percent as we move up from low income to high-income groups. Again, this is in line with what was reflected from the 1995/96 CSA survey data. About 70 percent of the energy budget of the poor goes to biomass fuels (Bereket et.al. 2001:20). Thus, as compared to the poor, the rich spend relatively more on modern fuels. The pattern is in line with the general pattern that emerges out of studies conducted in less developed countries (for instance, Barns and Qian (1992); Hossier and Kipondaya (1993) and Alam et.al (1998)).

Cross sectional comparison of consumption patterns of households within the same income group is essential to give substantive evidence on the impact of locations. It is expected that location has significant effect since prices and accessibility of fuels are different across the points. Specific town/city level observation also confirms the possibility of energy transition as we move up from low to high-income groups. Furthermore, the hypothesis for a decline in energy expenditure share as we move up from low to high income groups is strongly confirmed in all cities except for Jima where the expenditure share is lower in the middle income group, being a typical evidence for location effect.

Table 6: Expenditure Share of Energy, by income group and town/city

Income group	Addis Ababa	Awassa	Bahir Dar	Dessie	Dire Dawa	Jima	Mekele
Low(< 300 birr)	19.1	12.9	12.8	22	15.6	14.5	12
Middle(300-800)	14	12.1	10.6	14.4	13.6	9.5	9.9
High(>800)	10.2	5.9	6.0	5.5	10.4	11.9	7.1

Source: Ibid

In conclusion, comparison of the consumption pattern in the various income groups indicates that the budget share of traditional fuels is higher in low-income group and declines as we move up from low to high-income groups. Comparing the consumption patterns of similar income groups across the cross sectional units indicates that the general observation shows strict adherence to the general consumption pattern regardless of location. The energy expenditure-income relationship is such that the expenditure shares of energy decline as we move up from low to high-income groups. This is a typical relationship that holds for any good that is a necessity. Location specific consideration reveals that this holds for all cities/ towns except Jima where energy expenditure share is higher in the middle-income group than in the low-income group. This shows the importance of location specific factors such as prices, accessibility and availability of fuels in guiding energy consumption patterns.

We may also need to see how the importance of a particular fuel varies as we move along the various expenditure groups and across the cross sectional units. Regardless of location, expenditure shares of all forms of energy decline as we move from low to high-income groups. The only exception is electricity where the share in the middle-income groups is higher than that of the low-income group. In all the income groups, electricity is the most important form of energy followed by firewood except in the low-income group where firewood dominates electricity. The ranking between others, charcoal and kerosene is such that others dominate both kerosene and charcoal in low-income group. Charcoal is the third essential fuel for high and middle-income groups followed by kerosene. This comparison reveals that only households with low income rely on animal dung, branches and agricultural residues. As income increases, these are replaced by other forms of energy.

The general feature that traditional fuels dominate in low income groups and leave way for modern in high income groups is somehow mixed when we compare on individual basis. For instance, charcoal and firewood dominate over kerosene in all income groups. This indicates the extent of reliance on traditional fuels for cooking.

The pattern may some how differ if we compare across the cross sectional units. In Addis Ababa, electricity dominates in all income groups, followed by kerosene. Firewood is the most important fuel in the consumption patterns of low-income households in all cities/towns other than Addis Ababa. Its dominance extends to middle income group in Mekele, and Awassa. The importance of kerosene is very low in towns other than Addis Ababa for all income groups. This indicates that the importance of a particular fuel in households' budget of the same income group varies as we move along the cross sectional units in a nutshell. That is, the consumption pattern of people within the same income bracket varies based on their location. The impact of location in affecting consumption pattern in affecting energy consumption pattern is emphasized in the literature. For instance, Horen et al (1993) have indicated that where as electricity is more or less replacing coal and kerosene, this trend is not observed in locations nearby the coalmines. This is the impact of low cost of coal that resulted from nearness. Locations are varied in terms of their level of urbanization, which is positively related, with consumption of modern fuels. Cities/towns surrounded with significantly deforested areas face lower supply and higher price of fuel wood (Bereket, et. al, 2000). May be, the dominance of the modern energy in Dire Dawa could be due to this. Dire Dawa area is a semi desert area and owing to this, the highest price for charcoal and firewood is observed. Meanwhile, due to its nearness to Djibouti, kerosene price is the lowest of all others. This takes us to the consideration of the impact of price variation across the locations.

