Household's investment in energy efficiency and coping strategies to electricity tariff increase[1]

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Outlines

Summary

One of the mechanisms reducing power outages during peak load is by motivating households to adopt energy efficient technologies and other energy conservation activities. These activities are also an integral part of households copying strategies to an increased electricity tariff. In order to improve the quality of electricity services, recently Ethiopian electricity utility has revised the electricity tariff. If significant number of households adopts these energy efficient technologies and other copying strategies, the saved electricity may allow deferral of construction of new power plant. This in turn saves investment cost or helps to create access to areas with no electricity.

This report studies on household's investment in energy efficiency activities and their coping strategies to the increased electricity price. A random sample of 1400 urban households was selected from a MTF sample households, which were also randomly selected based on probability proportional to size sampling technique. Due to Covid-19 and the associated travel restrictions, a face-to-face survey was difficult to conduct and hence a phone survey was conducted in main urban centers of all regions of the country. Results of the collected data were analyzed using qualitative and quantitative analysis methods.

The study result shows that 61% of the sample households' did one or more of energy efficiency and conservation activities which includes shifting baking and cooking time, adopting energy efficient technologies, turning off light bubs and other appliances when not in use, and reducing the number of light bulbs. About 86% of the households use energy efficiency and conservations activities mainly to reduce energy expenses. Majority of these households purchase these efficient appliances before the implementation of the new tariff. Only 3.9% of these households purchased after the new tariff is implemented. Results related to the copying strategies show that more than 50% of the sample households use copying strategies like reducing the frequency of cooking and turning of appliances. This implies households engaged in cheaper coping activities or activities that do not require purchase of an item. Only small households (3.9%) have purchased energy efficient appliances in response to the increased electricity tariff. About 10% of the sample households also shift to biomass fuels for cooking activities.

The regression result also shows that household's educational status, income or occupational status, access to credit, and age to be significant determinants on households' investment on energy efficient technologies and copying strategies. Unlike many rural studies on energy efficient technologies, gender is not a significant determinant of adoption of energy efficient technologies, as both husband and wife will have similar incentive to save cost of energy consumption.

The study has policy implications on the product specification of energy efficient technologies.

1. Introduction

This report focuses on the adoption of energy efficient technologies and coping strategies to increased electricity prices. The first part of this report, adoption of energy efficient technologies, refers to households general investment in energy efficiency without referring to any policy changes or price changes while the second part is related to households coping strategies to increased electricity prices.

Investment in energy efficiency and energy efficient technologies in the residential sector (e.g. Light bulbs) has the potential to reduce the consumption of energy resources and this makes energy more accessible to many households and enterprises. Improved electric energy efficiency also has spillover benefits by reducing power outages caused by overburdened generation, transmission, and distribution infrastructure; which in turn may also improve customer satisfaction and reduction in payment rates. Further, investments in energy efficiency and energy efficient technologies have also the added advantage in reducing greenhouse gas emissions. Given these benefits of energy efficiency and efficient technologies, it is important to investigate on factors that promote or inhibit the diffusion or adoption of these technologies.

Although there are several driving factors for the households' adoption of energy efficient technologies, prices can be one factor. This means adoption energy efficient technologies are one of the coping strategies for increased electricity prices. In Ethiopia, electricity price had not been revised for in the past decade. However recently, electricity prices are increased depending on the consumption block ranging from 0%(lowest block (50kwh)) to more than 60% (highest block, more than 500kwh). Depending on the their consumption block, households will take different coping strategies. This study will investigate the different coping strategies households undertake and determinants of these coping strategies.

There are a growing number of studies in the developing countries that study on households' use of energy efficient technologies and coping strategies to increased prices (e.g. Reddy et al 2004; Steg et al,2008; Alem et al, 2014; Hassen, 2015). Previous studies focus on the adoption of a single technology and or coping strategies. A household will not only use one energy appliance or coping strategies, rather it uses multiple appliances for different services or multiple copying strategies. The decision to buy one efficient energy appliance/copying strategy may depend on the other technology either because the technologies are complementary or both depend on households observed and unobserved characteristics. A household may make in investment decision of multiple related energy efficient technologies or coping strategies or may make sequential decision in the investment of the technologies or coping strategies. Unlike previous studies in SSA, our study includes the effect of households' behavioral motives for engaging in energy efficiency and energy efficient technologies or coping strategies. Households may adopt the energy efficient methods and technologies either based on pure economic reasons i.e., save energy cost or out of concern for the environment or both. To best of our knowledge, studies in SSA countries did not take the effect of these factors into account.

