Assessing the Impacts of Rural Electrification in Sub-Saharan Africa: The Case of Ethiopia

by

Mekonnen Lulie Aragaw
BSc., Addis Ababa University, 1980
M.Sc., University of Surrey, 1988

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the Department of Interdisciplinary Studies

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University of Victoria

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Outside Member
Abstract

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Outside Member

This study links rural electrification and the transition to modern energy services with poverty reduction and rural development in Ethiopia. Benefits of rural electrification in reducing poverty and accelerating rural development in low-income developing countries have been insufficiently researched. This study analyses available empirical evidence at a local level and examines how electricity access translates into productive use beyond powering radios and lighting. A survey of 336 households was conducted in Northern Ethiopia on impacts of electrification on four rural towns with varying number of years of access to electricity. Evidence at household and community levels shows that access to electricity was followed by an increase in household connectivity rate, and slow transition to modern energy services based on level of household income and number of years of a household’s connection to electricity services. The pace of transition to modern energy services was slow, and household energy poverty and dependence on biomass fuels continued in most rural towns, having little impact on improved environmental management practices. Improvement in rural livelihood, poverty reduction, and delivery of public services was highest for those with more years of access to electricity, and higher income households. The fact that impacts of RE depend on number of years of a household’s electricity connection implies gradual improvements rather than immediate benefits after connection. In the short-term, households improved their quality of life through better lighting and reduced indoor-air pollution. In the medium and longer-term, households and communities diversified their income and received improved public services such as education, health, and potable water. Further benefits were wider off-
farm and non-farm employment, increased rural markets, and improved environment for rural development. Very poor households benefited least, while those better-off utilized opportunities created through rural electrification. Though necessary for development, rural electrification alone is insufficient, and requires strong government commitment and political will to invest in public services and infrastructure, and encourage private sector participation.

Keywords: rural electrification, modern energy services, Sub-Saharan Africa, Ethiopia, energy transition, Poverty Reduction, Rural Development.
## Acronyms, Units of Measurements, Ethiopian Words, and Conversion Factors

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ADLI</td>
<td>Agriculture Development-Led Industrialization</td>
</tr>
<tr>
<td>AFREPREN</td>
<td>African Energy Research Network</td>
</tr>
<tr>
<td>AQG</td>
<td>Air Quality Guidelines</td>
</tr>
<tr>
<td>BLT</td>
<td>Branches, Leaves and Twigs</td>
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<tr>
<td>CD</td>
<td>Compact Disc</td>
</tr>
<tr>
<td>CDM</td>
<td>Clean Development Mechanism</td>
</tr>
<tr>
<td>CESEN</td>
<td>Centro Studio Energia (CESEN)-Ansaldo/ Finmeccanica Group</td>
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<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
</tr>
<tr>
<td>CSA</td>
<td>Central Statistical Authority</td>
</tr>
<tr>
<td>DFID</td>
<td>Department for International Development (UK)</td>
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<tr>
<td>DVD</td>
<td>Optical Disc Storage Media Format</td>
</tr>
<tr>
<td>ECBP</td>
<td>Engineering Capacity Building Program</td>
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<tr>
<td>EEA</td>
<td>Ethiopian Electric Agency</td>
</tr>
<tr>
<td>EELPA</td>
<td>Ethiopian Electric Light and Power Authority</td>
</tr>
<tr>
<td>EEPCO</td>
<td>Ethiopian Electric Power Corporation</td>
</tr>
<tr>
<td>EREDPC</td>
<td>Ethiopian Rural Energy Development and Promotion Centre</td>
</tr>
<tr>
<td>EREP</td>
<td>Ethiopian Rural Electrification Program</td>
</tr>
<tr>
<td>ESMAD</td>
<td>Energy Sector Mapping and Database Development</td>
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<tr>
<td>ESMAP</td>
<td>Energy Sector Management Assistance Program</td>
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<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GEF</td>
<td>Global Environmental Facility</td>
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<tr>
<td>GNP</td>
<td>Gross National Product</td>
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<tr>
<td>GTP</td>
<td>Growth and Transformation Plan</td>
</tr>
<tr>
<td>GTZ</td>
<td>German Technical Cooperation</td>
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<tr>
<td>HH</td>
<td>Household</td>
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<tr>
<td>HICES</td>
<td>Household Income and Consumption Expenditure Survey</td>
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<tr>
<td>HIV/AIDS</td>
<td>Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome</td>
</tr>
<tr>
<td>IAP</td>
<td>Indoor Air Pollution</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>IDA</td>
<td>International Development Association</td>
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<tr>
<td>IEA</td>
<td>International Energy Agency</td>
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<tr>
<td>IPP</td>
<td>Independent Power Producer</td>
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<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
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<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
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<tr>
<td>MES</td>
<td>Modern Energy Services</td>
</tr>
<tr>
<td>MOFED</td>
<td>Ministry of Finance and Economic Development</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
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<tr>
<td>PASDEP</td>
<td>Plan for Accelerated and Sustained Development to End Poverty</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>PM</td>
<td>Particulate Matter</td>
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<tr>
<td>PPA</td>
<td>Participatory Poverty Assessment</td>
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<tr>
<td>PRSP</td>
<td>Poverty Reduction Strategy Paper</td>
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<tr>
<td>PV</td>
<td>Photo Voltaic</td>
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<tr>
<td>RE</td>
<td>Rural Electrification</td>
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<tr>
<td>REA</td>
<td>Rural Electrification Administration</td>
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<tr>
<td>SDPRP</td>
<td>Sustainable Development and Poverty Reduction Program</td>
</tr>
<tr>
<td>SHS</td>
<td>Solar Home Systems</td>
</tr>
<tr>
<td>SME</td>
<td>Small and Micro-Enterprise</td>
</tr>
<tr>
<td>SNV</td>
<td>Netherlands Development Organization</td>
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<tr>
<td>SPSS</td>
<td>Special Program for Social Sciences</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub-Saharan Africa</td>
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<tr>
<td>TB</td>
<td>Tuberculosis</td>
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<tr>
<td>TV</td>
<td>Television</td>
</tr>
<tr>
<td>UEAP</td>
<td>Universal Electricity Access Program</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>UNDESA</td>
<td>United Nations Department of Economic and Social Affairs</td>
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<tr>
<td>UNDP</td>
<td>United Nations Development Program</td>
</tr>
<tr>
<td>USD</td>
<td>United States Dollar (US$)</td>
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<tr>
<td>WB</td>
<td>World Bank</td>
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<tr>
<td>WEC</td>
<td>World Energy Council</td>
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<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WMS</td>
<td>Welfare Monitoring Survey</td>
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Units of Measurements

Btu  British thermal unit
Ec  Ethiopian cents
Gcal  Giga calorie
Gj  Gigajoule
GWh  Giga Watt Hour
Ha  Hectare
Kcal  Kilocalorie
Kgoe  Kilogram of Oil Equivalent
Ktoe  Kilo Tonnes of Oil Equivalent
Km  Kilometre/s
KVA  Kilo Volt Ampere
KWh  Kilowatt hour
Mcal  Mega calorie
Mg/M3  Miligram per cubic meter
MJ  Mega-joule
M/S  Meters per Second
MW  Mega watt
Tcal  Tera calorie
TCF  Trillion Cubic Feet
Toe  Tonnes of Oil Equivalent

Ethiopian Words

Birr  Ethiopian unit of Currency
Debo  Community group formed to share agricultural chores at peak seasons
Injera  Spongy pancake-like bread prepared mainly from a staple crop called teff
Keble  The lowest administrative unit equivalent to a county
Mitad  A clay pan of 50 to 80 centimetres diameter used for baking injera
Woreda  A lower local government administration unit equivalent to district
Wot  A type of stew commonly served and eaten with injera
Zone  An administrative unit higher than a woreda, equivalent to a province

Conversion Factors

US$ 1.00 = Eth. birr 117.65 (January, 2012)
1 GJ = 0.024 toe = 277.7 KWh = 239 Mcal
1 KWh = 3.6 MJ
1 Kcal = 4.187 KJ = 1.163 Wh
1 Tonne of Fuel-wood = 0.32 Toe = 13.6 GJ
1 Tonne of Charcoal and Briquette = 0.69 Toe = 28.9 GJ
1 Tonne of Agri-waste (Agri-residue) = 0.28 Toe = 11.6 GJ
1 Tonne of Dung Cakes = 0.21 Toe = 8.9 GJ
1 Tonne of LPG = 1.08 Toe = 45.2 GJ
1 Tonne of Kerosene = 1.03 Toe = 43.1 GJ
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Acknowledgements

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Dedication

To my wonderful wife, Bruktawit Mamo Abayneh, who gave me all the encouragement and support I needed. Bruke persevered by her own during my long absence for field work, raising three kids, studying, and working on two jobs to keep our family in good shape.

To my son Bemnet and my lovely daughters Bethel and Rediet, who all understood the value of my effort and appreciated the scope of work I had to go through. I am very glad to observe that my kids are inspired by this PhD study, which I believe they learned that education has no age-limit and that it is possible to achieve more through hard work.

To my late friend Dr. Elias Cheboud, who inspired me to pursue this study and supported me from the very beginning.
CHAPTER I
INTRODUCTION

This research is motivated by a desire to study how the delivery of modern energy services (MES)\(^1\), primarily electricity, can contribute to reducing poverty while stimulating sustainable development in Ethiopia in particular, and within Sub-Saharan Africa (SSA) in general. The working definition of poverty I employ in this dissertation is the pronounced deprivation of well-being represented by lack of sufficient food, income, employment, social services, status and adequate housing that result from growing inequality and powerlessness. (Johnson and Goldemberg, 2002; UNDP, 1996).

Understanding how households actually respond to Rural Electrification (RE) is an important first step in contributing to the knowledge required to tackle the broader challenges of poverty reduction, especially alleviating energy poverty. What I mean by 'energy poverty' throughout this dissertation is the absence of sufficient choice in accessing adequate, affordable, reliable, good quality, safe and environmentally benign energy services to support economic and human development (UNDP 2000a).

The research examines the impact of RE in specific communities in Ethiopia through field surveys at the local level during November 2007 to June 2009. Results of these surveys reveal that RE contributes to reducing poverty and improving rural livelihoods, and may therefore facilitate rural development. However, it is important to note two characteristics under which these benefits were achieved. One is the availability of complementary factors such as increased government budget for the expansion of infrastructure and social services, along with a greater commitment and support to private sector participation at local levels. Secondly, achievements were not immediate, and
required a number of years of connection to electricity services before substantial RE benefits were observed.

Poverty is a challenge that is deeply entrenched in these rural communities, and requires concerted actions over a long period. In spite of global claims and ongoing efforts in reducing poverty and destitution, over 2 billion people live on less than a dollar a day, while an equal number of people suffer from energy poverty - lacking access to modern energy services (UNDP/Johnson and Goldemberg, 2002). In SSA, a minimum of 400 million people do not have access to electricity services (Bergman, 2005). Emerging evidence suggests that the UN Millennium Development Goals (MDGs) will not be met without timely delivery of appropriate energy services (UNDP/Modi et al., 2005; UNDESA, July 2007). These facts, together with the ‘growth and poverty reduction’ agenda of low-income countries such as Ethiopia, have prompted the re-introduction of RE initiatives (World Energy Council, 2005a). However, actual benefits of RE are rarely documented and remain unclear, especially in SSA.

The present research addresses two specific questions: (1) what factors influence rural households’ electricity connectivity rate, level of electricity utilization, and energy transition to MES once rural villages acquire access to electricity services? (2) to what extent does rural electrification contribute to reducing poverty and promoting rural development in low-income developing countries? The objectives of this research are to examine the extent to which access to electricity services contributes to accelerated household energy transition to MES, and to assess the impacts of RE in reducing poverty and in achieving rural development in SSA. The research examines tangible benefits
observed in rural towns and households that received access and connection to electricity services\textsuperscript{2}.

Providing electricity services to rural villages in SSA is believed to transform quality of life through creating social benefits and stimulating economic growth, eventually enabling social equity, poverty reduction, and achievement of the MDGs (UNDP/ Modi et al., 2005; UNDESA, July 2007).

Rural electrification expansion programs in low-income countries face two fundamental challenges: low connectivity rates and limited absorption capacity of poorer households to fully utilize electricity services; and limited rural markets to stimulate the utilization of electricity services for productive use.

The use of electricity services by poor households after connection tends to be limited to lighting and radio/ TV reception, raising doubts about the contribution of RE towards reducing poverty and achieving sustainable development. While expanding access to electricity for the poor can contribute to alleviating energy poverty and improving quality of life, it is not clear how effectively and at what pace RE translates into sustainable development comprised of economic, social and environmental gains. In terms of economic benefits, data are required on the impacts of RE on expanding productive sectors, enhancing agricultural development and agro-processing, improving micro/ small-scale businesses, and generating employment and income. Socially, more local level data are needed on the impacts of RE in facilitating equity, reducing poverty, improving public services and the health of women and children, and improving gender relations by reducing workloads for rural women. It is necessary to measure the environmental impacts of RE on reducing air pollution from the continued use of solid
fuels. Such measurements would help determine whether RE can restore local ecosystems and eventually contribute towards mitigating climatic change and global warming at regional and global levels.

This study also examines whether these desired RE benefits, such as energy transition to MES, reduced poverty, rural development, and sustainable environment are attainable in the context of SSA.

Following this introduction of the research and main contents of the project, are five chapters. Chapter Two reviews available documents on potential roles of RE in reducing poverty and facilitating rural development. It is on the basis of these perceived RE benefits that the field research design was founded and empirical evidence collected.

Chapter Three discusses Ethiopian economic, social and environmental conditions followed by an overview of Ethiopia’s poverty reduction and sustainable development agenda. Next, the country’s energy policy, strategies, and power sector development plans are highlighted. The Ethiopian power sector development and RE expansion program are presented as background case studies for understanding RE benefits and challenges in SSA. Ethiopia was chosen because of its ongoing substantial power sector development and its ambitious rural electrification program. An aggressive export-oriented power sector development program has been implemented, doubling the 800 MW of installed power in 2008 to 1842 MW in 2010. Ethiopia also plans to reach 5,000 MW power production capacity in 2013 and further double that amount in ten years. In parallel, an ambitious rural electrification program is underway, delivering electricity services to over 50% of rural villages and towns from its baseline low outreach of only
17%. It is believed that vital lessons concerning expanding RE can be learned from the experience of Ethiopian RE and power sector development programs.

Chapter Four highlights the research methodology, which is based on primary data collection at household and community levels. The local level study comprises the bulk of this research project, as primary evidence could be recorded at household, community and district levels. Cross-sectional field surveys were conducted in four adjacent rural towns with varying numbers of years of access and connection to electricity services to assess the impacts of electricity access over time. Household responses were used to measure impacts of RE at the household and community levels, as well as associated improvements in rural livelihoods. Statistical tests were applied to measure possible association of a town’s number of years of access and a household’s number of years of connection to electricity services. Depending on data availability, household income, occupation, and family size were used as additional independent variables in testing the benefits of RE. Finally, household, community, and district, (woreda) level data were analyzed to examine impacts of RE in reducing poverty and in facilitating rural development.

Chapter Five discusses the research findings together with an interpretation of the field survey outcomes. This chapter presents the main research findings through reviewing RE impacts on household electricity connectivity rate, level of utilization of electricity services, household transition to modern energy services, and inter-fuel substitution after receiving access to electricity services.
Chapter Six further examines the benefits and impacts of access and connection to electricity services and improvements in the delivery of public services such as education, health, water supply and sanitation, provision of grinding mill services, and street lighting. Tables and figures are presented showing survey results generated at household, community, and district levels. Data analysis is supported by logistic regression tests, as most of the household and community responses were dichotomous. When applicable, linear regression models were applied in analysing continuous variables.

Chapter Seven concludes the research outcome with a summary of tangible RE benefits and impacts in reducing poverty and promoting rural development that have been achieved and recorded in Ethiopia over the last decade. The chapter further notes that the contribution of RE in facilitating these achievements is paramount, but is not sufficient on its own. Recorded benefits may not be judged by RE impacts in isolation from the contribution of a number of other interrelated and interdependent factors. These factors include expansion of income generation options through off-farm and non-farm employment creation, agricultural development, introduction of a favourable investment climate, and the development of infrastructure. These key factors must work simultaneously to create the right level of synergy. The role of RE is mainly in catalyzing the effective delivery and performance of these key factors.
CHAPTER II
POTENTIAL BENEFITS OF RURAL ELECTRIFICATION IN REDUCING POVERTY AND IN MEETING THE MDGs

This chapter reviews the available literature on benefits of rural electrification. The first section establishes the relationship between modern energy services, poverty and development in the context of SSA. Section two discusses the benefits of RE in meeting household, social, and economic energy needs, and describes its contribution to reducing poverty and promoting rural development. In section three, some of the impacts of RE on local culture are assessed.

2.1 Linking Modern Energy Services, Poverty and Sustainable Development in Sub-Saharan Africa

The relationship between energy poverty and overall poverty is easily visible in SSA. Over 50 percent of the total population in the sub-region live on less than 1.25 dollar\(^4\) a day, with one person in two living in extreme poverty (United Nations Press Release, 2008). Furthermore, poor households face energy poverty, with up to 95% of the total household energy needs within SSA dependent on traditional solid fuels such as fuel-wood, dung and agri-residues\(^5\) for cooking and heating (Karekezi 2002). Only 51% of the urban and 7% of the rural population have access to electricity (Komives et.al. 2005). Whenever households obtain access to electricity services, their consumption level is so low that most fail to benefit from the diverse services that electricity could provide. SSA has the lowest per capita electricity consumption in the world, with average
consumption for Africa being 125 KWh *per capita* per year, 2.5 times less than the average consumption in Latin America and the Caribbean (Karikezi and Kimani, 2002).

The presence of energy poverty in SSA is best summarized by Sten Bergman (World Energy Council, 2005a) as follows:

Africa is locked into a cycle of energy poverty. It has 13% of the world population, but accounts for less than 3% of global primary energy demand – *per capita* primary energy consumption is 0.063 tonnes of oil equivalent a year (toe/y) compared with the world average of 1.76 toe/ year. Biomass dominates consumption. The continent’s electricity sector lags far behind world standards, particularly in Sub-Saharan Africa (SSA): In 2000, the electrification rate was 34.3% – 22.6% for SSA – compared with the world average of 72.8%; The rural electrification rate was 17% – 7.5% for SSA – compared with 51% for other developing countries; and *Per capita* electricity consumption was 500 kilowatt hours a year (kWh/y), and less than 150 kWh/y excluding South Africa, compared with a world average of 2.5 megawatt hours a year.

Energy poverty and overall poverty are entangled with a cause and effect relationship at both household and national levels. Akinlo (2008) examined the causality between energy consumption and economic growth for eleven SSA countries, and found that energy consumption is ‘co-integrated’ with economic growth in seven of the countries; namely Cameroon, Cote d'Ivoire, Gambia, Ghana, Senegal, Sudan and Zimbabwe. Furthermore, energy consumption has a significant long-term impact on economic growth in Ghana, Senegal and Sudan.

The poor in SSA are not in a position to acquire MES due to the high cost of accessing these services, including energy, appliance and connection costs. This situation creates a loss of alternatives for low-income countries and poor households, forcing the poor to remain trapped in poverty. Because the poor cannot generate adequate income, they may not afford to use MES; because they cannot afford these services, they fail to
raise their incomes and improve their livelihoods. There is a very high tendency for the poor in SSA to remain trapped in poverty, partly as a result of limited access to MES.

At the household level, even under very low income conditions and a high share of biomass energy use, the proportion of energy expenditure to overall household expenditure remains substantial, exerting huge pressures on household livelihood. A rural household energy consumption survey conducted in Ada’a and Meskan districts in central Ethiopia showed that household energy expenditure accounted for up to 24 percent of overall household expenditure, the second largest expenditure category next to food. This is excluding nearly all biomass fuels that are self-produced and freely collected, and whose monetary value is over four times the value of purchased fuels (SNV Ethiopia, 2009). If the bulk of these self-produced biomass fuels were to be substituted by MES, the share of energy expenditure would increase to 41 percent\(^7\). Assuming that incremental income will spread proportionately to current and actual household expenditure share, household income must be doubled for these households to be able to acquire MES for all their household energy use. While the transition to MES is one very essential condition for breaking out of the poverty trap, it is equally important that a substantial increase in income is required to acquire MES. The development and use of MES thus requires a certain income threshold, which is lacking in SSA.

Household energy poverty contributes to perpetuation of overall poverty such that the use of traditional biomass fuels causes heavy workloads and health hazards for women and children while limiting a household’s chance of ensuring food security. Other than its adverse impact on continued level of poverty, lack of access to MES has a gender dimension. The 2009 SNV study also showed that female household members, that is
women and girls, were most exposed to both difficult working conditions and in-door air pollution. Survey results of over 251 sample households in Ada’a district showed that female household members collected energy (84%), collected water from distant sources (57%), and were exposed to smoke (94%) more than their male counterparts.

In addition to continued poverty and gender disparity impacts at the household level, the delivery and use of biomass such as fuel-wood, charcoal and dung exert huge pressures on the local ecosystem, causing land degradation in the form of massive soil losses and decline in agricultural productivity, which is one of the root causes of increasing food insecurity and poverty (Cecliski, 2000; UNDP, 2000b). At the national level, energy development and use in a country is highly related to the level of income, with the use of MES increasing as national economies climb to higher income levels.

Figure 1 shows the direct relationship of modern energy consumption to the level of income of a country, expressed by *per capita* GDP.

**Figure 1: Per Capita Modern Energy Consumption and GDP per Capita in SSA**

*Per capita* modern energy consumption of SSA countries such as Ethiopia and Burundi are the lowest, while Zambia and Zimbabwe are the highest, proportionate to their *per capita* GDP. Access to MES in SSA is further constrained by limited level of access to electricity services, especially for rural households. *Per capita* electricity consumption in SSA is directly related to levels of *per capita* GDP. Countries with relatively lower level of *per capita* GDP consume similarly lower level of electricity *per capita* such as Ethiopia, Malawi, Uganda, and Tanzania.

**Figure 2: Per Capita GDP and Per Capita Electricity Consumption in Selected SSA Countries**

![Graph](chart.png)


Note:  Data years range from 2004 to 2010

Electricity access has some relationship with level of poverty of a country within SSA. Figure 3 below shows that countries with lowest electricity access rate experience highest poverty ratios. Mozambique, Zambia, and Malawi face low electricity access and
higher poverty ratios. The case of Botswana explains the relationship more clearly where the country enjoys low poverty ratio while achieving over 40 percent electricity access. The case of Zimbabwe is an exception where high electricity access co-exists with very high poverty ratio, the latter taking place mainly due to the past decade of economic collapse. Tanzania, Ethiopia, and Kenya experience modest combination of both electricity access rate and poverty ratios.

Figure 3: Poverty Ratio and Electricity Access Rate in Selected SSA Countries

This implies that electricity access and electricity consumption have some relationship with income and level of poverty. Delivering alternative energy services from fossil fuels and traditional sources encounters two constraints: (1) increased volume of liquid petroleum imports and escalating world prices of fossil fuels are causing high energy import bills and compromising energy security while threatening investment for development in low-income countries. Volume of petroleum imports in Ethiopia grew by
an average of 90 percent between 2000 and 2009, while petroleum import prices grew by 380 percent over the corresponding period, consuming all of the country’s export earnings (ESMAD, Main Report, 2012a); (2) traditional solid fuels are growing scarce and are depleting fast as a result of being exploited beyond their sustainable yield (Cecliski, 2000; UNDP 2000b; ESMAD, Main Report, 2012a). A recent FAO Statistics report showed that above ground forest biomass stock in Ethiopia decreased by 24 percent, falling by an average of 8 percent every five years over the past 20 year period of 1990 to 2010 (FAO Report, 2010).

Augmenting the supply of biomass fuel resources may not be attainable in the short-term. It becomes apparent that the delivery of MES is needed to break this downward spiralling relationship of energy, poverty, and environmental degradation, and gradually improve the livelihood of rural people, especially women.

These concerns justify the need for expanding locally generated low-cost electricity from renewable and sustainable sources to the rural poor. However, the delivery of electricity services to meet projected economic development needs is a large task requiring huge investment. As national economies grow, investment in power generation and delivery will have to increase well in advance to meet such growing demand. In Ethiopia, electricity demand grew at an average of 9 percent per year approximately 10 years ago when the country’s GDP was growing at less than four percent. Demand for electricity grew at around 12 percent over the period of 2005–2008 and increased by an average of 25 percent in subsequent years, (ESMAD, Power Sector Database and Report, 2012b). This is a huge demand increase and requires equally high
investment in power system development, probably doubling every four years. Meeting the investment required for such a growing power sector is another challenge facing SSA.

The Engineering Capacity Building Program in Ethiopia has estimated that electricity supply will have to grow 48 times of the 2007 production level for the country to meet economic growth projections by 2030 (Figure 4). This magnitude of need for MES in Ethiopia may demonstrate the investment requirement in SSA in general.

Figure 4: Power Sector Expansion Requirements to Meeting Projected Economic Growth in Ethiopia


MES, especially electricity services, are all required to provide public services such as education and health in rural and impoverished areas. While poor households might face access barriers to electricity services for most of their end-use requirements, the delivery of electricity services at the community level will enable shared use of these services and facilitate the delivery of social services (at community level). However,
delivery of electricity services exclusively to community use purposes may not warrant the returns required to sustain supply, which might only be ensured when sufficient demand is created by the community and individual households at large.

2.2 Rural Electrification Benefits to Poverty Reduction and Development

“...The first benefit we received from the (Rural Electrification Administration) REA service was lights, and aren't lights grand? ... radio was the most popular appliance that had been bought. Next we bought an electric refrigerator. ...We changed our washing machine ....We changed our pump for the pressure tank in our bathroom and water system from a hand pump to an electric pump. The next benefit we received from the current was our electric stove.....” (Scearce, TVA, 1930).

There is evidence that RE benefits exceeded lighting services in the case of the USA just after the electrification of rural America in the 1930’s. At that time, households improved their quality of life and enjoyed the benefits of efficient, time-saving, and cost-saving electricity use for various chores including lighting, radio transmission, washing machines, water pumping, ironing, cooking, and vacuum cleaning (Scearce, TVA, 1930). This was a remarkable achievement for rural US in the 1930s where per capita income was the highest. The case of SSA today is by no means comparable with the economic conditions of the US 80 years ago. The challenge in the case of SSA is that poverty is so entrenched in rural communities that such expected benefits may not be fully gained through access to electricity services alone.

It has been documented that RE would enhance quality of life of rural households, provide social benefits and stimulate economic growth, including social equity and poverty reduction (UNDP/ Modi et. al., 2005; UNDESA, 2007). The following section
reviews available literature on RE benefits in reducing poverty and achieving social and environmental gains.

Despite extensive literature on RE, we have noted earlier that actual measurements of its impacts on the poor in developing countries are rare. The existing literature gives strong credit to RE for serving as a catalyst in accelerating rural development and delivering social services that can expand employment and income, eventually reducing poverty and improving quality of life of the rural poor. The presence of electricity facilitates the expansion of micro-businesses, strengthens the service sector, and improves quality of life at the community level.

Earlier records of actual RE benefits show similar household and social gains in developing countries that have introduced RE programs (Munasinghe, 1987). Common benefits of RE include lighting and communication for household use, and lighting and refrigeration services for community applications such as health facilities, schools and street lighting. Substantial improvement in quality of life was recorded after the introduction of RE programs in most of the participating countries, primarily from quality lighting services. Improved reading skills, higher literacy levels, and improved education are positively correlated with electrified households and communities.

The following electricity benefits are documented in the literature on poverty reduction and improvement of social services:

a) *Eradication of extreme poverty:* In SSA, extreme poverty rate is expected to fall below 36 percent (UN, MDG Report, 2011). One of the most important contributor to growth in income is access to electricity services, through expanding productive and commercial establishments, enhancing agricultural development and agro-processing,
improving micro/ small-scale businesses, and generating employment and income (UNDP/ Modi, et.al, 2005; DFID, 2002; UNDESA/ UN Energy, 2007).

As previously noted, poverty and hunger can be reduced if electricity services are delivered to the poor. However, access to electricity by poor households remains extremely low, with 1.6 billion people unconnected and with 2.4 billion people worldwide relying on traditional biomass fuels for cooking (UN-Energy paper, 2005). Electricity provides brighter illumination to households where women and other family members can use the light for reading and for productive activities. Home-based income generation activities and micro-businesses are facilitated and expanded through electricity (UN Energy Paper, 2005). The informal sector, one of the largest employers and the fastest growing segment of the economy in SSA, is also a substantial user of energy, and has wider potential for transition to electricity use if cost and connection barriers can be overcome (Karekezi and Majoro, 2002).

Grid expansion programs in Zimbabwe that targeted RE at income generation and productive uses of small and medium enterprises proved effective in reducing poverty. A study conducted in Southwest Zimbabwe on 73 business enterprises showed that rural employment increased after RE was introduced from 108 to 285 employees, and 41 percent of the new employees were female (Mapako and Prasad, 2006).

Perhaps the most visible benefit of access to electricity is the impact it can have on food security through the pumping of water for agriculture and home use. Agriculture productivity increases substantially both in terms of quantity produced per season and number of seasons under production. Irrigated agriculture is the most immediate option
available for ensuring food security by way of increased food production for one’s own use and for marketing cash crops (Modi.et.al. 2005).

Benefits of RE for agricultural development is evident in India where RE programs were primarily intended to increase agricultural productivity through pumped irrigation in the 1960s and 70s. Significant improvements were recorded in raising agricultural productivity and expanding land under irrigation (Bhagot, 1993). India has managed to energize 14.1 million pumps as of 2004, significantly contributing to agricultural development and food security (India Energy Portal, 2004). This level of coverage in energizing agriculture was possible by introducing favourable tariffs and farm site power connection arrangements. Unfortunately, most SSA countries such as Ethiopia have not developed their capacity of utilizing RE for pumping underground water resources for agriculture (Awlachew et.al. 2007).

There is no doubt that the delivery of modern energy services, and especially electricity, contributes to economic and social development. The very strong relationship existing between energy intensity and level of GDP of a country supports this assertion. However, the contribution of RE in reducing poverty and facilitating sustainable development comes into question when it is delivered to poor rural villages that experience extreme poverty, where the use of electricity may not go beyond lighting. As more evidence emerges that the delivery of modern energy services is essential for ensuring sustainable development, it is necessary to examine more closely poverty reduction and development processes in impoverished rural villages where electricity services are being delivered.
The delivery of successful RE programs calls for availability of adequate market structures, all of which are scarce in the countries of SSA, making the viability of RE more daunting. The delivery of electricity services to the rural poor becomes a challenge where the capacity to pay and the level of demand are very low. It is important to note that government priorities, coordination, financing, and full involvement are vital at the early stages of RE program development, while mechanisms should exist for private sector involvement through time. It is also vital that appropriate policies and regulations are in place for targeting the poor and ensuring financial sustainability of RE systems at the same time.

Rural social services comprise education, health, grinding mills, and street lighting services that are essential to improving quality of life in rural communities. Expanding electricity services to low-income and low-demand areas is expected to also expand access to improved social services and contribute to improving quality of life and well being for the poor. RE can improve the provision of public services such as education and health and alleviate the suffering of the poor, especially of women and children through reducing workloads and minimizing the exposure to indoor air pollution. And as previously mentioned, electric lighting allows extended reading and other productive work in the evenings (UNDP/ Modi et.al. 2005).

b) Improved education services:- Electricity services provide a direct means of enhancing primary education through lighting and the use of media/ ICT (Information and Communication Technology). Distance learning opportunities and the use of equipment in remote locations are facilitated through the use of electricity services in villages where school enrolment rates have remained low (UNDP/ Modi et.al. 2005). Lighting enables
evening classes to take place when youth and adults, especially women who are busy
during the day, can attend. Distance learning using ICT is one inexpensive and effective
means of expanding education in rural areas. Its use can enhance and standardize the
quality of teaching, narrow the disparity in quality of education at both primary and high
school levels while decreasing school dropout rates (UNDP/ Modi et.al. 2005). Such
benefits can only be achieved if there is access to electricity services. In locations where
grid extension is not possible, stand-alone mini and micro-hydro generators and
photovoltaic sets such as Solar Home Systems (SHS) have proved effective as

A number of additional indirect benefits arise from access to electricity in the
form of retention of motivated teachers who otherwise opt for transfer to main towns
where electricity services are available (UNDP/ Modi et.al. 2005). Electricity services
contribute to reducing household chores such as grinding, water and energy collection
that compete with school attendance for children, especially girls (UN Paper, June, 2005).
RE also contributes to improving health, sanitation, and income, thereby motivating
parents and children to attend schools. Access to radio, television and digital technology,
albeit in a community level arrangement, are enhanced following the delivery of
electricity, which both directly and indirectly contribute to the promotion of universal
education and exposure to learning (UNDP/ Modi et.al. 2005).

c) Improved Community Health Services:- Community health includes improvement in
child mortality rate, improvement in maternal health, and decrease in the prevalence of
killer diseases. It is believed that child mortality is substantially reduced by the presence
of electricity services. The substitution of traditional solid fuels by more efficient and
cleaner energy services such as electricity reduces indoor air pollution, which is the cause of death for nearly 11 million children in developing countries (DFID, 2002). The same study notes the possibility of delivering clean water nearer to homes as a result of access to electricity, further reducing waterborne diseases for children.

Alleviating workloads through access to electricity means that mothers have enough time to cook nutritious food for infants, improve child sanitation and better attend their children. Reduction of workloads for pregnant women might also minimize their hardships and improve their health status.

The presence of electricity services improves the provision of health services such as availability of preserved vaccines, mother and childcare services, and access to proper treatment at all times, including laboratory test facilities and safe child delivery, which substantially contributes to reducing child mortality (DFID, 2002; UNDP/ Modiet.al. 2005). Parents are able to learn more about childcare through electronic media, improving the health and well-being of children, and substantially minimizing child mortality.

Electricity services can contribute to maternal health by improving women’s quality of life through providing better health services, including prenatal care, which is one of the main factors for reducing maternal deaths (DFID, 2002). Health centres can be better equipped with lighting, refrigeration and use of other equipment for performing operations, including caesarean section. It is also easier to retain qualified health workers in remote towns if electricity services, media and communications facilities are available.

Availability of electricity services enables the delivery of more effective health services, which in turn can help combat HIV/AIDS, malaria and other killer diseases.
Electricity allows the use of refrigerators for storage of vaccines and medicines and use of sterilization/ incineration facilities to stop the spread of HIV viruses. Adequate awareness campaigns can be conducted using media services facilitated by the presence of electricity for radio and TV transmissions. Health education, training and counselling services are provided easily if electricity services are made available. Increased sanitation together with access to potable water through the use of electricity services substantially cuts water-borne diseases and epidemics such as cholera.

d) Promotion of gender equality and empowerment of women:

Access to electricity services is an essential means of promoting gender equality by addressing both ‘practical’ and ‘strategic’ gender needs; that is, in reducing workloads (improving the conditions) and empowering (improving the positions) women in the household and in society. Electricity facilitates the reduction of workloads for women and children by freeing the time needed to collect wood and water. This in turn contributes to increased attendance at schools, which eventually can improve a woman’s position in both the household and in society (UNDP/ Modi.et.al. 2005). Even though information is lacking on the pace of fuel switching from traditional fuels to electricity following connection, the use of electricity for cooking substantially reduces indoor air pollution, which is the main cause of respiratory diseases for women and children in the form of indoor carbon monoxide and particulate matter emissions (WHO, 2006).

e) Ensuring environmental sustainability:

Environmentally, the services from RE are expected to replace hydrocarbon-based fuels and alleviate dependence on traditional energy resources, contributing to pollution reduction and restoring ecosystems, respectively. RE can contribute to reversing environmental degradation at local levels
through providing alternatives to inefficient and polluting traditional fuels. It should be noted that over 90 percent of the biomass energy used in rural traditional open-fire-stoves is wasted (World Bank, 1991), contributing to deforestation, and therefore to global warming. On the other hand, developing countries will increase their use of electricity services as their economies develop, having significant consequences on global energy supply and on the global environment (IEA/OECD, 2008).

However, the transition to MES will have to be based on greener energy resources such as renewable energy instead of hydrocarbon based fuels to ensure a more sustainable path of development. RE outreaches could be expanded through generating electricity from decentralized and renewable energy sources and technologies (such as micro-hydro, solar, and wind), replacing large-scale and fossil fuels-based generation units that can be highly polluting. The issues of global energy security and global warming will both worsen if developing countries demand energy services in the same ways that industrialized countries have followed to date. The expansion of environmentally sound RE would contribute in providing options for sustainable development.

Increased access to safe drinking water can be achieved through the presence of electricity services in a community where electrically pumped water is delivered near to the household or village, alleviating workloads and improving community health by reducing water-borne diseases.

To conclude, electricity services offer wide ranges of benefits in reducing poverty, stimulating rural development and facilitating improved delivery of social services in rural communities. However, existing studies remain at a theoretical level and
fail to provide specific local level experiences, justifying the timeliness of this research project. Field surveys at local levels and secondary data collected at higher levels in Ethiopia concerning the impact of RE on poverty reduction and rural development may provide specific results as discussed in Chapters Five and Six.

2.3 RE Impacts on Local Culture and Social Well-being

The benefits and negative impacts of technology have been a focus of arguments among a number of scholars. Nye (1990) argues that technology is part of a social phenomenon and not merely an isolated system comprising machines. Accordingly, rural electrification becomes not an externally introduced phenomenon, but a result of a ‘social process that varies from one time period to another and from one culture to another’. A similar view is reflected by Pacey (1983) who argues that technology can be used for good or ill, and its impacts should not be associated with the technology per se, but rather in its use or misuse by society. Pacey further classifies technology of practice into cultural aspects, organizational aspects and technical aspects. Therefore, whether technology is culturally neutral or not depends on one’s perspective: whether one sees its technical aspect alone or in the context of human activities related to the technology in question.

Winner (1986) discusses a different point of view, arguing that human lives in a society are influenced by technology to the extent that human beings have turned to ‘a new order of human history’, which is the basis for a ‘a technopolitan culture’.

These scholarly views revolve around the issues of whether technology is an inherent social development process influenced by human choice, or whether it is a
neutral attribute whose system has implications for the latter. The discussion presented in Chapters Five and Six are from the perspective that RE is not a technology that has evolved from the rural inhabitants of SSA, but is rather a system brought in from outside and introduced into the culture of a society that, for centuries, did not have the means and capacity to access it. Therefore, as in any transfer of technology, RE is expected to have an impact on the cultural and social aspects of the local population to whom it has been introduced. Chapters Five and Six discuss the local impacts of RE in the four rural towns in which this research project has been anchored. The study has tried to accommodate additional information on cultural and social impacts of RE from other rural towns in Ethiopia that have been electrified over the last five years.

There are expected additional social benefits to be gained from RE programs in the form of curbing rural-urban migration and rehabilitating the local environment. Providing access to electricity services in rural locations should slow down migration to urban centres as quality of life improves in rural areas (DFID, 2002). While these impacts of RE in promoting economic development and social well-being are visible, such benefits are likely enhanced when RE is delivered with a package of infrastructure and advisory services such as improved health, education, agricultural extension, off-farm income generation, rural finance, and related community services.

**Chapter summary:** The relationship between delivery of electrical energy services and economic as well as social development appears to be strong. The correspondence between energy intensity and the level of GDP of a country supports this assertion. However, the contribution of RE in actually reducing poverty and facilitating sustainable
development goals may be compromised by extreme forms of pre-existing poverty. When electricity is delivered to very poor rural villages, the use of electricity may not extend much beyond lighting. Numerous studies I have cited describe a wide range of RE benefits at the household, social, and environmental levels. While such studies describe (and promote) the broad benefits of RE in promoting rural livelihood and ultimately poverty reduction, they are not firmly grounded on specific case studies based on empirical data. In the following chapters, the specific impacts of RE in promoting economic development and social well-being are examined, with data collected through what one might call the ‘sharp end’ of the development process: that is, local communities.
CHAPTER III
POVERTY, POWER SECTOR DEVELOPMENT AND RURAL ELECTRIFICATION IN ETHIOPIA

Figure 5: Map of Ethiopia

Country Profile:

Population (million): 73.9 (2007 Census), over 80 million by 2011
- Area (Sq. Km): 1.1 million
- Capital City: Addis Ababa
- GDP Growth Rate (%): 11% for 2004-2011 period
- GDP per Capita (US$): 358 (2011)
- Official Exchange Rate: Birr 17.25 = 1US$ (2011)
- Adult Literacy Rate: 38%
- Economic Activities: Agriculture, forestry, fishing, mining, manufacturing
- Energy Sources: Biomass, hydropower, imported oil
- Power Installed Capacity (MW): 814 MW (2008) and increased to 2000 MW in 2010 of which: hydro constitutes over 98 percent
- System Losses (%): 17.3 (2000)
- Electricity Consumption per Capita (kWh): 23 (2000) one of the lowest in the world
- Electricity Coverage (%): 14% of rural villages (2008) grown to 41% by June 2010

Sources: World Bank Database; UNDP/World Bank/ESMAP, 2003; EEPCO, Website Factsheet; World Resource Institute, 2006; MOFED/ PASDEP Report 2006/7.
Chapter Three discusses poverty reduction efforts, power sector development, and the RE expansion program in Ethiopia. It has two main parts: the first part highlights the socio-economic background, poverty levels, and poverty reduction efforts. The second part of the chapter deals with energy sector policy and programs, power sector development trends, and the rural electrification expansion drive taking place in Ethiopia. A discussion of the Ethiopian context is provided to familiarize readers with relevant topics leading to the main analysis in Chapters Five and Six of RE impacts on Ethiopian efforts at reducing poverty, facilitating rural development, and enhancing the delivery of social services.

3.1 Socio-Economic Background, Poverty, and Rural Development in Ethiopia

Ethiopia, found in Eastern Africa, is the second most populous country in the continent, after Nigeria, with a population of 73.9 million (based on 2007 census). Nearly 85 percent of the population live in rural areas concentrated at higher altitudes stretching over 45 percent of the country’s total land area of 1.1 million square kilometres. The Ethiopian highlands are centres for economic activity and are endowed with rich ecological, agricultural, historical and cultural diversities (FAO, 2004). Over 90 percent of the population depend on mixed farming practices, earning an average per capital income of US$130\(^9\), or about US$700 when purchasing power parity is taken into account, which is far lower than most countries in SSA. Over 44 percent of the population live below the poverty line as a result of high environmental and natural resource degradation (World Bank, 2006).
3.1.1 Socio-Economic Background of Ethiopia

This study focuses on Northern Ethiopia, where the presence of extreme poverty can be expected to create challenges for attaining significant benefits during the process of RE expansion. Northern Ethiopia experiences excessive natural resource degradation as a result of a growing population, ongoing extensive agriculture and poor resource management practices exacerbated by chronic energy poverty. Food production, livestock management and energy utilization interact adversely in such resource-scarce areas, forming a positive feedback loop of poverty, food insecurity, energy poverty, and natural resource degradation. Excessive farmland expansion, deforestation, and overgrazing contribute to serious soil erosion, high water run-offs, and subsequent land degradation. Soil loss level in Ethiopia has reached 1.2 billion tonnes annually with nearly 25 percent of the soils being seriously eroded, while 50 percent have been significantly eroded. Loss of forest resources and vegetation cover reaches 100,000 to 200,000 hectares annually (FAO/ Alemneh et.al. 2004).

The study area is within the Amhara regional state located in north-central Ethiopia. Nearly 88 percent of the Amhara population live in rural villages where access to electricity services is below 2 percent. The remaining 12 percent live in towns with urban migration rates at about 5 percent per annum. Traditional land holding remained under communal and semi-private ownership until the introduction of the two land reforms following changes of governments in 1975 and 1990, respectively. Land reform in Amhara Region has aggravated the ongoing poor natural resource management practices contributing to excessive land fragmentation, tenure insecurity and loss of
incentive to invest and properly manage land resources (Mekonnen, 1999). This practice is identical to other experiences in developing countries where land reform and external interferences have accelerated natural resource degradation (Dasgupta, 1997).

Households largely depend on scarcely available fuel-wood, dung, and agri-residues for cooking and lighting, and make nominal use of modern energy services such as kerosene and diesel for lighting and for grinding mills, respectively. Scarcity of fuel-wood and other biomass fuels forces households to rely on cow-dung and agri-residues for fuel, foregoing the valuable use of these resources as fertilizer. As early as 1984, the World Bank estimated that loss of agricultural productivity due to using dung and agri-residues for fuel costs Ethiopia over 2 billion dollars worth of grain loss annually. More recent estimates could be higher as land degradation has continued unabated.

Women shoulder the burden of productive as well as reproductive responsibilities, preparing food, collecting water and fuel-wood and assisting in the farms. In fact, their workload stretches over 16 hours of daily labour (Mekonnen and Melisew, 1999). Biomass fuels are the main causes of indoor air pollution (IAP) related health hazards such as respiratory and eye related illnesses for women and children in SSA. WHO report (2005) showed that Carbon Monoxide (CO) and Particulate Matter (PM) are the main causes of IAP related health problems in developing countries. The same report estimates emission rates of Ethiopian kitchens range “between 80-100 mg/m$^3$ for CO and between 0.98-2.17 mg/m$^3$ for PM. These are very high levels exceeding WHO Air Quality Guideline (AQG) standards by ten times for CO, and by more than forty times for PM.” (Forum for Environment, 2009)
3.1.2 Ethiopian Poverty Reduction Strategy and Development Achievements and Challenges

The level of poverty is wider and deeper in Ethiopia than in most SSA countries. The Ethiopian poverty line stands at birr 1,074 (around 110 US) per person per year, and the food poverty line is as low as birr 647 (US$ 70) per person per year at 1995/96 prices. Government reports show that the proportion of poor people in Ethiopia in 2004/2005 was estimated to be 38.7 percent of the total population of over 70 million. A larger proportion of the poor, 39.3 percent, live in rural areas, while those living in urban areas constitute 35.1 percent, indicating that the poverty level is relatively more severe in rural areas than in urban settings (MOFED/ PASDEP, 2006).

The Ethiopian government claims to have taken a number of actions toward reducing poverty over the last two decades. These actions include strengthening the required development institutions, collecting poverty related data, developing policy/strategy, and introducing a number of programmes towards reducing poverty. Poverty reduction strategies have been periodically developed and formulated in the following documents: (1) Interim Poverty Reduction Strategy Paper (MOFED/ PRSP, 2000), (2) Sustainable Development and Poverty Reduction Program (MOFED/ SDPRP, 2002), (3) Plan for Accelerated and Sustained Development to End Poverty (MOFED/ PASDEP, 2006), and (4) the Growth and Transformation Plan (MOFED/ GTP, 20010-2015).

The latest poverty reduction and development strategy was conceived in mid-2010 to replace PASDEP. It is known as the Growth and Transformation Plan (GTP) and runs from 2010/11 to 2014/15, in parallel with the deadline of the MDGs. The GTP strives to double the economy through faster and more equitable economic growth, and attempts to use a number of strategies such as creating favourable conditions for greater
private sector participation, industrial development, good governance and greater transparency, building local capacities, and increasing the participation of citizens - especially women.

The GTP builds upon the SDPRP (2001-2005) and PASDEP (2006-2010) and is aimed at sustaining the broader achievements of these previous two development strategies. The GTP envisages meeting all the MDG targets over the coming five year period, coinciding with the MDG end date in 2015. It is interesting to note that the GTP differs from its predecessors in that its plan incorporates the development of the energy sector as a tool for meeting planned growth and transformation of other sectors. While the PASDEP focused on power sector development, the GTP envisions a broader investment in the energy sector including power sector development and RE expansion, bio-fuels development, and alternative energy development (MOFED, 2010).

Progress so far in realizing these policies, strategies, and targets has been mixed. The focus on poverty reduction is encouraging. While poverty levels remain still higher than in most SSA countries, there are trends of improvement in Ethiopia when compared with poverty level results of 1999/2000, which was at 44.2 percent, showing a decline in rural poverty by 13 percent between 1999/2000 and 2004/5 (CSA/ HICES, 2004; MOFED/ PASDEP, 2006). The HICES 2004 report further associates the decline in the level of rural poverty with improved agricultural extension services and expansion of road infrastructure.