Apart from income, prices are also variable across the cities, except electricity tariff. Thus, the variation in consumption could also be due to price differences. This may greatly affect the consumption pattern. As opposed to the case of Dire Dawa stated above, traditional fuel consumption dominates in Jima due to a relatively better biomass stock in the southwestern region of Ethiopia and relatively high price of kerosene. Variation in average household sizes may also contribute to the difference. Thus, a more profound analysis of the consumption patterns of households requires the simultaneous consideration of all the underlying factors. To highlight this, a probability model that captures factors affecting the probability of one form of energy being consumed by a certain household is estimated. Our point of interest is to highlight the underlying factors that encourage greater use of traditional fuels against the modern fuels and vice versa. This will be helpful to indicate what targets a policy that envisages bringing about energy transition should consider.

2.2. Multivariate Analysis of Energy Consumption Pattern: Traditional Vs. Modern

The starting point is subdividing total energy expenditure in to two general groups; traditional and modern. Then, values equal to one (1) are assigned for non-zero observations, so that they have dichotomous value. Then, the following two equations are specified for both of them:

$P(Y_m = 1) = P(\mathbf{B'X>0})$ and $P(Y_t = 1) = P(\mathbf{B'X>0})$, where m and t stand for modern and traditional fuels respectively. The set of parameters **B** reflect the impact of changes in X on the probability of Y being 1. The coefficient estimates of a Probit model are not necessarily marginal effects so that we are required to solve through a partial differentiation of the regression equation with respect to the variable of our interest. The econometrics software we use, Stata® gives us both types of coefficients. The equations estimated are:

$$P(Y_M) = P((\alpha_0 + \alpha_1 X + \sum_i^n \gamma_i P_i + \alpha_2 hhsize + \alpha_3 Daddis + \lambda i) > 0)$$

$$P(Y_T = 1) = P((\alpha_0 + \alpha_1 X + \sum_i^n \gamma_i P_i + \alpha_2 hhsize + \alpha_3 Daddis + \lambda i) > 0)$$

Where: X stands for household budget (income), P_i stands for prices of the various energy groups (here we have price data for kerosene, charcoal and firewood), hhsize is household size, and Daddis stands for Addis Ababa dummy, which is meant to capture the impact of difference in the level of urbanization. Its impact is expected to be positive in the modern energy equation and negative in the traditional energy model. Household size is expected to positively affect both probabilities. The impacts of the others cannot be judged a priory. White (1980) heteroskedasticity consistent (robust) estimators are estimated using Stata® and the following table summarizes the result.

Table 7: Probit Analysis of Energy Consumption Pattern

Traditional					Modern			
Variable	Beta	Slope	Z value	P>|Z|	Beta	Slope	Z value	P>|Z|
Exp	-.0002	-1.82	-1.82	.07	0.00014	0.00001	0.67	0.5
Hhsize	0.61	0.14	3.62	.000	0.62	0.004	2.2	0.03
Daddis*	-1.03	-.2133	-3.5	00	0.63	0.044	1.92	0.05
Pwood	-.011	-.0025	-0.78	0.44	0.007	0.0004	0.4	0.7
Pkeros	.632	.144	3.5	000	-0.50	-0.03	-2.25	0.024
Pcharc	-0.006	-.0014	-.15	0.88	0.16	0.001	0.4	0.7
Constant	.51		0.621	0.534	1.7		1.9	0.6
No obs. 1447; Wald $X^2_{(6)} = 72.80$, Prob > $X^2_{(6)} = 0.00$; Log likelihood = -606. 3					No obs. 1447; Wald $X^2_{(6)} = 34.92$, Prob > $X^2_{(6)} = 0.00$; Log likelihood = -198.31			
* The slope is for discrete change of the variable from 0 to 1. - Z and p>|Z| are the test of the underlying coefficient being zero.								

The results indicate that increase in income level of the households leads to energy transition in that it increases the probability of consuming modern fuels while reducing the probability of consuming the traditional fuels. The other factor is that modernization/urbanization proxied by Addis Ababa dummy leads to reduction in the use of modern fuels while increasing the use of modern fuels. The factors captured by Addis Ababa dummy might not reflect the effect of urbanization only. It could be the case that the impacts are related with supply differences.