The rest of the report is structured in the following way. The second section discusses on the data sources and study method, sections three and four presents a discussion on households' investment in energy efficiency and coping strategies. The last section concludes.

2. Data and method

2.1 Data

The study is based on a phone survey data collected from nine regions of the country[2]. The sample households are from urban areas of these regions. In selecting the sample households, we followed a sampling frame of the World Bank's Multi Tier Frame Work (MTF), a survey that was conducted in 2016/2017. The MTF survey covers both rural and urban areas of the country, however, the study covers only the urban part because the mobile phone availability is limited in the rural area and there will be sample selection problem. In urban areas, the mobile phone access is 100% and all urban MTF sample

[2] Recently the country's regions become 10 by granting one zone to get a region status.

households have mobile phone number.

The MTF is a multi country survey data, which was, aimed at the Worlds Bank's a new measure of energy access called the Multi-Tier Framework (MTF). It divides energy access into six different levels, from Tier 0, where no or very little access to electricity is present (just enough to power a torch or a portable radio), to tier 5 where any high power appliances can be supported and cooking is done with the most efficient cook stoves. The approach is technology neutral, and encompasses off-grid, mini-grid, and grid solutions. The Ethiopian survey was one of these cross-country surveys.

The MTF survey used a nationally representative sample of households, which were selected based on two-stage cluster sampling approaches. In the first stage, it selected primary sampling units, i.e. the Enumeration Areas. It used the Ethiopian Central Statistics Agency (CSA) Enumeration Areas, which were used for the population and housing census conducted in 2007. A total of 337 Enumeration areas were chosen using probability proportional to size sampling technique, i.e., proportional to the size of population. These selected EAs cover the all regions, and include rural and urban areas. In the second stage, 12 households from each enumeration area were chosen using systemic random sampling method, except for Addis Ababa where 20 households were chosen systematically to include slum areas. If the enumeration area is under national grid electricity, 9 electricity-connected households and 3 non-connected households[3] were selected to make the total number of households for that EA 12. A total of 4317 households were used for the baseline MTF survey and about 2500 households were from urban areas.

In this study, due to resource limitation we do not conduct a survey of all MTF urban households. We randomly selected 1500 households from the list of 2500 MTF sample households. Due to Covid-19 and travel restrictions related to Covid-19, it was not possible to conduct the face-to-face survey. Hence, we used a phone survey method. On average the phone interview took about 45 minutes. For most of the households, the interview was non-stop (uninterrupted interview) while for others requires second call. About 100 of the 1500 were not interested to get interviewed during the second call and this dropout is not systemic to the observed socio-economic characteristics of the

[3] MTF obtained the g rid connection status from the Ministry of Water, Irrigation and Electricity.

households. Thus, this study is based on a sample of 1400 urban households from all regions of the country.

2.2. Method

Both qualitative and quantitative methods are used in the study. A qualitative method is used to analyze households' perception of the newly revised tariff. Households were asked their perception on the affordability of the new tariff, their wariness and whether they think the tariff has impacted their consumption. Further, a qualitative method was also used to analyze households' perception of impact of the new tariff on their electricity consumption. A qualitative method is also used to understand households motive to make investment in energy efficiency. In the qualitative method, percent, mean and standard deviations are used to analyze the study results. A quantitative (econometrics) method is also used to analyze determinant of multiple energy efficient technologies and /or coping strategies. In particular, we used multivariate probit econometric model. This model is used to estimate non-linear simultaneous equation model and control the bias that come from correlation of unobserved correlates of multiple energy efficient technologies and /or coping strategies.

3. Socio-Economic Status of the respondents

Tables 1-3 show the socio-economic characteristics of the sample households. From Table-1 , it can be seen that, on average, the sample households have either higschool or primary level of education. Table-2 shows the dis-aggregated education level of the respondents. About 76% of the sample households have high school or less than high school level of education, which has an implication on their knowledge about energy efficient technologies. Most of the energy efficient technologies are imported and description of items specification including their energy efficiency is in English. Households with primary or no formal education or some with high school will have difficulty in understanding the specifications. Fig-1 below shows language is one of the barriers of adoption of energy efficient technologies.