Though long overdue, one essential change introduced by the Ethiopian government was its focus on pro-poor budget spending, from 28 percent in 1999/2000 to 55 percent in 2004/5 (W B, 2007). Government effort and commitment in adopting
poverty-focused rural development has been substantial over the past decade, and especially after the contested election of May, 2005. This is reflected by its budget allocation for 2008/9 fiscal year. Appendix 3.1 shows that agriculture and rural development accounted for 9 percent, water resources development for 3 percent, roads for 13.4 percent, and rural electrification for 2.5 percent, while justice, security and defence accounted for nearly 10 percent of the 54 billion birr annual budget.

Reducing poverty requires designing a poverty reduction strategy that focuses on improving income earning capacity of the poor and improving quality of life through social services such as education, health, potable water, and related services (UNDP/World Bank/ESMAP, 2003). Such a strategy requires significant commitment to deliver modern energy services that will contribute to increasing household income on the one hand, and enhancing social services on the other. As shown in Appendix 3.1, government budget transfer of 2 billion birr annually to the rural electrification program accounts for 2.5 percent of the total country budget for 2008/9 fiscal year. This is a significant commitment when viewed in conjunction with an additional power sector investment in the range of US$4.5 billion for the generation of 4000 MW hydropower over five years.

3.2. Ethiopian Energy Sector: Current Status, Policies, Development, and Challenges

The Ethiopian energy sector has undergone significant transformation over the period 2008-2011, with growing investment in hydro-based power generation and an ambitious RE expansion program. The country’s energy sector remains underdeveloped, with biomass supplying over 92 percent of energy needs, while imported petroleum and
hydropower account for 6 percent and less than 2 percent, respectively, and reach less than five percent of the population (see Figure 6 below). The following section discusses the Ethiopian energy sector resource base, energy policy focus, power sector development programs, grid based and off-grid RE expansion programs and related achievements.

3.2.1 Ethiopian Energy Resource Base and Energy Utilization

Ethiopia has an ample natural resource base (see Appendix 3.2) from which adequate energy could be supplied to meet its development needs. As shown in Figure 6 below, woody biomass (including branches, leaves, and twigs) accounts for 92 percent of the country’s energy supply from an exploitable amount of 359.4 million toe. Available natural forestland accounts for only 3.5 million hectares, which is less than 3 percent of the country’s land cover. Ethiopia’s hydropower resources are estimated to generate up to 45,000 MW, making it second only to Democratic Republic of Congo within the continent. Geothermal energy potential is over 5,000 MW but remains unexploited, except on a trial site near Lake Langano that generates 7.2 MW. The presence of hydrocarbon resources is not well documented, although a substantial deposit of natural gas has been discovered in the Ogaden. Preliminary estimates suggest that about 1.3 trillion cubic feet of gas reserve exists, but its exploitation has been delayed primarily due to being remotely located from market centres. As Ethiopia is only 9 degrees north of the tropics, ample solar radiation is available reaching 5 KWh/m2/day. Data on wind speed is less documented, with estimated availability of 3.5-7 m/s. Recent wind speed data has shown that there are site specific wind potentials in Ethiopia where wind speed could be over 7 m/s, warranting wind farm development possibilities (ECBP, July 2009). As a
result, the Ethiopian Electric Power Corporation (EEPCO) has started construction of wind farm projects in Ashegoda (Tigray, 120 MW) and near Nazreth (Oromia, 52 MW) with a target of providing up to 10 percent of the country’s energy mix from wind sources. Coal is very low both in quantity and quality, with only 13.7 million tonnes of lignite having been discovered. As shown in Figure 6, the country is characterized by a very low level of consumption of modern energy services, with about 92 percent of the energy utilized coming from biomass sources.

**Figure 6: Energy Supply and Consumption in Ethiopia**


Note:  

a/ The inner circle shows energy supply while the outer circle is consumption.  
b/ Electricity is non-primary energy supplied mainly from hydro.
Utilization share by source shows that fuel-wood consumption (including charcoal and BLT) accounted for 85 percent of all energy supply, while agri-residue accounted for 7 percent of the total energy consumed in the country. Petroleum covered 6 percent while electricity’s share remained at 2 percent. This brings the total share of woody biomass to 92 percent.

As in most SSA countries, the low level of modern energy utilization in Ethiopia tends to be correlated with the very low level of GNP per capita, which currently stands at about US$ 390 per person per year (World Bank Database). Energy intensity is one of the lowest in the world, with about 7,000 Btu per dollar of GDP, while the world average is about 9,000 Btu/$ (US-EIA, 2004-2008).

Other than lack of access to modern energy services, the country is characterized by very low aggregate energy consumption, keeping the country at a very low level of the energy ladder. Excessive dependence on biomass fuels is associated with adverse social, economic and environmental consequences resulting in high energy losses, widespread health hazards, weaker energy interface for development, deforestation and land degradation.

As shown in Figure 6 above, the household sector is the major energy consumer, accounting for over 88 percent of all energy consumed. Industry follows as second at 5 percent of energy consumption while transport and services consume 3 percent each. Industrial energy consumption is mainly in the form of petroleum fuels. Services and public sector energy consumption mainly depends on biomass fuels. Electricity is predominantly consumed by industry and the household sector. The use of kerosene is substantial in rural households mainly for lighting, while urban households use it
predominantly for cooking. It is also interesting to note that the use of energy, especially petroleum fuels, for agriculture is insignificant (about 1%) in Ethiopia due to the traditional and rain-fed based agricultural practices.

Figure 7 below shows that the share of biomass energy has fallen from 96.6 percent in 1996 to that of 92 percent in 2010 and will continue to fall to 71 percent by 2030. The share of petroleum fuels has grown from about 4.8 percent in 1996 to that of 6 percent in 2010 and will jump to 22.6 percent by 2030. The share of electricity has doubled from 1 percent in 1996 to 2 percent in 2010 and will grow to 5.2 percent in 2030.

**Figure 7: Trends in Energy Supply and Consumption 1996-2010 and Projected Energy demand for 2030**

![Trends in Energy Supply and Consumption 1996-2010 and Projected Energy demand for 2030](image)


The share of electricity remained nearly constant in the 1990’s and early 2000s, followed by a sharp increase in both supply and demand after 2005, as shown in Figures 8 and 9 below. An aggressive government power sector development program and an ambitious RE program have both contributed to this marked increase.
Figure 8: Growth of Power Generation Capacity

Generated Energy (GWh)

Source: EEPCO, Website, Factsheet, 2011

Figure 9: Growth of Power Coverage by Electrified Towns and Customers Connected

3.2.2 Ethiopian Government Energy Policy

The Ethiopian government formulated its energy policy in 1994 with an overall goal of ensuring the provision of secured, adequate, clean and affordable energy services that are economically enabling, environmentally sound, socially acceptable, and gender responsive (Government of Ethiopia, 1994). Primarily, the country’s energy policy aspired to ensure that the energy sector would develop at low-cost and at equal pace with the country’s development goals. The Ethiopian energy policy objectives are to:

- ensure a reliable supply of energy at the right time and at affordable prices, particularly to meet agricultural and industrial development energy needs;
- ensure and encourage a gradual shift from traditional energy sources to modern energy services so as to minimize fuel-wood based excessive deforestation;
- increase energy utilization efficiency and reduce energy wastage; and,
- ensure that the development and utilization of energy meets sound environmental management practices.

The policy emphasized its focus and commitment to hydropower development and use, exploration and development of fossil fuels, sustainable use of woody biomass, development of renewable and alternative energy sources, and enhanced energy demand management practices. It identified key policy tools such as developing energy technologies and scientific capacities; encouraging the participation of the community, of women and of the private sector; ensuring sound environmental management practices and institutional development of the energy sector.
The main policy strategy identified was supply augmentation, primarily hydropower and transition from biomass energy to modern and renewable energy forms, supplemented by demand management practices. One area identified as a major priority was accelerated hydropower development and utilization, including rural electrification. The country opted for a gradual transition from traditional to modern energy services while at the same time adopting expanded demand management options such as energy efficiency and conservation practices. The development of human resources was given equal emphasis so as to ensure efficient and effective energy development and management practices. Private sector participation and addressing gender and environmental concerns in the development and delivery of energy services were equally taken as priority areas. The Ethiopian energy policy expressed a commitment to realize energy security through minimum dependence on imported energy, including minimized foreign exchange costs for energy imports.

While the Ethiopian energy policy of 1994 identified a number of key areas and strategic choices, it neglected to elaborate specific focus areas and strategic tools, which then had to be addressed urgently and in some depth to overcome existing challenges in aligning the country’s low level of energy economy with its development needs. Unwritten energy policy directions were realigned in recent years following growing global environmental concerns and global oil price increase. The following major policy directions were developed:

- aggressive hydropower resources development supported by a complementary regional power export option;
- ambitious RE expansion and universal access program through grid expansion;
• reorienting the country’s energy utilization by restructuring energy consuming sectors, primarily the transport sector, with the aim of minimizing these sectors’ dependence on fossil fuels and expanding their use of electricity;

• expanding the use of bio-fuels such as ethanol and bio-diesels towards replacing petroleum fuels; and

• financing hydropower investment benefiting from global carbon credit markets.

These policy directions may seem similar to earlier policy statements, but are more specific and practical, and are supplemented by full government commitment in financing, institutionalizing, and management. An aggressive hydropower development program is already in place aimed at increasing hydropower production and delivery from its 800 MW in 2008 to 1842 MW in 2011 and further doubling to 4,000 MW in 2013, with a total investment of over US$ 4.5 billion (World Bank, 2006). More recently, the Ethiopian government has unveiled its largest hydropower construction project at the Nile River. Known as the ‘The Millennium Dam Project’ it will produce 5,250 MW.

The second Ethiopian energy policy formulation process began in June, 2011, and was spearheaded by ESMAD. A draft policy working paper was circulated for comment, paving the way for eventual formation of the second national energy policy.

An RE expansion and universal access program currently in full swing is viewed as a critical tool for achieving the country’s ADLI (Agricultural Development-Led Industrialization) strategy through improving agricultural productivity and enhancing agro-processing capacities. The prioritization of RE was reinforced by political pressure from regional states for increased electricity access (Mengistu Teferra, 2002). A RE expansion and universal access program was launched in Ethiopia in 2005 with the aim
of reaching 50 percent of rural villages in five years, from its baseline low level of access of 17 percent. The program has been fully implemented, with a government budget allocation of over 2 billion birr in 2008/9 and 1 billion birr in 2009/10.

The Ethiopian government is currently commissioning an aggressive rail transport development plan to build over 5,000 kilometres of railway lines that will be electrically operated. This is a major project that could possibly change the country’s energy balance and ease growing dependence on fossil fuels for bulk and passenger transport.

### 3.2.3 Ethiopian Power Sector Policy and Development Program

The Ethiopian government introduced a modest reform of the power sector in 1997 (Government of Ethiopia, Proclamation no. 86/1997) by: (a) delineating the commercial operation and regulatory functions; and (b) liberalizing the power sector into a commercial entity to promote private sector investment. The national power supplying authority, Ethiopian Electric Light and Power Authority (EELPA), was split into two entities: one regulatory agency and one commercial company. A national regulatory agency, the Ethiopian Electric Agency (EEA), was established with a mandate to regulate electricity supplies through tariff recommendations and set the principles for easier access of private power suppliers to the national grid networks.

A commercial power producer and supplying company, the Ethiopian Electric Power Corporation (EEPCO), was formed with its main function, among others, in developing power infrastructures, (generation, transmission and distribution) and marketing electricity. While EEPCO was a commercial company, it was left to remain as a vertically integrated power monopoly. Free entry was granted to private investors (Government of Ethiopia, Proclamation No. 37/1997) to produce, use the national grid,
and sell power to EEPCO. National power producers were granted permits of up to 25 MW, while this limit was lifted for international investors (IPPs). To date, EEPCO remains the dominant player in power sector development in the country, with smaller national private companies operating in small-scale and self-contained areas of the rural electrification program. The involvement of international power companies was limited to consulting and advisory roles to EEPCO\textsuperscript{13}.

EEPCO builds new power generation plants, extends its grid networks and updates its distribution systems in line with Ethiopian development needs, promoting social and economic benefits such as industrial development, enhancing agricultural productivity, and extending social services such as education and health. EEPCO’s power sector master plan indicates that the country’s demand for electricity amounts to 1,360 MW of installed capacity by 2009, and a further 250 MW if planned export market to neighbouring countries of Sudan, Kenya, and Djibouti is to be realized. Existing and committed investment in the power sector was planned for production of 1,884 MW in 2009 and a total of 3,270 MW by 2010, with over 98 percent using hydropower resources under its power sector development program. Actual production capacity by the end of 2011 is at 1,842 MW with annual average energy production capacity of 7,722 GWh produced from its 12 power generation plants. EEPCO is currently constructing a number of new hydropower plants, of which two are the largest units yet. Gilgel-Gibe III power plant is nearly 70 percent completed with a production capacity of about 2000 MW. Together with the construction of the ‘Millennium Dam’, EEPCO will expand its hydropower generation capacity by additional 725 MW in the coming four years.
3.2.4 Status, Opportunities and Challenges of the Ethiopian Power Sector

This section discusses the status of the Ethiopian power potential, production, transmission, distribution, power quality/voltage fluctuation, tariffs, as well as challenges and opportunities.

**Production by source:** As indicated earlier, Ethiopia is endowed with huge hydropower resources with the potential to produce up to 45,000 MW. Less than 4 percent of this potential has been exploited so far with the production of 1,842 MW from 11 medium and large-scale hydropower sites. An additional 8,000 MW is currently under construction. The contribution of thermal and geothermal sources remains at only 7.5 percent; these are mainly used as peaking units. A total of 10,000 MW of potential wind power and 5,000 MW of potential geothermal resources are estimated, of which only 7.2 MW of geothermal energy is exploited while 172 MW of wind power is under construction in Ashegoda, Tigray region and in Adama, Oromia region.

**Transmission and distribution networks:** A total of 181 transmission lines exist in Ethiopia with 155 of them being single circuits while the rest are double circuit networks in 230 and 130 KVs. The total length of transmission lines reaches 10,880 kilometers while about 5,400 additional kilometers are planned. Critical transmission congestion is experienced in Ethiopia that contributes to substantial power losses and power outage problems facing the country. Efforts are continued in upgrading existing transmission lines while new transmission line developments are aiming at high transmission lines of up to 400 KVs, part of which are used for transporting power to neighboring countries such as Sudan, Kenya, and Djibouti.
EEPCO manages a total of 70,000 km of distribution lines comprising urban and rural networks with a voltage capacity of 60 kV and under. Substantial efforts are underway in upgrading existing distribution networks that are causing huge problems of system congestion, system losses, and load shedding (ESMAD, 2012, Electricity Database and Report).

**Customer base and electricity consumption structure:** The number of EEPCO customers has increased from 1.4 million customers in 2006/7 to 1.9 million in 2010/11, growing at 10.5 percent annually. Electricity consumption for the corresponding period grew from 2,715 GWh in 2006/7 to 3,283 GWh in 2010/11. The share of domestic consumption reaches 38.3 percent followed by the industrial sector (both low and high voltage) that accounts for 36.3 percent. The third electricity consumer is the commercial sector that accounts for 24.4 percent of the power consumption (ESMAD, 2012, Electricity Database and Report).

**Tariff Structure:** The Ethiopian power tariff structure is divided into four main categories of domestic, commercial, industrial, and street lighting. The domestic tariff is further categorized into seven blocks that vary on the basis of KWh consumed per month. The first block of domestic consumers are those that consume less than 50 KWh per month and are charged birr 0.2730, which is equivalent to 1.6 US cents. The second block of domestic consumers is the 50 -100 KWh per month category with a rate of birr 0.3564 or 2.1 US cents. The highest block consumers, the seventh block, are those that consume over 500 KWh and are charged birr 0.6943 or about 4 US cents. Commercial consumers are categorized into two blocks: those that consume below 50 KWh are the
first block and those who consume above 50KWh are the second block. The first commercial consumer block is charged birr 0.6088 while the second block pays birr 0.6943. Industrial tariff categories are divided into low voltage, medium voltage, and high voltage blocks; the tariff for each are set on the basis of peak and off-peak consumption. The tariff rate for industrial consumption is kept lower than commercial rates and decreases as one moves from low voltage to higher voltage consumers ranging between birr 0.3664 for high voltage consumers to that of birr 0.7426 for low voltage peak hour consumers. Street lighting is charged on the basis of a flat rate of birr 0.4843 (EEPCO, Operational Manual, 2009). The Ethiopian tariff is shown in Appendix 3.6.

While the Ethiopian tariff level is one of the lowest in international standards, its accessibility for the poor remains limited, with the lowest domestic tariff being only 40 percent of the rate paid by the highest consumer category. A life-line rate could be set that would allow the poor to access electricity at relatively cheaper cost.

**Power stability and quality:** The Ethiopian power system is characterized by frequent load shedding and voltage fluctuation. Load shedding has been more frequent over the past three years due to delays and technical setbacks in the commissioning of new power generation plants. Voltage fluctuation used to be less frequent in the past, but is becoming more prevalent in recent years due to overload of distribution systems and when power is released after load shedding that at times destroys household electricity appliances. EEPCO used to compensate for appliances damaged by voltage surge, but discourages its customers’ request for refund in recent years, probably due to more frequent appliance damage compensation claims.
Poor quality of electricity supply is experienced partly due to old distribution and transmission networks that were designed for voltage capacities far lower than prevailing loads. One remedial action required to improve power supply quality is by improving the load bearing capacity of transmission and distribution networks so that growing electricity demand at a certain location could be delivered without system overload. Ensuring reliable power supply requires producing more power than is needed to meet demand, which in Ethiopia is currently improving following the commissioning of new hydropower plants.

**System losses:** The Ethiopian power system experiences an average of 20 percent loss, mainly due to technical inefficiencies in transmission and distribution. System losses are mainly observed at the distribution end while losses due to theft and lack of bill collection are very minimal. Bill collection efficiency has improved over the last decade after EEPCO introduced improved bill collection system in 2003/4. Appendix 3.7 shows that system losses were registered to be the lowest in 2008 where it reached less than 10 percent. System losses were the highest in 2001 and 2007 with slightly higher than 20 percent losses for which no specific explanation is given by EEPCO (ESMAD, 2012, Electricity Database and Report). The Ethiopian historical power loss is documented in Appendix 3.7.

**Private sector participation in the Ethiopian power sector management:** The Ethiopian power sector management is characterized by the absence of private sector participation in power production and distribution. The role of the private sector in the development and management of the power sector is believed to create competition and
lower costs (Newbery, 200). The Ethiopian government has not so far created a level playing field for independent power producers (IPPs) to operate in the development and management of the power sector. Ongoing effort in setting feed-in tariff suggests that there are some interests towards opening up the power sector for IPPs to operate simultaneously with EEPCO, especially in the generation segment. However, this policy direction came very late and is applied partially at a gradual pace in view of the fact that more room could be created for IPPs to play a role in the distribution and local management (marketing and bill collection) operations.

**Cross-Border power market and emerging opportunities for power sector development in Ethiopia:** Ethiopia has a comparative advantage in exploiting and exporting its hydroelectricity to its neighbors and to the East African Power Pool. Primarily, the country has a huge hydropower and geothermal resource potential that could be harnessed. Second, Ethiopia can supply power far cheaper than its neighbors from its low-cost hydropower resources, enabling its power sector investment to be profitable and allowing the pool tariff margins to decrease. Its third advantage comes from the very limited environmental impacts that its hydropower development practices will cause as most of the dams and water reservoirs are in gorges within less populated areas, causing low displacement of inhabitants and little disruption of agricultural production, while enabling more controlled river flows downstream. Cross-border power market opportunities are expected to provide three pronged benefits to the Ethiopian power system development.

The first benefit is the generation of sufficient revenue that could enable financial self-sufficiency within the power sector. The second benefit is expected to come by way
of enabling IPPs, including international investors, to invest in the power sector as a result of the availability of higher regional power price opportunities than the domestic low tariff level. A third regional power market benefit is through enabling the continued lower domestic tariff that would allow the poor to access electricity services including further expansion of rural electrification. In the absence of sub-regional power markets, power suppliers may require higher domestic tariff rates to meet financial self-sufficiency objectives. Raising domestic tariffs will negatively affect the poor and cause overall price increase while further obstructing economic growth. The presence of cross-border power markets at relatively higher tariff rates will allow the provision of power at cheaper tariff rates for domestic customers in general and the poor in particular.

3.2.5 Rural Electrification and Universal Access Policies and Ongoing Projects

As highlighted earlier, the Ethiopian government has introduced an ambitious RE expansion program with the objective of reaching 50 percent of rural villages from its baseline level of only 17 percent. This policy direction and subsequent RE expansion program is one of the very visible government programs occurring in Ethiopia in recent years, and deserves to be studied as a major opportunity for learning how RE programs impact rural livelihood and how such major programs are best managed. In this section, the Ethiopian government RE expansion policy is presented to examine the depth of the RE expansion program, which is currently ongoing throughout the country.
3.2.5.1 Ethiopian Government RE and Universal Access Policy

The Ethiopian RE program aims to attain a number of economic, social, and environmental benefits by supporting the three priority programs of the Ethiopian government, namely: (a) the MDGs, (b) the poverty alleviation program, and (c) the national development objective of the government of Ethiopia. Specific objectives of the RE program are to:

- improve household income and employment possibilities by providing part of the infrastructure and social services needed to facilitate and support investment and agricultural development contributing to economic growth;
- provide cheaper, cleaner, more efficient, and enhanced lighting possibilities that would improve the condition and livelihood of the poor, primarily that of women and children;
- enable the provision of improved social services such as street lighting, better community health services and improved school facilities;
- provide pumped water for irrigation and home use, and
- alleviate the pressure on the environment by partially relieving existing excessive dependence on biomass fuels for cooking and other household uses.

The Ethiopian government has launched two RE expansion programs: a grid-based RE program known as the Universal Electricity Access Program (UEAP), and an off-grid RE program called Ethiopian Rural Electrification Program (EREP).

Strategically, both RE expansion programs, and especially the UEAP, try to ensure cheaper and reliable delivery of electricity services to rural towns, villages, and irrigation facilities in all regional states. Rapid expansion of power connection is supplemented by
a customer support scheme to use electricity services for income generating activities. Major principles of the UEAP include: (a) provision of equitable access in all regional states; (b) cost reduction through introduction of innovative electricity delivery systems such as mixed three-phase-single-phase systems and single-wire-earth-return methods; (c) building human, manufacturing and contracting capacities; (d) introduction of new institutional arrangements; and (e) building additional power generation and transmission capacities (EEPCO, 2005).

The simultaneous introduction of cross-border trade with neighbouring countries such as Sudan, Kenya, and Djibouti is considered to be a complementary strategy of absorbing possible domestic overproduction of hydropower resources, gradually giving way for RE expansion. The revenues from power export to African markets are expected to substantially improve EEPCOs financial self-sufficiency and contribute towards maintaining low domestic electricity tariffs structure over the longer-term.

3.2.5.2 Grid-Based RE and Universal Access Programs in Ethiopia

The grid-based RE program, that is the UEAP, aims at increasing access to electricity services in rural areas from its baseline access level of 17 percent to 50 percent in five years. Estimated UEAP budget is US$1 billion, financed partly by government contribution and partly through external donors and bank loans (World Bank, 2006). The Ethiopian government finances up to 2 billion birr in 2008/9 budget year, as shown in Appendix 3.1. The UEAP will primarily be using cheap and abundant hydropower resources with an extension of the main interconnected grid system. Alongside the RE expansion program will be an aggressive program of increasing hydropower based
generation capacity. A total of 7,542 rural villages and towns were identified as not having access to electricity services while 785 rural villages were already connected by the start of the RE expansion program (see Table 1 below).

The UEAP is managed by an independent public entity under EEPCO known as Rural Electrification Project Secretariat with the mandates of implementation and follow-up of the program, comprising engineering, construction, resource management (human, material, and financial) and project monitoring and evaluation. In effect, the UEAP extends the national grid close to major towns while actual distribution within towns and connection to households is managed by a separate department within EEPCO.

The UEAP started operation in 2005/6, connecting 179 towns the first year, 784 towns the second year, and 1206 towns the third year, of which 455 were completed while connection of 751 towns was under way. Connection of rural towns and villages by the time of this study is shown in Table 2 while level of rural electricity access in 2011 is shown in Figure 10 below. The UEAP had managed to connect 2169 rural villages by the time this study was in progress, bringing the number of electricity connected rural villages to a total of 2954. A 36 percent increase in access to electricity services was achieved in three years. By July, 2011, the UEAP connected 5,866 rural towns and villages, providing electricity access to 46 percent of rural villages in the country. (EEPCO: Factsheet, 2011).
Table 1: Status and Coverage of Rural Electrification in Ethiopia (by 2008)

<table>
<thead>
<tr>
<th>Regional States</th>
<th>Total Number of Villages</th>
<th>Non-Electrified before UEAP</th>
<th>Connectected before UEAP</th>
<th>Connected Level (%)</th>
<th>Connected Under UEAP</th>
<th>Total Connection to Date</th>
<th>Percentage with Access to Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afar</td>
<td>148</td>
<td>135</td>
<td>13</td>
<td>9</td>
<td>29</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td>Amhara</td>
<td>2503</td>
<td>2279</td>
<td>224</td>
<td>9</td>
<td>620</td>
<td>844</td>
<td>34</td>
</tr>
<tr>
<td>Benshangul</td>
<td>159</td>
<td>154</td>
<td>5</td>
<td>3</td>
<td>53</td>
<td>58</td>
<td>37</td>
</tr>
<tr>
<td>DireDawa</td>
<td>26</td>
<td>24</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td>Gambella</td>
<td>152</td>
<td>149</td>
<td>3</td>
<td>2</td>
<td>21</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Harari</td>
<td>20</td>
<td>13</td>
<td>7</td>
<td>35</td>
<td>5</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>Oromia</td>
<td>3208</td>
<td>2864</td>
<td>344</td>
<td>11</td>
<td>790</td>
<td>1134</td>
<td>35</td>
</tr>
<tr>
<td>SNNP</td>
<td>1203</td>
<td>1077</td>
<td>126</td>
<td>11</td>
<td>423</td>
<td>549</td>
<td>46</td>
</tr>
<tr>
<td>Somalia</td>
<td>282</td>
<td>265</td>
<td>17</td>
<td>6</td>
<td>58</td>
<td>75</td>
<td>27</td>
</tr>
<tr>
<td>Tigray</td>
<td>626</td>
<td>582</td>
<td>44</td>
<td>7</td>
<td>162</td>
<td>206</td>
<td>33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8327</strong></td>
<td><strong>7542</strong></td>
<td><strong>785</strong></td>
<td><strong>9.4%</strong></td>
<td><strong>2169</strong></td>
<td><strong>2954</strong></td>
<td><strong>36%</strong></td>
</tr>
</tbody>
</table>


Records show that 71 percent of the five-year connection target was achieved in the first three years. The Rural Electrification Secretariat is confident that it is in a position to meet its target of 50 percent coverage by the end of the five years. In the research area of this project alone, 22 rural towns have been connected over the first three years of the RE program, benefiting a total of 2785 households.

As can be seen in Figures 10, below, access to electricity services improved markedly after the introduction of the UEAP. The implementation of such an ambitious RE expansion program is one of many urgent programs and priorities in Ethiopia. The Ethiopian RE expansion program could be seen as a model for most of SSA, where RE access and coverage still remains low.
Figure 10: Ethiopian Electrification Levels by Number of Electrified Towns and Villages, (2011)

While these achievements are impressive, there are three questions that one must ask at this stage in relation to the RE expansion program in Ethiopia, namely:

- Is grid-based RE expansion the most optimal means of ensuring electricity access in rural areas as compared to standalone and alternative power supply sources?

- Should grid-based RE expansion be launched before the generation capacity of the whole system is developed commensurate with the level of load that such RE expansion would create?

- Would the capacity and efficiency of a state owned power monopoly be adequate to manage and operate RE services over scattered rural locations in the long-term?

These are very important questions that have relevance to balance large-scale hydro power development with that of smaller and alternative power sources. Before a wide-scale RE expansion program is launched, it is important to ensure sufficient installed capacity, develop internal management capacity, and decentralize the RE
management structure to encourage management efficiency at the local level. These questions are very relevant in understanding the scope and direction of RE expansion programs in SSA, but will not be addressed here as they are beyond the scope of the present research project.

3.2.5.3 The Off-Grid RE Program and its Barriers

The Ethiopian off-grid RE program is known as the Ethiopian Rural Electrification Program (EREP) and operates under the auspices of the former Ethiopian Rural Energy Development and Promotion Centre (EREDPC) – currently restructured as Alternative Energy Technology Development and Alternative Technology Promotion Directorates within MoWE. The EREP was launched in 2003 with the objective of providing electricity to remote rural areas for social services (schools, health services, water provision, and communication) and productive uses such as agro-processing, small-scale irrigation, and the development of micro and small-scale businesses. The EREP is primarily focused on developing renewable energy sources financed from an IDA/ WB loan of US$10 million and Global Environmental Facility (GEF) grants of US$ 4.93 million. The project has been fully operational, reaching 200 remotely located schools and 100 health posts through using solar PVs. One wind turbine and six micro-hydro units have been developed, of which one is privately owned while five units are owned by cooperatives. A total of 40 standalone diesel power generating and distribution stations have been established for remote rural towns with a capacity of 70-80 KVAs each. A total of 30,000 people are said to have benefited from the EREP (Discussion with EREDPC Director, July, 2008).
A second phase of EREP has been introduced, known as EREP II, which is a scale-up and extension of EREP I. The EREP II is primarily focused on providing small scale energy for extremely remote rural villages for lighting, under the initiative known as “Lighting Africa”. Secondly, EREP II aims to scale-up productive use of electricity mainly for agro-processing and specifically dairy processing and milling services.

While the government’s effort in expanding off-grid rural electrification is encouraging, there are a number of barriers to renewable energy development, especially Solar Home Systems (SHS) in Ethiopia. The EREDPC categorizes these barriers as institutional, entrepreneurial, financial, technical, and barriers related to customer behaviour, all of which revolve around the Ethiopian energy policy. These policy barriers are compounded by EEPCO’s lack of recognition of the role and benefits of alternative energy systems other than large-scale hydropower development.

The institutional barriers relate to the absence of appropriate institutions and market infrastructure for renewable energy sources such as public-private partnerships, community associations and support systems. One major problem facing the EREP is lack of coordination in the planning and execution of the EREP program with that of UEAP. The sudden arrival and takeover of cheaper and more reliable grid based electricity from UEAP has forced one micro-hydro and 8 diesel stations to be closed down. Lack of coordination between the UEAP and EREP, including harmonized expansion plans and absence or delay in the formulation of feed-in tariff, are seen as the major obstacles in the development of the EREP. Energy marketing agencies are less developed and only a few companies with little or no technical expertise are engaged in SHS markets.
Financial barriers take the form of high cost of equipment, high import duties and taxes, and lack of credit services to encourage consumers to purchase renewable energy systems and related appliances. Until very recently, the expansion of off-grid RE and especially SHS used to be curtailed by a high import duty on PV systems, which was in the order of 25 percent for lighting systems and 22 percent for PV water pumping system (Getnet, EREDPC, 2002) plus a 15 percent sales tax. Together with high capital costs, higher transport costs, and higher suppliers’ margin (up to 20 percent of systems cost), the duties and taxes on imported SHS used to be far too expensive for users. The lifting of import duties for solar energy is justified in view of the average subsidy of birr 0.16 per KWh the government provides to domestic grid-based electricity consumers. This subsidy amounts to an average of birr 170 per year per domestic customer, and to an annual total of birr 78 million, which is equivalent to US$8 million. (Getnet, EREDPC, 2002). Recent developments show that the government is lifting import duties on solar energy technologies, pending its actual implementation.

Technical barriers are associated with limited technological capacity to install, operate and maintain renewable energy technologies and accessories. Lack of technical knowledge results in the importation of poor quality products, and causes problems of system sizing, poor installation and lack of after-sales support services to users. Limited efforts are witnessed on the part of consumers to choose renewable energy technologies due to lack of awareness and high expectation from government.
As a result, the progress of EREP has been very slow and requires more push in resolving these barriers. Launching a successful off-grid RE expansion program is crucial in view of the likely cost reduction, and environmental and socio-economic benefits that it could provide in relation to the grid-based RE expansion option.

**Chapter summary:** Northern Ethiopia is at the centre of the nexus of energy poverty, resource scarcity, food insecurity, and environmental degradation. Efforts taken by the government to curb this downward spiral include the introduction of an aggressive power sector development program in conjunction with an ambitious RE program aimed at advancing economic growth and achieving the MDG targets.

The Ethiopian government has instituted substantial changes over the last five years in generally revitalizing the energy sector, particularly power sector development. Policies have focused on more specific areas of power generation and rural electrification, and on using the latter as a tool to reduce poverty. Progress in RE expansion has so far been remarkable, with over 5800 rural villages being connected to electricity services from the grid in five years, starting in 2005/06, raising the access level of rural towns to above 46 percent by the end of the first phase of the project.

While implementation of the RE expansion program is making good progress, the impacts of RE in attaining the desired objectives of poverty reduction and rural development could be compromised by a number of factors. The impoverished nature of most of the remotely located rural towns could delay possible benefits to be gained from the delivery of electricity services. One possible setback is that rural households may be connected to electricity services at a slower pace than expected. Households may not
expand their electricity use for productive uses, or may not replace their traditional fuel use even after connection to electricity services.

Additionally, RE expansion might not reach full-scale, probably compromising the projected RE benefits. Power system management inefficiency and limited power supply base could become barriers for managing a successful RE expansion program. Evidence on the ground over the past four years showed substantial levels of setback within the power sector, resulting in unprecedented power outages primarily due to high volume of demand from the production and service sectors and by RE expansion.

This research aims to facilitate the documentation of how RE has benefited less developed countries in easing localized poverty, in curbing resource degradation, and in alleviating socio-cultural barriers that impede the achievement of benefits from such programs. Current power sector and RE developments in Ethiopia show significant momentum, offering an opportunity to learn from experiences that may be applicable to other SSA countries. To this end, a methodological framework, described in the next chapter, was designed to collect and analyse empirical evidence of the impacts and benefits of rural electrification.
CHAPTER IV
METHODOLOGY

4.1 Research Questions and Design

The main research question of this dissertation is **how does rural electrification (RE) contribute to reducing poverty and promoting rural development in low-income developing countries?** As a first step toward answering this question, it was necessary to measure the impacts of RE on three constructs: energy transition, poverty, and rural development. This required assessing their localized differences against number of years of access and number of years of a household’s connection to electricity services, which are used as the main explanatory variables.

Thus, the main research hypothesis is that rural towns with more years of access to electricity services and households with more years of electricity connection exhibit a higher level of energy transition to MES, score higher levels of poverty reduction, and achieve substantial levels of rural development status. The separation of access and connection is vital as number of years of access to electricity services may not mean that individual households within a particular town have electricity connection. This is because some households tended to be connected to electricity several years after their town had access to electricity services, due to financial limitations or due to the supplier’s change of schedule for new connections. Hence, years of access of the study towns to electricity services and household electricity connection are treated as two separate variables.
The three dependent (or explained) constructs of energy transition, level of poverty, and rural development are highly interrelated. The process of household energy transition is likely related to household income, while poverty reduction is one of the goals of the rural development drive in low-income developing countries. It should therefore be noted that the contribution of electricity services to any one of the three variables may have compounded impact on the achievement of rural development. The benefits of RE on gender mainstreaming, education, community health, and improved environment are parts of the gains in rural development. Table 2 below summarizes the research design framework.

### Table 2: The Research Design Framework

<table>
<thead>
<tr>
<th>Explanatory Construct: rural electrification Variables:</th>
<th>Observed Data (Variables) at Local Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>- years of access to electricity services of a rural town; - years of a household’s connection to electricity; - household income; - occupation of head of household; and - household family size.</td>
<td>Ankober Kotu Shola Gebeya Gosh-Bado</td>
</tr>
</tbody>
</table>

**Constructs for which an explanation is sought**

<table>
<thead>
<tr>
<th>Electricity connectivity Rate</th>
<th>Household Level</th>
<th>Community Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The rate at which households connect to electricity after access has been created</td>
<td>- Overall connectivity rate of a rural town or village</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Utilization of electricity services</th>
<th>- The volume and diversity of use of electricity services after connection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Volume of sales of electricity services by consumer category</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transition to MES</th>
<th>- Level of transition to MES and replacement of existing use of traditional solid fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Level of use of electricity services by various sub-sectors within a rural town or village in relation to the use of traditional solid fuels;</td>
</tr>
<tr>
<td></td>
<td>- The pace of replacement of existing fuel sources by MES.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years of Local Access to Electricity Services</th>
<th>Ankober</th>
<th>Kotu</th>
<th>Shola Gebeya</th>
<th>Gosh-Bado</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
<td>&lt;1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Poverty Reduction</strong></td>
<td><strong>Rural Development</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- changes in household farm, off-farm, and non-farm income/employment, and food security</td>
<td>All observed data under poverty plus reported improvements in household access to:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- education, health, water supply, and sanitation, and grinding mills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- number of hours of work for women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- changes in decision making for men and women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- changes in ownership of assets for women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- changes in employment and income generation for women.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- household livelihoods and quality of life.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All observed data under poverty plus local level improvement in the provision of:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Education services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Health services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Other community services such as improved water supply, sanitation, and grinding mills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Community level changes in community related workloads, role of women in decision making at community level, access to employment and income, and role of women in management of community organizations and services.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- reported improvements in community access to rural development services such as:-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- human resource</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- local institutions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- local infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- farming systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- cultural impacts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Studying the relationship of RE with poverty reduction and rural development requires assessing the contribution of electricity services at household and community levels. This is because electricity services have varying degrees of impacts at these levels, and measuring these impacts requires examining them separately.

The local level study is focused on measuring whether the introduction of electricity services has brought added benefits to households, to the local community and to district (woreda) level institutions.
A number of specific questions are addressed in this research, contributing to answering the main research question of how far rural electricity contributes to poverty reduction and rural development. The type and level of data collection at household, community, and district (woreda) levels have depended on these secondary research questions. Table 3 summarizes the relationship between the various secondary research questions, data requirements and survey or data collection methods applied.

Table 3: Addressed Research Questions, Data Requirements, and Data Collection Methods

<table>
<thead>
<tr>
<th>Addressed Research Questions</th>
<th>Data Requirements</th>
<th>Survey Type/ Data Collection Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does household electricity connectivity rate vary and what are the factors influencing it?</td>
<td>Current connection status and number of years of connection of a household to electricity services by household income/ expenditure level</td>
<td>Household survey (Survey A) and local institutional survey (Survey B)</td>
</tr>
</tbody>
</table>
| Does household energy procurement, utilization, end-use diversity and energy transition respond following connection to electricity services? | - Household energy consumption level by energy types, energy expenditure levels by household income/ expenditure levels  
- Years since household received electricity connection by expenditure on electricity services, other energy services, household energy and end-use mixes | Household survey (Survey A) and local institutional survey (Survey B) |
| What are the reported and observed benefits and impacts of RE at:                           | - Reported quality lighting benefits  
- Reported decrease in expenditure levels on kerosene and batteries  
- Reported improvement in access to media and communication  
- Reported improvement in home based small businesses and household income | Household survey (Survey A) and local institutional survey (Survey B) |
| a. Household level?                                                                         |                                                                                                        |                                                          |


The local level study comprises the bulk of this research project as first-hand data could be recorded at household, community and district levels. Two main surveys were carried out: survey ‘A’ - a household survey; and survey ‘B’ - a survey on ongoing development and management of resources, institutions, micro-businesses, power suppliers and public services at community, town and district levels. Such categorization was necessary to capture the required information from various angles and to help cross-check accuracy and consistency of data collected at each level. A survey was the most

<table>
<thead>
<tr>
<th>Category</th>
<th>Reported benefits</th>
<th>Data Collection Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational benefits</td>
<td>Improvement in access to quality lighting</td>
<td>Local institutional survey and interviews with education offices and school principals (Survey B)</td>
</tr>
<tr>
<td></td>
<td>Improvement in the use of equipment/education media/ICT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes in school enrolment rates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes in school dropout rates and quality of education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retention of qualified and experienced teachers</td>
<td></td>
</tr>
<tr>
<td>Health benefits</td>
<td>Improvement in emergency response and overnight health services</td>
<td>Local institutional survey (Survey B)</td>
</tr>
<tr>
<td></td>
<td>Improvement in health equipment use</td>
<td>Interviews with health service personnel (Survey B) and Household survey (Survey A)</td>
</tr>
<tr>
<td></td>
<td>Decrease in child mortality rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease in maternal death</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retention of qualified health workers</td>
<td></td>
</tr>
<tr>
<td>Water supply and sanitation</td>
<td>Reported benefits in water supply and sanitation</td>
<td>Household survey (Survey A)</td>
</tr>
<tr>
<td>Access to electricity</td>
<td>Reported improvement in access to electricity run grinding mills</td>
<td>Household survey (Survey A)</td>
</tr>
<tr>
<td>Street lighting and night security</td>
<td>Reported improvements in street lighting and night security</td>
<td>Household surveys (Survey A), Small group discussions (Survey B)</td>
</tr>
<tr>
<td>Economic, productive and poverty reduction benefits</td>
<td>Reported improvements in economic, productive and poverty reduction benefits of RE</td>
<td>Interviews with woreda and zonal MFI officers (Survey B)</td>
</tr>
<tr>
<td></td>
<td>- Changes in the creation of new businesses and income/employment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Poverty reduction trends in newly electrified rural towns</td>
<td>Household survey (Survey A) &amp; national reports</td>
</tr>
</tbody>
</table>
appropriate method of data collection as RE specific secondary data is rarely available at the local level. Besides, a survey enables the collection of most appropriate and timely data in a flexible way that is sufficient to draw conclusive results and measurable impacts of RE. Detailed local level survey methodologies are discussed under section 4.2 below.

Data from EEPCO was used to document background information related to Ethiopian energy resource base, power sector, and rural electrification policies and strategies as well as power sector challenges as discussed in Chapter Three. Data from EEPCO was also used to document the Ethiopian government power sector reform agenda, legislative framework, institutional endowment, and the efforts being made in making power system management more efficient. More EEPCO data were used in the analysis of household energy transition from biomass fuels to electricity services.

The data collected from household and community level sources were considered to be sufficient to provide evidence on how electricity services contribute to poverty reduction and rural development, including social well-being and improved environmental management practices. Equally, the Ethiopian case study is believed to provide lessons learned and challenges faced in the Ethiopian RE expansion program, which could be useful for the rest of SSA.

4.2 Household and Community Level Data Collection

The local level survey was conducted on four representative rural towns with varying numbers of years of access to electricity services. Selection of the four survey towns was applied on the basis of their numbers of years of access in order to differentiate electricity impacts arising from differences in number of years of access
and number of years of connection to electricity services. The selection of study towns on the basis of number of years of electricity access is discussed in Section 4.2.2.

4.2.1 The Questionnaire Design and Survey Administration

The questionnaire was designed with the purpose of meeting the objective of the survey, which is to assess the impact of RE. This was ascertained by querying on two main fronts: Survey A: the household survey, and Survey B: the local area resources and institutions survey. Survey A was aimed at collecting data from selected sample households on the following five main themes: (a) income/employment and food security; (2) access to basic social services, such as primary education, health, potable water/sanitation and grinding mills; (3) workload reduction for women and children including changes in gender relations; (4) local environment; and (5) overall poverty levels including human resource development and institutional capacity development at the local level.

The questionnaire was structured into the following main categories: (a) household characteristics; (b) energy procurement and use; (c) access to community services pertaining to health, schools, water supply, grinding mills, and street lighting; (d) gender relations; (e) household livelihood; and (f) household farming and environment/natural resources management practices. Cutting across all of these main categories of data was the impact of access to electricity services. Furthermore, the questionnaire incorporated specific electricity related questions on options of providing cheaper electricity services, affordability and capacity to pay for electricity services and related appliances, connectivity and demand expansion on electricity services. These data
were required to understand household and community response to electricity services through such measures as connectivity rate, electricity consumption growth rates, household energy transition and substitution, and average annual growth in local electricity demand as a result of the access created.

Survey B comprised a local area supplementary survey on population, resources and local institutions in each of the four survey areas. Specifically, it contained a format for collecting data on population, resources, local social services (including education, health, water supply, grinding mills\textsuperscript{14} and related services) local businesses, local government and development agencies, and local energy/power suppliers.

Interviews and discussions were conducted through visits to local institutions, district administrative offices and sector offices representatives, education and health administrative offices, schools and health establishments, and major development stakeholders in these study areas (persons contacted are listed after the bibliography). Discussions revolved around major changes that took place within the specific sector in question, and what the contributions of access to electricity services were in stimulating changes. Results showed the interview process to be vital in generating qualitative information from the perspectives of government representatives and public service personnel. Such information would not have been collected through household surveys. Copies of relevant documents available in each of the district and zonal offices were collected for reference to supplement the data collected through surveys and interviews.

Survey B incorporated a second survey on sample business establishments representing the various businesses in each of the study towns. The purpose of the second survey was to collect information on the establishment of new businesses and the
transformation of existing ones in relation to the number of years of access to electricity services. This survey was required to supplement the household level data collected through Survey A and provide data on community, town, and district level changes and the contribution of electricity services in facilitating these changes. Vital information was collected on social services such as education, health, water supply, and related community infrastructure and the role of electricity services in serving these establishments.

Furthermore, focus-group discussions were held in each study town in the two areas of gender relations and natural resources management. Emphasis was given in documenting whether some changes had been observed in specific gender and natural resource management related issues, and whether there was visible contribution of electricity services in bringing about observed changes within those two themes. In an effort to record specific impacts of access to electricity services on each of the research areas outlined above, the survey questionnaire and discussion checklists reiterated questions regarding the contribution of RE in bringing about observed changes. The UN MDGs were considered in designing survey A and Survey B as discussed below.

**Poverty Reduction:** At the local level, the household and community level survey was designed to serve in collecting the following data on electricity induced changes: (a) access to affordable electricity; (b) income changes, savings or productivity changes due to use of electricity for lighting, heating, cooking or running machinery; (c) increased food production and improved food security due to pumped irrigation; (d) changes in market prices of food as a result of the above; (e) time saved for productive and income generating purposes from decreased workload; (f) health improvement as a result of
improved sanitation and safe drinking pumped water; (g) ongoing development programs and projects induced by electricity services; and (h) other income, employment and food security related improvements.

**Universal Primary Education:** The survey was designed to ensure the collection of the following data at the local level: (a) number of schools, quality of education, and increased shifts enabling the enrolment of all school-age children because of access to lighting, teaching-aids, and distance learning, including Information Communication Technology (ICT); (b) increased attendance and decreased dropout rates as a result of access to clean water, sanitation, and lighting; (c) reduced workload for children concerning water/ fuel collection, and grinding; and (d) improved retention of qualified teachers in the community as a result of improvement in living conditions due to electricity services.

**Health Service Improvement:** The data required at local levels to measure the impact of access to electricity services in achieving these targets included: (a) the decrease in child illness and recorded fall in deaths due to decrease in exposure to indoor air pollution; (b) increased availability of time for child care or decreased exposure of children to accidents as a result of decreased workloads and drudgery for women; and (c) the use of electricity in cooking and water heating/ boiling.

In the area of maternal health improvement, the role of access to electricity services was measured at the local level by collecting the following information: (a) improved healthcare services in the form of improved medical facilities for maternal care, refrigeration of vaccines and medicines, use of sterilization equipment, and operating
services; (b) alleviation of workload for women during pregnancy; and (c) retention of qualified health workers in remote areas made possible due to power availability.

In measuring the impact of access to electricity services, data were required on benefits in lighting, qualified staff retention, equipment use such as sterilization, refrigeration, and incineration of syringes. Additional data were collected on the use of electricity in local small-scale pharmaceutical processing and distribution of drugs, and the use of electricity for health education and ICT.