The other notable pattern is that there is strong impact of price of modern fuels, here proxied by the price of kerosene, in increasing the possibility of consuming traditional sources of energy. This is justified by significant positive coefficient in the traditional fuels and negative coefficient in the modern fuels equations. Traditional fuel prices negatively affect the probability of consuming traditional fuels while positively affecting the possibility of consuming modern fuels. Thus, in general, prices, income levels, and availability of the fuels are the major factors guiding the consumption patterns of urban households. As households' income increase, it is expected that greater reliance on the consumption of modern fuels is expected, while the opposite holds for the consumption of traditional fuels. The significant impacts of prices of modern fuels indicate that a slight increase in them can trigger greater reliance on the consumption of traditional fuels by discouraging consumption of modern fuels. The insignificant impacts of traditional fuel prices indicate that very large changes are expected to bring about shift in the consumption pattern. Energy consumption of all sorts is positively related with household size. However, this relationship is stronger in the case of traditional fuels as compared to the modern fuels. This implies that households with big household sizes have greater dependence on traditional fuels as compared to those with low household sizes.

This general pattern does not hold for electricity when we consider specific cases. Households' probability of consuming electricity decreases with increase in price of firewood. However, exact replica of the pattern observed for all modern fuels holds for kerosene. The probability is negatively related only with its own price. The pattern observed for the traditional fuels in general holds for all the three component; namely charcoal, fire wood and "other."

3. Demand for Household Energy

3.1. The Model

Consumer theory suggests that the demand of a utility-maximizing consumer for any commodity depends on the prices of all commodities available to the consumer and on his total expenditure. However, it has nothing to say about the precise functional form of the demand equation except the restrictions regarding what the demand functions should fulfill.

In empirical works, the restrictions imposed by the theory of consumer behavior are often difficult to achieve. In fact, most studies of the demand for a single good have been concerned with estimation than with testing the relevant theoretical restrictions (Thomas, 1987), choosing functional forms for their ease of estimation. The commonly used explanatory variables are own prices, prices of complements and close substitutes, the consumer price index, and total expenditure. Time series demand models include time trend in addition to the above variables, so as to capture change in tastes over time. The restrictions are imposed a priori rather than being checked for after estimation of demand equations.

So as to achieve the homogeneity restriction, the common approach is to use relative prices and real income as exogenous variables. Choosing one of the prices to be a numeraire does this. In practice, the consumer price index is used as a numeraire. However, although it has been possible to achieve homogeneity restriction by using relative prices and real income, adding-up restriction may not be fulfilled (Sadoulet and DeJanvery, 1995:41).

Practically, for a single equation, only the homogeneity restriction is of immediate relevance and it is only when we move on to complete systems of equations that the theory becomes more relevant. Thus, if one has to estimate a demand function for a few of goods that are in the consumption basket, the immediate concern is the homogeneity restriction. Since working in terms of relative prices and real income reduces the multi-collinearity between expenditure and price variable, it is advisable to impose homogeneity restriction a priori by using relative prices (Thomas, 1987).

Of all the models that are based on certain assumptions about the specific functional forms of the utility functions, two demand systems have received considerable attention in the practical work. These are the Linear Expenditure System (LES) developed by Stone (1954); and the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer, 1980 (Sadoulet, and DeJanvry, 1995). However, the LES model is too restrictive in that it can only be applied in the situation where the goods are all not inferior goods and assumes that the goods are gross complements. The AIDS specification allows single equation estimation and thus, it is the most suitable approach when the interest is to analyze the demand for only one item or few of all the times in the expenditure baskets of households since we can estimate demand functions of only those goods/services we are interested in.

In those situations where all we have are cross sectional data from household surveys where there is no price variation across the cross sectional units or there is no price data at all, it would be impossible to estimate demand functions. In such cases, we are limited to the estimation of Engel curves. That is, we deal with how consumption pattern vary between households at different income levels. In addition to income, we can also consider household size, education, etc. as sources of variation in consumption patterns.

According to Sadoulet and DeJanvry(1995:38), the Engel curves specified for estimation should satisfy the budget constraint; be able to represent luxuries, necessities, and inferior goods; and have variable income elasticities due to the empirical fact that income elasticities tend to decline as income increases.

Deaton and Case (1988) note that there is no reason to suppose that the same functional form applies to all possible household surveys, that expenditure, rather than income, should be used, and proposed an Engel equation which is a family of the AIDS model, in which only price variable is lacking.