Table-1: Socio-economic Characteristics of the Households

Variable	Obs.	Mean	Sd.
Education (0=no education,	1,400	1.103	0.864

1=high/primary school, 2 college, 3= university)			
Marital status (1=married, 0=not in marriage)	1,400	0.599	0.490
Main occupation (0=unemployed, 1=casual, 3=hired,4=own business)	1,400	1.737	1.157
Average Monthly expenditure	1,400	4229.5	2605.2
Average monthly income	1,400	5698.7	6164.4
Gender of the households (=1 male)	1,400	0.574	0.494
Age of the household head	1,400	50.883	14.383
Household size	1,400	4.787	2.016

Further, about 40% of the sample households are either casual workers or unemployed (depend on other family members or income property rent). This also has an implication on the purchase of the energy efficient workers. Casual workers in Ethiopia have subsistent wage income and will have difficulty to cover the upfront cost or to get a credit to buy the technologies. Unemployed household heads that depend on remittance or income of other family members may also have the challenge in the decision to buy the items. They need an approval from these family members to purchase the item on cash or on credit.

Table-2: Education level of the respondents (Sample Size=1400)

Education level categories	Percent
No education or informal education	21.83
Primary or high school education	56.85
College level	10.44
University complete	10.88
Total	100

Table-3: Main occupation of the respondents (Sample Size=1400)

Main income source occupation	Percent
Unemployed or unable to work	21.15
Causal or pensioner	20.07
Salaried professional	22.72
Own business	36.06
Total	100

From Table-1 we can also observe that about 43% of the household heads are women, which is higher than the rural areas. In rural areas, men are the default household head and made most household decisions. Table-1 also shows that about 60% of the

respondents are currently married and spending about 75% of their monthly income on food and non-food items.

4. Households investment in energy efficiency

Before presenting study's result on households' energy efficiency investments, we presented households energy expenditure and compare it with their monthly income.

Table-4 shows households energy expenditure. As can be seen from the table households mean monthly energy expenditure is about 243.5 birr (about 6 USD), which constitutes about 4% of households' income. This implies that households in Ethiopia send only a smaller fraction of their income on energy. Of all energy sources, electricity expenditure is the highest, which accounts about 66% of total energy expenditure. Households also use biomass fuels in addition to electricity, which has an implication for health and environmental impacts.

Table-4: Households monthly Energy Expenditures in ETB

Variable	Obs	Mean	Std. Dev.
Energy Expenditure	1,400	243.5	145.17
Electricity expenditure	1,400	161.60	57.51
Share of electricity in the total energy exp.	1,400	0.66	0.18
Biomass energy expenditure	1,400	77.10	113.94
Share of biomass in the total energy exp.	1,400	0.32	0.18

Table-5 shows whether households made energy conservation activities, which includes shifting baking and cooking time, adopting energy efficient technologies, turning off light bulbs and other appliances when not in use, and reducing the number of light bulbs. Table-5 shows that majority of respondents (61%) did one or more of energy conservation activities. These activities have the advantage in reducing the load during the peak hours.

Table-5: % of households who have done energy conservation(N=1400)

	Percent
1. Yes	61.29
2. No	38.71
Total	100

Households may have different motivation to conserve energy. The motivations could be to reduce energy expense, conserve natural resources and/or to future generation, reduce emission of greenhouse gas and etc. Respondents were asked their main motivation to use any of the energy conservation activities. About 86% of the respondents responded that their main motivation is to reduce expenses. About 12% of the respondents concern mainly for climate and future generations, which is encouraging.

Table-7: Main motivation to conserve energy (n=858(i.e. 61.29% of the total sample))

	Percent
Reduce expenses	86.93
Conserve natural resources and/or to future generation	11.66
To reduce emission of greenhouse gas	1.06
Other	0.35
Total	100

Table-8 shows the percentage of respondents using energy efficient technologies for various end use services. Almost all proportion of (about 92%) the respondents uses energy efficient light bulbs. It is expected because the government has banned the import and local production of the incandescent light bulbs. Further, between 2009 and 2012 there was a free and subsidized distribution of CFL light bulbs by the Ethiopian Electric Utility. This may have increased create awareness and continued use of energy efficient light bulbs.