**Gender Equality and Women Empowerment:** At the local level, the survey design looked into actual improvements in gender relations in terms of condition (workloads, health, and livelihood) and positions (education, decision making, access to employment and politics) as measured at national and local levels. Most of the gender disaggregated data collected in goal two (above) were useful for this goal. Additional data required were: (a) availability and use of electricity services alleviating workloads for girls and young women; (b) use of electricity services for cooking replacing health threatening environment such as indoor air pollution; (c) extended hours of study and evening class attendance for girls and young women due to lighting; (d) improved safety for women and girls due to street lighting; and (e) non-agricultural wage employment, income generation activities and access to financial resources induced by access to electricity.

**Environmental Sustainability:** The role of electricity services in achieving these targets at the local level were measured by meeting the following data needs: (a) increases in agricultural productivity due to pumped irrigation, storage and cooling facilities contributing to reducing overuse of land and reducing pressure on the
ecosystem; (b) reduced deforestation and contribution towards reducing greenhouse gases through the use of electricity services; (c) increased availability of cleaner water through electric pumping and (d) decrease in rural-urban migration due to rural electrification.

The questionnaire design was detailed enough to generate the required data at household, community, and district levels.

4.2.2 Selection of the Study Areas

The four representative study areas of Ankober, Kotu, Shola Gebeya, and Gosh-Bado were selected on the basis of three criteria: number of years of access to electricity services, proximity to the main city of Debre-Berhan, and population size. Of these three criteria, number of years of access to electricity services was the most important factor as it is believed that a town’s number of years of access to electricity services influence the level of household connectivity, income level, and level of access to social service. Ankober, was selected because it had five years of connection to electricity services. The second town, Kotu, had electricity connection for three years. The third rural town was Shola-Gebeya, which had no connection to electricity until very recently and was being connected while the survey was underway. The fourth rural town, Gosh-Bado, was a relatively smaller rural town without access to electricity services. However, electricity reached Gosh-Bado four months later, followed by actual power connection after eight months.

Proximity to a major city was considered to be another important factor affecting income, due to its influence on access to markets and seasonal employment. Rural towns further away from the zonal capital and major north-south highway were thought to be less developed, hence having limited markets and employment opportunities. In terms of
proximity to a major urban centre, Ankober and Shola-Gebeya are further away from Debre-Berhan and the main highway. However, both of these rural towns are woreda (district) capitals. Kotu and Gosh-Bado are nearer to Debre-Behrahn, the major urban centre of the study area. Table 4 and Figures 11 and 12 show the distribution and characteristics of the study areas.

### Table 4: Selected Survey Towns, Population, and Proximity to Debre-Berhan

<table>
<thead>
<tr>
<th>Town</th>
<th>Population Size</th>
<th>Electricity Connection Year (# of years)</th>
<th>Proximity to D. Berhan (Km)</th>
<th>Distance from Main Highway (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankober</td>
<td>3772</td>
<td>2003/4 (5 years)</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Kotu</td>
<td>2581</td>
<td>2005/6 (3 years)</td>
<td>35</td>
<td>7</td>
</tr>
<tr>
<td>Shola-Gebeya</td>
<td>5151</td>
<td>2007/8 (&lt;1 year)</td>
<td>80</td>
<td>45</td>
</tr>
<tr>
<td>Gosh-Bado</td>
<td>2235</td>
<td>None</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

**Figure 11: Map of Survey Area**

![Map of Survey Area](http://www.amharabofed.gov.et/ANRS/index.php)


The third criterion was population size of the study towns. Population size is important because it influences level of development of a town, market size, and employment opportunities. Selecting study towns below 2000 inhabitants was thought to
affect the comparison with other towns of higher population size. It was therefore necessary that all the four rural towns selected have a population size between 2000-5500 inhabitants. Population size of each of the study towns is shown in Table 4 above.

**Figure 12: Map of Specific Location of the Survey Area**

![Map of Specific Location of the Survey Area](Image)

Source: Google Earth

**4.2.3 The Study Towns**

The four rural towns surveyed are near and around the major city of Debre-Berhan, the zonal capital of North Shoa within the Amhara Regional State. Debre Berhan is 130 km North–East of Addis Ababa, the Ethiopian Capital. The four survey areas of Ankober, Kotu, Sholla-Gebeya and Gosh-Bado are highly dependent on Debre-Berhan economically, socially, and administratively.
Ankober

Ankober is about 42 km South-East of Debre-Berhan. It is situated on a hilly and beautiful place facing the south-eastward sloping escarpments of the Ethiopian Rift Valley at 2800 meters above sea level. The town of Ankober, also known as Gorebela, was established in 1733 by the then Shoa Noble Ameha Jesus (Endale Zatew & Beyene Yemane, 2007) and served as the Ethiopian capital and the seat of Emperor Minilik II until the capital was moved to Addis Ababa in 1886.

Figure 13: A photo of a Tourist Lodge in the Outskirts of Ankober Town where the Palace of Minilik II used to Exist

Ankober is one of the oldest Ethiopian towns, and was the gateway for the introduction of modern education, diplomacy and trade. It was the first fixed seat of the central Ethiopian kingdom. Despite all that, Ankober remained one of the very backward
rural towns and was not connected to electricity services until 2003. The lack of basic services such as electricity impacted negatively on its progress. It now serves as the woreda (district) capital and is a residence for up to 4000 inhabitants. Agriculture and trade are the two major forms of livelihood at Ankober. The town became the beneficiary of modern education in the 1890s. Modern medicine was introduced in the 1930s; postal services and telephones were introduced in the 1970s.

**Kotu**

Kotu is 7 kilometres east of the main Addis-Asmara highway and is 46 kilometres away from Debre Berhan. Kotu was established in 1925 and is known for its weekly Monday market where over 25,000 people gather from surrounding rural towns and villages to exchange a huge volume of commodities, agricultural produce and livestock. About 2600 people live in Kotu. The main form of livelihood in Kotu is service provision, mainly related to the weekly Monday market. The town faces scarcity of water where only 72 percent of the population has access to safe drinking water pumped from the ground, and the rest collect their water from unattended sources. Ground water is lifted using electricity services replacing an older diesel generator.

There is one elementary school to 8th grade in Kotu. This school has 1340 students, of whom 681 are girls. One health centre and one private clinic provide health services. Electricity was brought to Kotu in 2005.

**Shola-Gebeya**

Shola-Gebeya is a woreda capital located at 78 km south of Debre-Berhan and 38 Km after Kotu. Similar to Ankober, Sholla-Gebeya is one of the oldest towns, established
in 1842. Its development has been stagnant until recently due to its remote location and very limited development opportunities. However, Shola-Gebeya has undergone considerable changes in recent years for three main reasons: placement of a large number of civil service staff as part of the woreda staffing process, the opening up of a high school, and the introduction of electricity services. The population of the town is the highest of the four study towns at 5151 people, including seasonally residing high school students that come from surrounding rural villages.

One elementary school up to 8th grade and one high school to 10th grade operate in this rural town, with 763 students attending high school, 292 of whom are female. One health centre and one public clinic provide health services for over 25,000 people. Water supply is very poor with 11 percent of households connected to water pipes, while 453 households collect water from public water supply points. The rest fetch water from distant unattended sources with high risk of water-borne diseases. The municipal water system is pumped by electricity, replacing an older diesel pump that was insufficient. Electricity services reached Sholla-Gebeya in January 2008, two months before the start of the survey.

**Gosh-Bado**

Gosh-Bado is 18 kilometres north-west of Debre-Berhan and was established in 1955 when Gosh-Bado Elementary School was opened to serve adjacent low lying sub-districts and rural villages. Gosh-Bado is a relatively small rural town without municipal status. It has a total population of 2235, including those of surrounding villages. One elementary school (up to 8th grade) and one health centre serve the rural town and surrounding rural villages and communities.
Gosh-Bado was selected as a survey area because it had no access to electricity services by the time of the survey. A year later, it was connected to electricity from the grid, even though most parts of the town and major electricity consumers such as the health centre and the water pumping systems still remained without electricity connection due to delays in delivering metering services by EEPCO. Most grinding mills wishing to shift to electricity remained unconnected one year after access to electricity was ensured, due to a temporary restriction by the supplier in providing three phase metering services.

4.3. Survey Administration

Survey administration involved a number of steps such as authorization to conduct the survey, reconnaissance visit to the survey area, sampling and selection of sample households, recruitment and training of enumerators, data collection, data entry, and data analysis.

4.3.1 Authorization

Conducting field surveys in Ethiopia requires the authorization of government administration at all levels. A letter of partnership and cooperation was granted by the Ethiopian Rural Energy Development and Promotion Centre (EREDPC) specifying the purpose of the research and the need for collaboration by various regional and local government bodies towards the research work. The zonal administration office at Debre-Berhan issued a letter of cooperation to municipalities of the study towns that collaborated in all the research process.

4.3.2 Reconnaissance Visit to the Study areas

A reconnaissance visit was carried out to the research areas for a period of four days before actual field work commenced. This visit was intended to introduce the
research work to local authorities, collect support letters from lower level structures, identify the research towns, test the survey instruments, and recruit enumerators.

**4.3.3 Sampling of the Household Survey**

A random sampling technique was applied in determining the right sample size and identifying sample households. The local municipal household register was used as a basis upon which the total number of households within the rural town was applied as the sampling frame. The sample size was determined by using an Internet-based sample size estimator (Creative Research Systems, Sample Size Calculator, 2007-2010), by using a confidence interval of +/- 10 and confidence level of 95 percent, owing to the high level of homogeneity of the area.

After determining the sample size, the sampling frame (i.e. total number of households) was divided by the sample size to arrive at a number that was used as a sample interval for selecting the sample household from the main municipal register. The first household was randomly selected from a list of one to ten, while the next household was selected by adding the sample interval until the total number of sample households were identified and the list of households was completed. For example, if the sampling frame was 800 and the sample size was 80, the sample interval would be 10, by dividing 800 by 80. If the random number we pick (from 1 to 10) is 4, then the number 4 household on the main municipal register would be our first household to be surveyed. The next sample household would be number14, and the third 24, and so on until all the 800 households were examined and the 80 sample households were identified.
As shown in Table 5 below, 86 households were interviewed in Ankober, 83 households in Kotu, 85 households in Shola-Gebeya, and 82 households in Gosh-Bado.

Table 5: Population, Sample Frames and Sample Size of the Four Rural Towns

<table>
<thead>
<tr>
<th>Name of Town</th>
<th>Population</th>
<th>Sample Frame/ No. of Households</th>
<th>Sample Size</th>
<th>Actually Surveyed (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankober</td>
<td>3772</td>
<td>1050</td>
<td>88</td>
<td>86</td>
</tr>
<tr>
<td>Kotu</td>
<td>2581</td>
<td>698</td>
<td>85</td>
<td>83</td>
</tr>
<tr>
<td>Shola-Gebeya (b)</td>
<td>5151</td>
<td>750</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Gosh-Bado</td>
<td>2235</td>
<td>559</td>
<td>82</td>
<td>82</td>
</tr>
</tbody>
</table>

Note: (a) The difference between sample size and actual surveyed households represents number of households missing, showing that 2 households were not interviewed in both Ankober and Kotu.
(b) Population size in Shola-Gebeya was the highest while the number of households was relatively lower due to the high number of high school students from rural villages temporarily residing in the town renting residence houses. These residences were not considered as households in this study.

4.3.4 Enumerators Recruitment and Training

Efforts were put into recruiting sufficiently qualified and motivated enumerators through open notice as well as by way of ‘headhunting’. A total of 12 enumerators were employed and trained. Enumerators were properly trained with a view to ensuring that the quality of survey results would not be compromised. Training was provided for three days, including practical training. Trainees were first introduced to the purpose of the survey and were reminded why ensuring accuracy and maintaining quality standards were very important in influencing the research outcome. The training was therefore provided with the objective of ensuring accuracy and consistency throughout the survey administration.

Trainees were then provided with the questionnaire and explanations were given on the design of the questionnaire, the type of data that would be collected in filling each
question, what precautionary measures would have to be taken to avoid biases, and what tools would be applied to cross-check accuracy of data. After discussions on the contents of the questionnaires in the first day sessions, the second day training was dedicated to practical training in the field. Two trainees were accompanied by one supervisor and sent to conduct an actual interview. Once a first round data collection was conducted, trainees were all brought to a second day session where the process of survey administration was revised. On the third day, trainees were sent to collect data by themselves. A third day training session was conducted where each and every questionnaire filled in by each enumerator was reviewed, and possible errors discussed and corrected.

After training, the 12 enumerators were divided into two groups of six. One group was assigned to collect data in Ankober and Kotu, while the second group was assigned in Shola-Gebeya and Gosh-Bado. Each group was supervised by one supervisor, with the researcher playing the overall coordination role. The researcher and the two supervisors worked on filling in Survey B in collaboration with government agencies located in each of the survey towns.

4.3.5 Data Collection

Once survey households were identified, the enumerators began contacting survey participants. Selected households were invited to a meeting where the purpose of the survey work was explained. The actual survey commenced after all the preparatory work was completed. Each enumerator collected data on two households every day.
On-the-job training was given to enumerators by going through the contents of the questionnaire they filled in each day, and by training them to avoid errors. Corrections were also made with call-backs when necessary. Every filled questionnaire was reviewed daily by supervisors before it was cleared as complete.

4.3.6 Data Entry

All data collected were entered into the computer by designing key variables and by using SPSS program. Data entry personnel were employed and trained for accurate and quality data entry. Data were entered into computers as soon as a questionnaire was completed to facilitate timely completion of the study.
4.3.7 Data Analysis

Data were analyzed after entry into the computer using the SPSS database and data analysis features. Data analysis took the form of frequencies, mean, variance and median figures, as well as cross tabulations. Data were further transferred into graphs and figures to show clearer images of the relationships between selected variables and impacts of electricity access. When applicable, statistical tests were applied using logistic regression analysis and linear regression analysis. These data analysis tools were believed to provide sufficient basis for assessing the impacts of access to electricity services and measuring the contribution of RE towards poverty reduction and improving social well-being.

4.4 Limitations of the Research and Data Reliability

A number of problems were encountered while conducting the research. First, there was the problem of data availability. Data collection in Ethiopia is complicated by the culture of reluctance in transferring information to outsiders. The support letters provided by all levels of government were vital in minimizing this challenge. Multi-level data collection efforts fully overcame data scarcity at the local level, although national level data remain less complete.

Second, the quality of existing secondary data was compromised due to errors of past data collection practices, inappropriate data storage and labeling, including lack of explanation on the context and procedure of past data collection and use. Efforts were made to validate existing secondary data on its quality and methods of collection through accessing reliable data, and by supplementing it with primary information.
Third, there was difficulty in measuring the role of electricity services separately from other contributing factors and other energy services. Achievements of certain goals or targets depended on a number of factors, and it was difficult to accurately measure the impact of separate electricity services. It was equally difficult to collect time-series data using cross sectional survey. Two methods were used to overcome these problems: first, household responses were used as a proxy to measure the impacts and benefits of RE.

Second, the number of years of a town’s electricity access and number of years of household electricity connection were used as a proxy to account for inter-temporal variations of household responses. Third, as much as possible, verification was applied using qualitative methods and participant opinion, both of which were useful means of estimating the impacts of electricity services. What most interviewees at district (woreda) and provincial (zonal) levels agreed upon was that access to electricity services, when complemented with adequate infrastructure and budgetary commitments, had synergetic impacts on rural communities, addressing desired sectoral outcomes far more effectively than could have occurred otherwise.

Finally, the scope of the research posed a challenge. The content, data size and procedures of the research were too large to be covered with meager resources, and were beyond the requirements for a PhD dissertation. Efforts were made to substantially limit the size of data collection as much as possible and concentrate on key areas. Even then, the household level survey alone generated data with more than 400 variables by over 300 cases. Such large-scale local level data collection was required as there was insufficient information beforehand on the volume and quality of data available.
In conclusion, it was a daunting task to design the right methodology for measuring the impacts of rural electrification at household and community levels. Collecting the relevant data at these levels and analysing the data using both quantitative and qualitative analytical tools were appropriate methodologies in realising this research project. The household and community level surveys conducted at the local level were necessary for generating specific and timely data in order to arrive at conclusive results.

The survey faced a number of challenges such as problems of data availability, past data accuracy/data quality, data collection bias, and participant fatigue, as well as other confounding factors. This required cautious data validation, improved data collection practices, and systematic data analysis. The wide scope and larger size of the study required some trimming and focusing work.

4.5 Ethical Considerations

All the necessary care was taken to ensure that the research did not coercively intrude into the privacy of the local population and communities that were subject to the survey. All respondent households and community groups cooperated voluntarily. Administration of field surveys was preceded by public meetings involving groups of selected household heads to whom the intended survey, including its purpose and benefits, was explained with the objective of gaining their voluntary consent and confidence. Enumerators were trained on the importance of ethical considerations in administering the survey, and were required to sign a consent form stipulating that they would not create unnecessary expectations or enter false promises, and that they would not threaten respondents.
Religious and cultural issues were respected and protected from intrusion by the research. The survey was administered and conducted at the local level by local persons who had full knowledge of the people. Special care was given in contacting local women through recruiting local girls when available. The questionnaire design avoided asking intrusive questions that could be seen as compromising privacy. All research procedures were approved by the Human Research Ethics Board of the University of Victoria, under protocol number 07-105, concerning its adherence to ethical issues and standards.

The research outcome will contribute to enhancing local knowledge on local development processes. Results will be disclosed to the local community and discussed at that level just after the PhD project is completed, which could be one way of empowering local communities in reviewing their current situation in view of this research outcome. Regional and local government authorities have expressed interest in receiving copies of the research outcome. It has been verbally agreed that a follow-up discussion session will be held at Debre-Berhan, the zonal capital, to highlight the research findings.

Overall, the research methodology was designed to generate relevant data at a relatively low cost, without causing adverse consequences for the community from which information was gathered. Ample information has been gathered that was sufficient to address the research questions, and this information could be made available to local government authorities and researchers for future research.
CHAPTER V
RESULTS: EFFECT OF RURAL ELECTRIFICATION ON RURAL ENERGY TRANSITION

Chapter Five presents the results of the research in three parts. The first analyzes the connectivity rate of households to electricity services. The second part discusses electricity consumption patterns, and examines the pace of energy transition from biomass to MES after connection to electricity services. The third part deals with the effect of RE on the procurement and use of commercial household fuels, namely kerosene and batteries. The influence of various household and community level factors on existing household energy consumption structure and utilization of electricity services is discussed. The three sections try to address three specific research questions, namely:

(1) what factors influence rural electricity connectivity rate at household and community levels? (2) what determines the level of household electricity consumption after connection? (3) how does access and connection to electricity services influence households’ energy procurement, energy utilization, and energy transition to MES?

As discussed in the research methodology in Chapter Four, the local level survey was conducted in four rural towns with different years of access to electricity services at the time of the survey\textsuperscript{15}. The selection of the four rural towns with varying degrees of access to electricity services enabled the collection of cross-sectional data with inter-temporal references on impacts of RE. In the process, household energy consumption and procurement patterns were studied to look into the pace of household energy transition from existing biomass energy sources dominating consumption patterns to that of electricity services after electricity connection.
5.1 Household Electricity Connection and Consumption Behaviour

The household sector is the main energy consumer in Ethiopia, accounting for about 91 percent of the energy utilized, while rural households account for 84 percent of the national energy consumption (ESMAD Main Report, 2012a). As in most SSA countries, household energy consumption in the study areas is heavily dependent on traditional biomass fuels such as wood, charcoal, dung, and BLT (Branches, Leaves and Twigs).

The dominance of the household sector in the national energy scene and the disproportionate use of biomass within the household fuel mix present a number of household, community and national-scale challenges of which the following are most common. At the household level, rural households experience growing biomass energy scarcity as deforestation continues unabated. In Ethiopia, rural energy poverty is common, as demonstrated during the survey of the four rural towns, where about 80 percent of the households reported deteriorating energy access. Fifty-four percent of the respondents attributed the deterioration of energy access to overpopulation, and shortage of fuel wood to a dwindling forest resource. 8 percent of the respondents cited rising energy costs as the second major barrier to access and use of energy.

Second, the use of traditional fuels is associated with high energy loss of up to 90 percent (ESMAD Main Report, 2012a). Introducing demand management practices such as improved stoves is a very important means of addressing energy sector concerns for rural households. Doubling the efficiency of fuel-wood stoves to 20 percent can reduce fuel-wood demand by half, making a significant contribution to curbing deforestation, improving the management of natural resources, and helping to abate land degradation.
However, despite its promising future in addressing energy supply challenges, introduction of improved stoves is seldom practiced for various reasons, one of which is the cost barrier. Only 26 percent of the sample households reported that they introduced improved wood stoves, while 73 percent reported no efforts at introducing them. The main reasons for failure to introduce improved stoves were lack of financial capacity (22%), lack of awareness/exposure (20%), lack of supply of improved stoves (26%), and lack of space to install the stove within the household (3%).

Third, most of these households are exposed to indoor-air-pollution, affecting the health of women and children. According to the World Health Organization (WHO), in Ethiopia and twenty other countries, approximately 5 percent of the total burden of disease is caused by indoor air pollution. For Ethiopia, WHO estimates 0.5 to 1.0 deaths per 1000 people are attributable to indoor air pollution (WHO, 2009).

Fourth, a large number of those in rural households, especially women and children, are subject to travelling long distances over extended hours for fuel collection. Survey results show that about 40 percent of the households freely collect energy where at least one person is involved weekly. About 20 percent of surveyed households spend 3 to 15 hours traveling 2 to 30 kilometre distances weekly.

At the community level, excessive and inefficient use of biomass fuels contributes to overexploitation of forest resources, resulting in soil nutrient loss and deteriorating food security (FAO, 2004). At national and global levels, loss of forest resources and increased production of biomass-based pollution threaten environmental sustainability, contributing to increased green-house gases.
Ideally, rural households are expected to replace existing scarce, unclean, unhealthy, and inefficient biomass energy use by cleaner, more efficient and convenient use of MES as rural towns get access to electricity services, as rural households get connected, and as household income rises. Furthermore, occupation of household heads and family size of households are thought to contribute to the level of household energy consumption and accelerated transition to MES.

The following two sections analyse how changes in access to electricity services, differences in household income, type of occupation, and sex of household head influence a household’s decision over connectivity rate, increased use of electricity services, and the process of energy transition and inter-fuel substitution to MES.

5.1.1 Connectivity Rate after a Town’s Access to Electricity Services

One of the main challenges of RE expansion is low connectivity rate, which threatens cost-recovery for the supplier and slows the pace of reaching poor customers. After a rural town secures access to electricity services, connectivity rates may not be instantaneous for most customers, as it takes several years until poor households are connected. This is mainly due to two reasons: lack of financial capacity of a household to connect to electricity services, the household level factor; and limited infrastructure or power supply on the part of the power utility company due to shortage of electric meters or shortage of power, the community level factor. In this research, both household survey responses and EEPCO electricity bill records are used to analyze connectivity rate and changes in electricity consumption at household and community levels.
Surveyed households in the three electricity connected towns of Ankober, Kotu and Shola Gebeya were asked whether they were connected to electricity services, and if so, the number of years of connection. Results in Table 6 show that 87 percent of the households within the three electricity accessing towns reported having connection to electricity services, while 13 percent were without power connection.

Table 6: Connectivity Rate by Years since a Town’s Electricity Access (Cumulative Percentages)

<table>
<thead>
<tr>
<th>Connectivity Rate</th>
<th>Ankober</th>
<th>Kotu</th>
<th>Shola Gebeya</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still Not Connected</td>
<td>14%</td>
<td>12%</td>
<td>12%</td>
<td>13%</td>
</tr>
<tr>
<td>Year 1</td>
<td>38%</td>
<td>67%</td>
<td>88%</td>
<td>64%</td>
</tr>
<tr>
<td>Year 2</td>
<td>66%</td>
<td>81%</td>
<td>-</td>
<td>74%</td>
</tr>
<tr>
<td>Year 3</td>
<td>80%</td>
<td>88%</td>
<td>-</td>
<td>84%</td>
</tr>
<tr>
<td>Year 4</td>
<td>83%</td>
<td>-</td>
<td>-</td>
<td>83%</td>
</tr>
<tr>
<td>Year 5</td>
<td>85%</td>
<td>-</td>
<td>-</td>
<td>85%</td>
</tr>
</tbody>
</table>

Note: Total percentages for each town may not add up to 100 percent due to rounding.

In Ankober, 14 percent of the households were not connected to electricity services by the time of the survey, that is, five years after power was delivered to the town. Connectivity rate was limited to 38 percent in the first year of power access, and grew to 66 percent the second year, and to 80 percent the third year. Connectivity rate tends to be faster as one moves from Ankober to Kotu and to Shola Gebeya; that is, as one moves to towns with recent years of power access. In Kotu, the connectivity rate was 67 percent in the first year and grew to 88 percent in year three. Connectivity rate reached 88 percent in Shola Gebeya within less than 12 months after the town accessed the main grid.
As shown in Table 6 above, towns that had access to electricity most recently experienced higher household connectivity rate in the first year than those towns with prior history of access. Connectivity rate in the first year of access improved from 38 percent for Ankober to 67 percent for Kotu and 88 percent for Shola Gebeya, increasing by over 20 percent as one moves from earlier electricity accessing towns to most recent ones. This could be explained by a number of factors such as gradual improvement in household income, increasing prices of kerosene and alternative fuels, and easing of connectivity charges and infrastructure related constraints. The high connectivity rate in Shola Gebeya could be due to its relatively larger population size (over 5000 residents and number of households are over 1400) indicating that larger and relatively developed towns may show higher connectivity rate.

This is an interesting trend to note, since it may show that most rural households are financially able to pay for connection, or that there is a financing mechanism in place that has made connection easier. Other than financial factors, it could be possible that rural town residents are becoming aware of the benefits of electricity services and would subscribe earlier in larger numbers than was the case five years ago. The high cost of alternative fuels, especially the increasing cost of kerosene used mostly for lighting, could encourage households to consider earlier connection than was the case in towns that had access to electricity services in earlier years. Later in this section, it is highlighted that connectivity rate was highly related to a household’s capacity to pay, implying that the easing of financial barriers had more influence than the rest of the factors on improving connectivity rates in newly electrified towns.
Data from EEPCO’s electricity billing records show lower connectivity rates. In Ankober, nearly 272 residents and 29 business customers were connected the same year electricity was introduced into the area, showing a residence connectivity rate of 26 percent. Resident connectivity rate increased by 20 percent the second year and by 9 percent the third year, showing a slowdown in connectivity rate. On the other hand, businesses connectivity rate grew by 3 percent the second year and by 17 percent the third year, showing a substantial increase in business related connection.

EEPCO data for Kotu shows resident connectivity rate of about 18 percent the first year electricity was brought into the town. Connectivity rate grew by 59 percent the second year, dropped to -4 percent the third year, and rose again by 14 percent the fourth year. The drop in connectivity rate and consumption levels during the third year could probably be associated with limited supply of electric meters and substantial electricity rationing during the same period.

Recent slowdown in connectivity rate is associated with an external factor where the power supplier (EEPCO) was reluctant to provide metering and connection services due to the shortage of power supply, and shifting of priority to creating new access to unconnected areas rather than expanding the distribution of electricity services within connected towns. Gosh-Bado, which had no access to electricity services during the time of the survey, was connected a year later. A second visit to Gosh-Bado a year after the survey showed that less than 100 households had received electricity meters, and customer connection was stopped by the supplier, EEPCO, due to substantial power shortage associated with a delay in the commissioning of two hydropower plants.

Residents and community service workers in Gosh-Bado and Shola-Gebeya emphasized
during the second visit that there was a strong desire by residents and public service providers such as the health centre to become connected, indicating that connectivity rates would have been far higher if supply not been temporarily restricted.

In the short-term, recent power shortages and lack of electric meters contributed to the slowdown of household and community connectivity rates. While such supply side constraints tended to be temporary, a more deep-rooted and long-term factor for low connectivity rate was limited household capacity to pay for connection costs, as observed from household survey responses and EEPCO data.

Figure 15: Reasons for not being connected (Household and Community Factors)\textsuperscript{19}

Unconnected households in the three electricity accessing towns were asked why they were not connected. Figure 15 above shows that 11 percent of the households in Ankober, 31 percent in Kotu, and 17 percent in Shola Gebeya were not connected due to household factors\textsuperscript{20}, such as lack of financial capacity\textsuperscript{21}. Community related factors were mentioned by fewer households (26 percent in Ankober, 3 percent in Kotu, and 11
percent in Shola Gebeya). These observations imply that connectivity rate is highly related to a household’s capacity to pay for connection services.

The relationship between household income and connectivity rate is further shown in Figure 16 for all the three electricity accessing towns. The number of households connected to electricity services steadily increased as household income increased. The number of households not connected to electricity services dropped steadily as household income category increased.

Figure 16: Connectivity Rate by Income Category for Electricity Accessing Towns

Overall, connectivity rate in all the three towns continued to increase for households beyond monthly income level of birr 500, while up to 20 percent of the poor below this income bracket were unconnected. This result suggests that connectivity rate is affected by level of poverty, where the very poor remain unconnected after access to electricity services.
Households with no connection to electricity services were further asked when they were intending to connect. All unconnected households in Ankober, Kottu, and 80 percent in Shola Gebeya reported immediate connection when the power utility company lifted its restriction over connection. Such very high level of interest to connect indicates two possible developments: one is that income of rural households has improved slightly over recent years, raising the financial capacity of poorer households to connect. The second possible development is that even the poorest households are more motivated to be connected, foregoing other priorities as a result of the growing importance and expected benefits of electricity services.

A logistic regression model was run using SPSS (Allison, 1999, Wuensch, 2009) for connectivity rate of households. Household response on status of connection (yes/ no) was used as dependent variable with ‘yes’ responses given the value 1 and ‘no’ responses given 0. Independent or predictor variables were household electric access (ELACCESS), occupation (OCUPN), monthly income (INCOM), and sex of household head (SHH). Electricity access variable was the number of years the town had access to electricity services. The electric access variables were taken directly as 5, 3, and 1. For household income, household responses on monthly income were directly applied. For sex of household head, female household heads were given the value 1 while male household heads were given 0. Occupation had 9 categories and was applied directly. The logistic regression model result is shown in Table 7 below.
Table 7: Logistic Regression Result on Household Connectivity Rate by Access, Occupation, Income, and Sex of Household Head.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELACCESS</td>
<td>.015</td>
<td>.138</td>
<td>.011</td>
<td>1</td>
<td>.916</td>
<td>1.015</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.359</td>
<td>.111</td>
<td>10.379</td>
<td>1</td>
<td>.001</td>
<td>1.432</td>
</tr>
<tr>
<td>INCOME</td>
<td>-.002</td>
<td>.001</td>
<td>10.470</td>
<td>1</td>
<td>.001</td>
<td>.998</td>
</tr>
<tr>
<td>SHHH</td>
<td>-.370</td>
<td>.449</td>
<td>.681</td>
<td>1</td>
<td>.409</td>
<td>.691</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.764</td>
<td>.888</td>
<td>3.943</td>
<td>1</td>
<td>.047</td>
<td>.171</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ELACCESS, OCUPN, INCOME, SHHH.

Occupation and income variables passed the significance test while sex of household head and years of access of a rural town to electricity services failed the significance tests, indicating that these variables do not influence connectivity rate. The occupation and income variables were re-run separately and gave the results specified in Table 8 below.

Table 8: Logistic Regression Result on Household Connectivity Rate by Household Income

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCUPN</td>
<td>.333</td>
<td>.107</td>
<td>9.579</td>
<td>1</td>
<td>.002</td>
<td>1.394</td>
</tr>
<tr>
<td>INCOME</td>
<td>-.002</td>
<td>.001</td>
<td>12.137</td>
<td>1</td>
<td>.000</td>
<td>.998</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.187</td>
<td>.638</td>
<td>11.749</td>
<td>1</td>
<td>.001</td>
<td>.112</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: OCUPN, INCOME

The model result shows significant values of less than 0.05 for income category. The probability of ODDS of connection of a household if in a certain occupation and income level could be represented by the equation:

\[
\ln(\text{ODDS}) = 12.187 + 0.333 \text{OCUPN} - 0.002 \text{INCOME}
\]

The odds of being connected to electricity services for a household with occupations such as civil servants and skilled workers is 1.4 times more likely than those that are housewives, farmers and retirees. The influence of household monthly income on
household connectivity was rather mild with negative signs, showing that households with lower and middle income are connecting more for lately electricity accessing towns.

On the basis of the discussions and the logistic regression model results above, it may be possible to conclude that connectivity of rural households depends on the type of occupation and to a lesser extent on level of monthly household income. Other factors such as year of electricity access and sex of head of household head have little influence on connectivity rate of rural households.

5.1.2 Changes in Consumption Level and End-Use Diversity for Electricity Services

Other than slow connection rate, the second major challenge is low level of power consumption and limited diversification of use of electricity services beyond lighting and radio/TV reception. This section examines electricity consumption and expenditure structure by income category, and assesses reported changes in the procurement of electricity services. Electricity end-use structure is assessed in relation to household income. Finally, a logistic regression is applied to examine the influence of household income on changes in electricity expenditure category.

Average monthly household expenditure for electricity services is shown to reach birr 20, totalling birr 240 per annum and accounting for 24 percent of all energy expenditure. Electricity expenditure to total household expenditure reaches up to 4 percent for both Ankober and Kotu while that of Shola Gebeya is not yet known due to its very recent connection.
Table 9: Household Electricity Expenditure in the Four Rural Towns

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Ankober</th>
<th>Kotu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average monthly energy bill (birr)</td>
<td>99</td>
<td>95</td>
</tr>
<tr>
<td>Average monthly electricity expenditure (birr)</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Average Monthly household income</td>
<td>848.63</td>
<td>798.7</td>
</tr>
<tr>
<td>Percentage of electricity expenditure to average household energy expenditure (%)</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Percentage of household electricity expenditure to total household income</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

With average residential tariff of about birr 0.40 per KWh, average annual electricity expenditure of birr 240 per household translates into an average consumption of 600 KWh per household per year. Dividing this figure by average household size of 3.825 gives a *per capita* electricity consumption of 158 KWh, which is a far higher level of electricity consumption when compared with the national average of *per capita* electricity consumption of 40.3 KWh. However, this level of electricity consumption is far lower when compared with 549.4 KWh for SSA and 216.6 KWh for low-income countries on average in the year 2007 (World Bank Database).

As observed in Figure 17 below, household electricity consumption level remained below birr 15 for 55 percent of the households (N=169) with connection to electricity services. Percentage of households spending over birr 50 (about 3 USD) per month for electricity services dropped sharply, with only 6 percent of the households consuming above that level.
Household electricity consumption level was not only low, but also grew slowly with only 30 percent of the 146 electricity users in both Ankober and Kotu reporting an increase, while 55 percent did not change the volume of their electricity consumption. Nearly 14 percent of electricity users felt that they had decreased their consumption level over the years (see Figure 18 below). The largest changes in electricity consumption were observed in Ankober with 41 percent increase and 19 percent decrease. About 71 percent of Kotu residents reported no change in their electricity consumption pattern. These slow changes in household electricity consumption do not tally with that of EEPCO data that showed substantial growth. The reported slow change in electricity consumption by rural households as compared to higher power utility figures by the supplier could be due to the fact that household responses were on household consumption, while EEPCO data showed business and street lighting related electricity consumption at the town level. This implies that electricity consumption level increased in rural towns more than what was perceived by household residents.
Figure 18: Household Perceived Changes in Electricity Use in Towns with More Than One Year of Connection

From the power supplier data perspective, both household and business related electricity consumption showed substantial growth just after connection. In Ankober, total electricity consumption grew from 2,346 KWh per month in the first year of connection to 8,356 KWh per month the second year, growing by 256 percent in the second year and by over 60 percent annually the following years. Connected households expanded their average electricity consumption by 222 percent the second year, followed by a 120 percent increase the third year after connection. Businesses registered in 2004 expanded their electricity demand by 608 percent the second year, and by over 50 percent annually in subsequent years.

Average electricity consumption was lowest during the first year, but showed a substantial growth, nearly doubling every year. Business related electricity consumption grew far higher by 610 percent the second year, and by 110 percent the third year after connection. As shown in Figure 19 below, electricity consumption grew steadily with business related consumption levels increasing far higher than residential consumption.
Figure 19: Average Electricity Consumption Growth in Ankober in November 2004, May 2005 and July 2007 (KWh/ Month)

This is an important indicator of possible expansion of businesses after electricity access was established in rural towns. This trend explains the presence of gradual growth in electricity demand once households have been connected to electricity services. The tendency of widening and deepening of electricity consumption level suggests two important directions: the first is that access and connection to electricity services gradually expands to support local economies contributing to poverty reduction and promoting rural development. The second possibility is that RE expansion efforts could become self-financing in the longer-term as sufficient demand is created to warrant cost-recovery.

Household data on level of electricity consumption remained very low over the years while EEPCO data showed substantial increase\textsuperscript{27}. Such low levels of household power consumption could be associated with two very important factors: limited financial
capacity and the need for high-cost appliances to diversify electricity end-uses. Households were asked why their electricity consumption level remained low and could not be diversified other than lighting and radio/TV reception. Responses in the three electricity accessing rural towns of Ankober, Kotu, and Shola Gebea show that the high cost of appliances hindered most rural homes from diversifying their electricity use (41%) followed by limited financial capacity to pay for electricity bills (22%).

While absence and high cost of electric appliances restricts household demand for electricity services beyond lighting and communication, such a low level of diversification ultimately depends on limited financial capacity, as most households lack the capacity to buy these appliances. About 34 percent of the households in Ankober, Kotu and Shola Gebeya reported appliance related barriers, while 45 percent of surveyed households reported no appliance related barriers. Appliance related barriers were more often observed at lower income brackets, as reflected in Figure 20 below.

Households were specifically asked whether appliance related factors hindered the diversification of their electricity end-use. Figure 20 below shows that households at the lowest income category were the most influenced by appliance related barriers in their electricity end-use diversity. Household response on appliance related barriers decreased as household income category increased further indicating that higher income households were less susceptible to appliance related factors in diversifying their electricity use.
If financial and appliance barriers were resolved, households could expand their electricity demand for *injera* baking, refrigeration and ironing (66%) and for both household and business use (11%). Only 7 percent of surveyed households reported no interest in expanding their electricity use beyond current levels.

In the past, annual growth of household electricity demand was limited to 6 to 9 percent due to slow connectivity rates after access and low consumption levels after connection, which were the two main challenges facing EEPCO in ensuring financial viability of its RE expansion programs. In recent years, however, abrupt increase of demand for electricity services were recorded at a national scale, causing annual electricity demand to grow far higher than the traditional 9 percent annual demand growth to its current 24 percent per annum (EEPCO brief report, 2010). According to a local newsletter, Fortune (06 February, 2011), this trend of high electricity demand is likely to rise to 32 percent if the country is to achieve accelerated economic development (at high growth scenario of 15 percent GDP per annum) and faster rate of rural electrification (over 90 percent in five years). The rate of growth of demand is expected to continue to increase, probably beyond what EEPCO would be able to supply unless accelerated
power generation capacities are created. Overall, very low average household electricity consumption level is a sign of low income structure. It was encouraging to note that average residential as well as business consumption levels showed gradual and steady increase, indicating the gradual growth of household income and eventual diversification of electricity end-uses.

Households tended to diversify their electricity consumption gradually, expanding their electricity end-uses beyond lighting and radio/TV reception. Electricity end-use showed slight change in response to changes in income level. Figure 21 below shows that lighting and radio/TV reception end-uses grew simultaneously at a gradual pace as income categories passed the birr 1000 per month mark. This explains that households earning income below the birr 1000 per month tend to consume lower levels of electricity for radio/TV reception as compared with their consumption for lighting, probably due to limited ownership of these appliances. Diversification of electricity end-uses such as use of electric stoves (for Injera baking), mobile phone charging, and ironing remained low for most income categories, but showed marked increase for the highest income bracket, implying that households of the highest income category tend to diversify their electricity end-uses more than those at lower income brackets.

**Figure 21:** Percentage of Household Using Electricity for Lighting, Radio/TV, and Other End-Uses (Electric Mitad, mobile phone charging and ironing) by Household Income Intervals in Ankober, Kotu and Shola-Gebeya
Figure 22: Distribution of Perceived Changes in Household Electricity Consumption, by Income Intervals

Figure 22 above shows household responses on perceived changes on electricity consumption levels by income category. Households reported increased use of electricity services as their income category increased, with sharper increase at the highest income bracket. There was a drop in the percentage of households reporting no change in electricity consumption level as income category increased. Similarly, a decrease in electricity consumption level is more reported by households with lower income bracket. As a result, reported increase in the use of electricity services was associated with increase in household income.
Figure 23 above shows a steady increase in monthly electricity expenditure as income category increased, indicating that high income households consumed more and spent more on electricity services than poor households. Average monthly expenditure for electricity services was around birr 10 for the lowest income bracket while it was six times more for the highest income category.

A linear regression model was run for electricity accessing towns to test whether household expenditure for electricity services is associated with explanatory variables such as number of years of access to electricity services, reported household income, occupation of household head, number of years of a household’s electricity connection, family size, biomass energy consumption, and commercial fuels expenditure excluding electricity.

\[ Y_i = B_0X_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 \]

Where \( Y_i \) is the dependent variable – electricity expenditure, \( B_0 \) is the constant term, \( B_1 \) is the coefficient of \( X_1 \) for the electricity access, \( B_2 \) is the coefficient of \( X_2 \) for income, \( B_3 \ldots \) is number of years of household’s connection, \( B_4 \) is occupation, \( B_5 \) is family size, \( B_6 \) is total
biomass consumption, and B7 is commercial fuels expenditure excluding electricity. Results are shown in Table 10 below.

**Table 10: Linear Regression Results for Electricity Expenditure with 7 Independent Variables**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Expenditure</td>
<td>3.65</td>
<td>3.35</td>
<td>.021</td>
<td>-2.38</td>
<td>.36</td>
<td>6.22</td>
<td>-.14</td>
<td>-.20</td>
<td>11.62</td>
<td>37%</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(-.30)</td>
<td>1.08</td>
<td>.92</td>
<td>-.28</td>
<td>1.28</td>
<td>-.43</td>
<td>-.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>.77</td>
<td>.28</td>
<td>.000</td>
<td>.36</td>
<td>.78</td>
<td>.20</td>
<td>.670</td>
<td>.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results in Table 10 above show that all variables could not pass the significance test at a 95 percent confidence limit on a two tailed T test, except the income variable. A second linear regression model was re-run using a stepwise feature of the SPSS program for the purpose of automatic step-by-step exclusion of all non-significant variables. Results are shown in Table 11 below.

**Table 11: Linear Regression for Electricity Expenditure with Income as Independent Variable**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Expenditure</td>
<td>3.655</td>
<td>0.21</td>
<td>79.08</td>
<td>35%</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>1.206</td>
<td>8.893</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>.230</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The income variable shows a significant result with 35 percent of the change in household expenditure being explained by changes in household income. It is interesting to note that excluding the 6 other independent variables reduced the R Square by only 2 percent, indicating that the income variable is the only variable having a strong association with electricity expenditure.

In conclusion, changes in consumption level, expenditure, and end-use diversity for electricity services tend to be associated with household income. The poor (below a
monthly household income of US$40) consume less than one dollar a month worth of electricity services, mainly in the form of lighting. Monthly electricity expenditure increased as household income grew. This level of increase was supported by household response to changes in electricity consumption, with sharper increases being recorded in households with the highest income bracket. In a similar way, electricity end-use diversity responded positively to changes in household income. There is evidence showing that household income played a very important role regarding changes in electricity consumption/ expenditure and electricity end-use diversity. Equally, poorer households tended to be marginalized both in terms of connection, level of consumption and end-use diversity, suggesting that the very poor benefited the least from RE.

Both residence and business electricity consumption increased steadily from year to year after connection, implying that households with higher number of years of connection tend to consume more electricity services. A high level of increase in home-based business related electricity consumption is also recorded, signifying that business related electricity consumption showed the highest increase, and that expansion of businesses grew in line with electricity consumption.

5.1.3 Household Energy Transition and Inter-Fuel Substitution after Connection to Electricity Services

Ideally, households would substitute biomass with electricity services once connection is established in an effort to ease the variety of problems associated with biomass fuels, such as inconvenience, indoor-air pollution, and in most instances, scarcity. Unfortunately however, households tend to maintain their use of biomass fuels even after connection to electricity services, mainly due to two constraints: relatively
higher electricity bills and high cost of electric appliances. This section discusses observations on household energy consumption and expenditure behaviour after connection to electricity services. Two specific research questions are addressed: (1) does connection to electricity services influence overall household energy consumption/expenditure behaviour, energy end-use mix, and inter-fuel substitution? (2) what factors influence household energy transition to MES?

These questions are considered in the context of the following two areas: (a) transition from biomass fuels to electricity services, and the influence of household income and other factors in the transition process; (b) substitution of commercial fuels (kerosene and batteries) by electricity and resulting implications for biomass energy use and cost-saving opportunities in relation to some of the influential factors.

**Transition from Biomass Fuels to Electricity Services:** Earlier discussions showed how rural town residents behaved towards expanding their electricity utilization after connection, while household income, occupation, and years of electricity access influenced household diversity of use of electricity services. This sub-section continues discussion on existing household energy consumption/expenditure structure, followed by analysis of how access and connection to electricity services affects rural households’ energy transition from biomass to MES in the context of a basket of household fuels. Household energy expenditure and end-use mix data is used for analysis. First, household energy consumption structure within the four rural towns is discussed, followed by an analysis of the process of household energy transition to MES and inter-fuel substitution.
Table 12: Household Energy Expenditure in the Four Rural Towns (N = 337)

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Ankober</th>
<th>Kotu</th>
<th>Shola G.</th>
<th>Gosh Bado</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average monthly energy bill (birr)</td>
<td>99</td>
<td>95</td>
<td>85</td>
<td>45.4</td>
<td>81</td>
</tr>
<tr>
<td>Percentage of energy expenditure to total household income (%)</td>
<td>13%</td>
<td>16%</td>
<td>14%</td>
<td>5%</td>
<td>13.5%</td>
</tr>
<tr>
<td>Percentage of energy expenditure to total household expenditure (%)²⁸</td>
<td>12%</td>
<td>12%</td>
<td>14%</td>
<td>11%</td>
<td>12.3%</td>
</tr>
<tr>
<td>Average monthly electricity expenditure (birr) a/</td>
<td>20</td>
<td>19</td>
<td>none</td>
<td>none</td>
<td>19.5</td>
</tr>
<tr>
<td>Percentage of electricity expenditure to average household energy expenditure (%) a/</td>
<td>20%</td>
<td>20%</td>
<td>none</td>
<td>none</td>
<td>20%</td>
</tr>
</tbody>
</table>

a/ Electricity expenditure figures were only available for Ankober and Kotu while Shola-Gebeya was being connected and its residents did not pay their first electricity bills yet and Gosh-Bado was not connected by the time of the survey.

Survey results presented in Table 12 above show that households spend up to an average of birr 81 per month on energy, with a monthly energy bill of up to birr 99 in Ankober, birr 95 in Kotu, birr 85 in Sholla-Gebeya and birr 45 in Gosh-Bado²⁹. Energy expenditure to total monthly household income stands at an average of 13.5 percent, of which 13 percent is in Ankober, 16 percent in Kotu, 14 percent in Shola Gebeya and only 5 percent in Gosh-Bado. Electricity expenditure remains at only 20 percent of household overall energy expenditure, indicating an early stage of energy transition to MES. The three most used commercial energy forms are kerosene, dry-cell batteries, and electricity from the grid, all being used mostly for lighting. Dry-cell batteries and grid-electricity are both used for lighting and powering radios and TVs, signifying a great deal of substitutability between them.
Figure 24: Mean Household Energy Expenditure by level of access and Income

Note: Level of electricity access is grouped into four: the four study towns, towns connected for over three years (Ankober and Kotu), town just connected (Shola Gebeya), and town not connected (Gosh-Bado).

