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Energy insecurity and alternative sources in Ethiopia: New energy policy is the need of the day

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ABSTRACT

A study was conducted in southern Ethiopia with the objective of investigating the domestic energy consumption problems and related coping mechanisms among households residing both in and around Arba-Minch town. The research design is mainly based on the quantitative methods and complemented with the qualitative data. The field data were collected using questionnaires, focus group discussions and interviews with relevant individuals. For this purpose, 658 sample households were selected from in and around the town based on random sampling technique. The analysis indicates that wood fuels (wood and charcoal) are by far the most used cooking fuels for the majority of urban and peri-urban residents despite the fact that they have access to grid electricity. Although electricity has many benefits, it does not help address the major energy problem that most households in area face in terms of their daily cooking requirements. Over the years, the outskirts of the town have experienced intense deforestation and environmental degradation due to the activities of wood fuel poachers. Despite the fact that biomass fuels would remain important fuels for majority of the households, no efforts were made to increase its supply. The local authority does little to control access to the hinterland forests of the town from where wood fuel is extracted and supplied. The study reveals that the urban households in the study area are still inadequately served by energy supplies and face great energy crisis since both traditional and modern fuels became increasingly scarce and expensive. Most of the energy appliances employed in the sample area are traditional ones that function at low efficiency level. This indicates that majority of the households often lack the ability to optimize their consumption through improved technologies. Such inefficiency mode of utilization of traditional fuels leads to the massive waste of wood, and contributes to unnecessary high level of biomass resource extraction and consumption. Increasing end-use efficiency should be given greater emphasis as an important prerequisite by employing proper end-use technologies to change households' cooking practices so that household's energy-related problems are tackled and energy can lead to more equitable sustainable livelihood.

INTRODUCTION

Energy is undoubtedly, one of the most essential inputs for sustaining people's livelihood and without energy modern life would almost cease to exist (Clancy et al. 2003). Provision of energy services is important for almost all aspects of human welfare, including access to water, agricultural productivity, health care, education, job creation, and environmental sustainability (Ramakrishnan 2009; TERI 2010). As most towns in developing countries are growing rapidly, urban growth is paralleled by increasing demand for energy to meet consumption needs (World Bank 2011). In Africa, two out of three households lack access to convenient, efficient and reliable forms of energy to satisfy their basic needs and to perform economic tasks. Sub-Saharan Africa has 9 percent of the world's population and consumes only 2.7 percent of world commercial primary energy. More than 80 percent of its population depends on traditional biomass as their primary energy source (WHO 2009).

Like many other sub-Saharan African countries, Ethiopia depends heavily on traditional energy consumption with minimal use of modern energy sources (Zenebe 2007), hence the country is

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having difficulty in meeting the rapidly rising demand for modern energy (Nebiyu 2009). More than 67 million people are dependent on biomass energy to meet their cooking, heating, lighting and hygiene needs (UNDP 2009; IEA 2010). Araya and Yisak (2012) reported that for more than 75 percent of rural households and more than 57 percent of urban households are dependent upon fuel wood as the major source of fuel for cooking. In spite of the improvement in access to clean fuels in the last few years, most urban and peri-urban households in the study area of Arba-Minch still appear not to be benefiting significantly from improved modern fuel supply availability. A substantial portion of the urban households continues to suffer as their incomes have not kept pace with the rising prices and face higher financial burden to meet their cooking demands.

Many households in the study area, even with the substantial household electrification programme, still continue to use biomass fuels for cooking end-use. Besides, an irregular supply of electricity undoubtedly creates huge inconvenience for its users and its use for cooking is limited to very few households. There are sudden and frequent blackouts and voltage drops which can make electricity a very unreliable source of energy for use domestically and the users find it hard to predict its availability. Here, the purpose of the current study was to explore urban and peri-urban households' energy insecurity challenges and the adopted measures to cope with rising fuel scarcity.

MATERIALS AND METHODS

This study was conducted during 2014 on urban and peri-urban area of Arba-Minch town in Ethiopia which is located at 505 km south of the national capital, Addis Ababa and 275 km from the regional capital, Hawasa. According to Arba-Minch Town Administration Office (Anonymous 2014), the town together with its peri-urban localities, has an area of 5,557 hectares and an estimated total population of 104,107 with the population density of 13 people per hectare and average family size of 4.5 persons. The study area has an altitude ranging from 1300 m at the northern end to 1500 m above sea level at the southern end, and its climate is characterized by a relatively hot weather condition, with low and unevenly distributed rainfall pattern. The annual average rainfall ranges between 750 to 1100 mm, of which the substantial amounts fall in May to June and September to October (Aramde et al. 2012).

For primary data acquisition, this research used household survey method as the main methodological approach to collect information from selected households. Quantitative data were collected by using a cross-sectional survey of urban and peri-urban households carried out over three months from August to October 2014. Qualitative data were collected using Focus Group Discussions (FGDs) and in-depth interviews. Data on the consumption of energy resources for this study were gathered in terms of expenditures which were later converted into the unit of heat energy consumed by a household and data results have been organized and summarized by descriptive statistics.

The target population for the study was the entire urban households residing within the town and Kola-Shara *Kebele* which was taken to be one of the sample *Kebeles* with the intention to represent peri-urban area. Two-stage sampling technique was applied to select the sample households. In the first stage, sample *Kebeles* (the primary sampling units) were selected purposely from the study area and then sample households (the secondary sampling units) were selected from each *Kebele* randomly. For sampling purposes, the *Kebeles* were categorized into two strata based on the dominance of the type of residential housing units. After classifying the *Kebeles* into two strata, three *Kebeles* from each stratum were selected. Stratum one (*Kebeles* with more shanty houses) has three *kebeles*, namely, Birie, Kulfo and Kola-Shara. Stratum two (*Kebeles* with more of better-off housing units) had also three *Kebeles*, namely, Chamo, Dil-Fana and Mehal-Ketema. A total of 658 sample households were selected randomly based on the list available in all *Kebeles*. The number of sample households for each *Kebele* was proportional to the total number of households in each sample *Kebele* administration (Table 1).