Although the AIDS model is the most widely applied model in empirical studies of demand, simultaneous estimation of all the equations within a system, as was posited by Deaton and Muellbauer (1980), is not commonly adopted because the interest of the researchers is most often to estimate demand functions for a few of the several items in the expenditure basket of households. Thus, separate estimation of the equations pertaining to the variable of interest is conducted most of the time. The function that is commonly used includes demographic factors in addition to the originally proposed income and price variables, and is given as follows:

$$Wi = \alpha_i + \Sigma\, \beta_{ij} \ln p_{ij} + \Phi_i \ln X + \sum \gamma i \ln N + \mu \text{ --- } (1)$$

and then elasticity coefficients are computed by the following relationship

$$e_{ii} = -1 + \beta_{ii}/w_i - \Phi_i \text{ ------------------------------ own price elasticity}$$

$$e_{ij} = \beta_{ij}/w_i - (\Phi_i / w_i) w_j \text{ ----------------------------- Cross price elasticity}$$

$$\eta_i = 1 + \Phi_i / w_i \text{ --- Income elasticity}$$

where: N represents the demographic variables such as household size, age and gender ratios etc and w_i, p_i, and x are expenditure shares, prices and income/expenditure, respectively. Furthermore, due to several reasons, one may be interested in analyzing the Engel curves only. This could be due to absence of reliable price data or that non-linear relationship between income and consumption exits, which cannot be captured in demand functions. Demand functions are derived from utility theory, which assumes linear budget lines so that it is impossible to establish flexible relationship between consumption and income. To this effect, Deaton and Case (1988) have proposed the use of Engel curves that are a family of the almost ideal demand system:

$$W_i = \alpha_i + \beta_{ij} \ln X_i + u_i \text{ --- } (2)$$

Where: W_i and X_i are as defined above.
Total expenditure elasticity is derived by: $\eta_i = 1 + \beta_i / Wi$

The above equations could be estimated by the ordinary least squares (OLS) estimation if there are no or very small zero observations for the dependent variables. Existence of zero observations implies that the data are censored at zero so that OLS estimators become inefficient.

In this study, we are set out to estimate price and income elasticities for charcoal, firewood, kerosene and electricity. However, there is no cross sectional variation in electricity tariff so that it has become impossible to estimate its demand function. But, it is possible to estimate the Engel curves for electricity. Thus, we estimate an Engel curve for electricity.

The following are the points we have to consider before arriving at our proposed model specification of the Engel and demand equations:

1. There is marked variation between energy consumption pattern of households in Addis Ababa and other cities/town. Thus, we have to include a dummy variable that can capture this variation. Furthermore, since the prices used in the demand functions are the same within a city/town, the coefficient estimates of prices will be biased unless site dummies capture fixed city/town level effects. However, inclusion of site dummy together with prices will affect the results since they will be highly collinear. Inclusion of Addis Ababa dummy only will take care of this problem also since there is no marked difference in consumption pattern among the other cities/towns.
2. The relevant demographic variable in our case is household size. It is possible to include this demographic variable both in the Engel curve and the demand equations.
3. The result obtained should be able to indicate the substitution possibilities among the various sources of energy through the estimated cross price elasticities. However, there is no cross sectional variation in electricity tariffs so that we cannot include this in our equations. Since electricity is the major modern energy, the cross relationship between electricity and others is needed. Thus, we include electricity consumption in the estimated demand functions instead of its prices. Inclusion of the variable itself instead of its price is commonly practiced in the literature. For instance, Stevenson (1989) used volume of charcoal, LPG and kerosene in his demand model for firewood in Haiti. Furthermore, Moosa (1998) strongly argues that it is the availability of the alternative energy sources, which matters most rather than their prices, suggesting that including the quantity is even better in explaining the relationship.

Thus, the above points must be incorporated in to equations (1) and (2) to arrive at the required specification of the models to be estimated. Accordingly, the following models are estimated.

$$w_i = \alpha_i + \Sigma \beta_{ij} \ln p_{ij} + \delta_i w_e + \Phi_i \ln x + \gamma_i \ln hhsize + \phi Daddis + \mu ------------ 3$$

$$w_e = \alpha_i + \Phi_i \ln x + \gamma_i \ln hhsize + \phi Daddis + \mu ---------------------- 4$$

All the variables except w_e are as defined above. w_e is expenditure share of electricity. The price variables that are denoted by p_{ij} are price of kerosene (p_k), price of charcoal (p_c) and price of firewood (p_w). We apply the formulae in equation (1) to compute price and income elasticities. The elasticity with respect to electricity will be derived by the formula: $\delta_i w_e / W_i$.

Tobit maximum likelihood estimation is the most commonly used technique for censored data. However, this technique overcomes the weakness of OLS only if the normality assumption is correct and the disturbance terms are homoskedastic (Deaton, 1997: 87). If these two are not fulfilled, Tobit estimators are highly unreliable and inconsistent. Thus, we can use this estimation technique only when our variables are normally distributed and the residuals are homoskedastic. However, normal distributions are exceptions rather than a rule with many types of data such that the best we can hope for is symmetry. In addition, heteroskedasticity exists in many cross sectional economic data (Mukherjee, et. al, 1998).