Mean energy expenditure figures classified by level of access to electricity services (Figure 24) show that energy expenditure increases as income category increases, with towns having over one year of access spending higher amounts than those without. However, the increase in energy expenditure by level of electricity access was not very large, implying that household energy expenditure did not show dramatic increase in response to level of electricity access.

In Gosh-Bado, a relatively more rural setting with no electricity access, energy expenditure is the lowest, as households freely collected or produced the bulk of their fuels (See Figure 25 below). Freely collected and self-produced energy remains very low for the other three rural towns at an average of 10 percent of the wood consumed.
Figure 25: Share of Energy Expenditure by Fuel Type and Survey Town

Note: Energy types include fuel-wood, charcoal, BLT (Branches, Leaves & Twigs), dung, kerosene, batteries, and electricity.

Figure 26 below shows mean household energy expenditure for all four rural study towns disaggregated by income category and by fuel type. Household energy expenditure for biomass continues to grow as household income increases. The increase was substantial for wood, charcoal, kerosene and electricity. Expenditure for batteries and other biomass fuels such as dung and BLT showed a decrease as income level increased, showing low preference for these fuels at higher income brackets. The low level of consumption figures for BLT and dung could also be explained by the fact that most of these two fuels are freely collected by rural households. Expenditure for electricity services grew sharply as household income increased, but the growth was even higher for fuel-wood and charcoal.
Why wouldn’t households shift to using more electricity as their income increased, instead of spending more on biomass fuels? A number of explanations can be suggested: one is that the increase in household income may still not have been high enough to warrant payment of electricity bills for diversified uses of electricity services. Second, high cost and scarcity of electric appliances constrain the process of energy transition from biomass to electricity services other than lighting and radio/ TV reception. Households may have to pass a certain income threshold to be able to buy electricity appliances and substitute biomass-based cooking and injera baking with electricity services. Third, cost of using fuel-wood and charcoal may seem cheaper as efficiency losses associated with the use of biomass fuels continue to be hidden for household users. Forth, households in rural towns tend to be more culturally tied to biomass fuels and may require more years before shifting to use electricity services for diversified end-uses. Culturally, residents of rural towns prefer to use fuel-wood for cooking and injera baking, and charcoal for cooking. Fifth, fuel-wood and charcoal prices are markedly high.
even in rural settings, and an increase in household income tends to initially relax existing suppressed demand for these fuels in the short-term, until households consider shifting to MES.

A continued rise of household use of fuel-wood and charcoal at higher income brackets implies that electricity access and connection do not result in instantaneous transition from biomass to MES. As a result, the provision of electricity services may not have strong and immediate implications in reducing indoor air pollution, in improving rural livelihood, and in alleviating the pressure on the local environment.

**Figure 27: Mean Household Energy Expenditure by Income Category and Fuel Types in Ankober & Kotu**

Figure 27 above shows household energy expenditure for the two rural towns of Ankober and Kotu, with a longer history of electricity access. Three important features are highlighted: First, the use of fuel-wood and charcoal continued to grow even for highest income households, but with modest increase when compared with energy
expenditure structure of all the four rural towns combined. This modest increase at higher income categories for Ankober and Kotu is not due to substitution of fuel-wood and charcoal by electricity services, but rather to indirect substitution of these two biomass fuels by kerosene, in which the latter was further substituted by electricity services in the form of lighting. As shown in Table 17 (substitution of charcoal by kerosene) and in Table 21 (substitution of kerosene by electricity), the substitution of kerosene by electricity services enabled further substitution of fuel-wood and charcoal for cooking.

Second, the expenditure for kerosene and batteries decreased substantially, depicting a substantial level of substitution of these fuels by electricity services. The continued modest level of use of kerosene in electricity accessing towns could be explained by two factors: one is that non-connected households continue to use kerosene for lighting. The second reason is the substitution of kerosene for biomass, as discussed earlier.

Third, household expenditure for electricity services increased for the two rural towns (Ankober and Kotu), with substantial increase being observed as household income category increased.

Figure 28 below shows energy expenditure in Shola-Gebeya, where electricity expenditure was not documented as access to electricity was just taking place by the time of the survey. Two important features are exhibited in Shola-Gebeya: First, the use of kerosene is substantial and grows as income levels increases, indicating the early stage of substitution by electricity. Second, the expenditure on fuel-wood and charcoal was rather low even for the higher income bracket, probably indicating cheaper prices for these fuels.
In Gosh-Bado (see figure 29 below) the use of batteries is higher than kerosene indicating that batteries are the most preferred sources for lighting and radio reception. Kerosene was used more evenly across all income categories except for the 1500-1999 income group where its expenditure was the lowest.

Figure 29: Mean Household Energy Expenditure by Income Category in Gosh-Bado (birr)
Looking at the proportions of energy end-uses mixes, household energy services are predominantly used for cooking, coffee/tea making, lighting, water heating and to a lesser extent, home heating. As shown in Figures 30 and 31, the use of traditional energy forms (mainly wood and Charcoal) are used for wot cooking, injera baking, and coffee/tea making. Fuel-wood is used for Injera baking (56%) followed by cooking wot (21%). The use of fuel-wood for cooking is slightly higher for Gosh-Bado, indicating availability of more wood there.

**Figure 30: Mean Percentage End-Uses for fuel-wood**

![Mean Percentage End-uses for Wood](image)

The use of charcoal is fairly divided between tea/coffee making (49%) and cooking (35%) with the exception of Shola-Gebeya where the share of cooking is more dominant. BLT and dung are mainly used for Injera baking for up to 35 percent and 60 percent of the end-uses, respectively. The use of dung as fuel falls drastically to only 4 percent in Ankober where it is used traditionally as fertilizer, which is a peculiar characteristic of the area in contrast with most other parts of the country. 31
Figure 31: Mean Percentage End-Uses for Charcoal

In the remaining part of this section, the influence of connection to electricity services on household energy expenditure decisions and inter-fuel substitution are discussed. A linear regression analysis is applied by constructing separate fuel expenditure models for fuel-wood, charcoal, kerosene, and battery vis-à-vis electricity services.

**Fuel-wood:** To test what influences household fuel-wood expenditure decisions, household fuel-wood expenditure is used as a dependent variable while household kerosene expenditure (BRKROS), charcoal (BRCHAR), BLT (BRBLT), electricity (BRELECT), year of electricity access (ACCESS), year of household’s connection to electricity services (YRCONCT), family size (FMSIZE), occupation (OCUPN), and monthly income (INCOME) used as independent variables. The model was of the type:

\[ Y_i = B_0 X_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4 + B_5 X_5 + B_6 X_6 + B_7 X_7 + B_8 X_8 + B_9 X_9 \]

Where \( Y_i \) is the dependent variable – fuel-wood expenditure, \( B_0 \) is the constant term, \( B_1 \) is the coefficient of \( X_1 \) and so on. \( X_1 \) is expenditure on kerosene, \( X_2 \) is charcoal expenditure, \( X_3 \) is number of years of household’s connection, \( X_4 \) is electricity expenditure, \( X_5 \) is number of
years of access, X6 is number of years of electricity connection, X7 is family size, X8 is occupation, and X9 is household income.

The model outcome showed that most of the variables, BRKEROS, OCUPN, FMSIZE, BRELECT, BRBLT, INCOME, ACCESS, and YRCONECT all failed the significance test (Table 13).

Table 13: Linear Regression Model Result for Fuel-wood Expenditure as Dependent Variable with Nine Independent Variables

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>B8</th>
<th>B9</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel-wood Expenditure</td>
<td>-9.578</td>
<td>-.194</td>
<td>.759</td>
<td>-.123</td>
<td>-.142</td>
<td>-1.642</td>
<td>-.732</td>
<td>3.421</td>
<td>2.80</td>
<td>.006</td>
<td>9.05</td>
<td>.2</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(-1.34)</td>
<td>(.72)</td>
<td>(6.1)</td>
<td>(-.27)</td>
<td>(-1.1)</td>
<td>(-.21)</td>
<td>(-.33)</td>
<td>(2.5)</td>
<td>(.73)</td>
<td>(1.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.18)</td>
<td>(.47)</td>
<td>.000</td>
<td>(.79)</td>
<td>(.27)</td>
<td>(.83)</td>
<td>(.75)</td>
<td>(.013)</td>
<td>(.47)</td>
<td>(.11)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: BRKEROS, BRCHAR, OCUPN, FMSIZE, BRELECT, ACCESS, YRCONECT, BRBLT, and INCOME.

In contrast, charcoal expenditure (BRCHAR) and family size showed significant values for which the model was further re-run using the step-wise application. Improved linear regression model results are shown in Table 14 below.

Table 14: Improved Linear Regression Model Result for Fuel-wood Expenditure with Two Independent Variables

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel-wood Expenditure</td>
<td>-11.198</td>
<td>.796</td>
<td>3.684</td>
<td>38.932</td>
<td>.190</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(-1.98)</td>
<td>(7.62)</td>
<td>(2.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.05)</td>
<td>(.000)</td>
<td>(004)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: BRCHAR, FMSIZE.

The following can be summarized from Table 14 above: Fuel-wood expenditure is influenced by charcoal expenditure and family size with the latter having greater impacts. Obviously, households with more expenditure on charcoal may substitute their demand for fuel-wood while those with larger family size would require more
expenditure on fuel-wood. However, the positive sign of the coefficient shows that households that spent more on charcoal do as well spend more on fuel-wood, implying little or no substitution effect between the two biomass fuels.

The linear regression model test result for fuel-wood expenditure clearly shows that connection to electricity services has little or no influence on household demand for fuel-wood, as most households do not use electricity for cooking. While using an electric *injera* baker is very common in households residing in major towns, it is less commonly used in rural towns due to high cost of the appliance. Similarly, kerosene expenditure showed no association with fuel-wood expenditure. The model outcome further illustrates that a household’s fuel-wood consumption/ expenditure is positively related with the consumption of charcoal and BLT. This is understandable, as households prefer to use fuel-wood for *injera* baking complemented by BLT. Charcoal is predominantly used for coffee/ tea making.

**Charcoal:** Factors influencing household charcoal expenditure decisions were tested using a linear regression model. Household charcoal expenditure was used as the dependent variable, while years of a town’s access to electricity services (ACCESS), household kerosene expenditure (BRKEROSN), fuel-wood expenditure (BRWOOD), BLT expenditure (BRBLT), electricity expenditure (BRELECT), years of connection of a household (YRCONNECT), family size (FMSIZE), occupation of head of household (OCUPN), and monthly household (INCOME) were the independent variables.

The model was of the type:

\[ Y_i = B_0 X_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4 + B_5 X_5 + B_6 X_6 + B_7 X_7 + B_8 X_8 + B_9 X_9 \]
Where Yi is the dependent variable – charcoal expenditure, B0 is the constant term, B1 is the coefficient of X1 and so on. X1 is years of electricity access, X2 is kerosene expenditure, X3 is fuel-wood expenditure, X4 is BLT expenditure, X5 is electricity expenditure, X6 is number of years of household electricity connection, , X7 is family size, X8 is occupation, and X9 is household income.

Results (Table 15) show that five of the nine independent variables used in the model, namely years of access, kerosene expenditure, BLT expenditure, years of household’s connection, and family size could not pass the significance test at the 95 percent confidence limit of a two-tailed t-test.

Table 15: Linear Regression Model Result for Household Charcoal Expenditure with Nine Independent Variables.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$B_0$</th>
<th>$B_1$</th>
<th>$B_2$</th>
<th>$B_3$</th>
<th>$B_4$</th>
<th>$B_5$</th>
<th>$B_6$</th>
<th>$B_7$</th>
<th>$B_8$</th>
<th>$B_9$</th>
<th>$F$</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charcoal Expenditure (t-Values)</td>
<td>4.78</td>
<td>-3.15</td>
<td>.25</td>
<td>.135</td>
<td>.009</td>
<td>.009</td>
<td>3.69</td>
<td>1.17</td>
<td>5.65</td>
<td>.008</td>
<td>22.802</td>
<td>.387</td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.11)</td>
<td>(.34)</td>
<td>(.027)</td>
<td>(.000)</td>
<td>(.96)</td>
<td>(.87)</td>
<td>(.000)</td>
<td>(.044)</td>
<td>(.000)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, BRKEROSN, BRWOOD, BRBLT, BRELECT, YRCONNECT, FMSIZE, OCUPN, and INCOME.

The model was rerun using the step-wise reiteration the outcome of which gave six independent variables with significant results as shown in Table 16 below. The six independent variables are family income (X1), fuel-wood expenditure (X2), number of years of connection to electricity (X3), occupation (X4), kerosene expenditure (X5), and family size (X6).
Table 16: Improved Linear Regression Model Result for Household Charcoal Expenditure with Six Independent Variables

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charcoal Expenditure</td>
<td>4.267</td>
<td>.008</td>
<td>.136</td>
<td>3.082</td>
<td>.5.403</td>
<td>.260</td>
<td>1.187</td>
<td>34.257</td>
<td>.385</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(.48)</td>
<td>(5.78)</td>
<td>(6.17)</td>
<td>(4.7)</td>
<td>(3.45)</td>
<td>(2.37)</td>
<td>(2.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.14)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.001)</td>
<td>(.018)</td>
<td>(.034)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: INCOME, BRWOOD, YRCONECT, OCUPN, BRKERSEN, and FMSIZE.

The following can be summarized from the charcoal equation: Household income, fuel-wood expenditure, number of years of connection to electricity, occupation, kerosene expenditure, and family size are all positively related to a household’s charcoal consumption. Furthermore, household expenditure decisions on charcoal tend to be affected by occupation, where farmers and civil servants tend to use less charcoal, while business employed households use more of this fuel. It is understandable that other biomass fuels such as dung and BLT are not associated with a household’s charcoal expenditure, as the latter is used for cooking and coffee/tea making, which are not common end-uses of the former two fuels.

It is interesting to note that the improved model has similar R square indicating that the influence of the excluded three variables was negligible and that the 6 variables used in the improved model do effectively explain the variation in household charcoal expenditure. Number of years of a household’s electricity connection was related to a household’s expenditure on charcoal while electricity expenditure does not have relationship with charcoal expenditure. How would it be possible for a household’s charcoal expenditure to be related to the number of years of a household’s electricity connection while the level of electricity expenditure is not? It is understandable that
there is little or no substitution effect between the two fuels, or that substitution of charcoal by electricity services took place, if at all, in the early years of connection, probably indirectly, by substituting kerosene for lighting and charcoal for cooking. On the other hand, the relationship between charcoal and kerosene means that there exists a direct substitution of charcoal by kerosene as both fuels are used mainly for cooking and coffee/tea making.

Household monthly income remains one of the main factors influencing household energy expenditure decisions for both fuel-wood and charcoal. However, one needs to note that these relationships are positive, implying that household biomass consumption continues to grow as household income increases, which is a reflection of little or no substitution effect by MES. While relationship between monthly household income and energy procurement and use is well established, the influence of a town’s years of access to electricity services remains insufficiently correlated.

A linear regression analysis was run to assess the influence of a town’s number of years of access to electricity services together with household income on the use of various household fuels (Lind Et.al., 2008). A linear regression model was constructed with the form:

\[ Y_i = B_0 + B_1X_1 + B_2X_2 \]

Where \( Y \) represents the various household fuels bought and utilized, ‘\( B_0 \)’ is the constant term, ‘\( B_1 \) and \( B_2 \)’ represent coefficients of the independent variables, while \( X_1 \) represents years of electricity access of each town\(^{32} \), and \( Y \) is household income. Results of the linear regression model are shown in Table 17 below.
The model showed very weak results for fuel-wood, with insignificant values at 95 percent significance limit. Very poor relationship was observed between the independent variables as depicted by the very low R-square value of 5.8 percent. This implies that fuel-wood is the most dominant and basic fuel used in rural towns irrespective of income level and year of access to electricity services.

On the other hand, household charcoal expenditure is significantly influenced by both household monthly income and years of access to electricity services such that household charcoal consumption grew as household income increased and as the town’s number of years of access to electricity services increased. The two variables explained the model with an R-square of 25 percent with highest F-value. All t-ratios gave significant values. In other words, residents in rural towns with late or no electricity access spent less money on charcoal than those towns with earlier years of access. This positive relationship signifies that there was little or no substitution of charcoal by MES taking place after a town’s access to electricity services. On the contrary, households increased their expenditure on charcoal as their monthly income increased and as the years of electricity access increased.

Table 17: Linear Regression Model Result of Household Biomass Fuels Expenditure

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$B_0$</th>
<th>$B_1(AC)$</th>
<th>$B_2(Y)$</th>
<th>$F$</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel-wood</td>
<td>13.337</td>
<td>.525</td>
<td>.015</td>
<td>11.275</td>
<td>5.8%</td>
</tr>
<tr>
<td>(t-Values)</td>
<td>(3.048)</td>
<td>(.376)</td>
<td>(4.555)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.707)</td>
<td>(.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charcoal</td>
<td>14.172</td>
<td>2.153</td>
<td>.013</td>
<td>54.575</td>
<td>24.6%</td>
</tr>
<tr>
<td>(t-Values)</td>
<td>(7.500)</td>
<td>(3.594)</td>
<td>(8.890)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Biomass.</td>
<td>43.770</td>
<td>5.782</td>
<td>.043</td>
<td>44.358</td>
<td>21%</td>
</tr>
<tr>
<td>(t-Value)</td>
<td>(6.449)</td>
<td>(2.686)</td>
<td>(8.309)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Looking at all biomass fuels (fuel-wood, charcoal, BLT, and dung combined) a significant increase in biomass fuels expenditure was observed in line with increase in household income and in number years of a town’s access to electricity services. This result answers the question of whether biomass fuels are substituted as household income and number of years of access increase. *Households increased their biomass consumption/ expenditure as their income grew and number of years of a town’s access to electricity increased, implying little or no substitution and transition taking place from biomass to MES due to income and access factors.*

Reconsidering the specific research question on the factors influencing overall household energy consumption/ expenditure behavior, energy end-use mix, and inter-fuel substitution, one arrives at the following conclusion. While household income continues to influence household energy expenditure decisions, the impact of electricity access on household energy transition remains weak. Biomass fuels continue to be dominant after a town has long been accessing electricity, and after a household is connected to electricity services. The consumption of biomass continues to increase as household income grows. The continued use of biomass under these three changes can be explained by the very limited substitution of biomass by electricity for major energy intensive household end-uses such as *injera baking*, cooking, and coffee/tea making, while the use of electricity is primarily for lighting and radio/TV reception.

*Substitution of Kerosene and Dry-cell Batteries by Electricity Services:* - This section discusses the impact of electricity access and substitution of household commercial fuels such as kerosene and batteries by electricity services. Inter-fuel substitution is substantial among commercial fuels, that is, transition from kerosene and batteries to
electricity services, mainly for lighting. In the survey towns, households were asked what type of commercial fuels they used, the type of end-uses for which these fuels were utilized, and the amount of money spent in buying these fuels per month. Furthermore, households were asked the amount of money they spent on kerosene and batteries before and after they had accessed electricity services.

In Ankober and Kotu, there is a clear indication that kerosene and batteries were substituted by electricity for lighting and radio reception services. In all three electricity connected rural towns, kerosene expenditure decreased by an average of 47 percent, while battery expenditures decreased by an average of over 70 percent. The substitution of kerosene and batteries by electricity services was evenly distributed across all income categories (Figures 32 and 33) indicating that electricity for lighting is an essential end-use for the poor as well as for the rich. However, mean electricity expenditure levels grew as income levels increased, indicating that households tend to expand and diversify their electricity use beyond lighting as income level grows.

Table 18: Household Savings from Replacement of Kerosene and Batteries in the Four Rural Towns (in Birr) N= 337

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Ankober</th>
<th>Kotu</th>
<th>Shola G.</th>
<th>Gosh-B.</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean household expenditure on kerosene and batteries before connection to electricity services</td>
<td>25</td>
<td>27</td>
<td>28</td>
<td>17.20</td>
<td>24.30</td>
</tr>
<tr>
<td>Mean household expenditure on kerosene and batteries after connection to electricity services</td>
<td>6</td>
<td>9.10</td>
<td>16.8</td>
<td>none</td>
<td>10.63</td>
</tr>
<tr>
<td>Mean saving from kerosene &amp; batteries due to replacement by electricity (birr)</td>
<td>19</td>
<td>17.9</td>
<td>11.2</td>
<td>none</td>
<td>16</td>
</tr>
<tr>
<td>Mean household monthly expenditure on electricity services</td>
<td>20</td>
<td>19</td>
<td>No bills yet</td>
<td>none</td>
<td>19.5</td>
</tr>
<tr>
<td>Percentage of savings from kerosene and batteries due to replacement (by electricity) to average electricity expenditure</td>
<td>95%</td>
<td>97.4%</td>
<td>No bills yet</td>
<td>none</td>
<td>82.2%</td>
</tr>
</tbody>
</table>

Note: The average excludes the ‘none’ values in Gosh-Bado, which are actually not zero values.
It is interesting to note that households were able to save above 80 percent of their kerosene and batteries based lighting expenditure by shifting to electricity services as shown in Table 18 above.

Rural towns with no access to electricity services spent up to an average of birr 24.30 per household per month on kerosene and batteries, mainly for lighting and communication use. Ankober and Kotu had similar experiences before connection to electricity. This amount of household fuel expenditure is reduced to birr 10.63 after connection. The introduction of electricity services replaced the use of kerosene and batteries as shown in the form of reduced household expenditure on these fuels. The substitution of electricity for kerosene and batteries is so substantial that the savings could offset about 75 percent of the average household electricity expenditure. The bulk of this substitution took place in the form of lighting (for kerosene and batteries) and radio/ TV reception (for batteries). The savings on batteries for lighting is due to improved illumination that electricity provided in the household and on public roads.\(^{34}\)

**Figure 32: Mean Percentage End-Uses of kerosene**

![Mean Percentage End-Use for Kerosene](chart.png)

- Cooking
- Coffee/ Tea making
- Lighting
In towns connected to electricity services, the use of kerosene continued, albeit with slight reduction, but end-use shifted from lighting to that of cooking (22%) and tea/coffee making (17%). In non-electrified towns, the use of kerosene continued to be dominated by lighting for up to 91 percent of the end-uses.

This is explained by the substantial drop in kerosene and battery expenditure after electricity connection in Ankober, Kotu, and Shola-Gebeya (Figures 32 and 33).

**Figure 33: Mean Percentage End-Uses of Batteries**

<table>
<thead>
<tr>
<th>Survey Towns</th>
<th>Mean Percentage Use for Batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lighting</td>
</tr>
<tr>
<td>Ankober</td>
<td>20%</td>
</tr>
<tr>
<td>Kotu</td>
<td>25%</td>
</tr>
<tr>
<td>Shola-Gebeya</td>
<td>30%</td>
</tr>
<tr>
<td>Gosh-Bado</td>
<td>50%</td>
</tr>
</tbody>
</table>

Gosh-Bado, with no electricity access, continued to use kerosene for lighting for 91 percent of its end-uses (Figure 33). The use of dry-cell batteries was predominantly used for lighting, mainly for powering of flashlights, with its share growing in towns with no access to electricity services (Figure 33).

It is important to note that the use of electricity (Figure 34) remains limited to lighting and powering radios/TVs for most households, and is seldom used for other household end-uses such as cooking, *injera* baking, and coffee/tea making.
As shown above, the use of kerosene for lighting and the use of batteries for lighting and radio/TV reception are partially replaced by electricity after connection. The continued use of kerosene after connection is mainly for cooking and tea/coffee making as experienced in the three electricity accessing rural towns.

In these towns, the use of kerosene for lighting continued for up to 12 percent of the households, corresponding to the proportion of households without electricity.
connection. A drastic jump in kerosene consumption was observed in Gosh-Bado (see Figure 35 above), obviously due to absence of electricity for lighting.

A paired-sample T-test was conducted for 222 sample households connected to electricity services to test whether significant differences existed in kerosene and batteries expenditure before and after connection to electricity services. The result is shown in Table 19 below.

### Table 19: Paired Sample T-Test Result

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Paired Differences</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>df</th>
<th>Sig.(2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Amount of birr spent on kerosene before electricity use minus amount spent for kerosene after connection</td>
<td>10.02</td>
<td>26.4</td>
<td>1.77</td>
<td>6.53</td>
<td>13.52</td>
<td>5.66</td>
<td>221</td>
<td>.000</td>
</tr>
<tr>
<td>Pair 2</td>
<td>Amount of birr spent on batteries before electricity use minus amount of birr spent on batteries after connection</td>
<td>8.42</td>
<td>11.5</td>
<td>.77</td>
<td>6.90</td>
<td>9.94</td>
<td>10.92</td>
<td>221</td>
<td>.000</td>
</tr>
</tbody>
</table>

A paired sample t-test result shown above reaffirms a significant difference in the use of kerosene and batteries before and after connection to electricity services. The connection of a household to electricity services reduces the mean expenditure on kerosene by birr 10 per month, and batteries expenditure by birr 8.42 per month. The higher standard deviation for kerosene signifies more variability in substitution of kerosene by electricity services than batteries. It could therefore be concluded that the reduction in household kerosene expenditure of birr 10 and batteries expenditure of birr 8.42 is not chance, but rather due to household connection to electricity services and resulting fuel substitution.
Mean household saving from replacing kerosene and batteries add up to a total of birr 18.44 per month. The mean monthly electricity expenditure reported by households is at birr 19.50 for Ankober and Kotu. The savings from the replacement of kerosene and batteries constitutes about 95 percent of the cost households are paying for electricity services. This suggests that transition from kerosene and batteries to electricity services for lighting and radio reception may not require additional expenditure to what was originally spent on these replaced fuels. At this stage, one may conclude that access to electricity services has significantly reduced household kerosene and battery expenditure for lighting and radio reception, respectively.

Replacement of kerosene and batteries before and after connection to electricity services accounts for the amount of money saved as a result of substitution of the two fuels by electricity services for lighting and radio reception. Additional benefit that is gained but unaccounted for by replacing kerosene with electricity services is in the form of energy transition from biomass to kerosene for cooking and coffee/tea making, replacing fuel-wood and charcoal. As mentioned above, only 47 percent of the household kerosene expenditure is saved while the rest – about 53 percent – is still utilized within the household, probably through substituting fuel-wood and charcoal for cooking and coffee/tea making end-uses.

The remaining part of this section examines each commercial fuel as tested against major household fuels and other influencing factors. A linear regression analysis is conducted to test the influence of various factors on procurement and utilization of kerosene and batteries in particular and MES in general, including electricity services. Each fuel under consideration was used as a dependent variable against two or more
independent variables such as a town’s access to electricity services and a household’s monthly income.

**Kerosene:** A linear regression model was constructed by taking kerosene expenditure as a dependent variable and battery expenditure, electricity expenditure, year of electricity access, year of a household connection, and monthly income as independent variables. The model is of the type:

\[ Y_i = B_0X_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 \]

Where \( X_1 \) is battery expenditure (BRBATERY), \( X_2 \) is electricity expenditure (BRELECT), \( X_3 \) is years of electricity access (ACCESS), \( X_4 \) is Years of household electricity connection (YRCONECT) and \( X_5 \) is monthly household income (INCOME). \( B_0 \) is coefficient of the constant term while \( B_1 \) to \( B_5 \) are coefficients for each variable. The model result is shown in Table 20.

### Table 20: Linear Regression Model Result for Household Kerosene Expenditure

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>( B_0 )</th>
<th>( B_1 )</th>
<th>( B_2 )</th>
<th>( B_3 )</th>
<th>( B_4 )</th>
<th>( B_5 )</th>
<th>( F )</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene Expenditure</td>
<td>7.02</td>
<td>.755</td>
<td>-.089</td>
<td>-2.146</td>
<td>-.399</td>
<td>.005</td>
<td>12.851</td>
<td>.163</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(6.29)</td>
<td>(.7)</td>
<td>(-3.4)</td>
<td>(-1.38)</td>
<td>(-.87)</td>
<td>(7.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.486)</td>
<td>(.001)</td>
<td>(.169)</td>
<td>(.383)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- a. Variable(s) entered in the model: BRBATERY, BRELECT, ACCESS, YRCONECT, and INCOME.

Model result (Table 20 above) shows that battery expenditure (BRBATERY) and number of years of electricity connection (YRCONECT) failed the significance test at 95 percent confidence limit of the two-tailed t-test.

A re-run of the kerosene expenditure model using step-wise application was conducted. The model result is shown in Table 21 below.
Table 21: Improved Linear Regression Model Result for Kerosene Expenditure

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene Expenditure</td>
<td>7.373</td>
<td>.005</td>
<td>- .092</td>
<td>- 3.276</td>
<td>20.956</td>
<td>.159</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(8.86)</td>
<td>(7.03)</td>
<td>(-3.51)</td>
<td>(-2.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.001)</td>
<td>(.004)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A household’s expenditure on electricity services is negatively related to kerosene expenditure, showing that household kerosene expenditure declines as expenditure on electricity increases. Income is positively related, indicating that expenditure on kerosene increases as household income is increased.

The fact that electricity expenditure (BRELECT passed the significance test implies that electricity expenditure is related to kerosene expenditure as was demonstrated in the discussions above. On the other hand, the very low coefficient for household income (Table 21 above) signifies very little influence of the income variable on household monthly kerosene expenditure.

**Dry-cell Batteries:** A linear regression test was run for battery expenditure as a dependent variable and expenditures on fuel-wood (BRWOOD), charcoal (BRCHAR), kerosene (BRKEROSEN), electricity (BRELECT), as well as income (INCOME), occupation (OCUPN), and year of connection (YRCONNECT) as independent variables.
Table 22: Linear Regression Model Results for Battery Expenditure with Seven Independent Variables

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Expenditure</td>
<td>.710</td>
<td>.000</td>
<td>-.003</td>
<td>.002</td>
<td>-.001</td>
<td>-.000</td>
<td>-.062</td>
<td>.063</td>
<td>6.846</td>
<td>.128</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(14.18)</td>
<td>(.704)</td>
<td>(-2.328)</td>
<td>(.744)</td>
<td>(-.787)</td>
<td>(-.216)</td>
<td>(-1.57)</td>
<td>(-3.663)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.482)</td>
<td>(.021)</td>
<td>(.457)</td>
<td>(.432)</td>
<td>(.829)</td>
<td>(.118)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fuel-wood, kerosene, and electricity expenditure as well as occupation variables all failed the significance test while charcoal expenditure and number of years of connection showed significant results. A stepwise reiteration of the model (using SPSS program) gave the results shown in Table 23.

Table 23: Improved Linear Regression Model Result for Battery Expenditure with year of connection and charcoal expenditure and as independent Variables

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>F</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Expenditure</td>
<td>.714</td>
<td>-.075</td>
<td>-.003</td>
<td>21.476</td>
<td>.093</td>
</tr>
<tr>
<td>(t -Values)</td>
<td>(16.47)</td>
<td>(-4.724)</td>
<td>(-2.841)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.005)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONNECT and BRCHAR.

The use of batteries is inversely related to years of connection to electricity services and charcoal expenditure. In other words, households tend to decrease their expenditure on batteries after connection and as the number of years after connection increases. This shows a direct substitution of batteries by electricity, especially at the early stage of connection. The relationship of household expenditure on batteries with
that of charcoal expenditure is less direct. Overall, the very low R-square value implies that the two variables poorly explain the model.

**All Commercial Fuels:** A linear regression model constructed for all commercial fuels (kerosene, batteries, electricity, and all the three combined) gave the results shown in Table 24 below. The model specification for commercial fuels is of the type:

\[ Y_i = B_0 + B_1X_1 + B_2X_2. \]

‘Y’ represents household expenditure for the dependent variable considered (kerosene, batteries, electricity, and all combined), ‘B0’ is the constant term, ‘X1’ is a town’s number of years of access to electricity, and ‘X2’ is monthly household income.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>( B_0 )</th>
<th>( B_1X_1 )</th>
<th>( B_2X_2 )</th>
<th>( F )</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene</td>
<td>8.234</td>
<td>-1.160</td>
<td>.004</td>
<td>22.927</td>
<td>12.1%</td>
</tr>
<tr>
<td>(t-Value)</td>
<td>(9.441)</td>
<td>(-4.193)</td>
<td>(6.049)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>6.822</td>
<td>-1.053</td>
<td>.004</td>
<td>18.941</td>
<td>10.1%</td>
</tr>
<tr>
<td>(t-Value)</td>
<td>(12.466)</td>
<td>(-6.068)</td>
<td>(.307)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.779)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kerosene + Batteries</td>
<td>14.686</td>
<td>-2.129</td>
<td>.004</td>
<td>27.699</td>
<td>13.7%</td>
</tr>
<tr>
<td>(t-Value)</td>
<td>(13.624)</td>
<td>(-6.206)</td>
<td>(5.286)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>-7.328</td>
<td>3.596</td>
<td>.013</td>
<td>76.717</td>
<td>31.5%</td>
</tr>
<tr>
<td>(t-Value)</td>
<td>(-3.998)</td>
<td>(6.187)</td>
<td>(9.273)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All MES</td>
<td>7.728</td>
<td>1.384</td>
<td>.017</td>
<td>79.058</td>
<td>32.1%</td>
</tr>
<tr>
<td>(t-Value)</td>
<td>(4.016)</td>
<td>(2.268)</td>
<td>(11.663)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sig.)</td>
<td>(.000)</td>
<td>(.024)</td>
<td>(.000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: \( X_1 \) represents years of electricity access while \( X_2 \) represents household income.

The following results were observed:

(a) A town’s number of year of access is inversely related to household expenditure on kerosene, batteries, and both kerosene and batteries combined. This implies that
household expenditure on kerosene and batteries decreases as the number of years of a
town’s access to electricity and a household’s number of years of connection increases.

(b) Kerosene and batteries combined showed a stronger relationship with the two
independent variables, implying that their consumption is influenced by a town’s number
of years of electricity access and household income.

(c) a far stronger relationship was observed for all MES (kerosene, batteries and
electricity combined) where R-square is 32% and F-value is 79 with all the two
independent variables showing positively increasing coefficients and stronger
explanation of the model.

**Chapter summary:** Charcoal, kerosene and batteries are affected by access to electricity
services. This suggests that number of years of a town’s access to electricity services
does not affect the use of biomass except charcoal, which tends to be affected indirectly
through the substitution of kerosene by electricity where part of the kerosene saved as a
result of substitution replaces charcoal for cooking and coffee/ tea making.

Results remain consistent for fuel-wood where it is not influenced by access to
electricity services. For a number of reasons it is not surprising to note that fuel-wood
consumption is not affected by access to electricity services: fuel-wood remains the most
preferred fuel for rural as well as urban households, with its consumption level increasing
as household income increases, up to a certain income threshold. Second, the use of
electricity for cooking, heating, cleaning and ironing is constrained by the need for costly
electricity appliances that require a sufficient change in income level to purchase before
expanding the use of electricity services beyond lighting and radio/TV reception. Third,
the continued importance of fuel-wood in household energy procurement and use
signifies that expanding electricity access to rural communities in order to replace fuel-wood demand may not substantially limit deforestation in the near future. As a result, deforestation due to fuel-wood scavenging and subsequent land degradation will continue after RE has taken place, unless appropriate policy measures are introduced.

Access to electricity services has significantly displaced the use of kerosene and batteries for lighting and radio/TV reception, respectively. Two implications of this relationship are that costs for connection to electricity services can be substantially offset by savings from kerosene and battery expenditures for lighting and radio/TV reception, and that, as observed in Ankober and Kotu following their access to electricity, there is a tendency for households to expand their use of kerosene for cooking and for lighting. This is an important trend because households may gradually substitute their biomass energy use for kerosene as a result of access to electricity services, eventually minimizing their contribution to degradation of the local environment. However, it should be noted that observed increase in the use of kerosene for cooking did not result in decreased biomass use. Furthermore, due to growing world oil prices, the use of kerosene may not expand, and substantial substitution of biomass fuels for cooking will have detrimental effects due to expanded use of hydrocarbon based domestic fuels.

The influence of household income on the use of various household fuels showed some significant results, but coefficients remained very low (near zero) suggesting that the influence has been minimal compared to that of a town’s access to electricity services. The use of biomass fuels such as fuel-wood and charcoal continues to grow as household income increases. It is only electricity expenditure and diversity of electricity end-use that showed some increase in line with a rise in income level, indicating a
window of opportunity for rural households to expand and diversify their electricity services as their income level improves.
CHAPTER VI
RESULTS: BENEFITS OF RURAL ELECTRIFICATION

Chapter Six discusses the benefits and impacts of RE for rural households and communities in reducing poverty and catalyzing rural development. RE benefits and impacts are examined in the context of productive benefits, socio-cultural impacts, and environmental benefits. The main research question is addressed in this chapter: namely, How does rural electrification (RE) contribute to reducing poverty and promoting rural development in low-income developing countries?

Findings on RE benefits are based on field survey results in the form of household, business, and community responses on reported benefits/impacts of RE at household and community levels. The household survey was used for collecting detailed cross-sectional data, which was used for analyzing most of the quantitative data used in this chapter. The survey methodology has accounted for inter-temporal differences through incorporating data on years of a town’s access and years of a household’s connection to electricity services. This level of detail of survey data has enabled an examination of the previous five years before the survey without the need to collect time series data. Furthermore, incorporated in the survey are household characteristics such as household income, family size, and occupation of head of household. These five variables are believed to influence household responses. Of special interest are the electricity access and connection variables. It is assumed that analyzing household responses in relation to these two variables of access and connection would show whether an association existed between household responses and inter-temporal differences in
electricity use. When applicable, further reiterative statistical analysis was run by constructing logistic regression models to test the significance of observed associations.

In addition, the study area was revisited one year after the survey to assess possible observable changes related to impacts and benefits of RE. During this second visit, discussions were held with government agencies, community service providers such as school principals and health officers, and zonal and woreda level business and investment promotion agencies. Findings of the latter visit were used in providing qualitative data, supplementing the survey analysis.

Survey results and field observations from the later visit are presented in this chapter with a range of RE benefits and impacts grouped into five categories, namely: (1) quality lighting benefits, (2) media and communication benefits, (3) productive and poverty reduction benefits, (3) improved community service benefits such as education, health, and water supply, (4) socio-cultural impacts, and (5) environmental impacts.

Households were asked what benefits they gained after the town’s access and the household’s connection to electricity services. Responses were grouped into the seven categories presented in Figure 36 below in a descending order. Improved night reading, new business opportunities and improved health stand as the three most important RE benefits gained by rural households. The immediate and primary benefit of RE at the household and community level was shown to be quality lighting, resulting in improved quality of life for rural households and communities.
Improved water supply, improved safety for women at night, alleviation of daytime workloads through spreading out work at night, and information exchange are additional RE benefits reported by households. These household and community benefits are discussed in the context of the five groups of RE benefits and impacts mentioned earlier in this section.

6.1 Quality Lighting Benefits

According to household and community responses, the most important and immediate benefit of electricity is lighting, which has resulted in improved quality of life for rural households and communities. Based on household responses presented in Figure 36 above, about 48 percent of the respondents reported improved nocturnal reading for
students and adults alike, while 33 percent witnessed improved health from reduced indoor air pollution due to replacement of kerosene [by electricity] for lighting.

The other two reported lighting related RE benefits were improved safety for women at night and reduced workloads, both of which contributed to the safety and wellbeing of rural women. Introduction of street lighting enabled improved women’s safety while walking at night as reported by 17 percent of the households surveyed. About 16 percent of the households reported alleviation of workloads for women through spreading daytime workloads over extended evening hours due to the presence of quality lighting services. The decrease in work-burden through spreading out household chores benefited women, especially those working as civil service employees, who found it convenient to carry out household chores after office hours using electric lights. As learned from survey responses, the spreading of household chores over the evening hours provided a relaxed working environment in the form of increased leisure time during the day. Additional household based benefits were also mentioned in the form of savings gained through replacement of kerosene and batteries with electricity services, such as the ones discussed in Chapter Five.

Logistic regression models were constructed to analyse reported household and community quality lighting benefits of RE in relation to the five possible factors that were thought to have influenced a household’s response: namely, a town’s electricity access (ACCESS), household’s electricity connection (YRCONECT), household income level (INCOME), Family size (FMSIZE), and occupation of head of household (OCUPN).
Three models were constructed, with each of the following four dependent variables related to quality lighting benefits, namely: (a) reduced indoor air pollution from replacement of kerosene for lighting, (b) improved night reading benefits, (c) improved safety for women at night, and (d) reduced workload for women.

a) Reduced indoor air pollution benefits from kerosene for lighting: Results in Table 25 below show that the independent variables ACCESS, FMSIZE and OCUPN all failed the significance test while INCOME and YRCONECT showed significant results.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>-.038</td>
<td>.120</td>
<td>.097</td>
<td>1</td>
<td>.755</td>
<td>.963</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>1.842</td>
<td>.263</td>
<td>49.107</td>
<td>1</td>
<td>.000</td>
<td>6.312</td>
</tr>
<tr>
<td>INCOME</td>
<td>.929</td>
<td>.343</td>
<td>7.326</td>
<td>1</td>
<td>.007</td>
<td>2.533</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>-.073</td>
<td>.084</td>
<td>.760</td>
<td>1</td>
<td>.383</td>
<td>.930</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.098</td>
<td>.110</td>
<td>.789</td>
<td>1</td>
<td>.374</td>
<td>1.103</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.750</td>
<td>.660</td>
<td>7.024</td>
<td>1</td>
<td>.008</td>
<td>.174</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, YRCONECT, INCOME, FMSIZE, and OCUPN.

A re-run of the improved model is shown in Table 26 with YRCONECT and INCOME as the only independent variables that gave significant values.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>1.805</td>
<td>.245</td>
<td>54.154</td>
<td>1</td>
<td>.000</td>
<td>6.081</td>
</tr>
<tr>
<td>INCOME</td>
<td>.896</td>
<td>.329</td>
<td>7.417</td>
<td>1</td>
<td>.006</td>
<td>2.449</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.560</td>
<td>.250</td>
<td>38.806</td>
<td>1</td>
<td>.000</td>
<td>2.10</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, INCOME.
As year of connection and income are interrelated, there was doubt about the robustness of the model. A third logistic regression model was built to test whether further improvement of the model was possible. Results of a more robust model were achieved through introducing a third variable, which is the interaction of the two variables, as shown in Table 27 below. A household with one more year of connection to electricity services is 16.7 times more likely to report benefit from reduced indoor air pollution through kerosene replacement [by electricity] for lighting. Likewise, a household with higher monthly income is nearly 6 times more likely (instead of 2.5 times in the earlier model) to experience reduced indoor air pollution benefits from electricity services.

Table 27: Further Improved Logistic Regression Result of Reduced Indoor Air Pollution Benefits

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONNECT</td>
<td>2.813</td>
<td>.484</td>
<td>33.812</td>
<td>1</td>
<td>.000</td>
<td>16.665</td>
</tr>
<tr>
<td>INCOME</td>
<td>1.783</td>
<td>.454</td>
<td>15.408</td>
<td>1</td>
<td>.000</td>
<td>5.946</td>
</tr>
<tr>
<td>INCOME by YRCONNECT</td>
<td>-1.582</td>
<td>.547</td>
<td>8.367</td>
<td>1</td>
<td>.004</td>
<td>.205</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.023</td>
<td>.335</td>
<td>36.424</td>
<td>1</td>
<td>.000</td>
<td>.132</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONNECT, INCOME, INCOME * YRCONNECT.

One can observe from the model results that both household income and year of electricity connection influenced a household’s response, implying that households with better income and longer years of connection benefited most in reducing their exposure to indoor air pollution through replacing kerosene lamps with electric lights.

b) Improved night reading benefits: About 48 percent of the households interviewed in all the three rural towns with electricity access reported improved night reading benefits of RE while the rest (52%) did not agree or did not know. Improved night reading
benefits were received by both students and women in the household. Of the 337 households interviewed, nearly 50 percent of the respondents reported improved reading benefits for women. When disaggregated into the study towns, those with longer number of years of electricity access gave the highest responses of improved night reading benefits for women in the order of 67 percent in Ankober, 50 percent in Kotu, and another 50 percent in Shola-Gebeya while Gosh-Bado reported no benefits as it was not connected to electricity services by the time of the survey. It is interesting to note that Ankober, the longest electricity accessing town reported the highest improved night reading benefits for women (67 %), suggesting that households recognized improved night reading benefits for women the longer their town had access to electricity services. Household responses were also dependent on status of electricity connection of the household. Out of the 222 households that had electricity connection, 72 percent reported improved night reading benefits for women. While the impact of electricity services on level of literacy were not treated in the survey, it could be said that improved night reading benefits for women is well recognized in rural towns where electricity services have been delivered.

A logistic regression model was constructed for improved night reading as a dependant variable with five independent variables of INCOME, YRCONECT, ACCESS, FMSIZE, and OCUPN. With the exception of INCOME and YRCONECT, all the three variables of ACCESS, FMSIZE, and OCUPN could not pass the significance test (Appendix 6.1)\(^{36}\).

A re-run of the improved model with YRCONECT and INCOME as independent variables gave significant results as shown in Table 28 below. A household with one
more year of connection to electricity services was 3.8 times more likely to observe improved night reading benefits. A household with higher income was 2.3 times more likely to have experienced improved night reading benefits.

Table 28: Logistic Regression Result on Improved Night Reading Benefits

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>1.335</td>
<td>.135</td>
<td>97.694</td>
<td>1</td>
<td>.000</td>
<td>3.798</td>
</tr>
<tr>
<td>INCOME</td>
<td>.829</td>
<td>.337</td>
<td>6.054</td>
<td>1</td>
<td>.014</td>
<td>2.292</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.957</td>
<td>.341</td>
<td>75.301</td>
<td>1</td>
<td>.000</td>
<td>.052</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, INCOME.

As number of years of a household’s connection and household income could be interrelated, a further rerun of the model was conducted by incorporating the interaction of the two independent variables as a third variable. The model with the interaction variable was abandoned as no improvement was achieved.

This finding implies that reported improved night reading benefits of RE are related to the number of years of a household’s electricity connection and household income.

c) Improved safety for women at night: Improved safety for women at night refers to quality electric street lighting services provided after electricity has been delivered to rural towns. Results of the logistic regression model are presented in Table 29 below where INCOME and YRONECT showed significant results while ACCESS, FMSIZE, and OCUPN failed the significance test (Appendix 6.2).

An improved version of the model with YRCONECT and INCOME as the two independent variables is shown in Table 29 below. Households with one more year of connection to electricity services are 2.2 times more likely to witness improved safety for
women at night. A household with higher monthly income is 2.3 times more likely to agree with improved safety for women at night due to better street lighting.

Table 29: Logistic Regression Result on Improved Women Safety at Night

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>.767</td>
<td>.099</td>
<td>59.658</td>
<td>1</td>
<td>.000</td>
<td>2.153</td>
</tr>
<tr>
<td>INCOME</td>
<td>.838</td>
<td>.265</td>
<td>9.987</td>
<td>1</td>
<td>.002</td>
<td>2.313</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.316</td>
<td>.216</td>
<td>37.261</td>
<td>1</td>
<td>.000</td>
<td>.268</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, INCOME.

A further re-run of the model with the interaction variable of YRCONECT and INCOME as a third independent variable was less robust than the one shown in Table 29 above and had to be abandoned.

It is interesting to note that number of years of a town’s electricity access was not as significant as year of connection and income. There are two explanations for this outcome: One is that the responses were based on actual household experiences where households with better income and longer years of connection felt the presence of these evening safety benefits for women. The second reason is that street lighting is usually introduced immediately after power has been brought into a town with no visible variability in coverage over subsequent years after access has been created.

d) Reduced workload for women through spreading chores over evening hours:

Households reported reduced workloads for women after electricity connection by spreading household chores through evening hours and benefiting from relaxed day-time activities. Logistic regression model results are shown in Appendix 6.3.
With the exception of INCOME variable, all the four independent variables of YRCONECT, ACCESS, FMSIZE, and OCUPN had a strong relationship with decrease of work burden for women as shown in Table 30 below.