Table 1: Sample *Kebeles* and household size in the study area.

Sample Kebeles	Kolla-Shara	Kulfo	Bire	Mehal-Ketema	Dil-Fana	Chamo	Total
Total household size	1,463	1,796	1,712	1,346	1,471	1,717	9,505
Sample household size	86	132	118	98	96	128	658

Source: Arba-Minch Town Administration Office and Field survey, 2014

Justification of the study

This study examined household energy consumption patterns in the light of energy switching hypothesis which explain the shift between traditional solid fuels and modern non-solid fuels in order to meet household's energy needs as the household pass through certain income thresholds (Barnes et al. 2004; Reddy 2004; Farsi et al. 2005).

Survey conducted by Samuel (2002) has confirmed the energy transition hypothesis in urban Ethiopia. However, it is wrong to assume that electricity substitutes biomass use in urban areas, in spite of the fact that there are substantial number of urban households with access to electricity. The most important issue is not the electrification alone since the majority makes no use of electricity for cooking. Instead of moving up the ladder step-by-step as income rises, most households tend to consume a combination of fuels for cooking purposes depending on several factors. Even the majority of higher income households do not currently substitute wood fuels for other conventional fuels for the purpose of baking and cooking.

Although urban energy has recently become one of the major research topics attracting the attention of many researchers, several previous studies (Clancy 2000; Heltberg 2004; Khandker et al. 2010; Dawit 2012) emphasized the rural side and little has been done with respect to urban dimension of the problem. Barnes et al. (2010) also viewed that a significant part of the problem lies in rural areas, a significant number of urban households who continue to rely on biomass-based cooking fuels, are also at risk. The increasing dependence of the urban centres on rural hinterlands has a much more serious environmental consequence that has resulted in growing fuel scarcity and higher firewood prices in urban centres, thereby undermining the livelihood of the urban households (Barnes et al. 2004). The study area, Arba-Minch town and its surroundings, is one of the recently growing urban areas of the country which has been attracting people from the nearby rural areas. The expansion of the town to the periphery has intensified the transformation of rural settlement into urban land. Rising demand for commercially-traded biomass fuels shows a growing pressure on local forests to meet cooking demands of the urban households. Urban and peri-urban residents continued to use solid biomass fuels from the town's outskirts, even though the practice is illegal, and accelerate deforestation. This pressure has led to the enormous depletion of forest resources resulting in serious shortage of fuel wood and energy crisis. Thus, the surrounding indigenous forests were rapidly depleted as a result of increased wood fuel demands**.**

RESULTS AND DISCUSSION

Demographic and socio-economic characteristics of respondents

The gender composition of households revealed that MHHs (Male-headed households) are more in number (383) than their female counterparts (275). The total numbers of family members in the sampled households were 3,180, of which female constitutes 51.95 percent and male 48.05 percent. The majority of the sample respondents (65.96%) have reported to have family members between 4 and 6, while a few of them (21.28%) have members between 1 and 3. Out of the total sample households, the maximum age observed from sample respondents was 68, while the minimum is 23. The majority of the respondents (41.64%) were found to be between 41 and 50 years of age. Almost three-fourths of the sample households

(74.4%) have attended formal education and are literate. Regarding housing conditions, the majority of the residential units are poorly constructed and are of low standard. Most of the respondents are living in an overcrowded rooms and poor housing conditions with lack of basic facilities. Most of the housing units (89%) are made of mud, wood and corrugated sheets, while only a small share of the residential units (11%) were built using hollow blocks or concretes. With respect to dwelling ownership of the sample households, currently more than three-fourths of the sample households (75.4%) live in their own houses, and 17.5 percent and 7.1 percent in rented *Kebele* and private houses, respectively.

Table 2: Mean monthly incomes and expenditures (in ETB) by income group.

Household income			**Fuel expenditure**			
Mean	Sd	Cv	Mean	Sd	Cv	Percent of the income
2,315.09	1,076.08	46.48	290.15	71.82	24.75	12.53