Thus, so long as we are set out to utilize estimation techniques that rely on the homoscedasticity and normality assumptions of the residuals, the problems related with heteroskedasticity and non-normality must be taken seriously. Non-normality means that we cannot conduct hypothesis test about the significance of the coefficient estimates since the statistics used are generated under the assumption of normality. Furthermore, existence of heteroskedasticity causes non-efficient[3] parameter estimates. This also affects hypothesis testing by affecting the confidence interval. Thus, these problems lead us to wrong generalization. Particularly, in the case of Tobit models, the results will not only be inefficient, but also highly inconsistent (Deaton, 1997).

Recent literature in econometrics provides estimation technique that does not require the distribution assumptions in general, and gives consistent results even in the presence of heteroskedasticity and non-normality. This technique is the quantile median regression technique known as the least absolute deviation (LAD) when there are no censored observations and its extension known as censored least absolute deviation (CLAD) when there are censored observations (Deaton, 1997).

3.2. Estimation of the Models and Presentation of Results

Here we are interested in estimating demand functions for charcoal, firewood and kerosene. We cannot estimate demand function for electricity since its price is not variable across the cities/towns. However, we can estimate its income elasticity and highlight the impacts of other variables such as household size by estimating Engel cure.

The censored least absolute deviation estimation (CLAD) developed by Powel (1984) is used for estimation. The best way to understand the CLAD is to begin with Tobit. Tobit framework can be specified by defining a latent variable y*. This could, for example, be perceived as the index of households' desire for a particular form of energy. The observation of this latent variable is censored at quantities (expenditures) equal to zero. Formally, the framework is:

$$\boldsymbol{y_i^*} = \beta \boldsymbol{X_i} + \varepsilon \text{ --5}$$

where: $$y_i = \begin{Bmatrix} y_i^* & if\ y_i^* > 0 \\ 0 & y_i^* \le 0 \end{Bmatrix},\ \varepsilon \sim \boldsymbol{N}(0, \sigma^2)$$

Thus, the model could be re-written as: $y_i = \max(0,\ \beta \boldsymbol{X_i} + \varepsilon_i)$. The point to consider in Tobit estimation is that the coefficient estimates are not the marginal effects. The appropriate marginal effect is the change in the expected value of y_i with respect to x_i where as what we can observe from the regression result is change in the expected value of y_i* with respect to x_i. McDonald and Moffit(1980) indicated that the change in the expected value of y_i with respect to x_i (the

1. Non-efficient estimators are those not with low variance.

marginal effects) has two component parts: the effect on the conditional mean of y and the effect on the probability of y being greater than zero.

The CLAD, as the name implies, is an extension of the median (50^{th} quantile) regression. Quantile regression solves for the parameter estimates that minimize the sum of absolute value of the errors as opposed to OLS which solves for parameter estimate that minimize the error sum of squares. LAD estimators are solved by minimizing:

$$\phi = \left[\sum_{i=1}^{n} \left| y_i - X_i^{'} \beta \right| \right] = \sum_{i=1}^{n} (y_i - x_i^{'} \beta) \operatorname{sgn}(y_i - x_i^{'} \beta) = \text{-------------------------------------} 7$$

The sign function sgn(.) takes on values of -1, 0 and 1 as the argument is negative, zero or positive. The coefficient estimates are the median regression coefficients and are consistent (see Deaton, 1997 and Johnston and DiNardo, 1997). The corresponding median regression is given by:

$$q_{50}[y_i \mid X_i] = X_i \beta + q_{50}[\varepsilon \mid X_i] = X_i \beta \text{ ---} 8$$

where: q_{50} denotes that the regression line is for the 50^{th} quantile or the median.
No assumption of homoscedasticity and normality is required since what matters is the sign of the residual instead of the magnitude.

The above exposition is under the assumption that the data is not censored. If the data is censored at zero, it means equation (8) or the median regression equation will be:

$$q_{50}[y_i \mid X_i] = \max[0, q_{50}(X_i \beta + \varepsilon_i \mid x_i)] = \max(0, X_i \beta) \text{ ---} 9$$

Then, Powel (1984) suggests an estimation technique that provides consistent estimate of β which minimizes the sum of absolute deviations. This is known as censored least absolute deviation (CLAD) estimation technique. The consistency of this estimator does not require knowledge of the distribution of the errors, nor is it assumed that the distribution is homoskedastic (Deaton, 1997: 89). Buchnisky (1994) has developed a framework for estimation technique for CLAD estimators.