### Table 30: Logistic Regression Model for Reduced Workload Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>.477</td>
<td>.122</td>
<td>15.281</td>
<td>1</td>
<td>.000</td>
<td>1.611</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.297</td>
<td>.109</td>
<td>7.388</td>
<td>1</td>
<td>.007</td>
<td>1.345</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.170</td>
<td>.070</td>
<td>5.915</td>
<td>1</td>
<td>.015</td>
<td>1.185</td>
</tr>
<tr>
<td>OCUPN</td>
<td>-.202</td>
<td>.082</td>
<td>5.981</td>
<td>1</td>
<td>.014</td>
<td>.817</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.827</td>
<td>.524</td>
<td>12.145</td>
<td>1</td>
<td>.000</td>
<td>.161</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, ACCESS, FMSIZE, and OCUPN.

However, a further re-run of the model was tried to test for the interaction of YRCONECT and ACCESS. Results showed more robust values where households with one more year of connection to electricity services were 7 times more likely (compared to 1.6 times in the earlier model) to experience decrease in workload for women.

Number of years of a town’s access showed a similar stronger relationship, with households residing in towns with one more year of connection being 1.9 times (compared to 1.4 times in the earlier model) more likely to report workload reduction benefits. Households with higher family size reported some benefits from decreased workload with a response 1.2 times more likely for every additional family member in the household. This is probably because more workloads are felt in households with larger family size.
Table 31: Logistic Regression Model for Reduced Workload Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>1.954</td>
<td>.337</td>
<td>33.718</td>
<td>1</td>
<td>.000</td>
<td>7.060</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.647</td>
<td>.137</td>
<td>22.203</td>
<td>1</td>
<td>.000</td>
<td>1.909</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.194</td>
<td>.074</td>
<td>6.794</td>
<td>1</td>
<td>.009</td>
<td>1.214</td>
</tr>
<tr>
<td>OCUPN</td>
<td>-.209</td>
<td>.079</td>
<td>6.971</td>
<td>1</td>
<td>.008</td>
<td>.812</td>
</tr>
<tr>
<td>ACCESS by YRCONECT</td>
<td>-.352</td>
<td>.071</td>
<td>24.319</td>
<td>1</td>
<td>.000</td>
<td>.703</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.189</td>
<td>.631</td>
<td>25.551</td>
<td>1</td>
<td>.000</td>
<td>.041</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, ACCESS, FMSIZE, OCUPN, ACCESS * YRCONECT.

Occupation of head of household showed some relationship with decreased workload, but was negatively related. This implied that workload reduction benefits for women decreased for farmers, civil servants, skilled workers, laborers, and private employees while housewives, teachers, retirees, and business owners benefited the most.

In conclusion, quality lighting is one of the most important benefits of RE as reported by rural households. Lighting benefits came in the form of improved health from reduced kerosene smoke for lighting, improved nocturnal reading, improved safety for women at night, and decreased workload for women during the day. All reported that household quality lighting as a result of RE benefited women and contributed in improving gender relations. In most instances, household income and year of a household’s connection to electricity services were strongly associated with quality lighting benefits reported by surveyed households. Households with higher income and longer period of electricity connection tended to be benefiting the most from quality lighting brought by RE.
6.2 Improved Access to Media and Communication

The second most important and immediate reported benefit of RE next to lighting was the provision of media and communication services in the form of radio and TV for receiving news, information, and entertainment. As shown in Figure 37 below, nearly 74 percent of electricity-connected households reported use of electricity for radio and TV reception as their second best use of electricity services, next to lighting. About 70 percent of the residents in the four study towns owned radio, while 10.7 percent of the households surveyed had both television and radio receivers. Individuals without TV sets at home visited bars and restaurants with TV sets to attend news and entertainments.

**Figure 37: Electricity Use for Radio/TV for Connected Households**

For households not connected to electricity, a question was asked about what type of end-uses they expected to apply if connected. As shown in Figure 38, about 53 percent of the respondents planned to use electricity for radio/TV reception as their second best end use, next to lighting.
In a second visit to the study area one year after the survey, a substantial increase in customers was reported by bars and restaurants with television sets in both Shola-Gebeya and Gosh-Bado following the towns' access to electricity services, resulting in benefits for these businesses.

Surveyed households with electricity access were asked if they believed RE contributed to improved media/communication. Nearly 73 percent of the households reported media/communication benefits from RE. About 55 percent of the households reported that electricity access enabled the use of media/ICT in schools.

Another most important primary household benefit gained from RE was the easier access created to communication services such as recharging of mobile phone batteries in towns where reception networks were available. Households reported an average of birr 22.3 annual expenditure for landline telephone services. With the introduction of mobile networks in subsequent years, the use of mobile phones and recharging services was expected to rise considerably.
A logistic regression was run to determine whether year of access, years of connection, income level and occupation influenced household responses of RE benefits regarding media/ communication.

Model results are shown in Appendix 6.4, where only year of a town’s access to electricity services (ACCESS) passed the significance test.

Table 32: Improved Logistic Regression Result of Media/ Communication Benefits of RE with YRCONECT as Independent Variable

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.719</td>
<td>.235</td>
<td>9.371</td>
<td>1</td>
<td>.002</td>
<td>2.053</td>
</tr>
<tr>
<td>Constant</td>
<td>-5.760</td>
<td>1.051</td>
<td>30.008</td>
<td>1</td>
<td>.000</td>
<td>.003</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS.

Households residing in rural towns with one more year of electricity access were 2.1 times more likely to report increased media/ communication benefits of RE. On the basis of household responses, one may conclude that reported RE benefits on expansion of media and communication are based on number of year of a town’s access to electricity services. It is interesting to note that unlike quality lighting benefits, number of years of a town’s access had a significant relationship with household response on communication benefits of RE, implying that it is not only connected households, but the community at large that benefits from media/ communication benefits of RE.
6.3 RE Benefits in Reducing Poverty: Businesses Creation, Employment Generation, Investment, and Food Security

This section discusses the role of RE in creation of new businesses, generation of income/employment, facilitating investment, and enabling food security, all of which contribute to poverty reduction. Surveyed households reported a positive outlook on the contribution of RE towards reducing poverty. Table 33 below shows responses of households in the three towns with electricity access on contributions of RE in facilitating livelihood, contributing to businesses creation, improving productivity, generating employment, and increasing household income.

Table 33: Household Reported Benefits of RE after Connection (Percentages)

<table>
<thead>
<tr>
<th>Reported Benefits</th>
<th>Number of Years of Access</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td>Improved Household livelihood</td>
<td>50%</td>
</tr>
<tr>
<td>Enabled Business Creation</td>
<td>57%</td>
</tr>
<tr>
<td>Improved Use of Tools/ Productivity</td>
<td>54%</td>
</tr>
<tr>
<td>Facilitated Employment Generation</td>
<td>76%</td>
</tr>
<tr>
<td>Helped Increase Household Income</td>
<td>46%</td>
</tr>
</tbody>
</table>

Overall, responses were positive for over 50 percent of the cases in all three towns, with reports of RE benefits increasing as number of years of the town’s access to electricity increased.

a) Creation of small businesses:- The third important reported benefit of RE, following lighting and media/communication benefits, was the opportunities it created in establishing new businesses and expanding existing ones. As shown in Figure 36 above, about 39 percent of rural town residents reported the opening-up of new businesses after electricity services were introduced. Woreda (district) level data show that the
establishment of small businesses increased in rural towns after connection to electricity services as shown in Shola-Gebeya where memories of electricity induced changes were still fresh (Figure 39).

Figure 39: Number of Businesses Established and Percentage of Increase After 2008 in Shola-Gebeya (18 months after electrification)

As shown in Figure 39 above, new business establishments increased after electricity services were introduced to Shola-Gebeya from the beginning of 2008, showing substantial growth by mid 2009. Woreda SME office data show that establishments of retail trade increased by 32 percent, small-scale manufacturing increased by 25 percent, while services and SMEs increased by 54 and 50 percent respectively over the corresponding period. There were reported changes in the creation of new business opportunities after electricity connection as markets widened due to the retention of existing professional civil servants and inflow of entrepreneurs or skilled persons from larger towns expecting new opportunities for establishing new businesses.
Table 34 below shows the number of businesses established in the four study towns, most of which were home-based businesses\(^{37}\).

<table>
<thead>
<tr>
<th>Businesses Categories</th>
<th>Ankober</th>
<th>Kotu</th>
<th>Sh.-Gebeya</th>
<th>Gosh-Bado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal</td>
<td>300</td>
<td>118</td>
<td>350</td>
<td>20</td>
</tr>
<tr>
<td>SMEs</td>
<td>304</td>
<td>3</td>
<td>470</td>
<td>2</td>
</tr>
<tr>
<td>Informal</td>
<td>75</td>
<td>114</td>
<td>80</td>
<td>10</td>
</tr>
<tr>
<td>Total Business</td>
<td>679</td>
<td>235</td>
<td>900</td>
<td>32</td>
</tr>
</tbody>
</table>

Source: Data compiled from offices of Trade and Industry, Revenue Administration and SMEs Development in Ankober, Kotu, Shola-Gebeya and Gosh-Bado

While the figures in Table 34 above show data before and after electricity access, most SMEs were formed after electricity access, supplemented by aggressive promotion of SMEs at zonal (provincial) level over the three years before the survey. In Shola-Gebeya, 25% of the respondents reported an increase in the opening up of new home-based small businesses as a result of having access to electricity services within one month after electricity was introduced into the town.

Most of these businesses were not only using electricity for lighting, but were also using machines run by electricity. Eighteen months after electricity was introduced, the following businesses were opened or upgraded to using electrically run machines in Shola-Gebeya: tea/ coffee making machines in bars (1 bar), draught beer cooling machines (2 bars), establishment of metal workshop (3 shops), woodwork shop (2 shops), photocopy services (1 shop), fridge-cooled drinks in hotels (6 hotels), soccer sport television show (1 shop)\(^{38}\), installation of TVs in hotels and restaurants (12 hotels), and construction material suppliers (2 shops). Furthermore, use of mobile chargers in homes, introduction of one electronic shop, 8 barber shops, 2 hair dressing shops, 2 video rental shops, and one photo shop opened, all running by electricity. The introduction of wood
and metal workshops, the introduction of TV and video services, and the expansion of bars and restaurants were observed in Gosh-Bado following electricity connection during the second visit to the study area.

Indirect benefits of RE were reported by households and community representatives in the form of a substantial increase in the construction business after the towns’ connection to electricity services. Increasing numbers of individuals and families were motivated to build new homes in anticipation of fast urban expansion following the return of persons from major towns to the newly electrified ones. In Ankober, 300 additional houses were constructed in the three years before the survey, with most of these houses being owned by public servants who decided to reside in the area. It was reported in all the four study areas that far more houses would have been constructed if land availability had not been a constraint. In Shola-Gebeya, the construction of new homes and businesses is expected to increase substantially if current requests are met through lifting existing restriction on land allotment. In Gosh-Bado, where electricity was brought a year after the survey, land price increased by up to 25 percent over the first quarter of 2009 due to growing demand for land for home construction.

According to residents, increased construction work created substantial demand for the supply of doors, windows, cement-blocks and related construction materials, further enabling the creation of new small businesses. The presence of electricity services facilitated the introduction of metal and wood workshops that met growing demands for construction materials. Employment was created for increased numbers of people in the construction businesses, creating further demand for service providing businesses such as bars and restaurants.
A logistic regression model was constructed to test whether the establishment of businesses has strong association with YRCONECT, ACCESS, INCOME, FMSIZE, and OCUPN. Results were only significant for INCOME and YRCONECT variables while the rest of the independent variables (ACCESS, FMSIZE and OCUPN) all showed insignificant relationships (Appendix 6.5. A and B).

A re-run of an improved model with the two significant variables showed that households with higher monthly income were 2.3 times more likely to report increased business creation/ expansion after RE was introduced into the area (Table 35). Similarly, households with one more year of connection to electricity services were 1.7 times more likely to report positive contribution of RE in creating new businesses and expanding new ones.

Table 35: Logistic Regression Results on Business Creation/ Expansion Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>.837</td>
<td>.250</td>
<td>11.185</td>
<td>1</td>
<td>.001</td>
<td>2.310</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>.533</td>
<td>.080</td>
<td>44.817</td>
<td>1</td>
<td>.000</td>
<td>1.705</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.467</td>
<td>.216</td>
<td>45.904</td>
<td>1</td>
<td>.000</td>
<td>.231</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: INCOME, YRCONECT
Note: A re-run of the model with interaction variables of INCOME and YRCONECT showed insignificant outcome and was abandoned.

The reporting of increased business benefits from RE by households with higher income and more years of connection casts doubt on whether poorer households and those with no or recent connection gained business expansion related benefits from RE. Further analysis of the income/ employment generation benefits of RE is provided below in an effort to show clearer pictures.
b) **Generation of income/employment:**- Income and employment are generated from occupations such as businesses, agriculture, civil service, and provision of daily labour. In Ankober and Kotu, where electricity services were available for over three years, an average of 48 percent of the sample households reported improved income/employment benefits as the most important secondary benefits gained from having access to electricity services.

Table 36 below shows the ratio of employment to total number of households. In Ankober, 1,550 people were employed, which meant 1.5 persons were employed in every household. About 79 percent of the jobs created were through businesses. In Kotu, a total of 632 people had employment, excluding the over 25,000 or so people visiting the Monday market. Employment ratio was slightly lower than in Ankober, with less than one person being employed per household.

**Table 36: Household Members with Employment & Income from Small Businesses, Civil Service and Agriculture one Year after the Survey**

<table>
<thead>
<tr>
<th>Businesses</th>
<th>Ankober</th>
<th>Kotu</th>
<th>S.Gebeya</th>
<th>G. Bado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Business Employees*</td>
<td>1208</td>
<td>453</td>
<td>1113</td>
<td>60</td>
</tr>
<tr>
<td>Civil Service Employees</td>
<td>300</td>
<td>95</td>
<td>300</td>
<td>75</td>
</tr>
<tr>
<td>Agriculture Employees</td>
<td>42</td>
<td>84</td>
<td>116</td>
<td>457</td>
</tr>
<tr>
<td>Total Employed in All Occupations</td>
<td>1550</td>
<td>632</td>
<td>1529</td>
<td>592</td>
</tr>
<tr>
<td>Total Number of Households</td>
<td>1051</td>
<td>698</td>
<td>1447</td>
<td>520</td>
</tr>
<tr>
<td>Ratio of Business Employees to Number of Households</td>
<td>1.15:1</td>
<td>0.65:1</td>
<td>0.78:1</td>
<td>0.11:1</td>
</tr>
<tr>
<td>Ratio of All Employees to number of Households</td>
<td>1.5:1</td>
<td>0.91:1</td>
<td>1.1:1</td>
<td>1.1:1</td>
</tr>
</tbody>
</table>

Source: Data compiled from offices of Trade and Industry, Revenue Administration and SMEs Development in Ankober, Kotu, Shola-Gebeya and Gosh-Bado

Both Shola-Gebeya and Gosh-Bado reported 1.1 persons employed per household. Even though these employment figures incorporate employment levels before electricity access, sufficient data show that employment/ income generation opportunities
increased faster over the past two years, in parallel with the period of RE expansion. Over the 9 months of 2008/2009 budget year, a total of 880 new medium-sized businesses were registered at their respective districts within the North Shewa Zone (Province), creating employment for 825 persons. Of these, 136 jobs were occupied by women. The number of jobs created through establishment of new SMEs in the zone was even higher. Over the corresponding period, (September 2008 till May 2009), a total of 17,381 new jobs were created in all the districts of North Shewa Zone through the establishment of both individual and association run SMEs. New SMEs created over the 3rd quarter of 2008/9 budget year (March – May 2009) reached 2,260 enterprises generating employment for 6,450 people, of which 46 percent were women (North Shewa zone SME Promotion Office Records).

While the growth of businesses coincided with the period of RE expansion, there are no data substantiating that the recorded rapid growth in business creation was due to access created to electricity services alone. The efforts put into creating new jobs were more focused and well coordinated with the opening of SMEs promotion offices at wereda (district) levels. In this regard, the presence of electricity was one of the factors, amongst many, that contributed to the generation of employment/income in the areas.

A logistic regression model was built to assess the association of employment creation with the five covariates applied so far, namely, YRCONECT, ACCESS, INCOME, FMSIZE and OCUPN. Two of the variables - YRCONECT and INCOME passed the significance test (Appendix 6.6. A and B).

Results of the improved model with interaction variables of YRCONECT and INCOME are shown in Table 37 Below.
Table 37: Logistic Regression Model for Employment Generation Impacts of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>.767</td>
<td>.136</td>
<td>31.946</td>
<td>1</td>
<td>.000</td>
<td>2.154</td>
</tr>
<tr>
<td>INCOME</td>
<td>1.318</td>
<td>.347</td>
<td>14.457</td>
<td>1</td>
<td>.000</td>
<td>3.735</td>
</tr>
<tr>
<td>INCOME by YRCONECT</td>
<td>-.524</td>
<td>.168</td>
<td>9.773</td>
<td>1</td>
<td>.002</td>
<td>.592</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.317</td>
<td>.238</td>
<td>30.700</td>
<td>1</td>
<td>.000</td>
<td>.268</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, INCOME, INCOME * YRCONECT

Households with one more year of connection were 2.2 times more likely (compared to 1.6 times in earlier model without interaction variable) to report that RE contributed in employment generation. The income effect was even higher, with households earning higher monthly income being 3.7 times more likely (compared to 1.7 times in the earlier model) to report that employment generation was facilitated by RE.

Further analysis was conducted on the response of households on whether a family member was employed in businesses and private owned establishments, and whether these responses were related to number of years of a household’s connection to electricity services, the town’s electricity access, the household’s monthly income, and family size of the household. Results showed strong association with a household’s response on business related employment of household members on the basis of household income and years of electricity connection as shown in Appendix 6.7.

ACCESS and FMSIZE variables were excluded from the improved model results shown in Table 38 below as they failed the significance test. Households with one more year of connection to electricity services were 1.2 times more likely to be employed in business related jobs. Households earning higher monthly income were twice more likely to be employed in business related occupation than those that earned lower income. This outcome is consistent with that recorded in Table 37 above.
Table 38: Logistic Regression Results on Business Related Occupation of Household Members

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>.212</td>
<td>.070</td>
<td>9.033</td>
<td>1</td>
<td>.003</td>
<td>1.236</td>
</tr>
<tr>
<td>INCOME</td>
<td>.670</td>
<td>.247</td>
<td>7.360</td>
<td>1</td>
<td>.007</td>
<td>1.954</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.389</td>
<td>.211</td>
<td>43.263</td>
<td>1</td>
<td>.000</td>
<td>.249</td>
</tr>
</tbody>
</table>

a. Variable(s) entered on step 1: YRCONECT, INCOME.

Note: A third model built to test the interaction of INCOME and YRCONECT variables did not give significant results and was hence dropped.

Reports on business creation and expansion (Table 35), the employment generation benefits (Table 37), and the business related occupation benefits (Table 38) all showed that level of household income and number of years of a household’s connection to electricity services are highly associated with reported changes in business creation, employment/ income, and business related occupation. These consistent outcomes could imply that households with lower income level and those with no or late connection to electricity services may have benefited the least from RE.

Two important cases can be summarized from the above findings: one is that number of years of a household’s connection to electricity may have some relationship to household responses on the role played by RE in improving livelihood, business creation, employment generation and income. This suggests that more RE benefits are realized by households on the basis of how long households have utilized electricity services. This further signifies that RE impacts are gradual and may take several years after access has been created. Second, income disparity is an important factor influencing household responses where households with higher income tending to report the benefits of electricity access in improving household income and livelihood, in creating more income/ employment opportunities, and in expansion of businesses.
On the other hand, households with no connection or late connection to electricity services and lower income households reported lower benefits from access to electricity services. Understandably, households with no connection to electricity services may not gain as much benefit as those that connected earlier.

At this stage, one might ask whether the introduction of RE into rural towns has benefited the very poor. There are signs at the local level that following a town’s access to electricity services, the very poor may not have benefited as much as those better-off and the middle class. Access to and use of electricity services by the very poor is hampered by a number of factors such as high connection costs, high electricity bills, and high cost of appliances. About 14 percent of surveyed households in already connected towns were not connected to electricity due to high connection costs. Even after connection, electricity consumption level remained very low for most households, while some were not able to pay monthly electricity bills. The very poor did not benefit from electricity as fast as those with higher income. While this lag in gaining direct electricity benefit was experienced at the household level, benefits could have been higher and more equitable through community level services such as education, health and access to clean and sufficient water.

6.4 RE Benefits in Improving Community Services

Community benefits of RE relate to the delivery of improved social services such as education, health services, water supply and sanitation, grinding mills, and street lighting. Information on community level benefits of RE was collected from two sources, the household survey and community service establishments such as education, health,
water supply and grinding mill service providers at local, woreda (district) and zonal (province) levels. The following findings show the benefits gained by rural communities following access to electricity services, as reported by those communities.

6.4.1 Education Benefits of RE

A fast-track expansion of educational infrastructure has been witnessed in Ethiopia over the past ten years. There has been a sharp increase in the number and distribution of new schools, in the assignment of more and new teachers, allocation of budget, and associated sharp increase in the school enrolment rate all over the country irrespective of access to electricity services (MDG Report, Ethiopia, 2010). In North Shewa zone, where the field research has been conducted, the number of high schools has increased to 32 from only 8 schools 20 years ago. School enrolment rate has currently reached over 95 percent from that of less than 30 percent in 1990. About 35 percent of all secondary school age children in the study area have access to high school, while targets are a 100 percent access by 2020. The number of high school teachers in the zone has equally increased, reaching a total of 13,000, with 90 percent of them being degree holders.

While such improvements are in terms of coverage, the quality of education leaves much to be desired, requiring further upgrading to meet the required level of standards. The simultaneous expansion of rural electrification has contributed to achieving the required quality improvement, as reported by zonal and woreda educational offices in the study areas. In rural towns with recent electricity access, RE benefits are observed such as improved quality of education through access to quality lighting,
improved use of equipment and teaching aids, retention of qualified teachers, and extended school services through the evenings that enable the attendance of adult students. However, it is regrettable that limitations of data at the local level could not allow the disaggregation of RE impacts on improving school enrolment rates, better school attendance, distance learning, enhancing quality of education, and in reducing school dropout rates.

a) Access to quality lighting: - All education office representatives in the study area reflected that the most prominent benefit of RE to the rural education system is the availability of quality lighting services that enabled the provision of evening classes. In rural areas, adults and school-aged children who could not attend formal classes during the day have found it conducive to attend informal education classes offered during evening hours after completing their daily chores. All schools visited in Gosh-Bado, Ankober, Shola-Gebeya and Kotu have shown strong interest in introducing evening classes for adult literacy education. According to Mr. Mesfin Asseffa, principal of Ankober elementary school, evening literacy class is successfully enabling adults to attend classes after completion of their daily chores. It was further reported that availability of quality lighting has, in addition to evening classes, enabled using lighting services during the day when required.

In all the schools visited, principals reported benefits of quality lighting on improving education, not only in the schools, but also in households where students were able to study at night, improving their school performance and reducing dropout rates.
b) Improved use of equipment/ education media/ ICT: In almost all schools visited, a wide range and improved use of equipment and teaching aids were reported following access to electricity services. These benefits include the use of mini-media that facilitated communication and created awareness in school communities on sanitation, hygiene, and prevention of transmissible diseases such as HIV/AIDS. The presence of electricity encouraged the use of radio education, replacing the use of costly batteries. Schools were able to use video and CD players as teaching aids, enabling better understanding and exposure to information. School laboratories have become more operational through the use of electricity services. All high schools have been linked to centrally broadcasted television classes that are primarily aimed at providing quality and standardized education throughout the country, albeit from standalone power sources in places where grid connection is not possible. High schools with electricity services have been able to record these television sessions and offer the lessons to classes at flexible times rather than only during designated broadcasts.

The use of photocopying and duplicating machines has enabled the improvement of teaching aids, with more access to handouts and easier facilitation of examination papers. Some elementary schools were considering the use of computers, while most have already introduced computer based secretarial and communication services. School principals aspire to introduce computer classes and e-learning opportunities in the foreseeable future now that electricity access has been ensured.

In most of the elementary schools visited within the study area, teachers were observed relaxing in their spare time, watching international news and entertainments on
satellite TVs. The use of these facilities was not available before introduction of electricity services.

Logistic regression models were run reiteratively to test the association between the level of use of media/ICT services with five variables of YRCONECT, ACESS, INCOME, FMSIZE, and OCOPN. Results show that the INCOME and OCUPN variables failed the significance test while a re-run of the model of the three independent variables of YRCONECT, ACESS and FMSIZE gave significant results (Appendix 6.8A and B).

A further re-run of the model [with the interaction of YRCONECT and ACESS] gave robust results, but the FMSIZE variable had to be excluded as it failed the significance test. The final model is shown in Table 39 below.

| Table 39: Logistic Regression Results on Use of Media/ICT in Schools |
|-----------------|-----------|--------|--------|---|---------|
|                  | B         | S.E.   | Wald   | df | Sig.    | Exp(B)   |
| YRCONECT        | 2.675     | .431   | 38.454 | 1  | .000    | 14.505   |
| ACESS           | .653      | .133   | 24.016 | 1  | .000    | 1.922    |
| ACESS by YRCONECT | -.442    | .093   | 22.562 | 1  | .000    | .643     |
| Constant        | -2.926    | .411   | 50.622 | 1  | .000    | .054     |

a. Variable(s) entered in the model: YRCONECT, ACESS, ACESS * YRCONECT.

A household with one more year of electricity connection is 14.5 times more likely to have residents positively reporting the contribution of electricity in the use of media/ICT in schools. Likewise, a household residing in a rural town is nearly twice as likely with every additional year of electricity access to report that availability of electricity services has improved the use of Media/ICT in schools.
In conclusion, households residing in towns with more years of electricity access and longer period of electricity connection have more positive perception of electricity services in enabling the use of media and ICT in schools.

c) Improved School enrolment rates:- One of the remarkable improvements in the Ethiopian schooling system over the last fifteen years has been the recorded sharp increase in school enrolment. In all the four surveyed areas, the district and zonal school administration figures show school enrolment rates have grown to above 97 percent. In Gosh-Bado, enrolment rate is at 95 percent with the remaining 5 percent not attending school due to health problems, financial difficulties, and absence of household helpers in sheep rearing. Enrolment rate reached 98 percent in Ankober elementary school, more than the woreda average of 90 percent reported by all the rest of the 37 schools.

Interviewed households were asked two questions related to school enrolment: The first question was whether all school-aged members of the family attend school. The second school attendance question relates to the views of the household head on whether access to electricity contributed to improving school attendance rates. Household responses to these two questions are discussed separately below.

Household response on school attendance of family members showed that about 53 percent of surveyed households reported that they send all of their school aged family members to attend school. About 19 percent send some [but not all] of their family members, another 19 percent have children that are not school aged, while about 10 percent do not have children or family members to send to school.

Of those households not sending all of their family members to school, about 13 percent reported household obligations and family businesses as the main reasons for not
sending family members to school. This is mainly common for girls, who are usually confronted with demanding household chores. About 2 percent reported illness, while another 2 percent gave financial constraints as the main reasons for not sending children to school. Overall, 19 percent of the respondents ascribed financial constraints for not sending their children to school, while only 1 percent ascribed distance. The very low level of response associated with distance could be due to the presence of schools nearer to interviewed households. Whether similar responses would have been given by rural villages far away from schools is not known as the survey did not include villages far away from schools. There is a strong belief that female children tend to be the most affected as distance to school increases. Households did not report clearly on how parental decision in sending daughters to school would be influenced as number of years of school attendance increases.

A logistic regression analysis was conducted on household response on school attendance of school-aged family members. The three independent variables of Income, FMSIZE and OCUPN failed the significance test while the two independent variables of YRCONECT and ACESS passed the test (Appendix 6.9A and B).

A more robust model is reconstructed by incorporating a third variable on the interaction of YRCONECT and ACCESS variables (Table 40 below).
The model outcome shows that households with every additional year of connection to electricity services are 42 times more likely to report that electricity contributed to improved school attendance. Residents in rural towns with every additional year of access to electricity services are twice as likely to believe that electricity contributed to improved school enrolment. These are very high probabilities showing that school attendance rates might have improved as number of years of access and connection increased.

On the other hand, it is important to note at this stage that school enrolment rates increased in almost all rural schools irrespective of electricity access. While availability of quality lighting for schools and improved safety at night might have both strong implications in augmenting school attendance rates, there is no conclusive evidence that associates the rise in school enrolment to that of access to electricity services exclusively. It is very difficult to measure the impact of RE separately in improving school enrolment rates as a number of other factors contribute to this high level of achievement, such as strong government enforcement.
This being the case, one can conclude that the presence of electricity access contributes to enhancing school enrolment by enabling the provision of evening classes that facilitate attendance of children who would otherwise have not managed to attend during the day due to strict household obligations.

*d) Improvement in school dropout rates:* It was not possible to find specific data depicting the level of change in school dropout rates and the drivers for these changes in the study area. While access to electricity services, and especially improved night reading due to quality lighting benefits, would likely contribute to decreasing dropout rates, there were no sufficient data to associate changes in school dropout rates with contribution of electricity services. The analysis in this section therefore relied on household responses. Surveyed households were asked whether the presence of electricity services contributed to reducing school dropout rates. About 50 percent of the households responded yes. A disaggregated household response by number of years of connection is shown in Figure 40 below.

**Figure 40: Household Response on Contribution of Electricity in Reducing School Dropout Rates by Number of Years of Connection (Percentages)**
Nearly all households with no connection to electricity services reported no contribution of electricity to reducing school dropout rates. This was followed by a drop of responses to near zero for subsequent non-connected households. This is expected for households that did not connect to electricity services. For those with electricity connection, responses on contribution of RE continued to increase gradually as number of years of connection increased.

In a logistic regression analysis, responses were used as dependent variables with the five independent variables of YRCONECT, INCOME, ACCESS, FMSIZE, and OCUPN. Results (Appendix 6.10A and B) showed that only YRCONECT and ACCESS passed the significance test while the other three variables failed.

A reiterative reconstruction of the model was conducted with the interaction of the two variables, giving a more robust model as shown in Table 41 below.

<table>
<thead>
<tr>
<th>Table 41: Logistic Regression Model Results on Reduced Dropout Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B</strong></td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>YRCONECT</td>
</tr>
<tr>
<td>ACCESS</td>
</tr>
<tr>
<td>ACCESS by YRCONECT</td>
</tr>
<tr>
<td>Constant</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, ACCESS, ACCESS * YRCONECT.

For every additional year of connection of a household, it was 33 times more likely that the household would agree on the positive impacts of electricity access in decreasing school dropout rates. Likewise, a rural town with one more year of access to electricity services would have residents 3.6 times more likely to agree that access to electricity contributed to reducing school dropout rates.
Results so far have shown that there is a strong association of a household’s number of years of connection to electricity services and number of years of a town’s access to electricity with a decrease in school dropout rates and improvement in quality of education. In the latter case, household monthly income rather than town’s electricity access was found to be significant.

**e) Retention of qualified and experienced teachers:**- Almost all schools and educational institutions visited agreed that retention of qualified teachers has been ensured after towns gained electricity access. In Gosh-Bado, nearly all teachers used to commute daily to the nearby zonal capital of Debre-Berhan, which is 17 kilometres away. This practice changed after electricity was brought into the town, with nearly 50 percent of the teachers beginning to stay overnight during weekdays in the rural town. Gosh-Bado and Shola-Gebeya are considering construction of residential homes for teachers to ensure a more reliable stay within their work environment. Transfer requests by school teachers to larger towns have decreased substantially in recent years since rural towns have been connected to electricity services.

In the study towns, an average of 51 percent of the households interviewed reported contribution of electricity services in retaining qualified teachers. This figure is far higher when disaggregated into number of years of electricity connection of the households interviewed as shown in Figure 41 below.

Household reports on the contribution of electricity to retaining qualified teachers increased as the number of years of household connection to electricity increased. Households with ‘no contribution’ response reached as high as 30 percent for those with no electricity connection, gradually falling as number of years of connection increased.
This implies that household responses on contribution of electricity services to retaining teachers might have depended on number of years of connection.

**Figure 41: Household Response on Contribution of Electricity in Retaining Qualified Teachers by Number of Years of Connection (Percentages)**

![Graph showing contribution of electricity in retaining qualified teachers by number of years of connection.]

**f) Overall reported impact of RE on quality of education:** Similar to woreda or zonal level discussion results, household survey results gave higher percentage responses concerning benefits of (RE) to the education sector. In Ankober and Kotu where electricity connection was in place for over three years, RE impacts in improving school conditions were reported to be high: increased enrolment and attendance (90%), reduced dropout rates (90%), better retention of teachers (78%), improved use of education media and ICT (84%), and overall improvement in quality of education (80%). As depicted in Figure 42 below, overall improvement was observed in quality of education after electricity connection, and the level of reported benefits of RE were associated with the number of years of connection to electricity services. This association is demonstrated by the fact that Ankober has a higher level of overall benefits, followed by Kotu. The level
of benefits drops significantly in Shola-Gebeya, where electricity connection is very recent and electrification impacts are not yet fully visible. It shows that school dropout rates would not be reduced soon after electricity connection.

A similar model was run for impact of electricity on quality of education. Results show that number of years of a household’s connection and household income had significant values. The rest of the three variables, including number of years of a town’s access to electricity services, did not pass the significance test (Appendix 6.12). A reconstructed improved model gave the results shown in Table 42 below.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONNECT</td>
<td>1.108</td>
<td>.126</td>
<td>77.105</td>
<td>1</td>
<td>.000</td>
<td>3.029</td>
</tr>
<tr>
<td>INCOME</td>
<td>.591</td>
<td>.291</td>
<td>4.126</td>
<td>1</td>
<td>.042</td>
<td>1.806</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.699</td>
<td>.240</td>
<td>49.983</td>
<td>1</td>
<td>.000</td>
<td>.183</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONNECT, INCOME. Note: A third reiteration of the model with the interaction variable of YRCONNECT and INCOME was dropped as it failed to give more robust results.

The model gave the following results: households with an additional year of electricity connection are 3 times more likely to report contribution of electricity to improving quality of education. Households with higher monthly income are 1.8 times more likely to report that electricity contributed to improving quality of education.

Education officers in the study area indicated that other than benefits of improving quality of education in schools, availability of electricity services enabled educational planning and management institutions to be more efficient by using planning and monitoring tools such as computers and photocopy equipment.
One can observe in Figure 42 above that response on RE benefits on education changed in line with the number of years of electricity access of the towns surveyed. Reported RE benefits increase as one moves from Shola-Gebeya to Ankober, indicating that number of years of electricity access increases household satisfaction of RE and implies increased attainment of educational benefits.

Attaining overall improvement in quality of education is a challenging task, and more so in rural areas. Rural schools face a number of bottlenecks such as financial and budgetary limitations, and capacity limitations such as motivated and qualified teachers. Absence of school facilities such as chairs, tables, books, and even doors and windows have a strong bearing on the quality of education rather than electricity alone. Improving school quality is a gradual and long-term process that cannot be adjusted overnight through the provision of electricity services. Much depends on the quality and commitment of teachers, which again depends on the level of investment in terms of teacher training and refresher courses, teachers’ salaries and remunerations. Positive
results require a longer lead-time until all the key factors start working positively together.

In conclusion, access to electricity services is essential for attaining improved quality of education. However, the scale of electricity impact will depend on availability of more essential supplementary services such as teaching appliances, qualified teachers, laboratory chemicals, and sufficient budgets, all of which are needed for quality of education to improve. The presence of electricity services improves the performance of these interrelated factors.

6.4.2 Health Benefits of RE

This section discusses reported household and community health benefits gained from RE. Health service coverage has improved considerably over the last decade in rural Ethiopia, reaching most rural households within less than 10 km distance. The training and placement of health extension workers has equally increased to 30,193 personnel, attaining 98 percent of the placement required nationally. Availability of health facilities, increased health extension workers, and improved community awareness has contributed to increased community visits to health centres. Nearly 94 percent of the households attend health clinics and health centres, while about 39 percent still go to traditional healers, use holy water (27%) and apply herbal medicines (14%).

The recorded improvement in coverage and quality of health services was supplemented by the availability of basic infrastructure such as water, electricity, road connection, laboratories, blood banks, communication, and referral systems (MDG Report, Ethiopia, 2010).
One of the observed benefits of RE to health services in the study area has been its contribution in reducing most common respiratory diseases through replacement of polluting lighting practices. Over 58 percent of all household responses show that most common diseases observed in the study area were respiratory illnesses such as bronchitis, cold, and asthma. The high altitude of the area and relatively cold climate might have caused higher levels of exposure to indoor air pollution in the process of lighting and house heating using highly pollutant biomass fuels, mainly dung cakes. Respiratory diseases are further complicated by the two highly interrelated diseases of TB and HIV, the second most common illnesses as reported by 25 percent of the respondents. Availability of electricity services replaced wood and kerosene based lighting, further reducing exposure to indoor air pollution and contributing to improved respiratory health of the community.

This section assesses reported benefits of electricity services in improving emergency response and overnight health services, improved use of health equipment, decreased child mortality rate, decreased maternal mortality rates, retention of qualified health workers, facilitating other direct and indirect health benefits and overall health service improvement.

a) Improved emergency response, overnight health care services, and improved use of equipment:- All rural health centres visited reported night-time health services once electricity access was established. This enabled the provision of better child delivery services for mothers, avoiding referral to far away locations such as the zonal capital, Debre-Berhan, while in labour. Maternal and child delivery related deaths are common while travelling to the zonal referral hospital due to absence of appropriate transport
facilities. Health centres introduced quality lighting, replacing kerosene lamps, which they report has improved their health service delivery and emergency response capacity through the night.

The other contribution of electricity access on improved delivery of health services is through improved use of health equipment. All of the health establishments visited in the study area, with the exception of Gosh-Bado health centre - where no electricity connection took place, reported improved use of health equipment. These include improved electric powered refrigeration services for delivery of effective vaccines, use of sterilizer equipment, use of laboratory testing facilities, provision of X-ray services, and conducting minor operations.

According to all health officers interviewed, the use of electric powered refrigerators enabled the storage of effective vaccines and medicines in all the rural health centres with electricity connection. In the absence of electricity connection, health centres are equipped with kerosene-run refrigerators that incur excessive fuel costs, and sometimes stop working when kerosene stocks run out. This was reported as a major challenge for rural health centres where some of the vaccines and medicines lost effectiveness due to absence of regular refrigeration. According to Mr. Mohammed Said, an expert in the Office of Health in Ankober, some of the chemicals used in HIV testing, tetanus anti-toxins, and emergency blood clotting agents, all require cold storage, which is only possible by using refrigerators. In Kotu, the health centre provides refrigeration service to six surrounding health posts that do not have electricity connection.
Health officers in the survey area believe that the use of sterilization equipment facilitated the decrease in the spread of transmissible diseases such as HIV/AIDS. All health centres visited confirmed that while a number of other factors – primarily awareness creation and change of people’s attitude – have contributed to its fall, both HIV infection and its prevalence rates have decreased over the past five years in the study area.

Scaled-up laboratory testing services have become possible after health services were connected to electricity services, avoiding referral to distant health centres mainly at Debre-Berhan. All rural health posts practice preliminary testing on HIV/AIDS, the results of which are only indicative. When results are positive, further tests must be conducted at health centres with access to electricity services. In some health centres such as Kotu, absence of laboratory technicians and appropriate laboratory equipment has tended to slow down the possibility of extensive laboratory services, even after electricity connection was ensured.

Overall, health workers reported that availability of electricity services contributed towards providing extended health services through the night and improving the use of health equipment, both resulting in safe child delivery and better testing, diagnosis, and treatment of most common diseases.

**b) Decreased child mortality rate and child killer diseases:** Nearly 8 percent of the households surveyed reported incidence of deaths of children under five within the household mainly due to sickness. As shown in Table 43 below, a significant drop in occurrence of child killer diseases was observed by 74 percent of the households as a result of improved access to child health services, improved sanitation and hygiene.
(10%), and increased access to child vaccine services (89%). The role played by electricity access in decreasing child death was positively reflected by 84 percent of the respondents in Ankober, 78 percent of the households in Kotu, and 26 percent of the respondents in Shola-Gebeya. Again, the lower level electricity benefit reported in Shola-Gebeya is understandable owing to the very recent history of connection to electricity services, where 43 percent of the households reported no improvement or no change.

Table 43: Reported Child Health Impacts After Connection to Electricity Services

<table>
<thead>
<tr>
<th>Observed Child Health Impacts</th>
<th>Shola-G.</th>
<th>Kotu</th>
<th>Ankober</th>
</tr>
</thead>
<tbody>
<tr>
<td>- decreased child death</td>
<td>26%</td>
<td>78%</td>
<td>84%</td>
</tr>
<tr>
<td>- reduced indoor air pollution</td>
<td>93%</td>
<td>87%</td>
<td>54%</td>
</tr>
<tr>
<td>- improved child attendance</td>
<td>59%</td>
<td>78%</td>
<td>88%</td>
</tr>
<tr>
<td>- attained nutrition improvement</td>
<td>52%</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>- improved access to safe drinking water</td>
<td>14%</td>
<td>89%</td>
<td>95%</td>
</tr>
</tbody>
</table>

From the perspective of health officers, the decrease in child mortality rate observed after connection to electricity services was due to a number of factors working together, such as improved access to cleaner water supply, improved sanitation, better child care awareness, and improved vaccination services. Even though no specific data existed on child health improvement due to electricity access, health workers observed an overall trend of decline in child mortality rates since rural towns connected to electricity services.

As shown in Figure 43 below, responses of households on the decline of child killer diseases shows a substantial fall with the number of years of the town’s access to electricity services. Percentage of households reporting ‘no decrease or no change’ falls substantially as the number of years of access increased.
These results suggest that there could be some association between a household’s response on decrease of child killer diseases and number of years of the town’s electricity access.

Households were asked whether the presence of electricity services contributed to the decrease in child deaths in the community. Responses were run in a logistic regression model using YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN as independent variables. Results showed that YRCONECT, ACCESS and INCOME all passed the significance test, while the other two variables failed, namely FMSIZE and OCUPN failed the test. (Appendix 6.15 A). A re-run of the model with the three significant variables is shown in Appendix 6.15.B.

Reiterative run of the model to account for the interaction of YRCONECT, ACCESS, and INCOME showed a rather robust outcome as shown in Table 44 below. Households with an additional year of connection were 3.3 times more likely (compared to 2.3 times in earlier model without the interaction variable) to report that the presence of electricity contributed to reducing child mortality in the community.
Table 44: Logistic Regression Model on Contribution of Electricity on Decreasing Child Mortality

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>1.085</td>
<td>.167</td>
<td>42.448</td>
<td>1</td>
<td>.000</td>
<td>2.960</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.588</td>
<td>.123</td>
<td>22.860</td>
<td>1</td>
<td>.000</td>
<td>1.800</td>
</tr>
<tr>
<td>INCOME</td>
<td>.001</td>
<td>.000</td>
<td>16.209</td>
<td>1</td>
<td>.000</td>
<td>1.001</td>
</tr>
<tr>
<td>ACCESS by INCOME by YRCONECT</td>
<td>.000</td>
<td>.000</td>
<td>13.359</td>
<td>1</td>
<td>.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.680</td>
<td>.443</td>
<td>69.109</td>
<td>1</td>
<td>.000</td>
<td>.025</td>
</tr>
</tbody>
</table>

a. Variable(s) entered on step 1: YRCONECT, ACCESS, INCOME, ACCESS * INCOME * YRCONECT.

The access variable showed rather lower likelihood, but the income variable gave a higher result. Households with a unit higher income were trice more likely to report that the presence of electricity decreased child mortality rate in the community.

Households were further questioned on the changes in the prevalence of child killer diseases in the areas. A logistic regression model was run to assess whether household responses on reduction of child killer diseases in the study area was related to any of the five independent variables applied earlier in building the logistic regression models.

Table 45: Logistic Regression Result on Changes in Child Killer Diseases

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.624</td>
<td>.098</td>
<td>40.214</td>
<td>1</td>
<td>.000</td>
<td>1.867</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.313</td>
<td>.079</td>
<td>15.791</td>
<td>1</td>
<td>.000</td>
<td>1.368</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.034</td>
<td>.355</td>
<td>8.493</td>
<td>1</td>
<td>.004</td>
<td>.356</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, FMSIZE.

Household response on decrease of child killer diseases showed some association with a rural town’s access to electricity services and family size. Residents in towns with one more year of access to electricity services were 1.9 times more likely to respond that
The prevalence of child killer diseases had decreased. Family size showed a significant relationship with the response on decrease of child killer diseases in the area, probably because households with more children and family members tended to recognize the decline in child illness more than those with smaller family size. Understandably, households with longer history of exposure to child care may have better comparative understanding of the change in prevalence of child diseases.

c) *Decreased maternal death:* As with the case of reported changes in child mortality rate, there were no specific data at the woreda level showing how access to electricity services has impacted maternal death rates. However, responses of health workers confirmed that maternal death has decreased due to better vaccines, better child delivery and emergency response services, improved laboratory and early detection possibilities, as well as improved awareness about HIV/AIDS prevention. Most of these factors were positively affected by the presence of electricity services.

**Table 46: Reported Health Impacts After Connection to Electricity Services**

<table>
<thead>
<tr>
<th>Major Observed Mothers’ Health Impacts</th>
<th>Shola-G.</th>
<th>Kotu</th>
<th>Ankober</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced mothers’ pregnancy attendance</td>
<td>61%</td>
<td>1%</td>
<td>97%</td>
</tr>
<tr>
<td>Improved mothers’ access to vaccines</td>
<td>65%</td>
<td>94%</td>
<td>95%</td>
</tr>
<tr>
<td>Improved mothers’ health</td>
<td>59%</td>
<td>89%</td>
<td>95%</td>
</tr>
<tr>
<td>decreased workloads for pregnant mothers</td>
<td>28%</td>
<td>88%</td>
<td>91%</td>
</tr>
</tbody>
</table>

As shown in Table 46 above, percentage of responses on mother’s health improvement indicators increased as number of years of electricity access increased in the rural towns under study, indicating that electricity access benefits are positively related to a mother’s health improvement.

A logistic regression model was constructed with household responses on mothers’ health improvement due to electricity services as dependent variables with the
five independent variables applied so far. Results are shown in Appendix 6.17.A where only the two variables of YRCONECT and ACCESS passed the significance test.

Improved model results in are shown in Appendix 6.17.B with considerably higher results. Further reiteration of the model with an interaction variable of YRCONECT and ACCESS gave robust results as shown in Table 47 below.

Table 47: Logistic Regression Model on Mother’s Health Improvement Due to Presence of Electricity Services

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.849</td>
<td>.157</td>
<td>29.215</td>
<td>1</td>
<td>.000</td>
<td>2.337</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>2.848</td>
<td>.531</td>
<td>28.785</td>
<td>1</td>
<td>.000</td>
<td>17.256</td>
</tr>
<tr>
<td>ACCESS by YRCONECT</td>
<td>-.386</td>
<td>.145</td>
<td>7.124</td>
<td>1</td>
<td>.008</td>
<td>.679</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.001</td>
<td>.456</td>
<td>43.338</td>
<td>1</td>
<td>.000</td>
<td>.050</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, YRCONECT, ACCESS * YRCONECT

Households with one additional year of connection to electricity services were over 17 times more likely to report that mothers’ health improved due to presence of electricity services. Residents in towns with one more year of connection to electricity services were 2.3 times more likely to agree on the improvement of mothers’ health due to the presence of electricity services.

Most important factors for mothers’ health improvement were further reported by households, such as increased vaccination of pregnant mothers, increased mothers’ medical attendance, improved access to medical advice while pregnant, and decrease in workload for pregnant mothers.