Sd= Standard deviation, Cv= Coefficient of variation

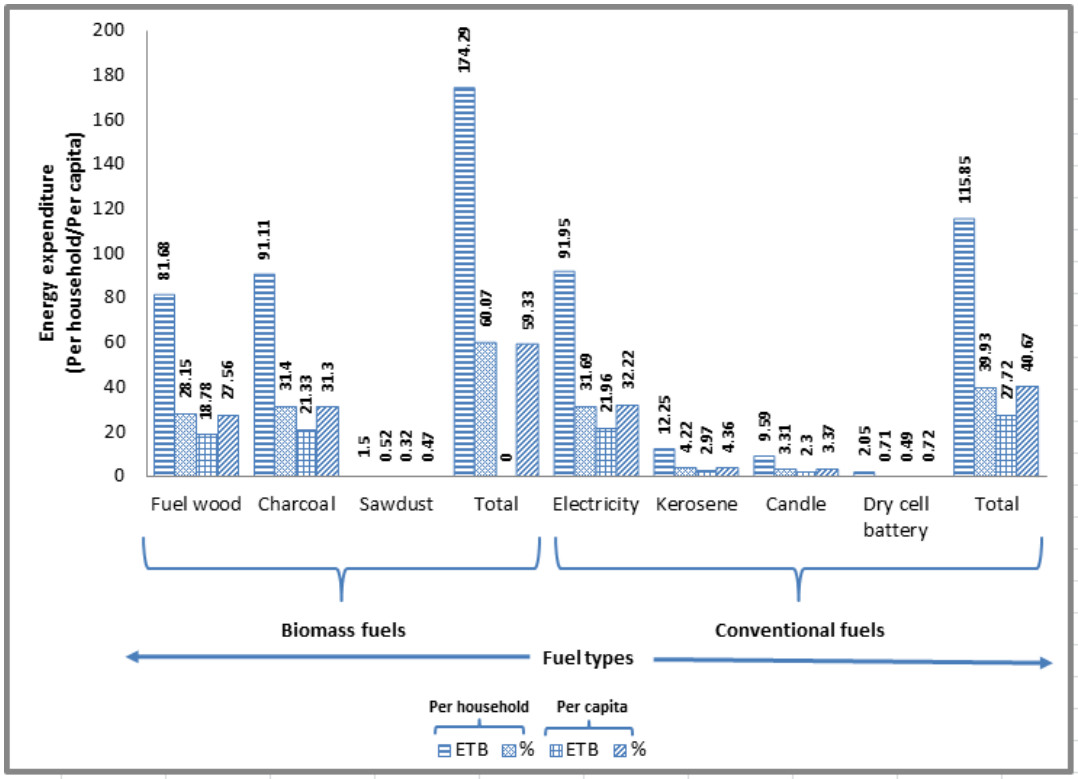

Figure 1: Mean monthly expenditure share of each fuel item (ETB and %).

Household income and fuel expenditure

More than one-third of the sample household heads (35.5%) are full time private and government employees and they receive much of their income from monthly salaries, whereas almost two-thirds of the participants (64.5%) do not earn a regular income or salary. Of the total non-employed household heads, nearly a quarter of them (23.6%) rely on petty trade for their main source of income. Nearly a quarter of the households (23.26%) are earning per capita income of more than 8,001 ETB (One USD was equivalent to 18.5 ETB at the time of the survey) a year, whereas 76.74 percent of the residents earn annual per capita income of less than 8,000 ETB to support basic needs of their family members. The study revealed that almost two-thirds of the sample

households (63.68%) earn mean monthly income of less than 2,000 ETB. Out of the surveyed households only 11.10 percent of the households were having an income greater than 3,000 ETB per month. However, the mean monthly income for the sample households was 2,315.09 ETB. The lowest monthly income for the sample households was 800 ETB, while the highest was 6,500 ETB. Obviously, there is wide disparity in income among these groups, which can be explained by coefficient of variation of 46.48 percent. The average monthly fuel expenditure for the sample households was 290.15 ETB, which made up 12.53 percent of the family mean monthly income. The lowest monthly expenditure for the sample households was 28.66 ETB, while the highest was as great as 455.81 ETB. However, the disparity in expenditure among sample households, which can be explained by coefficient of variation of 24.75 percent, is smaller.

The average monthly gross household expenditure on all sources of energy was 290.14 ETB, of which biomass fuel made up the largest share (60.07%), while conventional fuel accounted for 39.93 percent of the total domestic energy consumed in terms of energy expenditure. Households spend more than half of their gross energy expenditure on electricity and charcoal. The ratio of the average household fuel expenditure (290.14 ETB) to the average income of the household (2,315.09 ETB) was 12.53 percent (Figure 1). The ratio of the average household expenditure on biomass fuels (174.29 ETB) and conventional fuels (115.85 ETB) to the average income of the household (2,315.09 ETB) was 7.53 percent and 5 percent, respectively. The real access to other modern energy services could be limited by the purchasing power of the household and cost of energy-using equipment. Undoubtedly, the cost of energy consumption is getting alarmingly high and too burdensome for the households. Growing prices of modern fuels is the major concern to majority of urban consumers. This has serious implications for the slow rate of switching to other alternatives.

Data conversion

The amount of heat energy consumed from each specific energy source can be estimated by converting its expenditure into heat values. The price of fuel wood ranged from 50 ETB per 25 kg (2 ETB per kg) in peri-urban area to 80 ETB per 25 kg (3.20 ETB per kg) in the town. Fuel wood vendors serve almost all sample households at an average price of 2.60 ETB for one kg of fuel wood. This means, a household buys 0.38 kg for one ETB and one kg of fuel wood provides heat value of 15.07 MJ (Mega Joule). Thus, a household gets 5.73 MJ (15.07 x 0.38) gross heat value of fuel wood for one ETB.

Charcoal is sold at about 70 ETB for a sack of per 30 kg charcoal in peri-urban area (2.33 ETB/kg), while the price of the same quantity of charcoal is 120 ETB in the town (4 ETB/kg). The average price of a kilogram of charcoal was computed to be 3.17 ETB. One kilogram of charcoal provides heat value of 29.73 MJ. So, for one ETB a household could get 9.51 MJ (29.73 x 0.32) heat value of charcoal. In the case of sawdust, 5.02 percent of the sample households use this resource. Of the total users, only 1.22 percent got sawdust for free and the rest users normally buy the fuel from sawmill. The average price of sawdust was 5 ETB per kg. Thus, a household bought 0.2 kg of sawdust for one ETB and 1 kilogram of this fuel delivers 16.75 MJ heat value. So, a household could get 3.35 MJ (0.2 x 16.75) heat value from sawdust for the expenditure of 1 ETB on sawdust

According to Ethiopian Electricity Utility of Arba-Minch Branch, the price of electricity was based on fixed rate of payment for electricity consumed. The average price of electricity paid by surveyed households was 0.389 ETB per kWh. Since 0.389 ETB was equivalent to one kWh, 1 ETB was equivalent to 2.56 kWh. Thus, a household bought 2.56kWh of electricity for 1 ETB. One kWh of electricity is equivalent to 3.6 MJ of energy. Therefore, for 1 ETB, a household buys heat value of 9.22 MJ (2.56 x 3.6). As for kerosene, almost all users buy a liter of kerosene for 15 ETB from petrol station. Thus, 0.07 liter of kerosene was obtained for 1 ETB. One liter of kerosene delivers 33.62 MJ of heat value. Therefore, 0.07 liter of kerosene delivered 2.35 MJ (0.07 x 33.62) of heat value.