Table 11: Summary of Estimation Results of the demand equations

	CLAD Elasticity Estimates			
Variables	Charcoal	Kerosene	Firewood	Electricity
Constant				
LnX	1.015	0.86	0.88	0.84 (Engel curve)
$\ln P_c$	-1.50	1.55	-1.45	
$\ln P_f$	-0.374	0.25	-1.35	
$\ln P_k$	1.24	-2.5	-0.08	
Lnhsize				
Daddis				
W_e	-0.07	-0.0002	-0.214	

Estimation results from CLAD constructs three types of 95 percent confidence intervals for each coefficient estimates based on the bootstrap standard errors. These are the normal confidence interval, percentile and bias-corrected confidence intervals. Thus, whether a particular coefficient is significant or not is based on whether the estimated value falls within the bias-corrected confidence interval. However, bias corrected confidence interval will be the same as the percentile confidence interval when the final sample size is not significantly different from the initial sample size in the iteration algorithm. Accordingly, it has been observed that all the coefficient estimates of CLAD estimation fall within their 95 percent confidence interval except for household size in kerosene equation. This implies that all the respective elasticity estimates are statistically significant.

The estimation result indicates that kerosene; charcoal and fire wood consumptions are price elastic. That is, the rise in own prices lead to significant cut in the demand for these forms of energy. The fact that kerosene demand is negatively elastic with respect to own price indicates the potential hazard of the recent increases in kerosene price and the significance of price subsidy. The analysis of the cross price elasticities reveals that kerosene and charcoal are complementary with firewood owing to the actual use pattern; i.e., firewood is used mainly for baking where as kerosene and charcoal are basically for cooking. As a strong explanation for the actual use pattern, firewood demand is found to be significantly and negatively related with electricity consumption. These are highly substitutable since both are largely used for baking "injera."

Charcoal is significantly and positively related with price of kerosene. This is again in line with the actual use pattern since both are purely cooking fuels. When looked from the side of kerosene demand, the cross price elasticity indicates that kerosene demand is positively elastic to charcoal prices, strengthening the observation from the side of charcoal. This is a strong evidence for the impact of increases in kerosene price on the environment. Furthermore, this has a policy implication for the possibility of ensuring energy transition from the biomass fuel (charcoal) to a modern fuel (kerosene) through price incentives. The cross price elasticity of kerosene with fire wood price indicates that firewood are substitutes for kerosene. So, the negative and significant own price elasticity of kerosene has the implication for the consumption shift towards charcoal and firewood; the phenomenon which is not favorable. As a result, energy transition from greater use of the traditional fuels (fire wood and charcoal) to the modern fuel (kerosene) cannot be ensured only through reliable supply of kerosene, but also requires that kerosene is sold at a cheaper price than the traditional fuels. In many African countries, kerosene is subsidized so as to keep its price cheap since it is the best alternative to fuel woods (Elkan, 1986).

Electricity is found to be a substitute not only to the traditional fuels (charcoal and firewood), but also to the modern fuel, kerosene. This indicates a good long-run energy transition prospect in Ethiopia. The pattern of energy transition is that, in the long run, kerosene itself is substituted by electricity. Thus, if Ethiopia manages to exploit its hydroelectric power generation potential and supply electricity at affordable price to the people, many of the energy related problems could be curbed.

A look at income elasticities indicates that all fuels are necessities since the elasticities are around one for all of them. The effect of Addis Ababa dummy is insignificant for all the energy groups indicating that there is no signification variation between Addis Ababa and other towns. Its impact is positive and significant in the estimation of the electricity Engel equation. Thus, although there is significant variation between Addis Ababa and other cities/towns in terms of consumption of electricity, this variation could not be confirmed in the consumption of kerosene. The impact of household size is positive in all cases. But, the coefficient estimate is higher in firewood and electricity equations as compared to charcoal and kerosene equations. That is, the demand for cooking fuels is not much sensitive to the number of people in a household whereas baking fuels are sensitive. The reason is that households with large size bake "injera" more frequently than those with small size and/or require more units of energy each time they bake because the amount required to be baked is large. Since the most essential household fuels are used for "baking" in Ethiopia, the fact that household size bears significant positive coefficient indicates that household size is one important reason behind greater use of energy.