Logistic regression results show that all responses were strongly associated with number of years of a household’s connection to electricity services as shown in Table 48 below.
### Table 48: Logistic Regression Results on Improvement of Mothers’ Health

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccination of mothers during pregnancy</td>
<td>YRCONECT</td>
<td>.409</td>
<td>.121</td>
<td>11.437</td>
<td>1</td>
<td>.001</td>
<td>1.505</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>1.279</td>
<td>.199</td>
<td>41.185</td>
<td>1</td>
<td>.000</td>
<td>3.593</td>
</tr>
<tr>
<td>Medical attendance of mothers during pregnancy</td>
<td>ACCESS</td>
<td>.357</td>
<td>.097</td>
<td>13.432</td>
<td>1</td>
<td>.000</td>
<td>1.429</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>1.135</td>
<td>.212</td>
<td>28.608</td>
<td>1</td>
<td>.000</td>
<td>3.112</td>
</tr>
<tr>
<td>Mothers’ access to advice on mother and child care &amp; sanitation</td>
<td>ACCESS</td>
<td>.386</td>
<td>.100</td>
<td>14.974</td>
<td>1</td>
<td>.000</td>
<td>1.471</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>1.094</td>
<td>.211</td>
<td>26.878</td>
<td>1</td>
<td>.000</td>
<td>2.987</td>
</tr>
<tr>
<td></td>
<td>ACCESS</td>
<td>.715</td>
<td>.120</td>
<td>35.809</td>
<td>1</td>
<td>.000</td>
<td>2.045</td>
</tr>
<tr>
<td></td>
<td>YRCONECT</td>
<td>1.093</td>
<td>.187</td>
<td>34.102</td>
<td>1</td>
<td>.000</td>
<td>2.984</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-2.866</td>
<td>.314</td>
<td>83.454</td>
<td>1</td>
<td>.000</td>
<td>0.057</td>
</tr>
<tr>
<td>Decrease of work load for pregnant mothers</td>
<td>ACCESS</td>
<td>1.252</td>
<td>.208</td>
<td>36.329</td>
<td>1</td>
<td>.000</td>
<td>3.496</td>
</tr>
<tr>
<td></td>
<td>YRCONECT</td>
<td>3.455</td>
<td>.704</td>
<td>24.064</td>
<td>1</td>
<td>.000</td>
<td>31.663</td>
</tr>
<tr>
<td></td>
<td>ACCESS by YRCONECT</td>
<td>-6.19</td>
<td>.153</td>
<td>16.443</td>
<td>1</td>
<td>.000</td>
<td>0.538</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-4.873</td>
<td>.746</td>
<td>42.678</td>
<td>1</td>
<td>.000</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Note: Variables in the models represent only those that passed significance tests.

Number of years of a town’s electricity access was significant in the case of reduction of workload for pregnant women. A reiterative model result for workload reduction, incorporating the interaction of YRCONECT and ACCESS, showed that households with one more year of connection were about 32 times more likely to report reduced workload for pregnant mothers. Likewise, number of years of a household’s connection and a town’s access both showed association with vaccination of mothers, medical attendance of mothers during pregnancy, and mother and child care advice.

Households were further asked to list the general health benefits of RE. Extensive electricity benefits for mothers were listed, such as availability of extended hours in which mothers could spread workload, secured walking and working at night due to improved lighting, getting rid of smoke exposure through replacing kerosene lamps by
electric lights, possibility for mothers to receive emergency treatment during the night when needed, improved access to information on child and mother’s health care through media, decreased mothers’ deaths, and decreased costs of travel to health referral facilities.

The presence of electricity services provides direct benefits in improving the health conditions of mothers in a number of ways. First, mothers in remote rural towns benefit from availability of overnight healthcare services for delivering mothers and decreased referrals to faraway hospitals. Second, the use of equipment for minor operations and sterilization were possible, enabling safer child deliveries. Third, qualified health workers remained in remote health centres, enabling improvement in mothers’ health conditions. Electricity services provided further benefits for mothers such as improved vaccination, medical attendance, and mothers’ education about childcare. Overall, the benefits of RE in improving mothers’ health in rural towns was reported as direct and immediate.

d) Retention of qualified health workers:- All health centres, health posts, and health offices visited indicated substantial improvement in retaining qualified health workers after electricity access was established. Electricity provided better incentive for health staff to remain longer where they have been posted. This is due to improved lighting, better access to media and communication, cleaner water supply possibilities through electrically pumped water, and overall improvement in local amenities and services. In places where no such amenities are available, retention of medical staff has been very difficult. An example was given about a rural town called Tengego where a health centre exists without electricity. Despite the fact that Tengego is only 18 kilometres away from
Kotu and along the main highway, only one health officer remains there after all other staff left due to difficult living conditions, including absence of electricity services. Workers prefer to live in remote rural towns with electricity services rather than towns near a main city that have no electricity. Similar impacts were expressed in the case of retaining qualified education workers.

In Ankober woreda, the deputy head of the office of health service confirmed that most health workers wanted to get transfers to towns where electricity services are being provided. Such transfer requests are currently waning as more rural towns are connected to electricity services.

e) Other health benefits of RE:- There are reports of a number of other health related benefits gained by RE in the form of direct and indirect gains. One of the reported main benefits of RE was the reduction of major killer diseases such as HIV/AIDS and TB.

Reports on the prevalence of major killer diseases over the past few years both in the study areas and at national level show mixed results. At national level, the prevalence of HIV/ AIDS has levelled off while the epidemic continues to show no significant change with national prevalence rate standing at 1.1 million persons living with the virus. HIV incidence rate remained at 0.3 percent. The lower prevalence rate is attributed to ongoing coordinated efforts in counselling, and testing services facilitated by the presence of electricity. Malaria used to be the number one cause of morbidity and mortality in Ethiopia until it was contained, mainly through the distribution of 22.2 million insecticide treated mosquito nets. The reduction of TB cases was modest, from 94 per 100,000 in 2004 to that of 92 in 2007.
In the study areas, health office representatives and health workers reported a considerable decline in the prevalence of HIV/AIDS and related deaths due to improvement in counselling and testing, as well as provision of antiretroviral treatments for persons living with HIV/AIDS supported by increased educational services. HIV/AIDS control efforts were reported to be more effective in towns where electricity services were available.

At the household level, about 30 percent of households reported a decrease of HIV/AIDS occurrence and related deaths, while about 70 percent felt that it was rather increasing. When disaggregated into number of years of electricity access, those reporting ‘decreasing trends’ increases while those reporting ‘decrease’ falls, reaching at par with towns of the highest number of years of electricity access (Figure 44).

**Figure 44: Household Responses on Changes in the Prevalence and Related Deaths of HIV/AIDS**

![Figure 44](image)

Malaria was not prevalent within the study area due to its high altitude. On the other hand, the prevalence of respiratory diseases was most common, causing complications by the occurrence of TB and HIV/AIDS. The presence of electricity services has partly eased the pollution coming from kerosene burning for lighting.
Other than the direct health benefits gained from RE, there are reports of a number of indirect RE benefits that have enabled the improvement of health status at household and community levels. Some of the most common indirect gains are improved sanitation, reduced workload for women, and improved access to communication and mass media, which contributes to the creation of awareness about primary health care.

Electricity driven urban water supply has enabled improved sanitation and health conditions of households and the community in places where pumped water supply was possible. Number of years of connection to electricity services is strongly associated with overall health improvement benefits as shown in this section in Figure 45 below. According to household responses, provision of electricity services facilitated alleviation of workloads for women during pregnancy, which impacted positively on child and maternal health status.

f) Overall Health Benefits of RE:- There is a consensus among health workers in the study area that quality of health services improved considerably after electricity access was created. Interviewed households gave similar positive responses on the way their household and community health status improved over the previous five years, with nearly 76 percent of the households reporting major improvement, while 18 percent reported no major changes. Only 2 percent felt the health status of households and the community had deteriorated. Major reasons for these improvements were improved delivery of health services (56%) and improved household sanitation practices and personal hygiene (3%). Figure 45 below shows household responses on observed changes in the household’s health status related to the number of years of access of the town they reside.
Results show that household responses of improved health status within the household increased along with the number of years of the town’s access to electricity. Similarly, household response of no improvement or no answer decreased as the number of years of access of the town in which the householders lived increased, suggesting that household response on health status change may be related to years of electricity access of the towns of their residence.

In conclusion, household responses and field discussions show that a strong relationship exists between the use of electricity services and improved health status. Similar confirmation is recorded at zonal health offices that expressed benefits of RE in improving the delivery of rural health services. However, it should be noted at this stage that provision of electricity services coincided with the delivery of other essential factors for health service improvement, such as increased government commitment, availability of qualified health workers, allocation of sufficient budget, improved supply of appropriate medicines and equipment, and provision of adequate community based
disease prevention measures. The impact of RE on the provision of improved health services is further enhanced when complemented by these essential factors.

6.4.3 Water Supply and Sanitation

In Ethiopia, improving access to safe and sufficient potable water is one of the priority areas. At the national level, access to safe and sufficient water has increased from 19 percent in 1990 to 65.8 percent in 2009/10 (MDG Report, Ethiopia, 2010). One means of improving access to safe and sufficient water supply is through lifting water from sub-surface and lower ground sources by using electric water pumps.

Households were asked if they perceived any contribution of RE in the supply of sufficient and potable water, irrespective of their town’s electricity access. About 53 percent in Shola-Gebey, 78 percent in Kotu, and 61 percent in Ankober reported positive outlook⁴¹.

According to municipal officers in the study area, the supply of safe and adequate water for rural communities has enabled the emergence of healthy and productive society with a number of additional benefits such as improved sanitation practices, decreased water-borne diseases, decreased workload for women and children and decreased medication and treatment costs. Supplying rural towns with electricity driven water pumps ensures cheap, reliable, and steady supply of water all year round when compared with diesel pumps.
Households were asked whether the supply of sufficient and clean water to their town had improved, and whether the distances travelled and time spent collecting water had decreased. Responses are shown in Table 49 below, disaggregated by towns with number of years of access.

**Table 49: Responses on Water Availability, Distance and Time Spent for Water Collection (Percentages)**

<table>
<thead>
<tr>
<th>Water Related Responses</th>
<th>Years of Electricity Access of Town</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gosh-B. (No Access)</td>
</tr>
<tr>
<td>Sufficient Water is Supplied to Town</td>
<td>11%</td>
</tr>
<tr>
<td>Distance Travelled for Water Collection Decreased</td>
<td>14%</td>
</tr>
<tr>
<td>Time Spent for Water Collection Decreased</td>
<td>19%</td>
</tr>
</tbody>
</table>

Results show that household responses on availability of sufficient and clean water increased as number of years of electricity access increased. On the other hand, reports on distances traveled and time spent for water collection decreased substantially as number of years of the town’s access increased. Do these relationships have any significance?

A logistic regression model was constructed to examine household survey responses on availability of water supply and sanitation against a number of dependent variables, such as availability of sufficient water supply, and decrease in travelling long distances for water collection, with resulting time saving. Results are shown in Table 50 below.

Results of the model in Table 50 below show that water availability is associated with electricity access, household income, and the interaction of the two variables. Responses on availability increased as the number of years of access of the town in which
households resided increased, showing some association. Household income gave significant values, but was negatively related with dropping responses on availability of sufficient water for households as monthly income level increased. Travel distance and time spent for water collection showed some association with years of electricity access and connection, but rather low values.

Table 50: Logistic Regression Results on Improvement of Water Supply and Sanitation

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of sufficient potable water</td>
<td>ACCESS</td>
<td>.759</td>
<td>.146</td>
<td>27.119</td>
<td>1</td>
<td>.000</td>
<td>2.136</td>
</tr>
<tr>
<td></td>
<td>INCOME</td>
<td>-2.458</td>
<td>.525</td>
<td>21.936</td>
<td>1</td>
<td>.000</td>
<td>.086</td>
</tr>
<tr>
<td></td>
<td>ACCESS by INCOME</td>
<td>.707</td>
<td>.247</td>
<td>8.156</td>
<td>1</td>
<td>.004</td>
<td>2.027</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-.464</td>
<td>.229</td>
<td>4.095</td>
<td>1</td>
<td>.043</td>
<td>.629</td>
</tr>
<tr>
<td>Travel long distances to collect water?</td>
<td>YRCONNECT</td>
<td>-.614</td>
<td>.080</td>
<td>59.564</td>
<td>1</td>
<td>.000</td>
<td>.541</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>1.161</td>
<td>.177</td>
<td>43.159</td>
<td>1</td>
<td>.000</td>
<td>3.194</td>
</tr>
<tr>
<td>Time spent collecting water</td>
<td>ACCESS</td>
<td>-.395</td>
<td>.099</td>
<td>15.943</td>
<td>1</td>
<td>.000</td>
<td>.673</td>
</tr>
<tr>
<td></td>
<td>YRCONNECT</td>
<td>-.344</td>
<td>.115</td>
<td>8.876</td>
<td>1</td>
<td>.003</td>
<td>.709</td>
</tr>
<tr>
<td></td>
<td>INCOME</td>
<td>.595</td>
<td>.275</td>
<td>4.702</td>
<td>1</td>
<td>.030</td>
<td>1.814</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>1.303</td>
<td>.222</td>
<td>34.374</td>
<td>1</td>
<td>.000</td>
<td>3.680</td>
</tr>
</tbody>
</table>

Note: Variables in the models represent only those that passed significance tests.

Sanitation practices increased together with increased availability of sufficient and clean water. About 92 percent of the households had separate kitchens, while 72 percent had a latrine. As shown in Table 51 below, availability of separate kitchen is strongly associated with household income and not related to electricity access. Availability of a latrine in a household is associated with year of electricity access, connection, and household income.
Table 51: Logistic Regression Results on Sanitation Improvement

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of separate kitchen in household</td>
<td>INCOME</td>
<td>1.287</td>
<td>.451</td>
<td>8.136</td>
<td>1</td>
<td>.004</td>
<td>3.621</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>1.897</td>
<td>.234</td>
<td>65.722</td>
<td>1</td>
<td>.000</td>
<td>6.667</td>
</tr>
<tr>
<td>Availability of latrine in household</td>
<td>ACCESS</td>
<td>-0.369</td>
<td>.101</td>
<td>13.239</td>
<td>1</td>
<td>.000</td>
<td>0.692</td>
</tr>
<tr>
<td></td>
<td>YRCONNECT</td>
<td>0.290</td>
<td>.114</td>
<td>6.460</td>
<td>1</td>
<td>.011</td>
<td>1.336</td>
</tr>
<tr>
<td></td>
<td>INCOME</td>
<td>1.293</td>
<td>.275</td>
<td>22.045</td>
<td>1</td>
<td>.000</td>
<td>3.645</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>0.702</td>
<td>0.207</td>
<td>11.539</td>
<td>1</td>
<td>.001</td>
<td>2.018</td>
</tr>
</tbody>
</table>

Overall, there is sufficient evidence to conclude that both access and connection to electricity services have a strong relationship with availability of clean and sufficient water, water collection time reduction, and better sanitation practices.

6.4.4 Grinding Mills

Residents of towns with electricity access use electric grinding mills in over 96 percent of cases, as opposed to diesel-driven mills. Residents reported that electric milling services provided faster services, cheaper milling costs, more efficient grinding, and more instantaneous and cleaner applications as compared to diesel driven mills. Electrically-driven grinding mills cost up to a third less, are noise pollution free, face low maintenance requirements, and enable continuous supply of milling services all year round. Milling service providers prefer to use electricity for milling as it is cheaper than diesel both in capital and running costs. It was reported in Ankober that rural villages prefer travelling long distances to major towns for milling services powered by electricity, abandoning diesel mills installed nearer to their residence. The major reasons are substantially lower milling costs and more reliable services.
In Ankober alone, up to 15 grinding mills have shifted from diesel to electricity. Gosh-Bado and Shola-Gebeya residents have asked EEPCO for electricity connection to public services such as health centres, grinding mills and water pumping.

6.4.5 Street Lighting and Night-Time Security

Provision of street lighting services was one of the most important benefits that communities acquired after connection to electricity. Street lights enabled the continuation of movement of people within rural towns, encouraging longer opening hours of businesses during evening hours, and ensuring night-time security. Twenty-three percent of the households in Ankober and 24 percent of respondents in Kotu reported improved local security as one of the benefits of RE. Household responses on local security benefits dropped to 5 percent in Shola-Gebeya, as the town was just being connected by the time of the survey. Kotu, with its weekly Monday market attracting over 25,000 persons from as far away as Addis Ababa, continues to be a vibrant centre of activity into the evening, with little violence. A Monday evening would have been far more violent and chaotic in Kotu town before the introduction of electricity services. In Shola-Gebeya, households and communities reported improved business opportunities and extended markets over the night after the town gained access to electricity services.

6.5 Social and Cultural Impacts of RE

Socially, the presence of electricity services has enabled extended social interaction through the night, where shops remain open, bars operate over extended hours, and people continue to move freely with minimal security threats.
There were cases where the presence of electricity [in the town] provided positive external benefits for households with no electricity connection. Households and community members with no connection to electricity services benefited indirectly in the form of access to street lighting, improved business environment, and improved social services. A study conducted by MEGEN Power Ltd. (2002) showed that households with no direct connection to electricity services “were beneficiaries of improved services provided by commercial users as a result of the power scheme. The benefits obtained from connected institutions were mentioned by 60 percent of the unconnected households”. This was in addition to school, health, grinding mills and water supply benefits that community members gained even when households were not connected directly to electricity services.

In this section, RE impacts on gender relations and socio-cultural changes are discussed.

6.5.1 Impacts of Connection to Electricity Services on Gender Relations

In this section, the contribution of electricity in improving gender relations in households and in the community are discussed in two parts: (1) improving the living and working conditions of women through alleviating workloads; and (2) raising the positions of women in relation to their male counterparts both in the household and in society.

a) Improving living and working conditions for women:- Surveyed households in Ankober, Kotu and Shola-Gebeya reported an average of 10 hours of daily workloads for women and 8 hours for men. As shown in Figure 46 below, 68 percent of the 58
households in Ankober reported positive impacts of electricity use in alleviating workloads for women. Reported benefits of alleviation of workloads for women were the lowest for households with late or no connection to electricity services. This was the case in Kotu for 19 percent of the cases and in Shola-Gebeya for 7 percent of the respondents.

Similarly, more responses were recorded under ‘no observed changes’ or ‘no observed benefits’ by households with no electricity or lower number of years of connection. These responses could indicate that reported benefits of RE in improving workload for women had a gradual impact where households with late or no electricity connection gave little or no acknowledgment of the benefits, and households with longer years of connections were more aware and appreciative of the benefits in decreasing workloads for women.

**Figure 46: Reported Benefits of RE in Alleviating Workloads for Women**

In Shola-Gebeya, the highest response went to ‘no change’ (40%) followed by ‘no experience of benefits’ (17%), which is not surprising, owing to Shola-Gebeya’s connection history of only one month at the time of the survey. In Kotu, highest
responses (42%) were on electricity benefits in spreading tasks through the night as a result of availability of quality lighting.

When it comes to gender division of labour in the household, women performed most domestic activities such as preparing food (81%), cleaning (80%), child care (65%), and marketing activities (74%). There were no reported changes in gender division of labour as a result of access to electricity services. Instead, increasing awareness was reported to be one major reason for enhancing gender equality as reported in Ankober by 40 percent of the responses. In Kotu, 22 percent of the households reported improvement in gender relations at household and community levels due to improved media presence following access to electricity services. The other major electricity enabled benefit reported by women was in spreading their community-related workload by shifting some of their household chores to evening activities through the use of quality lighting, as reported by 43 percent of the respondents. The idea of spreading workload over a longer time frame within the day was strongly voiced by most women interviewed. Whether spreading workloads eases the whole volume of workload is not clear. What was observed was that women seemed to be managing their chores in a more relaxed time-frame than was the case before connection.

The impact of electricity access in alleviating cooking related indoor air pollution for women was reported least (Figure 49). This was mainly due to the very little impact electricity connection had on replacing existing wood and charcoal-based cooking practices, since electricity is seldom used for cooking in rural towns. However, substantial indoor air pollution reduction was reported (93% in Ankober, 87% in Kotu,
and 54% in Shola-Gebeya) from the replacement of kerosene lamps for lighting, which was not gender specific.

**b) Improving the positions of women in household and society:** One way of improving the position of women in relation to men is through enhancing their control over income sources. Non-farm businesses run by women were reported by 77 percent of the households in Ankober, 82 percent of the households in Kotu, and 66 percent in Shola-Gebeya. This is a significant finding in two aspects: increasing numbers of rural town residents are experiencing employment in non-farm businesses, and women are playing a leading role in running these businesses. Of these non-farm businesses, small-scale merchandise vending accounts for an average of 60 percent of the cases followed by bars, cafeteria and tea shops (11%) and street vending (9%). Electricity using businesses run by women include small scale retail vending, hairdressing and barber services, and preparing/ selling local drinks.

**Figure 47: Proportion of Electricity-Based Businesses Run by Women (Percentages)**
In terms of decision making between women and men, it was observed that both men and women make decisions through consensus on a majority of decisions such as planning and prioritizing daily activities (44%), on food items bought (43%), clothes bought (55%), managing income and expenses (46%), family planning (59%), and inviting guests (54%). Women had a higher decision making role on issues related to the type of food prepared on a daily basis in 47 percent of the cases. Presence of electricity services in the community had no influence on gender decision making roles as reported by 54 percent of interviewed households, while 15 percent reported some form of minor impacts. Less than 2 percent reported media related impacts in increasing awareness towards improving decision making roles for women.

As in the case of decision making roles, access and control over resources was experienced equally between men and women as opposed to women or men alone. Equal access to and control over resources was reported on access to education (58%), employment (46%), credit services (49%), training (53%), information (45%), and extension/advisory services (52%). Over 61 percent of surveyed households reported electricity related benefits in promoting equality on access to and control over resources. Media influence towards equality on access to and control over resources was reported by 13 percent of the respondents. Ownership of assets and resources was reported to be by both men and women for land (17%), house (49%), and livestock (25%). The low level response on land ownership was due to the fact that the survey was carried out in rural towns where most of the residents do not own farmlands.

Figure 48 below shows household responses on electricity benefits in improving gender relations as reported in Ankober and Kotu. Highest responses were recorded in
both Ankober and Kottu in three areas: in contributing towards enhancing participation of women in the community (84%), in reducing exposure to indoor air pollution for women and children from kerosene use (85%), and in promoting women run/ owned non-farm businesses (83%).

**Figure 48: Household Responses on RE Role in Improving Gender Relations in Ankober and Kotu**

In contrast, households with no connection to electricity services showed lower expectation for improved gender relations due to lack of access to electricity, which was as low as 13 percent.

It can be concluded that these electricity-related gender benefits came from six main sources: (1) improved media access and information on gender equality, (2) increased employment and income generation for women as a result of increased businesses after connection, (3) improved road safety at night due to better street lighting,
(4) better education for women due to increased night reading and night shift classes, (5) improved workloads due to spreading of household chores to night hours as a result of improved lighting services, and (6) improved health for women and children from reduced indoor air pollution for lighting. These six electricity related gender benefits were reported by 55%–84% of the respondents in electricity accessing towns of Ankober and Kotu.

In most of the survey responses, the role of electricity in contributing to improving gender relations is well reported with most positive responses coming from residents living in towns with more years of electricity access. Do these responses suggest some significant relationship? Logistic regression models run to test the significance of these responses are shown in Appendix 6.22. Results show that with the exception of reduction of exposure to indoor air pollution and reduction of workload for women, the rest of the responses were associated with either the number of years of a town’s electricity access, or the number of years of a household’s connection to electricity services.

Based on household responses, there were encouraging signs of improving gender relations in households and in the community related to living conditions and positions of rural women. The role played by electricity services in promoting gender relations were reported by increasing numbers of households living in towns with more years of electricity access, suggesting that RE might have significant influence in promoting improved gender relations in rural communities.
6.5.2 The Cultural Dimension of Rural Electrification: Observed Social and Cultural Impacts

The introduction of electricity services and subsequent energy transition to MES is influenced by culture, and MES in turn influences cultural practices. Households make decisions on the use of a basket of energy services for certain end-uses on the basis of existing cultural background, which depend on such things as whether the user is in a rural town or remote rural village. Some residents of rural towns may prefer replacing the traditional three-stone stove in favor of cleaner and efficient ones. However, many rural villages generally prefer the continued use of the three-stone stove as the energy lost in using the stove is used for heating the house at evening hours, especially in high altitude areas where it becomes colder during the night. Traditionally, rural households gather around the fireplace where they dine and pass their evening hours benefiting from the light and heat that the three-stone stove provides. Earlier rural household energy survey responses (Mekonnen Lulie and Melisew Shanko, 1999) showed that households in remotely located rural villages prefer using the traditional three-stone stove as opposed to switching to efficient stoves as they believe the “lost” heat warms the room while the smoke provides strength to their thatched roofs and kills bedbugs. These are examples of barriers to the deployment of new technologies. How electricity use is influenced by culture and how culture could be affected by technology remains beyond the scope of this dissertation, even if the following provides some observations on this topic.

One of the immediate social changes observed in towns with new electricity access was the reported increase in the number of people living and staying in these towns. Some migrated into these towns from smaller rural villages that were lacking public services such as lighting and health services. Some returned from larger towns
encouraged by the introduction of electricity services and by anticipating business and market opportunities. Increase in the number of persons staying in these rural towns was reported to cause both negative and positive effects.

On the positive side, increased urban population enabled the creation of sufficient market demand for goods and services that in turn encouraged the creation of new businesses such as bars, restaurants and groceries to thrive and expand.

On the negative side, the presence of electricity services stimulated the migration of rural households abandoning their original villages, and created concentration of people in rural town centres. This is not in contradiction to theories discussed in Chapter Two, where RE would facilitate the return of people who had migrated to major cities. The difference here is that current RE programmes have targeted rural towns, leaving rural villages without electricity, hence encouraging migration from these villages to rural towns with electricity services.

There has been increased overnight stay of men from rural villages in these rural towns with electricity. This trend was more visible on market days such as the famous Monday market in Kotu, where a huge number of individuals, especially men, stayed overnight. While such overnight stay might have contributed to stimulating service based businesses such as beds, bars, and restaurants, residents reported negative socio-cultural implications such as an increase in prostitution within these towns. The expansion of nightlife in these towns has attracted more young women to migrate there, abandoning married lives in rural villages, and aggravating the problems of prostitution.

Another observed socio-cultural impact of RE was an increase in the use of modern technologies, mainly electronics such as radio transmitters, TVs, DVDs, Videos,
and mobile phones. The introduction of RE has exposed more and more rural people to global television broadcasts, and has created more soccer fans for European and South American clubs. It is not uncommon to hear the youth in rural towns debating and commenting on performances of European soccer teams such as Manchester United or Arsenal, following a televised broadcast of international soccer club matches. While such development positively contributes to providing entertainment in rural communities and bringing the global community to a common cause and culture, it may also have its negative impacts by preoccupying rural communities with issues that are far from their daily lives, detaching them from realities within their communities.

6.6 Environmental Benefits of Rural Electrification at Local Levels

The number one environmental threat in Ethiopia and in the country’s rural communities in particular is land degradation, which has been taking place unabated due to a number of factors that are interrelated with the lives of rural communities. The most important factors contributing to land degradation continue to be ongoing energy utilization practices, farming systems, and the interaction between these two.

As discussed earlier, energy utilization is over 92 percent dependent on biomass fuels in the form of wood, charcoal, dung and BLT. The use of these fuels is inefficient, with up to 90 percent energy loss. High energy losses together with widespread fuel-wood scavenging cause deforestation, land degradation, and subsequent loss of food security. This situation perpetuates rural poverty. As fuel-wood scarcity takes its toll, farming communities rely more on dung for cooking and injera baking, which further compromises food production contributing to food insecurity.
Traditional farming systems rely on mixed farming where cattle ownership is culturally seen as one of the coping mechanisms. Unrestricted farming on steep slopes together with free grazing practices are contributing to deforestation and high soil erosion, further aggravating land degradation. This situation forms a key positive feedback loop in the process of land degradation and rural poverty, and remains one of the persistent challenges in harmonizing the interaction of energy utilization, food production and natural resource management.

Had the expansion of RE been followed by increased use of electricity for cooking, this cycle of environmental degradation and food insecurity would have been broken. The use of MES for cooking would relieve ongoing pressure on vegetation cover, and allow farmers to change their farming systems by using animal waste and agro-residues as natural fertilizer instead of burning it as fuel. Unfortunately however, the use of electricity services in rural communities remains limited to lighting and radio/TV applications, with little transition to MES (See Chapter Five) and limited replacement of ongoing dependence on biomass fuels.

Figure 49: Household electricity use in connected towns (Percentages)

[Graph showing household electricity use in connected towns (Percentages)]

- Lighting as no.1 use
- Radio/ TV as no. 2 use
- Stove, ironing, mobile charging
Figure 49 above shows that the use of electricity services is limited to lighting and powering radio/TV with the exception of Kotu, where some households use electricity for cooking, ironing, refrigeration, and charging mobile devices.

**Figure 50: Animal Dung Cakes Dried & Piled for Use as Fuel in a Rural Village Near Gosh-Bado**

**Figure 51: Animal Dung Used as Natural Compost Fertilizer near Ankober**
Farmers near Ankober town carry compost from home backyardands and spread it on a farm site, pooling their efforts in communal labour known as ‘debo’. This is the only site witnessed in the study area (and most other parts of the country) where compost is used as a natural fertilizer rather than as fuel.

Reported environmental improvements were not the results of RE, as the use of electricity services does not go beyond lighting and radio/TV application at the household level primarily due to the high cost of electricity services and associated appliances. The rest of household energy end-uses, such as injera baking, cooking and water heating, continue to be served through using biomass fuels.

However, there are reported RE benefits in alleviating pressure on the local environment while contributing to reducing poverty in the medium and long-terms. Reported environmental benefits achieved through RE include improved indoor air quality for women and children as a result of replacement of kerosene stoves for lighting. Improved access to media services is believed to be creating awareness and enhancing environmental management practices, and has the potential to eventually harmonize energy utilization, farming systems and environmental management.

The Ethiopian government is fully aware of the need for green growth practices through hydropower development, which is carbon neutral. There are growing efforts towards introducing carbon trading options at global carbon markets. However, carbon neutrality may not warrant the building of hydropower dams, because there can be adverse environmental impacts locally through such development. Environmental impact assessments need to be conducted in earnest to examine, and mitigate when necessary, any possible adverse environmental consequences hydropower dams could have on settlements, loss of agricultural land, on wildlife habitat, and loss of flora and fauna.
Chapter summary: The main findings of the research have been discussed in this chapter, and show that the immediate benefit gained from RE is quality lighting services. Improved lighting provided opportunities for night-time reading, spreading household chores longer into evening hours, and improved night-time security. The second important benefit of RE was the use of media and communication by rural town residents.

The chapter discussed significant associations of both access of a rural town and connection of its residents to electricity services with a number of household responses related to benefits of RE. Household monthly income appeared to be strongly associated with most of the productive benefits of RE, suggesting that poorer households benefited the least.

Rural households reported that RE benefited in creating small home-based-businesses. Significant benefits were recorded in the creation of SMEs and generating thousands of businesses, most of which were run by electricity services. Expansion of construction businesses and rural markets created favourable conditions for thriving businesses, further generating employment and income. The expansion of RE was not followed by improvement in productivity in the agricultural sector, as use of electricity for lifting surface and underground water resources was not widely used in Ethiopia.

Household and community responses were strongly associated with RE benefits that increased in the form of community services such as schools, health services, grinding mills, and water supply infrastructures.
The influence of RE on local culture showed mixed results where exposure to international media and entertainment improved the global outlook of the local population, but had negative impacts such as increased overnight stay and spread of prostitution in towns with new electricity access. The contribution of RE in improving gender relations has been substantial. Rural women benefited in improving their living and working conditions, in advancing their relationships with their male counterparts and in improving their positions in the household and in society. The provision of electricity services expanded women-run businesses and enabled the creation of non-farm and off-farm income/employment generation possibilities. Workloads for women decreased substantially as they were able to spread their chores over evening hours.

The role of RE in improving the local environment has been minimal, as access to electricity services could not be translated into substituting the use of biomass energy. The relationship of residents to the local environment is so complex that existing environmental challenges could not be overcome through provision of electricity services alone.

Overall, the benefits of RE at household and community levels show how the provision of electricity services brought tangible benefits beyond lighting and radio/TV reception, gradually translating into improved livelihood in areas where electricity has been served.
CHAPTER VII
CONCLUSION

This dissertation discusses the impacts and benefits of rural electrification in the process of household energy procurement and consumption, and in reducing poverty and facilitating rural development in Sub-Saharan Africa. The need for the delivery of modern energy services in SSA has become imperative as these countries strive towards reducing poverty and achieving accelerated rural development (World Energy Council, 2005a). Recent studies underline the importance of electricity services in transforming quality of life in low-income developing countries through enabling employment/income generation, stimulating economic growth, achieving social benefits (such as improved education and health services) and eventually enabling social equity and poverty reduction (UNDP/ Modi et al. 2005; DFID, 2002; World Bank 2008; OECD/IEA, 2010). However, empirical evidence on the role of electricity in transforming rural economies remains scant and even dubious.

The present research examines whether these stated benefits of RE are attainable in rural towns, given the conditions of very low levels of electricity demand that are probably due to limited household income and high cost of electric appliances. The research discusses whether these challenges result in: (a) slow electricity connectivity rate following a town’s electricity access, and (b) limited household electricity use that may not go beyond lighting and radio/TV reception. Two specific research questions are addressed in line with these challenges, namely: (1) what factors influence household energy transition to MES, including household electricity connectivity rate, level of electricity utilization, and fuel substitution once rural towns receive access to electricity
services? (2) How does RE contribute to reducing poverty and promoting rural development in low-income developing countries?

RE impacts and benefits observed in rural towns and households that received access and connection to electricity services are analyzed in comparison with towns and households without electricity, or with late electricity access and connection. Extensive data were collected through household and community surveys conducted in Northern Ethiopia, North Shewa Zone of the Amhara Regional State. Four adjacent rural towns were surveyed with 5, 3, <1, and 0 years of access to electricity services, covering a total of 336 households. The differences in years of electricity access of the four study towns, and difference in years of connection of households were used to measure the presence of inter-temporal differences in RE benefits and impacts.

Household responses were used to test the associations of reported RE benefits with number of years of a town’s electricity access and a household’s electricity connection. Furthermore, household income, household family size, and occupation of head of household were used as additional factors to measure their association with household response on impacts/benefits of RE. Household survey results were supplemented by qualitative data collected from the field, mainly at the community level through discussions with focus group informants and representatives of various government and community service establishments at the local level.

Research results are presented in two main parts. The first section analyses changes in household energy procurement and consumption following a town’s access to electricity services by looking into household connectivity rates, level of electricity use,
and household energy transition to MES. The second part discusses the benefits of rural electrification.

Findings show that household connectivity rates, level of electricity use, and household energy transition to MES were directly related to level of household income and number of years of a household’s connection to electricity services. Connectivity rates and the use of electricity services increased gradually, both in quantity of KWh consumed and in diversity of use as household income grew and as households’ number of years of connection to electricity services increased.

Household electricity connectivity rate has increased faster, by over 20 percent annually, as one moves from earlier electricity accessing towns to those most recent. Why would late electricity accessing towns show higher connectivity rate? This could be explained by a number of factors: improvement of household income in recent years, even before RE was delivered; increasing prices of kerosene and alternative fuels that prompted households to connect to electricity services faster than historical rates; and easing of connectivity charges and infrastructure related constraints in recent years as a result of the Ethiopian RE expansion drive. The high cost of alternative fuels, especially increasing cost of kerosene for lighting, could be prompting households to consider earlier connection than was the case years ago in towns that had earlier access to electricity services.

Secondly, findings show that households with higher income levels were more likely to be connected to electricity services than those households with lower monthly income. The poor and the very low-income households lagged behind in connecting to electricity services, hence benefiting the least from RE.
Once electricity connection was established, electricity consumption, electricity expenditure, and diversification of use of electricity services remained low, and grew very slowly. The low level of household electricity consumption could be associated with limited financial capacity to pay for electricity bills and high-cost appliances, hindering the diversification of electricity end-uses. From the logistic regression model outcome, there was evidence that electricity consumption, expenditure, and end-use diversity increased in response to changes in income level, years of connection to electricity services, and whether households heads were employed in their own businesses.

The following characteristics were observed in relation to household electricity consumption and end-use diversity. First, changes were slow, suggesting that the contribution of RE to poverty reduction and rural development is a gradual process. Second, these changes were associated with household income, where richer households consumed more while poorer households tended to be marginalized, suggesting that the very poor received the least advantage from RE. Third, both residence and business electricity consumption increased steadily from year to year after connection, implying that households with higher number of years of connection tend to consume more electricity services. Fourth, a very high level of increase in electricity consumption was associated with the type of occupation of the head of the household, with households employed in home businesses spending a higher amount of their revenue on electricity services as compared to farmers and retirees. This signifies that business related electricity consumption showed the highest increase, and that expansion of businesses grew in line with electricity consumption. Overall, there is some window of opportunity for rural households to expand and diversify their electricity services as their income
levels improve, and as their number of years of connection to electricity services increase.

Similarly, household energy transition to MES and inter-fuel substitution practices after connection remained low and changed very slowly. Ideally, one would expect substantial substitution of biomass fuels by electricity services after connection for reasons such as convenience, cleanliness, health, and time-saving. However, households continued using biomass fuels after electricity connection, mainly due to financial barriers associated with relatively higher electricity bills and high cost of electric appliances compared to biomass fuels that had little or no appliance requirements. Mean biomass energy expenditure continued to grow faster than the rate of growth of electricity expenditure as household income increased in the four study towns.

Fuel-wood consumption is not influenced by access to electricity services, signifying a number of implications: One is that fuel-wood remains the most preferred fuel for rural as well as urban households, with its consumption level increasing as household income increases. Second, the use of electricity for cooking, heating, and replacing fuel-wood is constrained by the need for costly electric appliances. As a result, the use of fuel-wood will probably continue until a certain income threshold is reached by rural households, and a complete replacement of biomass by MES becomes possible.

The continued dominance of biomass fuels such as fuel-wood, and to some extent charcoal, in household energy procurement and use signifies that energy induced indoor-air pollution, deforestation and subsequent land degradation will continue unabated in rural communities even after RE has taken place. Indoor-air pollution and land degradation impacts will only decrease if alternative energy use and substantial transition
to MES replace the use of biomass fuels for household energy use such as cooking and heating. Electricity has substituted the use of kerosene and batteries for lighting and radio reception, respectively. There are two implications of this substitution effect: first, electricity connection costs are substantially offset by the savings from kerosene and battery expenditures for lighting and radio reception. This suggests that credit facilities for electricity connection could be repaid from savings on kerosene and batteries expenditure. Second, there is a tendency for households to expand their use of kerosene for cooking following their access to electricity services, implying indirect substitution of charcoal by electricity.

Other than the impacts of RE on household energy transition, the second area treated in the research concerned the immense benefits of rural electrification for rural households and communities. There is evidence that the provision of electricity services to rural towns contributed to reducing poverty and facilitating rural development in Ethiopia. Several RE benefits were observed both at household and community levels, albeit with gradual and low-key impacts: (1) improved quality lighting benefits; (2) increased media and communication benefits; (3) improved delivery of community services such as education, health, grinding mills, safe and clean water supply and sanitation; (4) poverty reduction benefits resulting in increased employment and income; (5) socio-cultural impacts such as improving gender relations and cultural impacts; and (6) improved rural environment management practices.

The immediate and primary household and community level benefit of RE is quality lighting, which arrived in the form of (a) improved nocturnal reading; (b) reduced indoor air pollution due to replacement of kerosene lamps; (c) improved safety for
women at night; (d) reduced workloads for women through spreading of day-time household chores over evening hours; and (e) improved business opportunities as markets extended through night hours.

Night-time reading further contributed to improved literacy for women and improved study opportunities for children. Household members, especially women with earlier exposure to literacy, were able to expand their reading skills and improve their literacy and numeracy. Improved study opportunities at night for students contributed to better performance and decreasing dropout rates at schools. Reported improved night reading benefits of RE were strongly associated with the number of years of a household’s connection to electricity services and household income. Over 72 percent of the households with electricity connection reported improved night reading benefits for women after connection.

The introduction of electricity services contributed to replacing kerosene and batteries used for lighting and radio reception. Reduced indoor air pollution benefits came from replacement of kerosene lamps by electric lights, while pollution effects from burning biomass fuels continued in rural homes. Households with better income and longer years of connection benefited most in reducing their exposure to indoor air pollution from kerosene lamp smoke.

Improved safety for women at night refers to quality electric street lighting services provided after electricity has been delivered to rural towns. There were strong responses by households and community alike that access to electricity services contributed to improving road safety at night, which benefited women the most. Number of years of a household’s connection to electricity services and household income showed
strong association with household responses of improvement of women’s safety at night. Households further reported *reduced workloads for women* after electricity connection, by spreading household chores through evening hours and allowing more relaxed daytime activities. Reported reductions of workloads for women were strongly associated with year of a town’s connection, year of a household’s connection, household income, family size, and occupation.

*Media and communication benefit* was the second most immediate benefit of RE (next to quality lighting benefits) arriving in the form of radio and TV for receiving news, information, and entertainment. Media and communication have wide-ranging benefits on the lives of rural households and communities in improving their quality of life. These include varieties of media-based education and awareness campaigns on healthcare such as sanitation and prevention of HIV/ AIDS and malaria; on environmental management practices; and on women’s empowerment and gender relations. Availability of mobile phone networks and the presence of electricity for charging phone batteries are becoming vital means of expanding rural communication. Reported RE benefits on expansion of media and communication are strongly associated with number of year of a town’s access to electricity services, implying that not only connected households, but the community at large benefited from media/ communication benefits of RE.

The third important reported benefit of RE, following lighting and media/ communication benefits, was its contribution in *poverty reduction*, through establishment of *new businesses* and expansion of existing ones. Similarly, there are sufficient data
supporting the fact that employment/income generation opportunities increased faster alongside RE expansion.

A household’s electricity connection and household income are associated with reported changes in business creation, employment/income generation, and business related occupation. Three cases can be summarized from the findings on the benefits of RE in poverty reduction: one is that number of years of a household’s connection to electricity may have influenced household responses on the role played by RE in improving livelihood, creating business, and generating employment/income. This implies that more RE benefits are realized by households with longer years of connection to electricity services.

Second, RE impacts are gradual and may take several years after electricity access has been created. This could signify that access to electricity services has gradual and longer-term impact on poverty reduction than shorter-term and immediate ones.

Third, income disparity is an important factor influencing household responses, where households with higher income tend to report the benefits of electricity access in improving household income and livelihood, in creating more income/employment opportunities, and in expansion of businesses. These relationships probably imply that households with lower income levels and those with no connection or late connection to electricity services may have benefited the least from RE. There are signs at the local level that the very poor may not have benefited as much as the middle class and those better-off following a town’s access to electricity services.

RE provided further benefits in improving the quality of delivery of public services such as education, health services, water and sanitation, street lighting, and
grinding mill services. The delivery of education improved through better use of quality lighting enabling extended school services through the evenings and facilitating school attendance for adults, use of equipment and teaching aids, use of media/ICT services, retention of qualified teachers, and improved overall quality of education. There was a consensus among local educational officers that RE brought benefits of improved delivery of education services.

Households residing in towns with more years of electricity access and longer periods of electricity connection had more positive perception of electricity services in enabling the use of equipment and media/ICT in schools. These responses indicate very high probabilities that school attendance rates improved as number of years of access and connection increased. The presence of electricity access contributed to enhancing school enrolment by way of enabling the provision of evening classes that facilitated attendance of children who would otherwise have not attended during the day due to household obligations.

Survey results further show that there is a strong association of a household’s number of years of connection to electricity services and number of years of a town’s access to electricity with household response on decrease in school dropout rate, on improvement in quality of education, and in retaining qualified teachers and school employees. Both statistical tests and observations at the community level suggest a strong association between electricity access and retention of qualified teachers. On the other hand, the significance of electricity services on a household’s decision in sending all their school aged children to school was found to be low, as it was influenced by family size rather than electricity access and connection. In other words, households with larger
family size were able to send all their school-aged children to school, as other family members could meet household chores.

Overall, access to electricity services is essential for attaining improved quality of education. However, the scale of electricity impact depends on availability of more essential supplementary services such as teaching appliances, qualified teachers, laboratory equipment and chemicals, and sufficient budget to improve quality of education. The presence of electricity services improves the performance of these interrelated factors.

_Rural health services_ benefited significantly as a result of access to electricity services. Major observed RE benefits in improving the delivery of health services include _overnight health services, better use of health equipment, retention of qualified health workers, and other indirect benefits such as improved sanitation, reduced workload for women, and improved access to communication and mass media._ Availability of electricity services contributed towards providing extended health services through the night and improving the use of health equipment, both of which resulted in safer child delivery and better testing, diagnosis, and treatment of most common killer diseases. Reported decrease in _child mortality_ was associated with household income, while decrease of child killer diseases was associated with a rural town’s access to electricity services and family size. These results suggest that poorer households were more vulnerable to child deaths than richer ones. Households residing in town with more years of electricity access, and households with more years of electricity connection reported improved _mothers’ health_; such as increased vaccination for pregnant mothers, increased mothers’ medical attendance, improved access to medical advice while pregnant, and
decrease in workload for pregnant mothers. The prevalence of major diseases such as HIV/AIDS, malaria and TB decreased substantially as the number of years of a household’s electricity connection increased.

Household responses and field discussions show that a strong relationship exists between the use of electricity services and improved health status in the study areas. However, it should be noted at this stage that provision of electricity services coincided with the delivery of other essential factors for health service improvement, such as increased government commitment, availability of qualified health workers, allocation of sufficient budget, improved supply of appropriate medicines and equipment, and provision of adequate community based disease prevention measures. The impact of RE on the provision of improved health services is further enhanced when complemented by the provision of these essential factors.

RE brought about the improved delivery of other community level benefits such as electricity-run grinding mill services replacing diesel-run mills and street lighting.

Electric mills could instantaneously provide faster, more efficient, cheaper and cleaner milling services at low maintenance costs compared to diesel mills. Street lighting services enabled the continuation of movement of people within rural towns, encouraging the longer opening of evening businesses, ensuring overnight security, and decreasing the vulnerability of women to rape and violence in dark streets. Street lighting together with the presence of TV and video facilities in rural towns improved the rural business environment through increased income for bars and restaurants while expanding community entertainment facilities. The presence of electricity services enhanced the
performance of public service workers and facilitated the use of ICT, both of which are essential for rural development.

*The social and cultural dimension of RE* was also substantial in the ways that it improved gender relations. These improvements in the conditions of rural women came from six sources: (1) improved media access and information on gender equality, (2) increased employment and income generation for women as a result of increased businesses after connection, (3) improved road safety at night due to better street lighting, (4) improved education for women due to increased night reading and night shift classes, (5) improved workloads due to spreading of household chores to night hours as a result of improved lighting services, and (6) improved health for women and children from reduced indoor air pollution from use of kerosene for lighting. The presence of electricity services created a favourable environment for improved gender relations within the household and in society.

Socially and culturally, one of the immediate outcomes of RE was the increase in population in newly electrified rural towns, having both positive and negative impacts. On the positive side, increased urban population enabled the creation of sufficient demand for newly opening businesses such as bars, restaurants and grocery stores to survive and expand. This further stimulated growth of household income and employment.

Negative impacts of RE were observed due to migration of rural villagers to nearby rural towns and increased overnight stay in towns with electricity services especially on market days, resulting in the spread of prostitution and migration of more young women to these towns.
Furthermore, in electricity connected rural towns the use of modern technologies such as radio receivers, TVs, video systems, satellite receivers, mobile phones and electronics increased significantly. Such developments contributed positively to bringing entertainment, media, and communication services to rural communities, and bringing those communities closer to the global community. The negative impacts involved detaching rural communities from their daily life and realities, frequently overwhelming them with global, regional and national issues and events.

Environmentally, RE potentially contributes to reducing dependence on biomass fuels, and eases the use of dung as fuel instead of as fertilizer. Such reduction of biomass fuels would eventually contribute to abating deforestation and breaking the vicious circle of land degradation and food insecurity. However, realities on the ground show that the use of electricity services in rural communities has not been followed by sufficient replacement of biomass fuels. Environmental benefits of RE that have been reported include improved indoor air pollution for women and children as a result of replacement of kerosene lamps for lighting. Improved access to media services are believed to be creating awareness and enhancing environmental management practices, which could eventually contribute to harmonizing energy utilization with farming systems management.