Considering the price of each energy type, expenditure made on source of fuel was converted to gross energy in terms of heat value (MJ).

Accordingly, on average, fuel wood, charcoal, sawdust, electricity, kerosene, candle and dry cell battery contain a gross heat value of 5.73, 9.51, 3.35, 9.22, 2.35, 0.62 and 0.002 MJ, respectively. As far as dung cake and biogas are concerned, households usually procure them for free from own cattle near the house throughout the year. Unlike other fuels, this study used the amount of heat energy per their respective units of energy rather than their prices as reference to find out their gross heat values. It has been reported by UNDP (2009) and MoWE (2011) that one kilogram of dung cake and one cubic meter of biogas can provide heat values of 14.50 MJ and 22.80 MJ, respectively. Therefore, these constants are also important to convert household consumption into gross energy heat values.

Households' input (gross) energy utilization

Based on the gross energy heat value constants, the mean monthly household gross energy consumption was estimated to be 2,251.96 MJ. Out of this, consumption of biomass fuels accounted for the highest proportion (60.51%), while the rest (39.49%) monthly household gross energy consumption was from conventional fuels (Figure 2). With regard to the average per capita gross energy consumption, the biomass fuels still had greatest share (59.93%), with an average monthly per capita gross energy consumption of 316.61 MJ, while the rest (40.08%) monthly per capita gross energy consumption was from conventional fuels. This implies that energy sources and end-use technologies employed by the majority of the population are traditional and very inefficient.

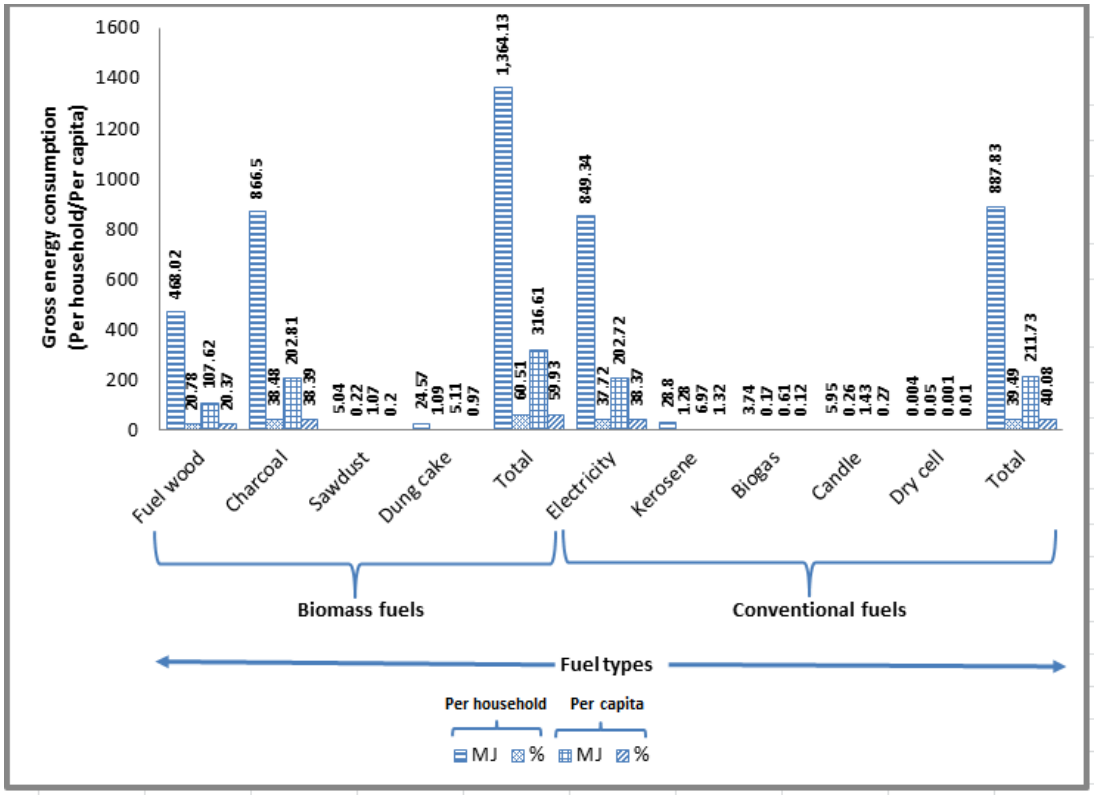

Figure 2: Share of mean monthly gross energy consumption (MJ and %) based on fuel types.

Households' end-use (useful) energy utilization

In order to convert expenditures on various resources of energy into end-use energy in terms of heat value, first the constant already obtained for gross heat value of fuels was multiplied by the efficiency level at which the source of energy was utilized. For instance, the efficiency level of fuel

wood (0.10) was multiplied by the constant (5.73), which is gross heat value of fuel wood. Then, the product obtained (0.573) becomes another constant used to convert expenditure on fuel wood into heat value of end-use energy. For the rest of energy sources, the constants were manipulated in the same way. Thus, constants computed to obtain end-use heat value for charcoal, dung cake, sawdust, electricity, kerosene, biogas, candle and dry cell battery come to be 1.902, 1.74, 0.536, 6.915, 1.175, 11.40, 0.403 and 0.0014, respectively. These are constants to convert expenditures on various resources of energy in to end-use energy in terms of heat value (MJ).