4. Conclusion

The most immediate policy concern in Ethiopia is to insure sustained supply of biomass fuel, which requires agro forestry, and maintenance of large land size under forest cover. This is the feasible option given that the majorities of the households rely on biomass fuels and cannot afford to use the modern fuels given the very low income.

To ensure sufficient supply of wood fuel and combat environmental degradation, agro forestry, which contradicts with the objectives of fulfilling the increased requirement to produce grains, is essential. Diffusion of improved stove, and pricing policies to encourage greater use of modern fuel are the most recommended solution (Catania & Huang (1996)). Improved wood stoves not only raise energy efficiency, typically by 30-50% but also reduce indoor pollution by a factor of 20 to 100, to levels well within WHO guidelines (Anderson, 1996: 12).

However, the long-run objective should be to emphasize the energy transition from the traditional to the modern ones. Anderson (1996) argues that in-door air pollution, deforestation, and soil degradation could almost entirely be eliminated by substituting gas, kerosene, or electricity for traditional fuels used for cooking and steady transition to cleaner fuels occurs as incomes rise and as industries expand. Thus, income growth plays important role in the energy transition process. Since the current income level is very low in the country, it is likely to be dependent on bio-fuels for some time, leaving a room for the possibility of "moving up the energy ladder" through a combination of demand and supply side policies. According to Elkan (1988), so as to encourage more use of modern energy instead of biomass fuel, kerosene is subsidized in many African countries where as electricity tariffs are always kept below the average cost of production. In Ethiopia, Kerosene is subsidized and also, it is said that electricity tariff is much below the average generation cost. These policies are essential and useful since the price elasticities of their demands are negative in general.

Specific to kerosene for instance, Dahl (1994) notes that the income elasticity of kerosene demand could be either positive or negative. That is, for the very poor, increase in income would switch his consumption from traditional fuel to kerosene, i.e. the demand is positively related with income. However, as income increases further, the demand may shift out of kerosene to electricity and other commercial fuels such as liquefied petroleum gas (LPG).

It must be noted, however, that the transition may not be neat in the sense that at higher income, households may tend to use one or more of a particular traditional energy source together with the modern energy sources may be due to non-replaceable use of some of these energy sources and cultural reasons. It was indicated that higher income households consume more of charcoal and electricity in Ethiopia implying that charcoal remains important even at higher levels of income. Similarly, the situation in Tanzania indicated by Hossier and Kipondya (1993) shows that kerosene consumption decreases with income, electricity accounts for larger share of energy requirement and the importance of charcoal varies little as income increases. This indicates that households use a mix of different fuels almost at all levels of income, and hence emphasizing the importance of maintaining sustained provision of almost all types of energy at any point in time.

It has been observed that demand based policies are widespread to ensure energy transition. Furthermore, the “energy ladder” hypothesis maintains that energy transition is a positive function of household income. This implies that energy demand should be negatively related with its own price; positively related with income but income elastic if it is modern, but inelastic if it is a traditional fuel. That is, modern fuels are luxury while the traditional fuels are necessity. The energy transition path in all countries may not be similar though. Therefore, country-specific situations should be indicated through estimation of demand models. The result from the estimations in this study confirms that all household energy sources are necessity. Thus, in the foreseeable future, energy demand rises proportionately with increase in income. Thus, supply is the major in our case.

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Appendix: Regression Results of Demand Equations

1. Charcoal
Initial sample size = 1447
Final sample size = 1440
Pseudo R2 = .04569228

Bootstrap statistics

Variable	Reps	Observed	Bias	Std. Err.	[95% Conf.	Interval]	
lhhsize	100	.0291732	-.0034115	.0590895	-.0880732	.1464196	(N)
					-.0588235	.2222222	(P)
					-.0140187	.2584862	(BC)
daddis	100	-.6463395	.1747671	.4264969	-1.492602	.1999229	(N)
					-1.175601	.3713364	(P)
					-1.540158	.0061353	(BC)
lnexp	100	.0291732	-.0118719	.0342978	-.0388811	.0972275	(N)
					-.0588235	.0925926	(P)
					-1.28e-09	.1363636	(BC)
lpwood	100	-.6628649	.4128142	.6572214	-1.966935	.6412049	(N)
					-1.373004	.9508225	(P)
					-1.62824	.1239828	(BC)
lpkero	100	2.479264	-.0222211	1.444035	-.3860148	5.344543	(N)
					-3.33e-16	4.735188	(P)
					-3.49e-16	4.474365	(BC)
lpcharc	100	-.9193255	-.2081824	1.247533	-3.394702	1.556051	(N)
					-3.292288	1.3048	(P)
					-3.177151	1.311307	(BC)
electric	100	-.0291732	.0019282	.0198313	-.0685228	.0101764	(N)
					-.0666667	4.82e-11	(P)
					-.0714286	1.92e-18	(BC)
const	100	4.951827	-.5436258	4.405853	-3.79034	13.69399	(N)
					-4.769262	11.58984	(P)
					-4.690938	11.77966	(BC)