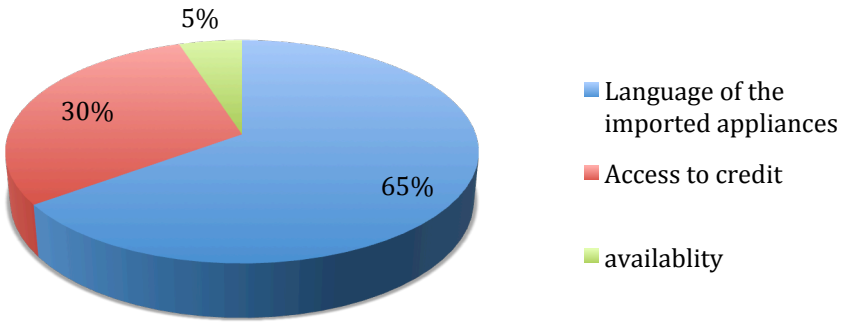
About 34% of the respondents use energy efficient electronic appliances, which is higher than the rate of adoption of light bulbs. These products may be purchased in recent years. Recently purchased electronic appliances are mostly energy star as the energy inefficient electronic appliances are becoming out of the market. In Ethiopia, second hand market for electronic appliances is not commonly available and hence households will only have the chance to buy the new appliance when they plan to purchase the item.

Table-8: Adoption of Energy Efficient Technologies

	Freq.	Percent
Adopt Energy Efficient bulbs	1285	91.75%
Adopt Energy Efficient biomass stove	379	27.07%
Adopt Energy Efficient Electronic appliances	481	34.36%

Sample households were asked to list the main barriers of adoption of energy efficient appliances. Figure-1 shows that more than half of the respondents reported that they have a difficulty of identifying the efficient appliances in the market because the description of product specifications is not in local languages. Almost all imported products have product descriptions in non-Ethiopian languages. In most European and Latin American countries, imported products have product descriptions in the national language of importing country. Further, lack of access to installment-based credit is also one of the barriers for low use of energy efficient electronic appliances. 30% of households also reported that access to credit as a barrier of adoption.

Fig-1:Barriers to adoption of energy efficient technologies



Intra-household decision-making power is one of the key variables in the decision of purchase of energy efficient appliances. For example in rural area, because households mostly use biomass fuels from forest and it is the wives responsibility for cooking and biomass collection, the husband has less interest to spend money on energy efficient biomass stoves as this does not save his monthly expenditure. Thus, it will be in the interest of the wife to buy it. The more the wife has the power in the household decisions, the more likely will be the energy efficient stove to be purchased. Alem et al (2020) found that rural wives with higher decision-making power are more likely to buy energy efficient technologies. However, the urban case is different from rural areas. This is mainly because most urban households depend on purchased energy sources and hence

both husband and wife have an interest to buy energy efficient appliance to reduce energy expenses. Consistent with our expectation, Tables-9 shows that most urban households decide either together or the wife has more power when they buy energy efficient appliances.

Table-9: Decision making on the purchase of energy efficient appliances

	Percent
Wife	24.12
Both husband and wife	65.9
Husband	9.98
Total	100

A multiverse probit regression model was employed to analyze the determinants of adoption of the energy efficient technologies. The regression result a shows that household's educational status, income or occupational status, access to credit, and age to be significant determinants on households' investment on energy efficient technologies. Unlike many rural studies on energy efficient technologies, gender is not a significant determinant of adoption of energy efficient technologies, as both husband and wife will have similar incentive to save cost of energy consumption (see the separate paper for details).

5. Households coping strategies to electricity tariff increase

Staring with the acceptability and affordability of the increased electricity tariff, table-10 shows households response to acceptability and affordability of the new tariff. From this table we can see that around 74% of the sample households characterize the tariff as expensive or very expensive. On the other hand, 67% of the households were aware of the second tariff increment (implemented in December 2019). Since the tariff increment is for the second time, it may be challenging for most of the households. Consequently, about 82% of the sample households characterize the second tariff increment as expensive/very expensive. As a result, households take measures to cope up tariff increments.

Table-10: Households acceptability, affordability and awareness of the new tariff

Variable	Obs.	Mean	Std. Dev.

Affordability of the 2018 electricity price increment	1,400	0.264	0.441
Awareness about the 2019 electricity price increment	1,400	0.674	0.469
Affordability of the 2019 electricity price increment	1,400	0.180	0.384

Table-11 shows households' perception of the effect of new tariff on their electricity consumption. Households were asked whether the new tariff has decreased, increased or unchanged. In the first tariff increment (i.e. in 2018), around 54% of the households reported that they did not significantly change their electricity consumption. This could be because only a few households (42%) were aware of the tariff increment. However, in the second tariff increment, about 49% households reported that their consumption is decreased while about 47% of the households did not change their consumption. Those households who decreased consumption may have used different coping strategies, such as switching to other energy sources such as biomass fuels.