As can be seen in Figure 3, the average monthly household and per capita end-use energy consumption in terms of heat value are 878.83 MJ and 208.36 MJ, respectively. Out of the heat value of gross energy a household received (2,251.96 MJ), the average monthly amount of end-use energy consumed was 39.03 percent. In terms of end-use energy consumed, conventional fuels occupy the leading position (74.63%), while biomass fuels provide low energy heat values (25.37%) due to low efficiency of utilization. In spite of the fact that biomass fuel would remain important household fuel for majority of the households, the share of electricity is also significant in the consumption of end-use domestic energy in the town. Out of the heat value of per capita gross energy received (528.34 MJ), the average monthly per capita end-use energy consumed was 39.44 percent. The average monthly per capita end-use of biomass and conventional fuels energy consumption were 51.90 MJ (24.93%) and 156.46 MJ (75.07%), respectively. This implies that the consumption of electricity shows a drastic growth to meet the largest share of the total domestic energy requirement, while charcoal and fuel wood are by far the most used biomass source of energy.

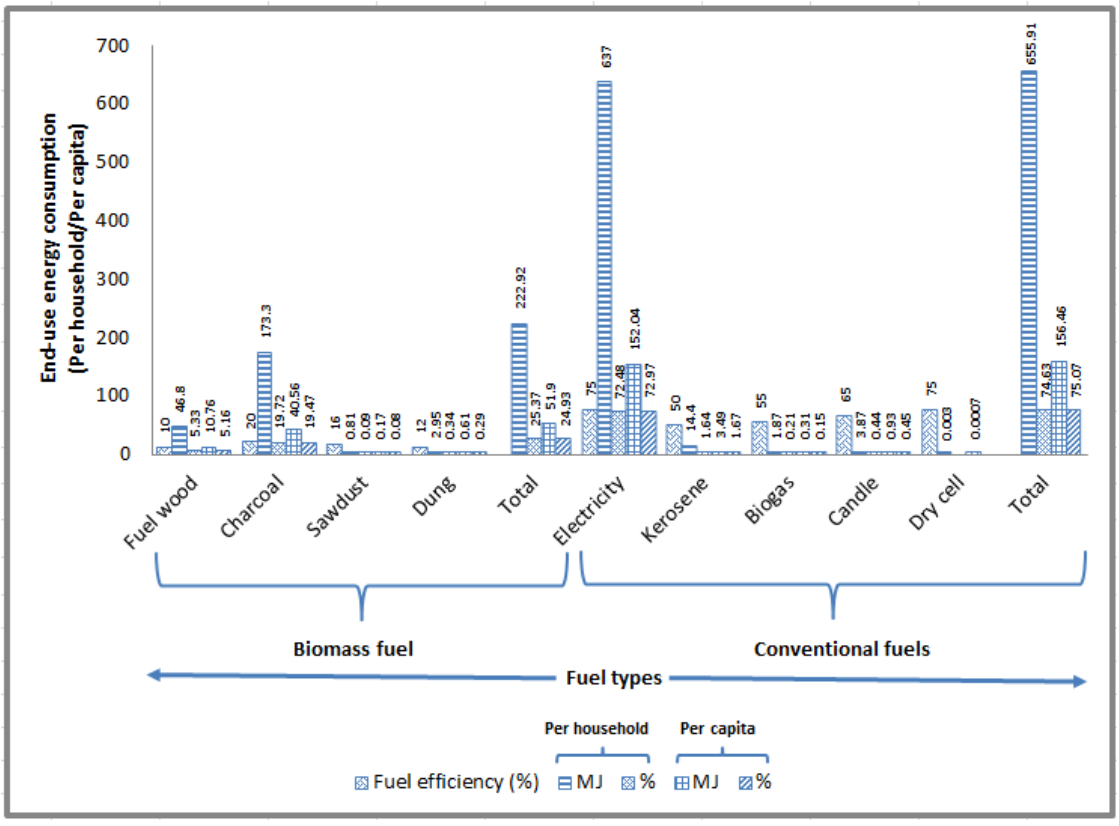

Figure 3: Mean monthly end-use energy consumption (MJ and %) obtained from various fuel types.

Households' energy insecurity and alternative energy sources

As the data in the Table 3 indicate, fuel wood tends to be the primary baking fuel for 72.94 percent of *Injera*-baking households, and is used on at least a supplemental basis by 14.01 percent households for the same purpose. Sample households numbering 12.77 percent utilize dung for *Injera*-baking. Despite the existence of large furniture factory in the town, sawdust is used only by 5.15 percent of sample urban households. On the other hand, over a quarter of the sampled households (27.06%) in the town use electricity to bake *Injera*. For preparing local foods, nearly two-thirds (62.48%) of local foods such as *Kurkufa* and *Fossessie* consuming households use fuel wood as the main source of fuel for local foods cooking, while 25.44 percent, 20.56 percent and 5.92 percent of these households use dung cakes, charcoal and biogas, respectively. Moreover, fuel wood (48.08%) and charcoal (23.53%) are considered as secondary fuels for local foods making. Most people are used to eat such local foods cooked on a pot over an open fire. Fuel wood is the most used primary local foods-cooking fuel. Most people prefer fuel wood to other fuel sources such as kerosene or charcoal for the cooking of local foods as they require longer cooking time and reported to be tasteful, and the fact that the burner surfaces in kerosene and charcoal stoves are too small to cook a large amount at once.

Charcoal is the most used primary fuel for *Wot* cooking, accounting for 56.85 percent, while few households (2.52%) in peri-urban areas use biogas as a primary fuel for *Wot* preparation. Fuel wood (36.49%) and kerosene (31.08%) were considered secondary fuels for making *Wot.* Charcoal is also identified as the most important fuel source by 83.69 percent of the respondents who make coffee at home. Moreover, it is used at least on a secondary basis in 2.88 percent of the total coffee-making households. Other fuel like kerosene (35.19%) is taken as main supplementary fuel. With regard to making tea, about half of the tea-making households (53.03%) prepare tea using mainly charcoal and 31.39 percent of the surveyed households also utilize kerosene as a primary fuel (Table 3).

Table 3: Percentage distribution of survey households by fuel-choice for baking and cooking end-uses.