Additional perceived environmental benefits of RE include the potential for lifting of sub-surface water for irrigation and enhanced food security, retention of qualified agriculture and natural resources staff, and building of local capacities through information and Internet access, and improved access to communication services. However, the prevalence of electric pumps for lifting sub-surface water for irrigation is
limited in Ethiopia, and more so in the study area. Further opportunities exist for accessing carbon trade markets as a result of using cleaner energy sources, replacing biomass fuels and further rehabilitating the local environment while enhancing carbon-sink capacities.

However, there were very few signs showing that these benefits were being actualized. Land degradation continues in rural communities unabated and there are no signs that overuse of land will ease in the foreseeable future as a result of introduction of electricity services. The environmental impact of hydropower dams in displacing rural communities, in disrupting wild life habitat, and in permanently changing the flora and fauna of the rural ecosystem needs to be sufficiently reviewed and mitigated. For electricity services to provide some benefits, the policy environment will need to improve and will require stronger government commitment on land resource management. Such management would involve soil and water conservation and reforestation programs, stronger promotional work on energy conservation practices, increased advisory services and extension work on electrically pumped ground water irrigation development, reformulation of government policy on land ownership and allocation of sufficient funds for such programs, and application of thorough environmental impact assessment and mitigation measures on new hydropower developments. The provision of electricity services in rural communities could then be geared towards serving the realization of these policy directions, eventually generating synergy in reducing poverty and improving the local environment.

Access to electricity services impacted positivity on supply of safe and sufficient potable water. There were cases in the study areas where water supply to rural towns
shifted to electric pumps, resulting in a number of benefits such as adequate water supply, cheaper water supply costs, and reliable and steady supply of water compared to diesel-run pumps. The supply of safe and adequate water for rural communities throughout the year enables the emergence of a healthy and productive society with a number of additional benefits, such as improved sanitation practices, decreased waterborne diseases, decreased workload for women and children, and decreased medication and treatment costs.

Overall, rural electrification created short, medium and longer term benefits for rural town residents by contributing to household energy transition to MES and enhancing household, community and social benefits. Greater RE benefits were observed in facilitating the delivery of better social services, reducing poverty, and assisting in rural development. Most RE benefits occurred gradually over a longer term rather than immediately. Household income and number of years of electricity connection of households showed stronger association with most household responses on energy transition, business creation, employment generation, and improvement of social services.

The role played by electricity services in reducing poverty has been encouraging, generating more jobs and incomes, and enabling more sustainable livelihood. However, the income of the very poor has remained low, while those in the middle and higher income bracket have benefited early. This suggests that the benefits of RE are received by higher income households while the very poor have benefited the least.

The contribution of RE in facilitating poverty reduction and rural development is paramount, but is not sufficient on its own. RE benefits and impacts may be more
effective when supplemented by a number of other essential, interrelated, and interdependent factors. These factors include expansion of income generation options through off-farm and non-farm employment creation, agricultural development, introduction of favourable policy environment for investment and private sector participation, allocation of budget and qualified personnel for local level public services such as schools, health facilities, and business promotion services and the development of infrastructure such as roads and telecommunication. These key factors must work simultaneously to create the right level of synergy. The role of RE will mainly be in catalyzing their effective delivery and performance.

The provision of electricity services alone may not be sufficient for reducing poverty/, but its delivery to remote locations may enhance the effectiveness of the various interdependent factors towards meeting poverty reduction, rural development, and improved quality of life in rural communities.

The way forward: This research has attempted to address the process of household energy transition to MES and the benefits of rural electrification once rural towns obtain access to electricity. Substantial evidence is provided, with extensive analysis of RE benefits at the local level. However, absence of disaggregated data on RE benefits on each of the various specific cases remains a challenge, limiting the study to household responses rather than actual figures. Secondly, the analysis is confined to local levels, as national and regional level data that could offer a higher level perspective of the benefits of RE are lacking. In addition, as a proxy for time series data set, the data analysis was carried out by looking historically at the number of years for the study towns to gain
access to electricity and for households to become connected. The analysis would have been more complete if actual time series data were used, but such data were not available. Future study of RE benefits and impacts could focus on improving the availability of disaggregated and time series data at local, national, and regional levels.

Another area of future research in the field of RE could involve redirecting research objectives towards more dynamic poverty reduction and sustainable development through RE in low income developing countries. Two very important issues could be extracted from the present research. One is the fact that poor and low-income households benefited least from the provision of electricity services. The second finding is that RE may not be sufficient on its own, and greater benefits could be gained if other complementary factors were delivered. Two appropriate research questions would then be: (1) how could electricity benefits become more accessible for the poor and low-income segment of rural society in low-income developing countries such as SSA? (2) how can low-income developing countries enhance the effectiveness of benefits gained from RE?

This research has so far addressed the demand side of rural electrification, covering the perspectives of electricity consumers. An additional area of research could address the supply side of rural electrification with a number of research questions, such as: (1) how can the provision of RE be competitive in the absence of adequate electricity markets and in the presence of challenges such as high cost of electricity supply to scattered rural villages? (2) in supplying RE to rural communities, what are the best mixes in terms of reliability of supply, efficiency, cost-recovery, and environmental sustainability?
Bibliography


Creative Research Systems, Sample Size Calculator, [http://www.surveyszsystem.com/sscalc.htm#one](http://www.surveyszsystem.com/sscalc.htm#one)


Rose Dudley Scearce, Member, Shelby (Ky.), Rural Electric Cooperative, (1930). *What REA Services Mean to Our Farm Home*. Tennessee Valley Authority, Electricity for all. ttp://newdeal.feri.org/tva/tva10.htm


Survey Systems, Sample Size Calculator: [http://www.surveysystem.com/sscalc.htm#one](http://www.surveysystem.com/sscalc.htm#one)


Resource Persons Contacted in the Study Areas

1. Mr. Desta Ergete – Principal Goshe Bado Elementary School – Gosh-Bado
2. Mr Kebede – School Teacher at Goshe Bado Elementary School – Gosh-Bado
3. Mr. Abebe Tekle, Finance Officer, Gosh-Bado Health Centre – Gosh-Bado
4. Mrs. Asnaketch Ashagre, Statistics Officer, Gosh-Bado Health Centre – G.-Bado
5. Mr. Berhanu Nigussie, Natural Resources Officer, Office of Agriculture and Rural Development, Gosh-Bado
6. Mr. Simech Lette, Principal, Kotu Elementary School, Kotu
7. Mr. Dejene Mekitie, Nurse, Kotu Health Centre, Kotu;
8. Mr. Endeshaw H. Michael, Nurse, Kotu Health Centre, Kotu;
9. Mr. Shewamenew Dejene, Mayor, Ankober Town, Ankober;
10. Mr. Awlachew Yigezu, Head Trade & Industry Office, Ankober;
11. Mr. Getye Mamo, Statistics and Archives, Trade & Industry Office, Kotu;
12. Mr. Michael Shiferaw, Organization and Awareness Officer, Office for SME Development and Promotion, Ankober;
13. Mr. G. Tsadik Berhane, Archives Officer, Office of Finance & Revenue, Ankober;
14. Mrs. Tiblech Asseffa, Revenue Collection Officer, Office of Finance & Revenue, Ankober;
15. Mr. Mesfin Asseffa, Principal, Ankober Elementary School, Ankober
16. Mr. Ejigayehu Tekle, Deputy Head, Office of Education, Ankober;
17. Mr. Mohammed Said, Expert, Office of Health, Ankober;
18. Gedion Kebede, 8th grade student, Shola-Gebeya
19. Mr. Yilam Belaneh, Secretary, Shola-Gebeya Minicipality;
20. Mr. Bogale Tekeste, Head, Trade & Industry Office, Shola-Gebeya;
21. Mr. Tibebu Kebede, Expert, Trade & Industry Office, Shola-Gebeya;
22. Mr. Fanta Zewd, SME Organizer, SME Office, Shola-Gebeya;
23. Mr. Negalign Shenkute, Information Officer, SME Office, Shola-Gebeya;
24. Mr. Mohammed Adem, Office of Health, Shola-Gebeya;
26. Mr. Giram W. Selassie, Departmetn of Trade & Industry, Debre-Berhan;
27. Mr. Giram Tekle Hanna, Department of SME Development & Promotion, Debre-Berhan;
28. Mr. Gettu Mengistu, Investment Agency, Debre-Berhan;
29. Mr. Aklilu Yirgu, Head, Department of Education, Debre-Berhan;
30. Mr. Fikade Tekle, D. Head of Department of Health, Debre-Berhan.
31. Mr. Asfaw Abebe Eregnaw, Deputy Manager, Micro& Samll Trade & Industry, Amhara Regional State, Bahir Dar.
Appendix

Appendix 3.1 Ethiopian Government Budget Allocation 2008/09 and 2009/10 (In Millions of birr)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2008/09 Budget</th>
<th>2009/10 Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount</td>
<td>Percentage Share</td>
</tr>
<tr>
<td>Total Budget</td>
<td>54,277.10</td>
<td>100</td>
</tr>
<tr>
<td>Justice &amp; Security</td>
<td>1,057</td>
<td>1.9</td>
</tr>
<tr>
<td>Agriculture &amp; RD</td>
<td>4,960</td>
<td>9.1</td>
</tr>
<tr>
<td>Water Resources</td>
<td>1,714</td>
<td>3.2</td>
</tr>
<tr>
<td>Roads</td>
<td>7,295</td>
<td>13.4</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrification</td>
<td>1,350</td>
<td>2.5</td>
</tr>
<tr>
<td>Defence</td>
<td>4,000</td>
<td>7.4</td>
</tr>
<tr>
<td>Education</td>
<td>4,873</td>
<td>9</td>
</tr>
<tr>
<td>Health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional Subsidy</td>
<td>17,438</td>
<td>32.1</td>
</tr>
</tbody>
</table>

### Appendix 3.2: Ethiopian Energy Resource Potential and Utilization

<table>
<thead>
<tr>
<th>Energy Resources</th>
<th>Potential</th>
<th>1984 Consumption</th>
<th>% Share of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fuel-wood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- forestland</td>
<td>24 million ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- savannahland</td>
<td>3.5 million ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- planted forest</td>
<td>20 million ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Fuel-wood</td>
<td>358.4 million toe</td>
<td>9.7 million toe</td>
<td></td>
</tr>
<tr>
<td>2. Charcoal</td>
<td>Part of the above</td>
<td>0.144 million toe</td>
<td>1.1</td>
</tr>
<tr>
<td>3. Dung</td>
<td>23 million tons/yr</td>
<td>1.1 million toe</td>
<td>8.2</td>
</tr>
<tr>
<td>4. Agri-residues</td>
<td>638,000 t</td>
<td>0.98 million toe</td>
<td>7.8</td>
</tr>
<tr>
<td>(state farms only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sawdust &amp; Slabs</td>
<td>150,000 t</td>
<td>negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>6. Bagasse</td>
<td>150,000 t</td>
<td>0.0073 million toe</td>
<td>0.1</td>
</tr>
<tr>
<td>Total renewables</td>
<td></td>
<td>12 million toe 1984</td>
<td>94.2</td>
</tr>
<tr>
<td>excluding hydro</td>
<td></td>
<td>17 million toe 1999</td>
<td></td>
</tr>
<tr>
<td>7. Hydropower</td>
<td>Up to 40,000 MW</td>
<td>0.063 million toe</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.138 ml. toe (1999)</td>
<td></td>
</tr>
<tr>
<td>8. Geothermal</td>
<td>5,000 MW</td>
<td>7.5 MW</td>
<td>None</td>
</tr>
<tr>
<td>9. Petroleum</td>
<td>Adequate area of sedimentary formation</td>
<td>0.572 million toe</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.962 mil toe (1997)</td>
<td></td>
</tr>
<tr>
<td>10. Natural gas</td>
<td>1.3 trillion cubic ft.</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>11. Coal/ Lignite</td>
<td>20 million t</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>12. Solar</td>
<td>5 KWh/ m2/ day</td>
<td>none</td>
<td>None</td>
</tr>
<tr>
<td>13. Wind</td>
<td>3.5 – 5.5 m/s</td>
<td>none</td>
<td>None</td>
</tr>
</tbody>
</table>

Appendix 3.3 MDGs with SSA and Ethiopian Achievements by 2011.

<table>
<thead>
<tr>
<th>MDGs</th>
<th>Target by 2015</th>
<th>Achievement Indicators</th>
<th>Performance and Achievement in 2006 (percentages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eradicate extreme poverty</td>
<td>- cut by half the proportion of people living in extreme poverty</td>
<td>Proportion of people living on less than $1.25 a day</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of children &lt; age five who are underweight</td>
<td>27%</td>
</tr>
<tr>
<td>2. Achieve universal primary education</td>
<td>- all children complete primary education</td>
<td>Net enrolment ratio in primary education</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Literacy rate</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ratio of girls to boys in primary schools</td>
<td>83%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ratio of girls to boys in secondary schools</td>
<td>85%</td>
</tr>
<tr>
<td>3. Promote gender equality &amp; empower women</td>
<td>Eliminate gender disparity</td>
<td>Share of women in non-agriculture wage employment</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Share of women in single or lower house of parliament</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Reduce child mortality</td>
<td>Reduce under five mortality rate by 2/3rd</td>
<td>Under-five mortality rate per 100 live births</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage of children (12-23 months old) immunized against measles</td>
<td>55%</td>
</tr>
<tr>
<td>5. Improve maternal health</td>
<td>Reduce maternal mortality ratio by 3/4th</td>
<td>Maternal deaths per 100,000 live births</td>
<td>870</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of deliveries attended by skilled health care personnel</td>
<td>42%</td>
</tr>
<tr>
<td>6. Combat HIV/AIDS Malaria &amp; Other Major Diseases</td>
<td>Halted and began to reverse the spread of HOV/AIDS</td>
<td>HIV Prevalence</td>
<td>2.5 ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HIV related deaths</td>
<td>200,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mosquito-net sold or distributed in SSA</td>
<td>&lt; 500,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of tuberculosis deaths per 100,000 population</td>
<td>32</td>
</tr>
<tr>
<td>7. Ensure environmental sustainability</td>
<td>Integrate Sust. Dev’t principles into country policies &amp; programs &amp; reverse the loss of env. Resources</td>
<td>Proportion of land area covered by forests</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy use per unit of GDP (kgoe/ 1000 dollars GDP in 2000 PPP)</td>
<td>360 %</td>
</tr>
<tr>
<td>Half propr. of people without sust. access to safe drinking water &amp; basic sanitation</td>
<td>Proportion of people using improved sanitation</td>
<td>26%</td>
<td>31%</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Proportion of population using improved drinking water resources</td>
<td>49%</td>
<td>58%</td>
<td>19%</td>
</tr>
<tr>
<td>Achieve a significant improvement in the lives of at least 100 ml. slum dwellers by 2020</td>
<td>Annual growth of urban and slum population</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>8.Develop global partnership for development</td>
<td>ODA Flows per Capita in current US$</td>
<td>$19.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exports (Percent of GDP)</td>
<td>7.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>External Dept to GDP ratio</td>
<td>126%</td>
<td>&lt;7%</td>
</tr>
</tbody>
</table>

### Appendix 3.4: EEPCO Five Year Targets Under Power Sector Development Program

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increase electricity coverage</td>
<td>Coverage in %</td>
<td>16</td>
<td>17</td>
<td>22</td>
<td>32</td>
<td>41</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Increase number of customers in thousands</td>
<td>No. of Customers</td>
<td>952666</td>
<td>1126464</td>
<td>1378000</td>
<td>1900000</td>
<td>2250000</td>
<td>2600000+</td>
</tr>
<tr>
<td>3</td>
<td>Increase number of electrified towns</td>
<td>Number of electrified towns</td>
<td>648</td>
<td>900</td>
<td>1907</td>
<td>3621</td>
<td>4457</td>
<td>6000</td>
</tr>
<tr>
<td>4</td>
<td>Increase electric power generation (MW)</td>
<td>Capacity in MW</td>
<td>791</td>
<td>791</td>
<td>976</td>
<td>1396</td>
<td>1796</td>
<td>3028</td>
</tr>
<tr>
<td>5</td>
<td>Increase electric power generation (GWH)</td>
<td>Energy in GWH</td>
<td>3112</td>
<td>3112</td>
<td>3926</td>
<td>6490</td>
<td>6490</td>
<td>10907</td>
</tr>
<tr>
<td>6</td>
<td>Increase high voltage lines (in km)</td>
<td>Length in km</td>
<td>7528</td>
<td>8383</td>
<td>9395</td>
<td>10666</td>
<td>11336</td>
<td>13054</td>
</tr>
<tr>
<td></td>
<td>230,132,66 kv</td>
<td>Length in km</td>
<td>0</td>
<td>0</td>
<td>787</td>
<td>787</td>
<td>787</td>
<td>1252</td>
</tr>
<tr>
<td></td>
<td>400kv</td>
<td>Length in km</td>
<td>0</td>
<td>0</td>
<td>787</td>
<td>787</td>
<td>787</td>
<td>1252</td>
</tr>
<tr>
<td>7</td>
<td>Increase medium &amp; low voltage lines (in km)</td>
<td>Length in km</td>
<td>25000</td>
<td>32227</td>
<td>62788</td>
<td>83892</td>
<td>114772</td>
<td>136320</td>
</tr>
<tr>
<td>8</td>
<td>Reduce system power loss</td>
<td>Acceptable system loss</td>
<td>19.5</td>
<td>17</td>
<td>16</td>
<td>15.5</td>
<td>15</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Appendix 3.5. Rural Towns Connected Over Three Years Through RE Program in Ethiopia

<table>
<thead>
<tr>
<th>Region</th>
<th>Connected in 2005/6</th>
<th>Connected in 2006/7</th>
<th>Connected in 2007/8</th>
<th>Under Connection in 2007/8 (a)</th>
<th>Total Connected (b)</th>
<th>Total (a) + (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afar</td>
<td>3</td>
<td>15</td>
<td>6</td>
<td>5</td>
<td>24</td>
<td>29</td>
</tr>
<tr>
<td>Amhara</td>
<td>47</td>
<td>224</td>
<td>92</td>
<td>257</td>
<td>363</td>
<td>620</td>
</tr>
<tr>
<td>Benshngul</td>
<td>3</td>
<td>19</td>
<td>22</td>
<td>9</td>
<td>44</td>
<td>53</td>
</tr>
<tr>
<td>DireDawa</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Gmbella</td>
<td>3</td>
<td>11</td>
<td>7</td>
<td>0</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Harari</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Oromia</td>
<td>68</td>
<td>264</td>
<td>161</td>
<td>297</td>
<td>493</td>
<td>790</td>
</tr>
<tr>
<td>SNNP</td>
<td>34</td>
<td>171</td>
<td>102</td>
<td>116</td>
<td>307</td>
<td>423</td>
</tr>
<tr>
<td>Somalia</td>
<td>6</td>
<td>16</td>
<td>26</td>
<td>10</td>
<td>48</td>
<td>58</td>
</tr>
<tr>
<td>Tigray</td>
<td>13</td>
<td>61</td>
<td>33</td>
<td>55</td>
<td>107</td>
<td>162</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>179</strong></td>
<td><strong>784</strong></td>
<td><strong>455</strong></td>
<td><strong>751</strong></td>
<td><strong>1418</strong></td>
<td><strong>2169</strong></td>
</tr>
</tbody>
</table>

### 1.1 Electricity Sales Price (Tariff)

<table>
<thead>
<tr>
<th>No.</th>
<th>Tariff Category and blocked ID</th>
<th>Monthly Consumption kWh</th>
<th>Rate BIRR/Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1</td>
<td>Domestic</td>
<td>Equivalent Flat Rate</td>
<td>0.4735</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First Block</td>
<td>01-50 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second Block</td>
<td>51-100 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Third Block</td>
<td>101-200 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fourth Block</td>
<td>201-300 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fifth Block</td>
<td>301-400 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sixth Block</td>
<td>401-500 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seventh Block</td>
<td>above 500 kWh</td>
</tr>
<tr>
<td>1.1.2</td>
<td>General (Commercial)</td>
<td>Equivalent Flat Rate</td>
<td>0.6723</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First Block</td>
<td>First 50 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second Block</td>
<td>Above 50 kWh</td>
</tr>
<tr>
<td>1.1.3</td>
<td>Low Voltage (380 V) Industrial Tariff</td>
<td>Equivalent Flat Rate</td>
<td>0.5578</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Peak</td>
<td>0.7426</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Off-Peak</td>
<td>0.5435</td>
</tr>
<tr>
<td>1.1.4</td>
<td>Medium Voltage (15 or 33 kV) Industrial Tariff</td>
<td>Equivalent Flat Rate</td>
<td>0.4086</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Peak</td>
<td>0.5085</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Off-Peak</td>
<td>0.3933</td>
</tr>
<tr>
<td>1.1.5</td>
<td>Medium Voltage (15 or 33 kV) Industrial Tariff</td>
<td>Equivalent Flat Rate</td>
<td>0.3805</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Peak</td>
<td>0.4736</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Off-Peak</td>
<td>0.3664</td>
</tr>
<tr>
<td>1.1.6</td>
<td>Street Light Tariff</td>
<td>Equivalent Flat Rate</td>
<td>0.4843</td>
</tr>
</tbody>
</table>

### 1.2 Service Charge

<table>
<thead>
<tr>
<th>1.2.1 Domestic Sector</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Single Phase (220V)</td>
<td>0—25</td>
</tr>
<tr>
<td></td>
<td>26—50</td>
</tr>
<tr>
<td></td>
<td>51—105</td>
</tr>
<tr>
<td></td>
<td>106—300</td>
</tr>
<tr>
<td></td>
<td>Above 300</td>
</tr>
<tr>
<td>b) Three Phase (380V)</td>
<td>Monthly</td>
</tr>
<tr>
<td>c) Active/Reactive (380V)</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

### 1.2.2 General Sector (Commercial)

<table>
<thead>
<tr>
<th>1.2.2 General Sector (Commercial)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Single Phase (220V)</td>
<td>Monthly</td>
</tr>
<tr>
<td>b) Three Phase (380V)</td>
<td>Monthly</td>
</tr>
<tr>
<td>c) Active/Reactive (380V)</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

### 1.2.3 Low Voltage (380V) Industry Tariff

<table>
<thead>
<tr>
<th>1.2.3 Low Voltage (380V) Industry Tariff</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Phase</td>
<td>Monthly</td>
</tr>
</tbody>
</table>
2. MINIMUM CHARGE AND POWER FACTOR

2.1. Minimum Charge (For Industrial & High Power Consumers)

<table>
<thead>
<tr>
<th>2.1.1 Inter-Connected System (ICS)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) High or Medium Voltage Consumer</td>
<td></td>
</tr>
<tr>
<td>First 20 kW</td>
<td>31.086</td>
</tr>
<tr>
<td>Next 400 kW</td>
<td>15.543</td>
</tr>
<tr>
<td>For the balance</td>
<td>7.771</td>
</tr>
<tr>
<td>b) Low Voltage Consumer</td>
<td></td>
</tr>
<tr>
<td>First 20 kW</td>
<td>34.197</td>
</tr>
<tr>
<td>Next 200 kW</td>
<td>17.104</td>
</tr>
<tr>
<td>For the balance</td>
<td>8.552</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.1.2 Self-contained System (SCS)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Voltage Consumer</td>
<td></td>
</tr>
<tr>
<td>First 20 kW</td>
<td>41.9680</td>
</tr>
<tr>
<td>Next 200 kW</td>
<td>20.2032</td>
</tr>
<tr>
<td>For the balance</td>
<td>7.771</td>
</tr>
</tbody>
</table>

Minimum charge is fixed at Birr per kW per month and is payable if the customer’s power consumption is below 50% of the maximum demand of the previous twelve months and if this decline can be paralleled by a corresponding similar fall in kWh consumption. This charge is applicable to all customers with installed capacity of 20 kW and above.

2.2 Power Factor (For Industrial & High Power Consumers)

<table>
<thead>
<tr>
<th>2.2.1 Inter-Connected System (ICS)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) High or Medium Voltage Consumer</td>
<td>61.634</td>
</tr>
<tr>
<td>b) Low Voltage Consumer</td>
<td>68.369</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.2.2 Self-Contained System (SCS)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Voltage Consumer</td>
<td>83.363</td>
</tr>
</tbody>
</table>

Power Factor charge is a penalty to be paid when the power factor level falls below 85%. For the unit decline of the power factor below 0.85 the customer shall pay 1% of the demand charge. Demand charge is the result of the monthly kW demand achieved by the customer multiplied by the unit kW charge as in table above.

Source: EEPCO. Copyright © 2002-2008 Ethiopian Electric Power Corporation (EEPCo). All rights reserved.
Appendix 3.5: The Ethiopian Historical Power System Loss (2000 -2009)

EEPCO ICS Energy Loss as % of Generation

Appendix 5.1: Establishment of New Businesses in North Shewa Zone

<table>
<thead>
<tr>
<th>Type of Business</th>
<th>Until 2005/6</th>
<th>2006/7</th>
<th>2007/8</th>
<th>2008/9 (9 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Trade</td>
<td>4020</td>
<td>2202</td>
<td>1330</td>
<td>714</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>8</td>
<td>60</td>
<td>49</td>
<td>17</td>
</tr>
<tr>
<td>Services</td>
<td>100</td>
<td>535</td>
<td>258</td>
<td>117</td>
</tr>
<tr>
<td>Industry</td>
<td>1273</td>
<td>285</td>
<td>107</td>
<td>31</td>
</tr>
<tr>
<td>Total Businesses</td>
<td>6608</td>
<td>3083</td>
<td>1744</td>
<td>880</td>
</tr>
<tr>
<td>Employment</td>
<td>7847</td>
<td>3290</td>
<td>1556</td>
<td>825</td>
</tr>
<tr>
<td>Of which women</td>
<td>1653</td>
<td>582</td>
<td>271</td>
<td>136</td>
</tr>
</tbody>
</table>

Source: North Shewa Zone Trade and Industry, Debre-Berhan
### Appendix 6.1: Logistic Regression Results on Improved Night Reading Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>1.246</td>
<td>.182</td>
<td>46.873</td>
<td>1</td>
<td>.000</td>
<td>3.475</td>
</tr>
<tr>
<td>INCOME</td>
<td>.731</td>
<td>.350</td>
<td>4.353</td>
<td>1</td>
<td>.037</td>
<td>2.076</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.121</td>
<td>.137</td>
<td>.784</td>
<td>1</td>
<td>.376</td>
<td>1.129</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.087</td>
<td>.083</td>
<td>1.095</td>
<td>1</td>
<td>.295</td>
<td>1.091</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.011</td>
<td>.103</td>
<td>.012</td>
<td>1</td>
<td>.913</td>
<td>1.011</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.402</td>
<td>.682</td>
<td>24.876</td>
<td>1</td>
<td>.000</td>
<td>.033</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, INCOME, ACCESS, FMSIZE, OCUPN.

### Appendix 6.2: Logistic Regression Results on Improved Women Safety at Night

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>.849</td>
<td>.145</td>
<td>34.363</td>
<td>1</td>
<td>.000</td>
<td>2.337</td>
</tr>
<tr>
<td>INCOME</td>
<td>.944</td>
<td>.279</td>
<td>11.455</td>
<td>1</td>
<td>.001</td>
<td>2.570</td>
</tr>
<tr>
<td>ACCESS</td>
<td>-.099</td>
<td>.109</td>
<td>.813</td>
<td>1</td>
<td>.367</td>
<td>.906</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>-.106</td>
<td>.068</td>
<td>2.428</td>
<td>1</td>
<td>.119</td>
<td>.899</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.025</td>
<td>.084</td>
<td>.090</td>
<td>1</td>
<td>.764</td>
<td>1.025</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.003</td>
<td>.513</td>
<td>3.832</td>
<td>1</td>
<td>.050</td>
<td>.367</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, INCOME, ACCESS, FMSIZE, OCUPN.

### Table 6.3: Logistic Regression Model Results for Workload Reduction Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>-.229</td>
<td>.299</td>
<td>.588</td>
<td>1</td>
<td>.443</td>
<td>.795</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>.504</td>
<td>.124</td>
<td>16.665</td>
<td>1</td>
<td>.000</td>
<td>1.656</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.292</td>
<td>.108</td>
<td>7.237</td>
<td>1</td>
<td>.007</td>
<td>1.339</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.181</td>
<td>.071</td>
<td>6.389</td>
<td>1</td>
<td>.011</td>
<td>1.198</td>
</tr>
<tr>
<td>OCUPN</td>
<td>-.195</td>
<td>.083</td>
<td>5.526</td>
<td>1</td>
<td>.019</td>
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<tr>
<td>Constant</td>
<td>-1.812</td>
<td>.524</td>
<td>11.943</td>
<td>1</td>
<td>.001</td>
<td>.163</td>
</tr>
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</table>

a. Variable(s) entered in the model: INCOME, YRCONECT, ACCESS, FMSIZE, OCUPN.
### Appendix 6.4: Logistic Regression Model Results for Media/ Communication Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>.966</td>
<td>.809</td>
<td>1.426</td>
<td>1</td>
<td>.232</td>
<td>2.628</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.621</td>
<td>.280</td>
<td>4.932</td>
<td>1</td>
<td>.026</td>
<td>1.861</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>.141</td>
<td>.213</td>
<td>.435</td>
<td>1</td>
<td>.509</td>
<td>1.151</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.233</td>
<td>.179</td>
<td>1.695</td>
<td>1</td>
<td>.193</td>
<td>1.262</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.583</td>
<td>1.519</td>
<td>24.920</td>
<td>1</td>
<td>.000</td>
<td>.001</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: INCOME, ACCESS, YRCONECT, OCUPN.

### Appendix 6.5: Logistic Regression Results on Business Creation/ Expansion Benefits of RE

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.171</td>
<td>.100</td>
<td>2.944</td>
<td>1</td>
<td>.086</td>
<td>1.186</td>
</tr>
<tr>
<td>INCOME</td>
<td>.835</td>
<td>.261</td>
<td>10.199</td>
<td>1</td>
<td>.001</td>
<td>2.305</td>
</tr>
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<td>YRCONECT</td>
<td>.401</td>
<td>.119</td>
<td>11.282</td>
<td>1</td>
<td>.001</td>
<td>1.493</td>
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<tr>
<td>FMSIZE</td>
<td>-.040</td>
<td>.065</td>
<td>.384</td>
<td>1</td>
<td>.536</td>
<td>.961</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.061</td>
<td>.076</td>
<td>.659</td>
<td>1</td>
<td>.417</td>
<td>1.063</td>
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<td>Constant</td>
<td>-1.767</td>
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<td>13.046</td>
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<td>.000</td>
<td>.171</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, INCOME, YRCONECT, FMSIZE, OCUPN.

### Appendix 6.6.A: Logistic Regression Results for Employment Generation Impact of RE

<table>
<thead>
<tr>
<th></th>
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<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>.362</td>
<td>.117</td>
<td>9.581</td>
<td>1</td>
<td>.002</td>
<td>1.436</td>
</tr>
<tr>
<td>ACCESS</td>
<td>.085</td>
<td>.097</td>
<td>.766</td>
<td>1</td>
<td>.382</td>
<td>1.089</td>
</tr>
<tr>
<td>INCOME</td>
<td>.665</td>
<td>.255</td>
<td>6.781</td>
<td>1</td>
<td>.009</td>
<td>1.944</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>-.116</td>
<td>.063</td>
<td>3.408</td>
<td>1</td>
<td>.065</td>
<td>.891</td>
</tr>
<tr>
<td>OCUPN</td>
<td>-.033</td>
<td>.074</td>
<td>.205</td>
<td>1</td>
<td>.651</td>
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a. Variable(s) entered in the model: YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN.
Appendix 6.6 B: Improved Logistic Regression Results for Employment Generation Impact of RE

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a. Variable(s) entered in the model: YRCONNECT, INCOME.

Appendix 6.7: Logistic Regression Results on Business Related Occupation of Household Members

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<td>.571</td>
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a. Variable(s) entered in the model: YRCONNECT, INCOME, ACCESS, FMSIZE.

Appendix 6.8.A: Logistic Regression Results on Use of Media/ICT in Schools

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a. Variable(s) entered on step 1: YRCONNECT, ACCESS, INCOME, FMSIZE, OCUPN.
Appendix 6.8. B: Improved Logistic Regression Results on Use of Media/ICT in Schools

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a. Variable(s) entered in the model: YRCONECT, ACCESS, FMSIZE.

Appendix 6.9.A: Logistic Regression Results on Improved School Attendance

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a. Variable(s) entered in the model: YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN.

Appendix 6.9.B: Improved Logistic Regression Model Results on Better School Attendance

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a. Variable(s) entered in the model: YRCONECT, ACCESS.

a. Appendix 6.10.A: Logistic Regression Results on Reduced School Dropout Rates

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a. Variable(s) entered in the model: YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN.
### Appendix 6.10.B: Improved Logistic Regression Model Results on Reduced Dropout Rates

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a. Variable(s) entered in the model: YRCONECT, ACCESS.

### Appendix 6.11: Logistic Regression Results on Retention of Qualified Teachers in Schools

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a. Variable(s) entered in the model: YRCONECT, INCOME, ACCESS, FMSIZE, OCUPN.

### Appendix 6.12: Logistic Regression Results on Quality of Education

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a. Variable(s) entered in the model 1: YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN.
Appendix 6.13: Logistic Regression Model Results for Changes in Health Status of Household/Community over Last Ten Years

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a. Variable(s) entered in the model: ACCESS, YRCONECT, INCOME, FMSIZE, OCUPN.

Appendix 6.14: Logistic Regression Model Results for Changes in Under-Five Mortality in Household

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a. Variable(s) entered in the model: ACCESS, YRCONECT, INCOME, FMSIZE, OCUPN.

Appendix 6.15.A: Logistic Regression Model Results for Electricity Contribution in Decreasing Child Death

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a. Variable(s) entered in the model: YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN.
### Appendix 6.15.B: Improved Logistic Regression Results on Contribution of Electricity in Reducing Child Mortality in the Community

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a. Variable(s) entered on step 1: YRCONNECT, ACCESS, INCOME.

### Appendix 6.16: Logistic Regression Model Results for Changes in Child Killer Diseases in the Community

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<td>FMSIZE</td>
<td>.317</td>
<td>.080</td>
<td>15.603</td>
<td>1</td>
<td>.000</td>
<td>1.373</td>
</tr>
<tr>
<td>OCUPN</td>
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<td>.096</td>
<td>.628</td>
<td>1</td>
<td>.428</td>
<td>.927</td>
</tr>
<tr>
<td>Constant</td>
<td>-.691</td>
<td>.571</td>
<td>1.464</td>
<td>1</td>
<td>.226</td>
<td>.501</td>
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</tbody>
</table>

a. Variable(s) entered in the model: YRCONNECT, ACCESS, INCOME, FMSIZE, OCUPN.

### Appendix 6.17.A: Logistic Regression Model Results for Improvement in Mothers’ Health Due to Electricity Access

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.682</td>
<td>.133</td>
<td>26.306</td>
<td>1</td>
<td>.000</td>
<td>1.977</td>
</tr>
<tr>
<td>YRCONNECT</td>
<td>1.856</td>
<td>.336</td>
<td>30.442</td>
<td>1</td>
<td>.000</td>
<td>6.397</td>
</tr>
<tr>
<td>INCOME</td>
<td>.311</td>
<td>.377</td>
<td>.681</td>
<td>1</td>
<td>.409</td>
<td>1.365</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>-.018</td>
<td>.089</td>
<td>.041</td>
<td>1</td>
<td>.840</td>
<td>.982</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.061</td>
<td>.108</td>
<td>.325</td>
<td>1</td>
<td>.569</td>
<td>1.063</td>
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<tr>
<td>Constant</td>
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<td>.718</td>
<td>15.629</td>
<td>1</td>
<td>.000</td>
<td>.058</td>
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</table>

a. Variable(s) entered in the model: ACCESS, YRCONNECT, INCOME, FMSIZE, OCUPN.
### Appendix 6.17.B: Improved Logistic Regression Model Results on Improved Mother’s Health Due to Presence of Electricity Services

<table>
<thead>
<tr>
<th></th>
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<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.698</td>
<td>.132</td>
<td>28.064</td>
<td>1</td>
<td>.000</td>
<td>2.010</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>1.916</td>
<td>.322</td>
<td>35.362</td>
<td>1</td>
<td>.000</td>
<td>6.796</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.506</td>
<td>.346</td>
<td>52.347</td>
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<td>.000</td>
<td>.082</td>
</tr>
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</table>

a. Variable(s) entered in the model: ACCESS, YRCONECT

### Appendix 6.18: Logistic Regression Model Results for Reported Changes in Prevalence of and Death from HIV/AIDS

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.164</td>
<td>.102</td>
<td>2.601</td>
<td>1</td>
<td>.107</td>
<td>1.178</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>.150</td>
<td>.114</td>
<td>1.750</td>
<td>1</td>
<td>.186</td>
<td>1.162</td>
</tr>
<tr>
<td>INCOME</td>
<td>.062</td>
<td>.266</td>
<td>.055</td>
<td>1</td>
<td>.815</td>
<td>1.064</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.083</td>
<td>.064</td>
<td>1.669</td>
<td>1</td>
<td>.196</td>
<td>1.086</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.012</td>
<td>.073</td>
<td>.027</td>
<td>1</td>
<td>.870</td>
<td>1.012</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.944</td>
<td>.485</td>
<td>16.084</td>
<td>1</td>
<td>.000</td>
<td>.143</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, YRCONECT, INCOME, FMSIZE, OCUPN.

### Appendix 6.19: Logistic Regression Model Results for Reported Availability of Sufficient and Clean Water for Household

<table>
<thead>
<tr>
<th></th>
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<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>.820</td>
<td>.147</td>
<td>30.959</td>
<td>1</td>
<td>.000</td>
<td>2.270</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>.570</td>
<td>.192</td>
<td>8.768</td>
<td>1</td>
<td>.003</td>
<td>1.768</td>
</tr>
<tr>
<td>INCOME</td>
<td>-1.800</td>
<td>.375</td>
<td>23.103</td>
<td>1</td>
<td>.000</td>
<td>.165</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.093</td>
<td>.075</td>
<td>1.534</td>
<td>1</td>
<td>.216</td>
<td>1.097</td>
</tr>
<tr>
<td>OCUPN</td>
<td>.133</td>
<td>.107</td>
<td>1.559</td>
<td>1</td>
<td>.212</td>
<td>1.142</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.757</td>
<td>.619</td>
<td>8.055</td>
<td>1</td>
<td>.005</td>
<td>.173</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: ACCESS, YRCONECT, INCOME, FMSIZE, OCUPN.
Appendix 6.20: Logistic Regression Model Results for Long Distance Travel for Water Collection

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS</td>
<td>-.066</td>
<td>.102</td>
<td>.421</td>
<td>1</td>
<td>.517</td>
<td>.936</td>
</tr>
<tr>
<td>INCOME</td>
<td>.085</td>
<td>.281</td>
<td>.092</td>
<td>1</td>
<td>.761</td>
<td>1.089</td>
</tr>
<tr>
<td>YRCONECT</td>
<td>-.536</td>
<td>.141</td>
<td>14.372</td>
<td>1</td>
<td>.000</td>
<td>.585</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>.106</td>
<td>.066</td>
<td>2.633</td>
<td>1</td>
<td>.105</td>
<td>1.112</td>
</tr>
<tr>
<td>OCUPN</td>
<td>-.104</td>
<td>.087</td>
<td>1.446</td>
<td>1</td>
<td>.229</td>
<td>.901</td>
</tr>
<tr>
<td>Constant</td>
<td>-.054</td>
<td>.514</td>
<td>.011</td>
<td>1</td>
<td>.917</td>
<td>.948</td>
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</table>

a. Variable(s) entered in the model: ACCESS, INCOME, YRCONECT, FMSIZE, OCUPN.

Appendix 6.21: Logistic Regression Model Results for Reduced Time in Water Collection

<table>
<thead>
<tr>
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<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YRCONECT</td>
<td>-.359</td>
<td>.121</td>
<td>8.837</td>
<td>1</td>
<td>.003</td>
<td>.698</td>
</tr>
<tr>
<td>ACCESS</td>
<td>-.405</td>
<td>.101</td>
<td>16.071</td>
<td>1</td>
<td>.000</td>
<td>.667</td>
</tr>
<tr>
<td>INCOME</td>
<td>.626</td>
<td>.284</td>
<td>4.866</td>
<td>1</td>
<td>.027</td>
<td>1.870</td>
</tr>
<tr>
<td>FMSIZE</td>
<td>-.002</td>
<td>.065</td>
<td>.001</td>
<td>1</td>
<td>.978</td>
<td>.998</td>
</tr>
<tr>
<td>OCUPN</td>
<td>-.081</td>
<td>.078</td>
<td>1.085</td>
<td>1</td>
<td>.297</td>
<td>.922</td>
</tr>
<tr>
<td>Constant</td>
<td>1.716</td>
<td>.498</td>
<td>11.877</td>
<td>1</td>
<td>.001</td>
<td>5.562</td>
</tr>
</tbody>
</table>

a. Variable(s) entered in the model: YRCONECT, ACCESS, INCOME, FMSIZE, OCUPN.
## Appendix 6.22: Logistic Regression Results of RE Impacts in Influencing Gender Relations

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity access improved women-run businesses</td>
<td>INCOME</td>
<td>.853</td>
<td>.333</td>
<td>6.551</td>
<td>1</td>
<td>.010</td>
<td>2.346</td>
</tr>
<tr>
<td></td>
<td>YRCONECT</td>
<td>1.816</td>
<td>.233</td>
<td>60.950</td>
<td>1</td>
<td>.000</td>
<td>6.148</td>
</tr>
<tr>
<td></td>
<td>OCUPN</td>
<td>.213</td>
<td>.110</td>
<td>3.743</td>
<td>1</td>
<td>.053</td>
<td>1.237</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
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<td>.627</td>
<td>21.888</td>
<td>1</td>
<td>.000</td>
<td>.053</td>
</tr>
<tr>
<td>Changes in non-farm and off-farm income generation/employment for women</td>
<td>INCOME</td>
<td>.692</td>
<td>.256</td>
<td>7.281</td>
<td>1</td>
<td>.007</td>
<td>1.997</td>
</tr>
<tr>
<td></td>
<td>ACCESS</td>
<td>.574</td>
<td>.075</td>
<td>58.604</td>
<td>1</td>
<td>.000</td>
<td>1.776</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
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<td>.225</td>
<td>35.031</td>
<td>1</td>
<td>.000</td>
<td>.264</td>
</tr>
<tr>
<td>Changes in workload for women due to electricity access</td>
<td>ACCESS</td>
<td>.280</td>
<td>.108</td>
<td>6.714</td>
<td>1</td>
<td>.010</td>
<td>1.323</td>
</tr>
<tr>
<td></td>
<td>YRCONECT</td>
<td>.498</td>
<td>.122</td>
<td>16.774</td>
<td>1</td>
<td>.000</td>
<td>1.645</td>
</tr>
<tr>
<td></td>
<td>FMSIZE</td>
<td>.160</td>
<td>.069</td>
<td>5.320</td>
<td>1</td>
<td>.021</td>
<td>1.174</td>
</tr>
<tr>
<td></td>
<td>OCUPN</td>
<td>- .203</td>
<td>.083</td>
<td>6.055</td>
<td>1</td>
<td>.014</td>
<td>.816</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-1.763</td>
<td>.522</td>
<td>11.410</td>
<td>1</td>
<td>.001</td>
<td>.172</td>
</tr>
<tr>
<td>Most exposed to pollution in household</td>
<td>FMSIZE</td>
<td>.826</td>
<td>.240</td>
<td>11.882</td>
<td>1</td>
<td>.001</td>
<td>2.284</td>
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<tr>
<td></td>
<td>Constant</td>
<td>.912</td>
<td>.542</td>
<td>2.828</td>
<td>1</td>
<td>.093</td>
<td>2.489</td>
</tr>
<tr>
<td>Changes in workload for women due to electricity access</td>
<td>FMSIZE</td>
<td>- .276</td>
<td>.076</td>
<td>13.111</td>
<td>1</td>
<td>.000</td>
<td>.758</td>
</tr>
<tr>
<td></td>
<td>INCOME</td>
<td>1.203</td>
<td>.284</td>
<td>17.971</td>
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<td>.000</td>
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<td>.304</td>
<td>6.820</td>
<td>1</td>
<td>.009</td>
<td>.453</td>
</tr>
<tr>
<td>Changes in electricity access for both women and men</td>
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<td>.272</td>
<td>.098</td>
<td>7.681</td>
<td>1</td>
<td>.006</td>
<td>1.313</td>
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<tr>
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<td>YRCONECT</td>
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<td>.120</td>
<td>20.667</td>
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<td>.000</td>
<td>1.726</td>
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<td>.207</td>
<td>50.234</td>
<td>1</td>
<td>.000</td>
<td>.230</td>
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</table>

Note: Variables in the models represent only those that passed significance tests.
Appendix 6.23: Perceived Household Benefits of RE

<table>
<thead>
<tr>
<th>Study Towns</th>
<th>Percieved Primary Household RE Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankober</td>
<td>- improved health/ avoided kerosene smoke</td>
</tr>
<tr>
<td></td>
<td>- improved night reading for students</td>
</tr>
<tr>
<td>Kottu</td>
<td>- expanded town with facilities &amp; milling</td>
</tr>
<tr>
<td>Shola Gebaya</td>
<td>- decreased work burden</td>
</tr>
<tr>
<td>Average</td>
<td>- work extra hours at night</td>
</tr>
<tr>
<td></td>
<td>- new small businesses have opened</td>
</tr>
<tr>
<td></td>
<td>- got information through radio/ TV</td>
</tr>
</tbody>
</table>
Appendix 7: Survey Instruments Used in Collecting Field Data

Assessing the Impacts of Rural Electrification in Sub-Saharan Africa: The Case of Ethiopia

Survey A: Household Survey
(To be administered in each of the selected household – up to 400)

Household Characteristics
Energy Procurement and Use
Public Service
  3.1 Education Services
  3.2 Health practices
  3.3 Safe drinking water supply
  3.4 Grinding mills
Gender Relations
Household Livelihood
  4.1 Household Ownership of Assets
  4.2 Household Expenditures
  4.3 Household Income
  4.4 Household access to development services
  4.5 Change in livelihood
Environment and natural Resources Management Practices

Zone: _______________________________
District: _______________________________
Town: _______________________________
County: _______________________________
Household Identity code: _______________________________

Questionnaire Identification No: _______________________________

Enumerator: _______________________________ Signature: _______________________________

Date Questionnaire is filled _______________________________

Interviewing started at: _______________________________ completed at _______________________________ hours
Verbal Consent given: Yes _____ No _______
A.1. Household Characteristics
1.1 Year since household was formed _______Years.
1.2 Household members register chart (Start with household head)

<table>
<thead>
<tr>
<th>HH Member Code</th>
<th>Age</th>
<th>Sex</th>
<th>Level of Education</th>
<th>Relation to HHH</th>
<th>Occupation</th>
<th>Monthly Income</th>
<th>Marital Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HH Head</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Spouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total # of Members</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.3 Household Members Deceased including at Birth and Infants

<table>
<thead>
<tr>
<th>Deceased HH Member Code</th>
<th>Sex</th>
<th>Age at Death</th>
<th>Date of Death</th>
<th>Relation to HHH</th>
<th>Level of Education</th>
<th>Reason for Death</th>
<th>Treatment at Time of Death?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


A.2 Energy: Household Energy Consumption Structure

2.1 Household Energy Procurement and Use Table

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Monthly Utilization</th>
<th>Total in money value (birr)</th>
<th>End – Use in Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purchased</td>
<td>Own Produce</td>
<td>Qt.</td>
</tr>
<tr>
<td>1. Wood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Charcoal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. BLT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Dung</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Kerosene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Battery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Electricity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other(Specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

__
2.2 If energy is collected/produced in household, who collects energy?_______________
2.3 How many people are involved in energy collection per week? _______ people;
2.4 How long is spent in energy collection/production & delivery for one trip?
_____ hours/week
2.5 How far do you travel to collect energy? Total Kms traveled per trip_____ # of travel
per week _____ times.
2.6 Did the household’s access to energy services improve or deteriorate over the last five
years? ______________
2.7 If improved or otherwise please state reason and extent of change ______________

2.8 If you often faced energy access challenges, what remedial measures do you apply to
solve these challenges? __________________________
2.9 Do you use fuel saving stoves? Yes/ No ______ If no, why aren’t you using one?