Table-11: Households perception on the effect of new tariff on electricity consumption

Perception of tariff change	2018 tariff increment (N=1,400)	2019 tariff increment (N=1,400)
Increased	1.74	2.37
Decreased	41.61	48.89
No change	53.84	47.38
No opinion	2.82	1.36

Households use different coping strategies in response to this increase electricity tariffs in Ethiopia, one of which is the adoption of energy conservation strategies. 61% households have been using energy conservation methods prior to the increment of the price. These households may cope the increased electricity price better than those households that do not use the energy conservation methods after the increment.

In this study, we investigated five coping strategies undertaken by households, which are shown in Table-12. About half of the sample households have not taken any new action to cope with the higher tariff. However, the remaining half of the households has used at least one coping strategy following the introduction of the new tariff.

Only about 4% of the sample households purchased energy efficient appliances following the increased electricity tariff in Ethiopia. About 31% of the sample households reduce the frequency of cooking and baking following the two tariff increments, while about 11% reported that they have shifted to other fuels, such as biomass, for cooking and baking activities. This shift has implications for forest degradation and greenhouse gas emissions.

Table-12: Households response to increase tariff

Actions taken	**Percent (Sample size=1400)**
No new action taken in response to the tariff increase	22.56%
Reduced frequency of baking and cooking	31.36%
Adoption of energy efficient appliances	3.96%
Turning off light bulbs and other devices when not in use	27.32%
Reducing the number of light bulbs	2.86%
Switching to other fuel sources, such as biomass fuels	10.99%
Others	0.95%
Total	100%

In a separate paper on the determinants of households coping mechanisms, a multivariate probit regression model was used to analyze the results. From the model estimates, household size, previous energy consumption experiences/patterns, ownership of bank account, access to credit and also the affordability of the first tariff change plays a significant role in determining the coping strategies selection.

6. Conclusions and policy implications

This report studies on household's investment in energy efficiency and their copying to an increased in electricity price. A random sample of 1400 urban households was selected from a MTF sample households, which were also randomly selected based on probability proportional to size sampling technique. Due to Covid-19 and the associated travel restrictions, a face-to-face survey was difficult to conduct and hence a phone survey was conducted in main urban centers of all regions of the country. Results of the collected data were analyzed using descriptive and econometric data analysis methods.

The study result showed most households (76%) have low level of education and this has an implication in reading and understanding of the description of the specification energy efficiency appliances, which are written in English. Language is mentioned as one of the

barriers of adoption. Further, Lack of access to credit is one of the barriers of adoption of energy efficient stoves. Households mean energy expenditure constitutes about 4% of their income, which implies that energy expenditures constitute only small proportion of their monthly income and hence this may lower the motivation to adopt energy efficient technologies. In addition to electricity, households also use biomass fuels, which has health and environmental impacts.

The study also finds that majority of respondents (61%) did one or more of energy efficiency and conservation activities which includes shifting baking and cooking time, adopting energy efficient technologies, turning off light bubs and other appliances when not in use, and reducing the number of light bulbs. Most households (86%) use energy efficiency and conservations activities mainly to reduce energy expenses. Only 14% of the sample uses these activities out of concern for climate and future generations.

The result also shows that at least 74% of the households characterized the revised tariff as expensive or very expensive which shows a need for diversified coping strategies.

In response to the increased prices, more than 50% of the sample household's use coping strategies that do not require purchase of an item(or do not have further monetary expense). More than 50% of the sample use reducing the frequency of cooking and baking and turning of appliances when they are not in use. Only small households (3.9%) have purchased energy efficient appliances in response to the increased electricity tariff.

The regression result also shows that household's educational status, income or occupational status, access to credit, and age to be significant determinants on households' investment on energy efficient technologies and copying strategies. Unlike many rural studies on energy efficient technologies, gender is not a significant determinant of adoption of energy efficient technologies, as both husband and wife will have similar incentive to save cost of energy consumption.

The study results have the following policy implication. First, most of the sample households in the study have high school or less level of education and households identify language as a barrier of adoption, which has the difficulty to understand the description of the product specification, which is written in English. This implies that the government needs to set a new law, which mandates to include specifications in local language. Most European and Latin American countries have this privilege. Second, the

results also imply that access to credit is important in the use of energy efficient technologies. A policy that incentivizes or promotes firms to sell energy efficient products on installment based is needed.

In relation to the new tariff, as the tariff burden gets tougher households look for cheaper coping strategies that includes switching to biomass fuels. This will have negative impacts on health and the environment. Hence, the utility company should include education through media on coping strategies that help households reduce their cost and those do not have significant health and environmental impacts.

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