Energy end-uses	Fuel choice	Fuel type used					
		Fuel wood	Charcoal	Dung cake	Kerosene	Biogas	Electricity
Injera baking	Primary	72.94	-	-	-	-	27.06
	Secondary	14.01	-	12.77	-	-	11.46
Local food cooking	Primary	62.18	20.56	25.44	-	5.92	-
	Secondary	48.08	23.53	12.61	-	3.36	-
Wot cooking	Primary	9.92	56.85	-	23.94	2.52	6.77
	Secondary	36.49	19.59	3.72	31.08	1.35	7.77
Tea making	Primary	0.65	53.03	-	31.39	12.81	12.12
	Secondary	22.03	22.37	-	29.49	-	26.10
Coffee making	Primary	8.40	83.69	-	5.11	2.80	-
	Secondary	51.92	2.88	-	35.19	2.44	7.67

Even with high access to electricity, biomass still remains the primary energy source for baking and cooking. The proportion of households using fuel wood for baking *Injera*, cooking local foods as well as brewing local alcoholic drinks (*Chekka, Tella and Areki*) is higher, while charcoal and kerosene are by far the most important types of cooking fuels used by two-thirds of sample households. Charcoal is found to be the significant source of energy for cooking *Wot*, coffee and tea in both urban and peri-urban areas followed by kerosene. Though kerosene was second to charcoal, its use is less common as a primary cooking fuel. However, more people use it as a secondary fuel, mainly for fast cooking. The data indicate that 23.10 percent of households still use

kerosene as a cooking fuel and 26.90 percent use electricity for domestic cooking purpose, while in the case of biogas there were only 17 users within the sample households.

Here it should be well emphasized that most of the sample households utilize more than one type of fuel for different types of fuel end-uses. Use of a mix of two fuels for cooking purposes is common and helps manage their daily cooking activity. Biomass fuel is very important in the energy mix of all households interviewed. The majority of the households interviewed fall into the category that use both charcoal and fuel wood together. They were used as the main baking and cooking energy source in a considerable number of urban households (66.26%), while electricity and kerosene appear only in a limited category for the purpose of cooking. Even if the use of charcoal is always accompanied by fuel wood, to offset the supply problems linked to biomass fuels, about 18.69 percent of sample households have chosen to diversify their choices by combining charcoal and kerosene as their main energy source for cooking purpose. Kerosene was used for emergency cooking along with biomass fuels.

Charcoal is most preferred urban cooking fuel and is still very important in the energy mix of all households. The results show that majority of the households regardless of their economic status combine the use of charcoal with other source of energy in their household. Assessment of fuel end-use showed that roughly half of those surveyed households use charcoal as their primary fuel and many more use it in combination with kerosene and/or electricity to satisfy some cooking needs. The survey revealed that a quarter of the sample households (25.84%) use charcoal and electricity, which is another most common cooking energy mix. For those households who use electricity as the main source of baking and cooking energy, they also use charcoal in substantial amounts.

Peri-urban households using biogas for cooking also use fuel wood to supplement their cooking fuel requirement. As it was directly observed during the survey, all of the bio-digesters of the surveyed peri-urban households were functional. Nearly 5 percent have been using the digester for less than 5 years. Only 2 percent are functioning for more than 5 years. The visible challenges of the biogas technology could also be noticed during the study. During the field visit, it was found that majority of peri-urban households used fuel wood for cooking although a few households had installed the biogas plant recently. Over half of those surveyed (56.20%) indicated that the input from their cattle dung was not enough to feed the bio-digester, hence they collect additional dung from grazing areas and it is fed irregularly to the plant. According to the survey findings, the challenge is how to facilitate access to biogas plants for all communities to improve their livelihood. The use of LPG for cooking is almost negligible. Access and consistent availability of modern cooking fuels are important, for example, households that are willing and able to pay, simply will not make the switch from charcoal to LPG if the gas, stove, and gas bottles are not consistently available in a convenient location. This implies insignificant potential for reducing the pressure on local forest resources by substituting or switching from biomass to modern fuels.

Only 19.3 percent sample households used single source of energy for cooking, while the proportion of sample households who depend on multiple energy options as main energy sources is 80.7 percent. The study has acknowledged that households do partial switching towards the use of cleaner technologies such as kerosene and electricity. The study revealed that urban and peri-urban households are not directly moving up the energy ladder even as their incomes grow. Fuel switching does not occur to the extent often hoped in the case of cooking. Almost all households have moved up the energy ladder and eventually switching to electricity was for lighting, not for cooking. This implies that access to electricity might not be a very good indicator for the welfare of households. When respondents were asked to reason out as why a problem exists in energy-use in the household, they replied, physical access to energy is hampered by frequent shortages of LPG, irregular supply of grid electricity, high cost of fuels and energy appliances among others. One central issue at the heart of households' energy-insecurity is the inability to afford to pay for the fuel and energy-using appliances.

The majority of sample households (60.5%) reported that there was no enough money to pay for the energy they need. These people cited the rising cost as the main reason for non-adoption of conventional fuels and improved stoves for cooking purpose. The prices of conventional fuels are still rising and the high up-front costs for improved appliances prevent the majority of households from changing their consumption patterns. More than half of sample households (52.43%) have the feeling that biomass fuels are scarce. The proportion of fuel wood and charcoal consumers who reported shortages were 52.23 percent and 52.47 percent of the total, respectively. Less than half of electric-using households (46.5%) perceived irregular supply of electricity as the main problem and almost less than a third of those who responded (32.98%) expressed the opinion that there is shortage of kerosene, whilst a minority (17%) mentioned the unavailability of LPG as the major problem associated with energy-usage in their community.