N = normal, P = percentile, BC = bias-corrected

2. Firewood
Initial sample size = 1447
Final sample size = 744
Pseudo R2 = .04504014

Bootstrap statistics

Variable	Reps	Observed	Bias	Std. Err.	[95% Conf.	Interval]	
lhhsize	100	.7876588	-.4093463	.3895732	.014661	1.560657	(N)
					-.558447	1	(P)
					.4759106	1.285714	(BC)
lnexp	100	-.3125	-.0409513	.2515647	-.8116589	.1866589	(N)
					-.8250445	.1111111	(P)
					-.6295978	.4285714	(BC)
lpwood	100	-1.702934	-.1177529	.720026	-3.131622	-.2742461	(N)
					-3.206557	-.4232326	(P)
					-2.897676	-.3671454	(BC)

```
lpkero    100  -.9552622   .3920417   1.437244   -3.807065  1.896541(N)
                                                 -3.568129   2.32547(P)
                                                 -3.687118  1.728689(BC)
lpcharc   100   -4.32385  -.5600455   1.315334   -6.933758 -1.713942(N)
                                                 -6.501686 -1.377813(P)
                                                 -5.519296 -.1378055(BC)
electric  100      -.125  -.0076299   .0520777   -.2283334 -.0216666(N)
                                                 -.2020468 -1.79e-10(P)
                                                 -.2 -1.37e-10(BC)
const    100    20.24293    2.589964   4.668194   10.98022  29.50564(N)
                                                  12.1485  30.54773(P)
                                                  10.60141   25.4135(BC)
                              N = normal, P = percentile, BC = bias-corrected
```

3. Kerosene

Initial sample size = 1447
Final sample size = 1447
Pseudo R2 = .1081396

Bootstrap statistics

```
Variable    Reps   Observed      Bias   Std. Err.   [95% Conf. Interval]
lhhsize    100  -2.54e-09   .0341247   .1481681   -.2939976  .2939976(N)
                                                   -.3333333   .4431818(P)
                                                   -2.73e-09   .5(BC)
lnexp      100  -6.49e-10     -.3561   .2990594    -.5933987   .5933987(N)
                                                   -1          1.15e-09 (P)
                                                    .          .BC)
lpwood     100   .6343984   .5739015   .6901658    -.7350403  2.003837(N)
                                                   -.0007492  2.695469(P)
                                                   -.0007492  1.773312(BC)
lpkero     100  -3.805654  -2.657843   1.817855    -7.412673 -.1986355(N)
                                                   -9.480077 -3.805654(P)
                                                   -3.654658 -3.654658(BC)
lpcharc    100   3.965246   .4938283   .8637526     2.251374  5.679119(N)
                                                    3.021905  6.443079(P)
                                                    2.640526  5.689036(BC)
electric   100  -9.39e-11  -.0089706   .0170698    -.0338702  .0338702 (N)
                                                   -.0454545  .0179276(P)
                                                    3.75e-10  .028169(BC)
const     100  -9.144424   .2765845   3.394111     -15.87908 -2.409773(N)
                                                   -15.05106 -2.204849(P)
                                                   -14.53823  .7592634(BC)
                              N = normal, P = percentile, BC = bias-corrected
```

4. Electricity

Initial sample size = 1447
Final sample size = 1447
Pseudo R2 = .02977742

Bootstrap statistics

```
Variable    Reps   Observed       Bias   Std. Err.   [95% Conf. Interval]
lhhsize    100   2.22e-15   .0991429   .2795365    -.554661   .554661(N)
                                                      -.5        .5(P)
                                                      -9.06e-09   1(BC)
lnexp      100       -.5  -.0242143     .2660045   -1.027811  .0278106(N)
                                                      -1   4.51e-17(P)
```

					-.5	6.39e-17(BC)
daddis	100	1.5	.3715952	.2397674	1.024249	1.975751(N)
					1.5	2.5(P)
					1.5	2 (BC)
const	100	6	-.1120476	1.64701	2.731975	9.268025(N)
					3	9(P)
					4.333333	9(BC)

N = normal, P = percentile, BC = bias-corrected