The majority of households (78.6%) complained about frequent and unexpected power interruption. Sudden power cuts and interruptions which make electricity a very unreliable source of energy as the users find it hard to predict its availability. Such erratic supply of electricity, according to the interviewees, affects their social as well as economic life. Many tasks cannot be performed in the evening at the time of power disruptions. Some even complained of having their appliances damaged due to the frequent unannounced power outages. Other problems in the supply of electricity are high electric tariff (9.6%) and voltage fluctuations (9.1%) as well as poor quality of electric power (2.8%). The outcomes of the focus group discussions also identified inefficiencies and mismanagement by the electricity providers. Interview with representative of Ethiopian Electricity Utility of Arba-Minch branch admitted that there is a major power shortage which happens for various reasons like overloading of electricity network, damage to electric transmission lines and substations. He said the power consumption trend in the country is changing. The problem is that there is a high power demand that the transformers at times are unable to accommodate. Such high power demand is beyond the capacities of transformers. The problems, according to the energy providers, emanate from inadequate infrastructure, lack of finance and capacities of personnel. In period of failure of electricity or power interruption, candle and rechargeable electric batteries are immediate substitute sources used for lighting. The other sources of energy used for lighting are dry cell batteries and solar lamps. Focus group discussions revealed that the problem of energy insecurity is not only related to electricity but it also applies to kerosene. As already stated, 32.98 percent of sample households asserted that they have always problems with kerosene supply. Kerosene makes food preparation faster but the shortage associated with it makes it unreliable. When kerosene shortages occur, sometimes it takes a month to get back into the market.

Table 4: Proportion of households reporting fuel shortages by source of energy.

Activity	Fuel type	Number of households reporting shortage	Number of households reporting no shortage	Total number of respondents
Baking/cooking	Fuel wood	259	237	496
	Charcoal	297	269	566
	Sawdust	31	2	33
	Dung cake	68	28	96
	Electricity	89	102	191
	Kerosene	54	111	165
	Biogas	4	13	17
Lighting	Electricity	205	438	643
	Biogas	4	13	17
	Candle	38	458	496
	Dry cell battery	21	28	49

It is important to consider households' actions to address the energy insecurity challenges that confront them. Households pursue a number of strategies to cope with problems that affect energy security. One of the most appropriate strategies to provide a sustainable energy source for the urban and peri-urban households is to give a considerable focus on alternative sources of energy that can alleviate the energy problem. Survey results reveal that households employed different coping mechanisms to handle increasing scarcity of fuels. About 43 percent of the respondents tried to manage the problem by using alternatives. Charcoal is the cheapest alternative when compared to other commercial fuels and for this reason it will continue to be the most preferred cooking fuel for some time in the future. Electricity and kerosene are still too expensive for most of the families in the town. Charcoal is most important substitute of fuel wood as reported by 65.46 percent of the total fuel wood consumers. It appears that urban households are showing a tendency to switch from firewood to charcoal– mainly due to convenience of the latter and not price advantages. When firewood is scarce, peri-urban households cope by substituting fuel wood with dung cake (14.89%). The growing shortage of fuel wood for household consumption in these areas has led to the dung cake as principal cooking fuel. However, biogas and kerosene play minor role as fuel wood substitute. The results suggested that in most cases fuel wood and sawdust might be complement. A possible explanation for this is that, when the two fuel types were used together, they burned longer.

Charcoal is used mainly for cooking function and in periods of its shortage, fuel wood (49.77%) and kerosene (27.44%) were common substitutes. The alternative wood fuels still remain viable solutions for low income peri-urban households with a significant health risk as a result of indoor pollution. Moreover, in peri-urban residential area, among higher income households biogas is most common renewable energy technology that can practically substitute the fuel wood and charcoal for cooking in peri-urban area. Kerosene appears to be consumed by a relatively small segment of the peri-urban population. The result of the study showed that kerosene is relatively expensive; therefore, its use is limited. During the time of kerosene shortage, the most common substitutes are charcoal (51.90%) and fuel wood (32.90%). The interviewees pointed out that they decided to use both charcoal and wood because sometimes they find it difficult to get kerosene to buy. Thus, they would shift to charcoal as soon as kerosene becomes unavailable or they would use both at the same time in order to maintain constant supply of energy in the house. Most households are forced to shift to charcoal whose supply is relatively regular.

When many of the sample households face electric power interruption, residents use alternative energy sources such as fuel wood, charcoal and kerosene for baking and cooking. The use of electricity as domestic fuel other than for lighting is limited due to low income levels of the majority of the households. When urban households get connected to electricity they generally continue to use biomass fuels for cooking and the use of electricity was mainly for lighting and TV viewing and radio listening rather than cooking. Many people with access to grid electricity are still relying on biomass for baking and cooking end-uses. As a coping mechanism from the sample households who still utilize electricity, 37.7 percent of electric users tried to cope up by minimizing consumption, 27.5 percent shifted to biomass fuel, while 34.8 percent utilize both ways. In period of electricity shortage for baking purpose, more than a third of these electricity users (39.60%) utilize fuel wood as alternative baking fuel. Charcoal and kerosene are also used as major electricity substitutes for the purpose of other cooking as reported by 43.56 percent and 12.87 percent households of electricity consumers, respectively. The result indicates that for a small proportion of sample households (26.90%) electricity is found to be a substitute not only to the wood fuels (charcoal and firewood), but also to the modern fuel, kerosene, while for the majority (73.10%) electricity is not found to be a substitute to the wood fuels (charcoal and firewood) with respect to baking and cooking. Most urban households cannot easily make a transition from biomass to electricity for cooking end-use since the high costs of modern cooking stoves are major constraints for them.

Table 5: Alternative cooking fuels which are being promoted as a substitute for cooking end-use.

Main cooking fuels	**Alternative fuels when there is shortage of main cooking fuels**							**Number of respondents**
	Fuel wood	Charcoal	Sawdust	Dung cake	Electricity	Kerosene	Biogas	
Fuel wood	-	170	7	39	11	18	14	259
Charcoal	149	-	nil	24	29	82	13	297
Sawdust	26	3	-	2	nil	nil	nil	31
Dung cake	46	12	4	-	nil	nil	6	68
Electricity	35	39	nil	nil	-	11	4	89
Kerosene	18	28	nil	nil	8	-	nil	54
Biogas	2	2	nil	nil	nil	nil	-	4

Cooking energy consumption patterns are characterized by a high dependence on biomass fuels. The sample households were asked for their view concerning the impact of biomass combustion. The consumption of traditional biomass fuels reveals that women are at a disadvantage to men as far as negative health and safety impacts of these fuels are concerned. Among the households that reported use of biomass fuels for cooking, the majority (91%) were using an open fire which emits very high levels of smoke that contains a wide range of potentially hazardous pollutants. This is the main risk factor contributing to the health problems of householders due to exposure to indoor air pollution. Traditional biomass energy-use has direct negative impacts on women who are the most vulnerable group in terms of biomass energy scarcity and adverse indoor air pollution impacts. The health impact of biomass fuel-use is well understood by almost all biomass users. According to the responses, over three-quarters (75.8%) of the women are kept to stay indoors, even though they know the impact.

There were a total of 120 women victims of health problems due to continuous burning of biomass fuels. The most commonly cited health effects related to biomass cooking are eye and breathing problems. Among the total victims, the findings show 47.5 percent of the women respondents in urban households suffer from eyesight problems. Almost a third of those who responded (32.5%) indicated that they had breathing problems. Just a quarter (25.83%) felt they had back strain problems. Very few (2%) reported 'no problem'. Residents in peri-urban area were more inclined to perceive high health problems compared to residents in the town as they are significantly dependent on biomass fuels for baking and cooking.

Obviously, women, who are responsible for cooking meals for the family, suffer disproportionate health risks associated with such cooking practices (WHO 2009). The conditions of cooking in most households are poor; kitchen location affects the exposure to and concentration of pollutants. Most of the kitchens were built in simple ways having no proper ventilation. The majority of urban households use privately owned kitchens for *Injera* baking and cooking purposes. More than half of the households (51.98 %) have private kitchens that are separated from the main house for baking and cooking and about a quarter of sample households (25.68%) share kitchens with neighbors. The rest 22.34 percent of the households have private kitchens which were found attached with the living house. Most of the households who live in rented *Kebele* houses share kitchen and this has become a problem to own fuel- saving technology for *Injera* baking which needs space for its installation. Kitchen problems as in the case of *Injera* baking were not mentioned in *Wot* and coffee preparation by the sample respondents as they can be performed indoor in a small space using mainly charcoal. A lack of space around the kitchen and poor ventilation or chimney systems for the smoke lead to very high level of exposure to the pollution in the homes, especially

of women and young children. It is important to improve the efficiency of the traditional cooking stoves and change their cooking practices by employing cleaner alternative fuels and end-use technologies to improve energy efficiency so that the pressure on surrounding forests could be alleviated and household energy-related problems tackled. In addition to adopting improved stoves, women need to have well housing status. There is a need to scale up the kitchen and housing conditions for cooking since many of the households were found to be not only lacking their own houses but also living in overcrowded rooms with poor housing conditions and lacking basic facilities.

CONCLUSION

The study results indicate that many households rely on wood fuels (wood and charcoal) as their primary source of baking and cooking energy despite the accessibility to grid electricity. The existing supply of fuels could barely cope up with the ever increasing demand for more domestic fuel requirement. Biomass fuel prices in urban markets often rise rapidly as wood resources are seriously depleted in the study area. The study revealed that an increase in household income does not necessarily mean an overall switching, where biomass cooking fuels totally substitute for clean cooking energy sources. Despite many efforts, most urban households still appear not to be benefiting significantly from modern fuel supply availability. Electricity is likely to reach nearly all the households, nevertheless, most households do not enjoy the full benefits of electricity. Most households move up the "energy ladder" and eventually switching to electricity for lighting, not for cooking. Most urban and peri-urban households cannot easily make a transition from biomass to electricity for baking and cooking end-uses since the high costs are major constraints for them. Cost of electrical cooking and LPG gas-using appliances are beyond the financial reach of most households.

An increase in household energy demand has led to massive deforestation on the outskirts of the town. This has resulted in serious shortage of wood fuels and higher prices. One great concern, however, is the local authority does little to control access to the hinterland forests of the town from where wood fuel is extracted and supplied. The local government should give attention to the amount of depleted natural resources and rate of rapid deforestation to lessen the environmental impact from overexploitation of these resources. There is a need to practice afforestation and encourage conservation of natural vegetation by growing trees so that the pressure on surrounding forests and soil resources could be alleviated and household energy-related problems tackled. The local government should give attention to the amount of depleted natural resources and control or restrict the flow of wood fuels into the town and take immediate actions over the illegal harvesting of forest resources. Limited numbers of urban-based wood fuel traders must be made able to obtain exploitation permits.

This study suggests that increasing end-use efficiency should be given greater emphasis as an important prerequisite and cost-effective solution to tackle household level energy problem. Most end-use technologies used by most households in the town are inefficient and it is important to change households cooking practices by employing proper end-use technologies. The ability to use any modern fuel is dependent on the energy-users' ability to afford not only the fuel on a regular basis but also their ability to pay for the energy-using appliances. One solution to the environmental consequences of unsustainable wood exploitation requires that modern cooking fuels and related appliances be made more accessible and affordable. The government should develop policies and regulations that are directly targeted at reducing the upfront cost of energy-saving devices, hence making it accessible and affordable. A price subsidy policy for modern fuel may be one of those policy instruments to reduce the consumption of wood fuels and increase the choice of modern energy sources. Further research should be undertaken to investigate what changes in household circumstances may have an impact on energy consumption. To generate achievable policy strategies and development targets with regard to energy poverty, there is a need for more studies at the local level to allow further assessment of local dimensions of the subject. A further study could assess the long-term and wider-range effect of energy poverty at household

levels. Such studies could help in the design of better strategies and policy instruments in the energy sector.

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