2.10 Do you have access and connection to Electricity? Yes ____/ No ____.
2.11 If yes, answer the following: If no go to 2.26. below:
2.12 Before the household got connected to electricity services, how much was your
kerosene and battery use for lighting and other services? (a) kerosene_______ liters per
month which is equal to Birr _____ per month (b) Batteries ______ units/ month,
equivalent to ___ birr/ month
2.13 How much are you billed per every month at an average? _____Birr/ Month
2.14 Are you comfortable with your current use and billing? Yes__/ No ___
2.15 If not comfortable, why not? __________________________
2.16 What suggestions do you have for improvement? __________________________

2.17 What specific end-uses are you using electricity for?
   i.______________________ ii. _____________ iii ______________________
2.18 Why is your household electricity use limited only to the above mentioned end-
   uses? ______________
2.19 If these key challenges are surmounted, for what additional end-uses you would be
   using electricity for? __________________________________________
2.20 Has your household electricity use been affected due to lack of access to appliances?
   Yes/No _____ Explain in what way it is affected or not affected. __________
2.21 Has your household electricity use been affected due to lack of access to appliances?
   Yes/No _____ Explain in what way it is affected or not affected. __________

2.22 Has your electricity consumption increased or decreased over the years since
   connection? Increased by i) _________ % , ii) decreased by _________%, no
   change__________.
2.23 Reason for increase or decrease or for no change?________________________

2.24 What aspect of your livelihood has changed since you got connected to electricity
   services? (small business/income, education/reading, health/sanitation, women safety,
   water supply, etc.)______________________________________________

2.25 What household and community level benefits did you achieve since the community
   got connected to electricity services? (mention what has changed and explain in what
   way it changed): __________________________________________
For households with no electricity connection:

2.26 If Household does not have electricity connection while power is available in the community, why didn’t you get connected? _____________________________
__________________________________________________________________.

2.27 If Household does not have electricity connection while power is available in the community, when are you planning to get connected? _____________________________

2.27 If lack of access is due to high cost of connection:
2.28 How much are you willing to pay for connection charges? Birr______
2.29 What type of connection arrangement would you suggest? __________________
______________________________________________________________________

2.30 If lack of access is due to absence of electricity or due to delay in extending the line, would you connect if delivered to town? Yes___/ No ____ 2.31 if no, why not? ______

2.32 If you get connected to electricity, how much bill would you be willing to pay? ______Birr/month
2.33 What end-uses would you afford to use electricity for?
i.______________________ ii. ___________________ iii_____________________
2.34 What type of benefits do you foresee and what aspects of your life would improve of being connected to electricity? (ex. economic, education, health, environmental, gender equality benefits) a) ______________________________________________________
b) ___________________________________________________________________
c) __________________________ ____________________________________________
d) ___________________________________________________________________

A3: Access to Public Services: Education, Health, Safe Drinking Water And Grinding Mills

A3.1. Access To Education Services
1. Do you send school-age family members to school? A)Yes all___, (b) yes partially____, (c) none all ____ , (d) No children to send_____. (check with Q. A1)
2. If answer is a and b, how many family members go to school? ______________
3. If answer is b and c, explain why all school-age children are not attending school (check if distance, gender based decisions/ early marriage, money shortage, etc. affected school attendance decisions) ____________________________
4. How does access to electricity influence school attendance, studying and performance at school? (use support of school attendees in household) ____________________________

5. What aspects of school and learning improvement have you noticed in the household and in community after being connected to electricity services? Which ones of the following has taken place?:
- child friendly environment has been created such as improved child attendance?______
- has it contributed to increasing study time at home for students? __________________
- has schools drop out figures been reduced? ________________________________
- did adult and non-formal education increase as a result? ___________________
- has lighting at schools and residences contributed to retaining teachers? ______
- did access to education media/ ICT, distance learning and communication in schools increase/ improve? ____________________________
- did use of equipment for education improve? ________________________________
- did quality of education change/ improve? _________________________________
- has lighting at schools and residences contributed to retaining teachers? ______
- did access to education media/ ICT, distance learning and communication in schools increase/ improve? ____________________________
- did use of equipment for education improve? ________________________________
- did quality of education change/ improve? _________________________________

8. If household/ community is not connected to electricity, what could have changed in terms of school enrolment and facilitating studying if connected to electricity? ______

A3.2: Access To Health Services
1 General Health Issues

1.1 What are the most prevalent diseases in the family and in the community? _______

1.2 Where do you go for treatment? ________________________________

1.3 Do you apply traditional treatments? Y/N _____ Why? ________________

1.4 Has community and family health status improved over the last ten years? Yes/ No change/ deteriorated ___________ If yes, what has changed? If no, why not? If deteriorated, why? __________________________________________________________

2. Reduced Child Mortality
2.1 Was there a situation where there was under five years old child death in the household? Y/N _______ (check with Q1 on family member death history).

2.2 If yes, state the reasons for death. __________________________

2.3 Has occurrence of child life threatening diseases increased or decreased in your household? ____________, 2.4 Reason for increase/ decrease ________________

2.5 Did treatment against such child health threatening diseases improved, deteriorated or no change? __________ 2.6 Reasons for change? ____________________________

2.7 Do you get your children immunized as required? Y/N ____________________

2.8 If not, why not? ________________________________

2.9 Which of the following child mortality related benefits were observed due to household’s connection to electricity?
- reduced child mortality? __________ if yes, by how much? ______________
- reduced indoor air pollution for children? __________________________
- reduced exposure of children to risks / improved child care? ______________
- improved nutritious food preparation,
- improved health/ sanitation for children? ______________________________
- access to pumped and purified water? _________________________________
3. Improved Maternal Health
3.1 Do mothers in the household get immunized while pregnant? Y/N______________
3.2 If not, why not? ________________________________
3.3 Do mothers in the household follow-up their pregnancy? Y/N ________________
3.4 If not, why not? ________________________________
3.5 Do mothers in the household deliver at clinics/hospital? Y/N ________________
3.6 If not, why not? ________________________________
3.7 Do mothers in the household get sanitation, child care and MCH advice from local health facility? Y/N ________________
3.8 If yes, what type services? ________________
3.9 If not, why not? ________________________________
3.10 Which aspects of the following were changed due to household’s connection to electricity?
- improved health services, medical facilities for maternal care? ________________
- reduced workload for pregnant women? ________________
- other maternal benefits due to connection to electricity services? ________________

4 HIV/AIDS, Malaria, and other major diseases
4.1 Has the prevalence, infection rates and number of death due to HIV/AIDS in your neighborhood increased/ decreased or no change? ________________
4.2 What do you thing are the main factors for these changes? ________________
4.3 What preventive actions does the household take to prevent infections with HIV? ________________
4.4 Has infection rates and number of death due to major diseases such as TB increased/ decreased in your neighborhood? ________________
4.5 What do you thing are the main factors for these changes? ________________
4.6 What preventive actions does the household take to prevent infections with TB? ________________
4.7 How does access to electricity influence access to health services and decrease in death rates? ________________
4.8 If household is not connected to electricity, what could have changed in terms of better access to health services and facilitating healthy life if connected to electricity? ________________

5 Sanitation Practices:
5.1 Does the household have separate kitchen? Y/N ________
5.2 If no, why not? ________________________________
5.3 If yes, does it have a chimney and minimize smoke ________________________________
5.4 What is the households experience with smoke related exposure and who suffers most? ________________________________
5.5 Does the household have adequate and clean latrine? Y/N __________ If no, why not? ________________________________
5.6 What other sanitation problems does the household face? ________________________________
5.7 What sanitation measures does the household take to improve childcare, prevent diseases, and related purposes? ________________________________

5.8 What sanitation benefits were gained due to household’s connection to electricity?

A3.3 Access To Safe And Adequate Drinking Water

1. Do you have access to clean drinking water? Y/N_____ If no, why not/ if yes, how do you get it? ___________________________________________

2. Do you have to travel to collect water? Y/N ______; If yes, how far do you have travel to collect potable water? _____________________________

3. How many hours are spent in collecting water per week? ______________

4. Who collects water for household use? ________________________________

5. If water is unsafe, what types of diseases are caused by water? ______________

6. Do you have enough water for other uses than drinking? Y/N ______; If yes, for what uses/ if no, why not? ________________________________

7. If with no access to safe drinking water, what is being considered to alleviate this problem? _________________________________________________

8. Could connection into electricity services enhance your access to clean, safe and adequate drinking water? Y/N_____; If yes, how? ________________________________

A3.4 Access To Grinding Mills And Other Services

1. Do you have access to grinding mill/s? Y/N_____; If yes, what energy is used to drive the mill? _______________________________; If electricity driven, what are the benefits you got from diesel driven mills? _________________________________

2. If electricity driven, what was your mill like before electrification ______________

3. If diesel driven, what are the disadvantages you faced? _________________________________

4. If town is connected to electricity services, what other mechanical drive services are available? _________________________________

5. If currently not connected to electricity services, how do you believe you milling services would be improved and existing challenges alleviated? _________________________________

6. If not connected to electricity services, how do you believe the town will benefit from electricity driven mechanical power after electrification? _________________________________
A.4. Gender Relations, Workload, Access, And Positions
Which ones of the following gender related changes were observed due to having access to electricity services?

1 Daily work calendar: Total working hours improved for women? ____________
   If so, how? ______________________________

2 Gender division of labor in the household: workload for women improved in relation to men? (food preparation ___, cleaning____, child care____, selling/ buying produce___) if improved how? ________________________________

3. Non-farm and Off-farm income generation activities: Did the role of women change in contributing to non-farm and off-farm activities? (example: shop keeping, bee keeping, etc. as applicable) Y/N ______. 4.2 If yes, which ones? ______________

3.3 What major changes were obtained in the form of income generating activities and income due to having access to electricity? For women? _____________________________ For men? ______________________________________

4. Gender division of labor in community (wedding, funerals, etc.): 4.1 What changes were observed in community related services due to having access to electricity services? For women_____________________________ For men? ________________________

5 Decision making: 5.1 What changes were observed in decision making roles for women and men due to having access to electricity services? ______________________
   _______________________________________________________________________

6. Access to and control over resources: 6.1 Who has access to: ? Women, Men, Both education ____, employment ____, credit____, training___, information ___ extension services____.
   6.2 What changes were observed in access to and control over resources for men and women due to having access to electricity services? _____________________________

7. Ownership: 7.1 Who owns the following? (Women-W, Men-M, Both): land ____,
   house ____ , livestock_____  7.2 What changes were observed in ownership for men and women due to having access to electricity services? _____________________________

8 Position of women in household, community: As a result of connection to electricity services, has workload and condition of women in the community improved? (example meetings, confidence, elections, leadership, jobs) Y/N ______. 9.8 If yes, how/ why?______
   ________________________________________________________________________
   9.9 If no, why not?_________________

9.1 Which improvements were observed due to connection to electricity services?
   - reduced exposure to indoor air pollution and better health for women and children/ ___
   - improved home study for women and increased evening classes? ____________
   - improved women safety due to improved street lighting? ______________
   - improved/ increased women enterprises/ _________________________________

10. If not connected to electricity, do you believe connection to electricity services will improve the condition and position of women? Y/N ______. If yes, in what way? _____
A5: Household Livelihood And Poverty Reduction Efforts

5.1 Does your household have food enough (3 meals a day) for all family members all year round? Y/N ________ 5.2 If no, why not? _______________________________

5.3 If household does not have enough food, how many times in a day do you get food? ______ times

5.4 Most frequently prepared food type in household? ________________

5.5 From what source do you get your food (own production, purchase, aid) __________

5.6 Household Ownership of Assets: 1. land____ha, 2. house___, 3. livestock:
  a) Oxen____, b) Cows____, c) Sheep____, goats____, d) donkey____, Other ________
  i. 4. household assets: (a) radio___, b) television___, c) beds____, Other d)_____
  e) ______

5.7 Household Expenditures: (list all household expenditures in month, 3 months, 6 months, annually as appropriate)

1. Food expenses
   1.1 cereals (teff, wheat, barley, etc.): qt. _____unit ___ period_______ in birr_______
   1.2 fruits and vegetables- qt. _____unit ___ period_______ in birr_______
   1.3 food oil and butter: qt. _____unit ___ period_______ in birr_______
   1.4 pepper, shiro, kik, misir, and spices: qt. _____unit ___ period_______ in
      birr_______
   1.5 meat (beef, lamb, chicken, etc.): qt. _____unit ___ period_______ in birr_______
   1.6 milk, coffee, and tea: qt. _____unit ___ period_______ in birr_______
   1.7 drinks (tella, arekia, tej, etc.): qt. _____unit ___ period_______ in birr_______
   1.8 others (specify) a. qt. _____unit ___ period_______ in birr_______
      b. qt. _____unit ___ period_______ in birr_______

2. Energy (refer to no. 2 of this questionnaire): total energy expenditure___ __birr/month

3. Grinding mills service __________birr per month

4. Water utility expenses __________birr per month

5. Sanitation and hair/body care (soap, toilet papers, etc) ____________birr per month

6. Clothing and shoes: __________birr per year

7. Health and medical expenses __________birr per year

8. Transport (all forms of transport) __________ birr per year

9. Education (school fees, uniforms, stationery, distance learning expenses) ___ birr/year

10. Telephone expenses ______birr per month

11. Purchase of durable goods and household furniture (sofa, radio, TV, chairs, tables, cooking utensils, etc.) : _____________birr per year

12. Agricultural input including purchase of live animals _______ birr per year

13. Taxes __________birr per year

14 Debt and outstanding bill payments _______ birr per year

15. Contributions (for membership, community expenses): _____________birr per year

16. Other expenses (specify)

   a. _____________ _____ birr per _______
   b. _____________ _____ birr per _______
   c. _____________ _____ birr per _______

Grand total of household annual expenditure _____________birr.
5.8 Household Access to Development Services
1 Do you benefit from development services provided in your area/community? Y/N__
   2 If yes, what type of services do you get? (ex. credit, training, business/employment
generation, etc) ________________________________________________________
3 Do you have access to credit services? Y/N____ 5.3.3.1 If yes, how much did you
   borrow? Birr______ at what interest rate?______ who in the HH has access to credit?__
4 Do you get capacity building support?: training Y/N____, business support Y/N____,
gender equality Y/N____, literacy Y/N____, improved agriculture/resource
   management Y/N ___.
5 Are you a member of community based organizations? Y/N ___. If yes, which ones?
   ___________________________ What benefits did you gain from it? ____________________________

5.9 General Improvement in Household Livelihood
1 Has your household livelihood improved/worsened over the past five years? _______
   2 If improved how and why was it improved/worsened? __________________________
3 Has your household income improved over the last five years? Y/N __________
   2 If income/employment improved, why and from what sources?__________________
4 How did general price increase affect your livelihood? __________________________
   __________________________________________________________
5 What efforts do you do to compensate for worsening livelihood such as price rises?
   __________________________________________________________
6 Do you believe the presence/absence of electricity had an impact in the way you live
   now? Y/N __________ 6.2 In what way did it influence your livelihood? _____________
7 Which aspect of livelihood changes were due to access to electricity services?
   enterprise development?________________________income generation beyond lighting hours?
   __________________________improved productivity due to increased use of machinery?
   __________________________improved employment opportunities?
   __________________________improved energy efficiency/ cost saving?
   __________________________better storage and post harvest prevention?
   __________________________Other electricity access related impacts? __________________________
8 Have you heard of the MDGs? Y/N __________ 8.2 What did you or your community
   benefit from it? __________________________

6.1 Do you do environmental management practices? Y/N _________ 6.1.2 If yes, which ones?

6.2 What environmental management initiative and support are provided by government or development actors in the area? __________________________________________

6.3 Has your overall environment and natural resource management practices improved over the last five years? Y/N ______ 6.3.2. If no, why not? ____________________________

6.3.3 If yes, which ones of the following do you apply or started applying over the last 5 years?

6.4 Do you plant trees? Y/N _______ How many trees have you established?___________

6.5 Are you energy self-sufficient from your own tree plantation Y/N ______ ________

6.6 Do you apply improved soil conservation practices? Y/N ______ ________

6.7 Do you apply improved water conservation practices? Y/N ______ ________

6.8 Do you apply other improved farming practices ____________________________

6.9 Do you use improved sanitation practices? Y/N ______ Which/ how?___________

6.10 What is your observation of changes in natural resource management practices and agriculture and farming systems improvement in your area over the last five years? (fill in each one: significantly improved, little improvement, no change, worsened together with explanation)

a. Property rights on land/ common properties_____________________________________

b. Marginal land management __________________________________________________________________

c. Number and coverage of tree planted______ ____________________________________________

d. Deforestation _________ __________________________________________________________________

e. Soil erosion ________________________________________________________________

f. Water run-offs, flooding and silting ___________________________________________

g. Farming systems improvement?_________________________________________________

h. Composting and natural fertilizer production/use ______________________________________

i. Food productivity of the land____________________________________________________

Water/ spring occurrence / river regular water flow_______________________________

j. Wild life habitat occurrence _____________________________________________________

k. Animal feed availability________________________________________________________

l. Livestock management practices ______________________________________________

m. Availability of biomass/ fuel wood for energy use _____________________________

6.11. Were natural resource/ environmental management practices coordinated with national policies? Y/N _____ Explain _________________________________________

6.12 In what way did access to electricity contributed to improved natural resource management?______________________________________________________________

6.13. What community and local efforts are put over the last five years to improve the environment and natural resource management practices in the area? ___________________________

6.14. What major challenges are faced due to deteriorating environment? __________

6.15. What needs to be done to improve the environment/ resource management? ______
Survey B: Study-Area Supplementary Surveys

I. Population and Resources survey (one in each of the 4 survey areas)
II. Local Public Services Survey (one in each of the 4 survey areas)
   3.1 Education
   3.2 Health
   3.3 Safe and adequate drinking water
   3.4 Grinding mills and other services
III. Local Business Survey (all non-household based businesses 15-20 in each of 3 areas)
IV. Local Government and Development Partners Impact Survey (about 4 in a survey area)
V. Local Market Survey (one in each the 3 survey areas)
VI. Local Energy/ Power Suppliers Survey (one for every major energy supplier in each of the 3 survey areas)

Zone: _______________________________
District: _______________________________
Town: _______________________________
County: _______________________________
Household Identity code: _______________________________

Questionnaire Identification No: _______________________________

Enumerator: _______________________________ Signature: _______________________________

Date Questionnaire is filled _______________________________

Interviewing started at: ________________ completed at ________________ hours
**Survey B: Area And Community Based Surveys**

**B1. Population And Resources Survey**

1. Total district population ______; Of which: Women _____, Men _____, below 21____
2. Total population in survey town______, Of which: Women _____, Men_____, <21____
3. Number of people employed: in government____ of which: women____, Men_____; In private businesses____ of which: women____, Men_____; In agriculture____ of which: women____, Men_____; in development work____ of which women____, men____
4. Total size of district:
5. Land-Use____________________________________________________________
7. Agricultural produce (2006/7) _____________________________
8. Cattle population __________________________________________________________________

   9.1 changes/ improvement in land-use ___________ in what way changed? ______________
   9.2 improvements in farming systems _______________ in what changed? ___________
   9.3 changes in soil and water conservation ___________ In what way changed? __________

9.4 changes in forestry management and tree planting practices – five years ago? ___________ Current changes and overage? ______________

In what way changed? ________________

9.5 Other significant natural resource management changes ________________________________

10. Significantly available local resources: irrigation_____; forest_____; hydro-electricity potential________________________________________

Other resources potential (specify)____________________________________

11. Is the local resource management and environmental practices linked into a provincial and national level sustainable development policy? Y/N _____ how is it linked? _______
B2. Community/ Public Services Survey

B.2.1 Education

1. Above 12 grade- # in district_____; # in town_____; av. # of students____ of which F____ M____; av. enrolment rate ____%, F____ M____; av. dropout rate, ____%, F____ M____;
   av. # of teachers___

2. High school- # in district_____; # in town_____; av. # of students____ of which F____ M____; av. enrollment rate ___, F__ M__; av. dropout rate, __, F__ M__; av. # of teachers___

3. Elementary schools # in district_____; # in town____; Av.# of students____ of which F____ M____; Av. enrolment rate __, F___ M___; av. dropout rate, ___, F___M___; Av.# of teachers___

4. Other education establishments: # in district_____; # in town____; av. # of students____ of which female___ male_____; av. enrollment rate ___, F____ M_____; av. dropout rate, ___, F____M____; Av.# of teachers____

5. What was the overall increase in school enrolment over the last five years? a) high school _____% per year; elementary school ____%/year, c) planned school enrollment target in five years? _____%

6. What was the overall fall in dropout rate over the last five years?  a) high school ______% per year; elementary school ____%/year, c) planned school dropout rate target in five years? _____%

7. # of new schools built over last five years? a) high school #___ b) elementary #____

8. What practical steps were taken to improve quality of education? _______________________
   ______________________________________________________________________

9. Planned new schools to be build over the coming five years? _____High schools ___
   elementary

10. Efforts don in education sector as part of realizing the MDG? _______________________
    ______________________________________________________________________

11. If households and community have connection to electricity services, how does access to electricity influence school attendance, studying and performance at school? (use support of school attendees in household) _______________________
    ______________________________________________________________________

12. What aspects of school and learning improvement are noticed in the community after being connected to electricity services? Which ones of the following has taken place?:
   - child friendly environment has been created such as improved child attendance?_________________________
   - has schools drop out figures been reduced?_______________________________
   - has lighting at schools and residences contributed to retaining teachers?_________________________ 
   - did access to education media/ ICT, distance learning and communication in schools?_________________________

13. If community is not connected to electricity, what could have changed in terms of school enrolment and facilitating studying if connected to electricity? _______________________
    ______________________________________________________________________
### B.2.2. Health

1. Health establishments functional in the area?     Popul’n

<table>
<thead>
<tr>
<th>Type of health serv</th>
<th>total # in district</th>
<th>total # in town</th>
<th># of doctors/ nurses</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1. Hospitals</td>
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<td>1.2 Health centres</td>
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<td>1.3 Clinics</td>
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<td>1.4 Health posts</td>
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2. MDG indicators statistics

<table>
<thead>
<tr>
<th>District/Local area</th>
<th>Reason for change</th>
<th>5 yrs ago</th>
<th>Now</th>
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<tbody>
<tr>
<td>2.1 Child mortality at birth</td>
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<tr>
<td>2.2 Under-five mortality rate</td>
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<td>2.3 % children immunized</td>
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<td>2.4 (1-2 yrs old) against measles</td>
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<td>2.5 Improve maternal health</td>
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<td>Proportion of deliveries attended by skilled personnel</td>
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<td>2.6 2.5 HIV Prevalence</td>
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<td>2.7 HIV related deaths</td>
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<td>2.8 Malaria prevalence</td>
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<tr>
<td>2.9 Malaria related deaths</td>
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<tr>
<td>2.10 Mosquito-net distribution</td>
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<tr>
<td>2.11 # of new TB cases</td>
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</table>

Other health statistics

4. What are the most prevalent types of diseases in the area? ________________________

5. What are the main causes of these diseases? ________________________________

5. How is the functioning of health services facilitated/ affected by the presence/ absence of electricity services? ________________________________________________

6. What major services are enhanced/ not delivered due to presence/ absence of electricity services? ________________________________________________

7. If household and community is connected to electricity services, which of the following child mortality related benefits were observed?
   - reduced child mortality? ___________ if yes, by how much? ___________
   - reduced indoor air pollution for children? ____________________________
   - reduced exposure to risks / improved child care? ______________________
   - improved nutritious food preparation, better health/ sanitation for children? ___________
   - access to pumped and purified water? ________________________________

8. Do mothers in the community get immunized while pregnant? Y/N________  
   If not, why not? ____________________________________________________

9. Do mothers in the community follow-up their pregnancy and deliver at clinics/ hospital? Y/N ________________.  If not, why not? ______________________________

__
10. Do mothers in the community get sanitation, nutrition management, child care and MCH advice from local health facility? Y/N ____________, If yes, what type services? ____________________________
   If not, why not? ____________________________

11. If household/ community is connected to electricity services, which aspects of the following were changed?
   - improved health services, medical facilities for maternal care? ____________________________
   - reduced workload for pregnant women? ____________________________
   - other maternal benefits due to connection to electricity services? ____________________________

12. If HIV prevalence increased/ decreased in the community, ________________
   If increased, why and how? If decreased, why and how? ____________________________

13. If TB cases and deaths decreased/ increased ____________, why? ____________________________

14. Which of the following changes were observed as a result of connection to electricity services?
   - improved health services to combat major diseases such as:

15. If household is not connected to electricity, what could have changed in terms of better access to health services and facilitating healthy life if connected to electricity? ____________________________

16. What health service improvements are needed in the shorter-term? ____________________________
   in the medium-term? ____________________________

B.2.3. Safe And Sufficient Drinking Water

1. Do you have adequate and safe drinking water in the area? Y/N ______

2.1 If yes, what was the means of supply? ____________________________

2.2 Was constructed in ____________(year) By ____________________________

2.3 Who manages the water supply system? ____________________________

2.4 What costs are covered by the community for its sustainable use? ____________________________

2.5 Is electricity used for pumping water? Y/N ______ If yes, sources used? ____________________________
   If no, what other delivery systems are used? ____________________________

2. If there are no safe and adequate water supply,

6.1 Why couldn’t you have one? ____________________________

6.2 Where do households get drinking water from? ____________________________

6.3 Distance traveled? ____________kms, 6.4. Hours spent daily in water collection? Daily? ______
6.5. Who collects water for regular household use? _____________________________
6.6. What water borne diseases are experienced as a result of lack of access to safe
drinking water? ____________________________________________________________
6.7. What sanitation problems are experienced as a result? ______________________

B2.4 Grinding Mills And Other Public Services
1. How many grinding mills operate in the area? _______________________________
2. What are they running with (diesel, electricity)? _____________________________
3. If the area is supplied with electricity, are there cases where electricity is not used?
   __________
4. Was there an effort to building hydro based grinding mill in the area? __________
   __________
5. What was used to grinding before the introduction of ________ run grinding mills? __
   __________
6. If not provided with electricity in the area, would energy sources for grinding mills
   change after electrification? Why, and how? ________________________________

B2.5 Other Public Services ____________________________
B 3. Local Businesses Survey

(This survey excludes household based businesses and includes both formal and informal businesses in the study area)

a. Type of business ___________________

b. Name ___________________ 3. Formal/ Informal?______________

4. Number of employees _______ of which: female______ family owned and run?
   Y/N____

5. Capital Birr_______ Annual revenue Birr_______ Profit_______

6. Energy used for running the business:
   Energy type    end-use    quantity used      cost of energy used
   a) ____________________    _______________    __________   __________
   b) ____________________    _______________    __________   __________
   c) ____________________    _______________    __________   __________

7. If area has got access to electricity and business uses electricity services:
   a) Purposes of use in the business?_________________________
   b) KWH used per month_______
   c) Electricity bills in each month _______ % of all energy used _____%

8. If area has got access to electricity and business does not use electricity, why not?
   ___________________________________________________________________

9. Has there been a major change in the study area due to access to electricity services?
   Y/N _____ If yes, in what way?_____________________________

10. If area has no electricity connection:  a) Would the business have used electricity services? Y/N _____ if no, why? If yes, for what use? ____________________________
    b) Would the business have changed (improved/ expanded) if there was electricity services? Y/N ___, In what way would it have changed? ___________________________
    c) What disadvantage do businesses face due to absence of electricity? ______________
    d) Up to how much would the business be willing to spend for connection? __________
       for monthly bills?_____________________ for appliances_____________________

11. What challenges does the business face? ___________________________________

11. What prospects do you foresee for the future?_____________________________

____________________________________________________________________

Question to Local Business Registration/ Promotion Office

1. How many businesses in the study area? a) formal _____ informal_____ c) by type
   i)_______   , ii)_______, iii)_______ , iv)_______, v)_______

2. How many people are employed a) in formal business sector? __ of which women __
   b) in informal businesses _____ of which women_________

3. Contribution of the businesses to local economy____________________________

4. Any future business development prospects/ plans? ________________________
(This survey will be done with local government representative offices and development partner organizations that are responsible in the planning and coordination of development, poverty reduction and implementation of MDG)

1. What development, policies, plans and programs are designed at local level?
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

2. Are existing local policies, plans and programs coordinated in line with national and provincial PPPs? Y/N _____ If no, why? If yes, how are they coordinated? _________
_____________________________________________________________________

3. What is the role of your organization in facilitating and supporting development in the area? __________________________________________________________________
_____________________________________________________________________

3.2 Which major activities are you implementing in the area? __________________
_____________________________________________________________________

3.2 What major achievements and impacts have you recorded so far? ___________
_____________________________________________________________________

4. Are UN Millennium Development Goals under implementation by your organization/ in the area? Y/N _____ if no, why not? If Yew, which ones? ______________________
_____________________________________________________________________

5. If MDG is being implemented, which ones are being implemented?____________
_____________________________________________________________________

5.2 Where does the fund come from?________________________________________

5.3 How much is allocated per year?_______________________________________

6. What are the achievements in realizing the MDG so far? __________________
_____________________________________________________________________

7. Who are the major development partners in the area? _____________________
_____________________________________________________________________

8. Are most of the development activities in the district implemented in a coordinated manner? Y/N _____ if yes, how are they coordinated? _________________
_____________________________________________________________________

9. What are the major impacts of development activities on the MDG so far? ______
_____________________________________________________________________

10. Did the town benefit from connection to electricity (if connected) or missed development opportunities (if not connected)? Y/N _____ If yes, in what way? __________________________________________________________________

11. Could you give some examples where connection to electricity services have impact on achieving the MDG? __________________________________________________________________

12. What suggestion do you give to improve coordination of development and impacts to achieve the MDG? _________________________________
B5. Local Energy/ Power Suppliers Survey

(This survey will be administered for local energy supply centres only including: Fuelwood, Charcoal, Diesel, Kerosene, and Electricity)

1. **Type of energy marketed** __________________ Number of suppliers in town______

2. **Quantity of the specific energy sold per month______/___ Price per unit_____/___ Seasonal price variation from ______ to ______

3. **Who are the major customers**______________________________

3.2 How many of these customers buy form this supplier? __________________________

3.2 Where is the man supply source?_______________________________________

3.3 How many diesel/ oil run generators and water pumps are estimated to exist in the district? ______________ estimated fuel consumption? ______________

3.4 How much fossil fuel could be replaced if connected to electricity? ______________

4. For Local Power Supplier

4.1 What year electricity connection take place? __________ Interconnected? ______

4.2 How many customers were initially connected? __________ Percent of Total _____%

4.3 What was the annual growth rate of customers? ______________

4.4 How many customers does the supplier has currently? __________

4.5 How many customers have their own meter and contract? __________

4.6 How many customers are informally connected? __________

4.7 Why are informal connections taking place? _______________________

4.8 What is the average household electric energy consumption per month? ____KWh/m

4.9 What is the average household electricity bill per month Birr_____/ month

4.10 What is the total cost of administering and providing electricity services locally? __________/ month (use estimates if no accurate figures)

4.11 What is the total amount of electricity services provided per month? ____KWh/M

4.12 What is the total revenue collected from providing electricity services? ____Birr/M

4.13 Does the supplier breakeven? ______ make profit? ______ under cross-subsidy? ______

4.14 Do peak loads and capacity shortages experience locally? ______________ If experienced, what are the reasons? __________________________

4.15 What major problems are experienced in bill collection, transmission congestion, distribution congestions, peak loads/ outages, etc. ______________

4.16 What remedial measures are applied? __________________________

4.17 What efforts are done to improve household connectivity? __________________________

4.18 What pricing policies are applied different from the national level? ______________

4.19 What electricity conservation and load management practices are promoted? ______________

4.20 What targeted pricing mechanisms are applied to reach the poor? ______________

4.21 How did the connection to electricity services contribute to local economic growth? Give tangible examples of what has been changed and improved: ______________

_____________________________________________________________________________
Survey C. Focus Group Discussions

I. Gender relations, Workload and Positions

II. Environment and Natural Resource Management Practices

Zone: _______________________________
District: _______________________________
Town: _______________________________
County: _______________________________
Household Identity code: _______________________________

Discussion Group comprised _____ persons of which; ______ are women ______ are men and are from _______________________________________________________

Discussion moderated by: _______________________________
Signature:___________________
Date Discussion Held ________________
Discussion started at: ________________ completed at ________________ hours
Consent form read and verbal consent given Yes______ No_______
C1. Gender Relations, Workload, Access, And Positions

1 Daily Work Calendar
1.1 Wake-up time: women____, men_____; 1.2 Sleep time women____, men____
1.3 Total rest/leisure hours in 24 hours, women_______ men____
1.4 Average Total number of hours worked women _____ hours; men ______ hours
4.5 What is the impact of having access to electricity services on total workload and working hours for women? ____________________, for men? __________________

2 Gender division of labor in the household:
2.1 Has workload in household for women increased/decreased in 5 years?______ 2.2 what was the level of change? ________ , 2.3 Which of the following roles changed (show +/-)? food preparation ___, cleaning___, child care___, selling/buying produce___; 2.4 If significant changes what were the main reason for these changes? ____________________________________________________________________________
2.5 Who collects: wood______, (f) water______, (g) grinding milling________
2.6 Which household activities do men do? ______________________________________
2.7 Which household activity do girls and boys do? ____________________________
2.8 Who has got the most exposure to smoke and related diseases in the household? ___
2.9 What health problems are faced due to exposure to smoke ___________________
2.10 What changes were recorded in division of labor as a result of access to electricity services? ______________________________________________________________
2.11 Which changes were observed in household division of labor related to: fuelwood collection? ________________, fetching water? ________________, cooking efficiency? ________________, food processing by hand? ________________, Others (specify) __________________

3. Gender division of labor in agriculture:
3.1 Do women work in Agricultural activities? Y/N _____, If yes, which ones? ______________________________________________________________________
3.2 What changes were observed in gender division of labor in agriculture due to access/no access to electricity services? ______

4. Non-farm and Off-farm income generation activities:
4.1 Do women in household contribute to non-farm and off-farm activities? (example: shop keeping, bee keeping, etc. as applicable) Y/N _____, 4.2 If yes, which ones? ______________________________________________________________________
4.3 Who provides household income? Wife_____ Husband_______ other______
4.4 Number of household members generating income outside agriculture:___ of which women __
4.5 What major changes were obtained in the form of income generating activities and income due to having access to electricity? For women? ______________________ For men? ______________________
5. **Gender division of labor in community** (wedding, funerals, etc.):
5.1 Do women in the household provide labor services in community obligations? (example: preparing food, stewardship, collecting water, collecting wood, etc). Y/N ____
5.2 If yes, which ones? ______________________________________
5.3 Which community services do men provide? ______________________________________
5.4 Did you observe a shift in the volume of community related services for women and men? Y/N ____. If yes, which changes were observed? _______________________
5.5 What changes were observed in community related services due to having access to electricity services? For women____________________ For men? ______________

6 **Decision making:**
6.1 Who decides in your family on: (Women, men, Both) food cooked in the house _____, work to be done _____, food to be bought _____, purchasing cloths _____, allocation of income _____, family planning _____, inviting people _____, marketing farm produce _____, managing stored food _____.
6.2 What changes were observed in decision making roles for women and men due to having access to electricity services? ________________________________________

7. **Access to and control over resources:**
7.1 Who has access to: ? Women, Men, Both education ____, employment ____, credit____, training___, information ___ extension services____.
7.2 What changes were observed in access to and control over resources for men and women due to having access to electricity services? ______________________________________

8 **Ownership:**
8.1 Who owns the following? (Women-W, Men-M, Both): land ____, house _____, livestock____. 8.2 What changes were observed in ownership for men and women due to having access to electricity services? ______________________________

9 **Position of women in household, community:**
9.1 Has the level of participation/role of women improved in the community? Y/N: ______ (example meetings, confidence, elections, leadership, jobs) 9.2 Reason______________________
9.3 Household member elected in community #_____, Of which: # of female_____.
9.4 Has the overall position of women and gender relations in household, community and government improved/ worsened over the last five years? __________.
9.5 If improved, why and how?______________________________
9.6 If worsened, why __________________________
9.7 Has workload and condition of women in the community improved as a result of connection to electricity services? Y/N ______. 9.8 If yes, how/ why?______ 
9.9 If no, why not?_________________________

10. Which improvements were observed due to connection to electricity services?
- reduced exposure to indoor air pollution and better health for women and children/ ____
- improved home study for women and increased evening classes? ________________
- improved women safety due to improved street lighting? ______________________
- improved/ increased women enterprises/ ___________________________________

9.11 If not connected to electricity, do you believe connection to electricity services will improve the condition and position of women? Y/N ______, If yes, in what way? ______

2.1 Does your community do environmental management practices? Y/N____
2.1.2 If yes, which ones? ______________________________

2.2 What environmental management initiative and support are provided by government or development actors in the area? ______________________________

2.3 Has your overall environment and natural resource management practices improved over the last five years? Y/N_____ 2.3.2. If no, why not? ______________________________
2.3.3 If yes, which ones of the following do you apply or started applying over the last 5 years?

2.4 Planting trees? Y/N____ How many hectares have been covered by trees? ______

2.5 Is your community energy self-sufficient from own tree plantation Y/N ______

2.6 Does the community apply improved soil conservation practices? Y/N ________

2.7 Does the community apply improved water conservation practices? Y/N ______

2.8 Does the community apply other improved farming practices__________________

2.9 Does the community use improved sanitation practices? Y/N____ Which/how?________

2.10 What is your observation of changes in natural resource management practices and agriculture and farming systems improvement in your area over the last five years? (fill in each one: significantly improved, little improvement, no change, worsened together with explanation)

a. Property rights on land/ common properties____________________________________
b. Marginal land management ______________________________
c. Number and coverage of tree planted__________________________________________
d. Deforestation _____________________________________________________________
e. Soil erosion ______________________________________________________________
f. Water run-offs, flooding and silting __________________________________________
g. Farming systems improvement? ____________________________________________
h. Composting and natural fertilizer production/use ______________________________
i. Food productivity of the land________________________________________________
j. Water/ spring occurrence / river regular water flow____________________________
k. Wild life habitat occurrence _____________________________________________
l. Animal feed availability ____________________________________________________
m. Livestock management practices __________________________________________
n. Availability of biomass/ fuel wood for energy use ____________________________

2.11. Were natural resource/ environmental management practices coordinated with national policies? Y/N ____ Explain _______________________________________

2.12 In what way could natural resource management be improved if access to electricity is established? _____________________________________________________________

2.13 What efforts are put to improve the environment and natural resource management practices in the area? ________________________________

2.14 What major challenges are faced due to deteriorating environment? ______________

2.15 What needs to be done to improve the environment/ resource management? ______

2.16 How did your community’s access to electricity services influence your natural resource management practices? ______________________________
Appendix 8: University of Victoria Human Research Ethics Board Certificate (Copy)
## Appendix 9: Schedule of Field Activities

<table>
<thead>
<tr>
<th>Research Phase</th>
<th>Field Activities</th>
<th>Duration in Weeks</th>
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| **Drafting of Data Collection Instruments** | - Organize and develop draft data checklist  
- Design draft questionnaire ‘A’  
- Prepare draft discussion checklist for survey ‘B’ | Before travel to Ethiopia and 4 weeks after arrival in Ethiopia | Sept. – Oct. ‘07 | Addis Ababa |
| **Preliminary Field Activities** | - Identify areas & establish field contacts in the four rural survey towns  
- Test the survey questionnaire & checklists (‘A &B’)  
- Conduct reconnaissance survey and collect first hand data/ documents | Total of 4 weeks (1 week in each survey area) | Nov.’07 Nov.’07 | The four rural survey towns of Ankober, Kotu, Shola-Gebeya and Gosh-Bado. |
| **Finalizing Data Collection Instruments** | - Finalise questionnaire ‘A’  
- Develop/ finalise discussion checklist i.e. questionnaire ‘B’  
- Identify and list further data requirements at field level | Total of 2 weeks | Dec.’07 | Addis Ababa |
| **Field Surveys and Discussion** | - Administer household survey ‘A’ and conduct focus group discussions – survey ‘B’  
in Ankober  
in Kotu  
in Shola-Gebeya  
in Gosh-Bado | 2 weeks  
2 weeks  
2 weeks  
| **Coding and Data Entry** | Coding and data entry of survey ‘A’ & ‘B’ | 12 weeks X 3 persons | Jan.-Apl 30/ ‘08 | Addis Ababa |
| **First Hand Data Collection at National Level** | National level data collection and document review | 10 weeks | Apl-Jun 30/ ‘08 | Addis Ababa |
| **Data Collection at Regional Level** | Sub-Saharan Africa level data collection | 2 weeks | June ‘08 | Addis Ababa |
| **Compilation, Coding & Entry of National/ Regional Data** | All data collected at national and regional level will be coded and entered into a computer | 3 weeks | May-June ‘08 | Addis Ababa |
| **Data Analysis and Possible Call-backs** | Preliminary data analysis, validity test and call-backs if needed | 6 weeks | June – July’08 | Addis Ababa and relevant survey areas |
Modern Energy Services (MES) denote energy types that are clean and convenient to use and are delivered after passing through a number of stages of processing and transformation. These include electricity, mechanical power, and improved fuels and devices used for running certain technologies to provide services such as lighting, cooking, heating, processing, mechanical power, and transport (Modi, et.al. 2005). In contrast, traditional energy forms relate to primary forms of energy such as wood, charcoal, and other biomass that are less clean, less efficient and are used to fuel mainly basic household energy needs.

Access and connection to electricity services are given slightly different meanings in this study. Access to electricity services refers to the delivery of electricity to a rural town, while connection represents the actual delivery of electricity services to a particular household. Households may not connect to electricity even when the town has already established access to electricity.

When this PhD field research started in September 2007, Ethiopia produced only 800 MW installed power. By the time this research was completed in September 2011, the country had commissioned three medium sized hydropower plants totaling 1,118 MW over three years – Tekeze 300 MW in 2009, Gilgel Gibe II 420 MW in 2010, and Beles 460 MW in 2010. Construction is underway on two hydropower plants that would produce 7,000 MW, that is 2000 MW at Gilgel Gibe III and 5,250 MW at the Blue Nile Millennium Dam (ESMAD, 2012b).

Unless otherwise specified, a dollar used in this dissertation is meant to represent US dollar.

Agri-residues are residuals that are left behind in the process of agricultural production such as straw, corn, sorghum, and legume stalks. Under energy abundance areas, agri-residues are left in the farm to decompose and be used as natural fertilizers. In fuel-wood scarce areas, they are burned as energy, forgoing their fertilizer benefits.

The word “co-integrated” is used to signify that not only are energy consumption and economic growth interrelated, but also that both change proportionately when one of them changes.

In substituting freely collected biomass fuels by MES, a substantial time saving is expected to take place, which could be additional financial gain. As a result, the share of expenditure on MES could be lower than 41 percent if the time saved due to the use of MES (opportunity cost of labor for biomass fuel collection) is to be accounted for.

Micro-businesses or micro-enterprises are small-size businesses usually established with small amounts of capital of less than Birr 20,000 (US$1,600) and are managed by family labor. They include crafts shops, retail trade, small shops, etc. In contrast, small-scale businesses have a capital of Birr 20,000 to Birr 500,000. (Definition by: Micro and Small Businesses Promotion Agency, Amhara Regional State).


The Ethiopian government measures the income dimension of poverty by taking consumption as a proxy for household income, which reflects a household’s ability to meet basic needs, representing a household’s actual standard of living (welfare) and access to credit and saving at times of decreased income. The level of real total per capita consumption expenditure is estimated at 1,256 Birr per capita per year (US 146) in 2004/5 while total per capita food expenditure was 577 Birr. The balance (Birr 678) was spent on non-food items (PASDEP, 2006).

Poverty line is a line drawn from household expenditure surveys. Households living on or below this level of per capita expenditure per annum are considered to be poor, while those households spending less than the food poverty line per person per year are said to fall below the absolute poverty line.

In the field of data/information search and analysis, sufficient data were generated through the CSA by conducting the Household Income and Consumption Expenditure Survey (HICES) every five years.
Additional sources of data were the Welfare Monitoring Survey (WMS) and Participatory Poverty Assessment (PPA) that are conducted periodically. These sources of data were the basis for the design of a number of poverty reduction strategies and programs.

13 As discussed further in this Chapter, the current arrangement in which EEPCO remains a vertically integrated national power monopoly has helped expedite the development of the power system efficiency, despite registered adverse consequences of more radical reforms of the power sector in other SSA countries.

14 Grinding mills are mentioned throughout this document as one of the few important community services in rural Ethiopia. This is because Ethiopian households, both rural and urban, have a culture of having their grain ground at grinding mill centres under the supervision of the household. In remote rural households where grinding mill services do not exist, grinding is done by hand by female household members.

15 By the time of the survey, Ankober had had electricity access for over five years, while Kotu had over three years of access. Shola Gebeya was being connected to the main grid when the survey was in progress. Gosh Bado was not due to access power until a year later.

16 In places where fuel-wood consumption exceeds its regeneration capacity, fuel-wood induced deforestation takes place, resulting in a two pronged impact on the environment: as a source of pollution in the process of fuel-wood burning at lower efficiency, and as a reduction of carbon sink capacity. Methodology for calculating the impact of biomass burning on green-house gas emission and its displacement thereof can be referenced in: (1) UNFCCC General Guidelines on Leakage in Biomass Project Activities, EB47 Report Annex 28, (version 03), Attachment C of Appendix B. and (2) form R.E.A.P. – Canada, “Displacing Unsustainable Biomass Use and Methodology Issues with Household Cook stoves under the CDM”

17 It is discussed further in this chapter that household and community benefits from connection to electricity services such as productive and business development benefits were the highest in Shola-Gebeya, most likely due to relatively higher population threshold by the time of access to electricity services.

18 Connectivity rate is calculated by taking a total population size of 3772 and a family size of 3.6 (from household survey), and arriving at a total number of households to be 1048.

19 Household factors are affordability and residing in town, while community factors are power supplier and settlement related.

20 Household factors relate to issues at the household level, such as household not being able to pay for connection, and household not yet settled in town. On the other hand, community factors include power provider related problems and newly built villages.

21 About 58 percent of the 31 households that did not have electricity connection in the three rural survey towns lacked financial capacity to pay for connection. Supplier related factors such as shortage of electric meters and shortage of power were mentioned by only 26 percent of the households with no connection.

22 Level of significance for each variable is determined by the value of the column Sig. and by discarding variables with values over 0.05.

23 Lack of sufficient demand and low level of consumption were significant challenges for EEPCO in the past. With growing level of electricity demand following the high pace of rural electrification and faster rate of development, the demand for electricity is likely to increase far higher than what the power supplier will be able to provide in future. The outage of power during the months of May to November, 2009 was temporary in nature and is currently resolved after two new hydropower plants have been commissioned.

24 The relatively lower share of energy expenditure to total household expenditure as compared to total household income reflects the presence of under reporting of household income, which is a very common mistake in household surveys.

25 Survey result shows that mean family size is 3.59 for Ankober, 3.7 for Kotu, 3.56 for Shola Gebeya, and 4.3 for Gosh Bado giving an overall average family size of 3.8 persons per household in the survey areas.
EEPCO power sale receipt data was collected for the towns of Ankober and Kotu for over five years, which was useful in observing historical electricity consumption data for households, businesses, and public services.

This major data difference between the two could be explained by two factors: one is that EEPCO data includes business related consumption data, which household consumption data did not account for. Second, the household consumption data is a sample survey with some sampling error while EEPCO data is actual consumption figure.

Household expenditure tends to be higher than reported household income in most household surveys mainly due to tendencies of households to report lower income and higher expenditures, making it difficult to arrive at accurate accounts.

Energy expenditure figure in Gosh Bado is the lowest, at nearly half that of the other survey towns due to relatively more free collection and use of biomass fuels as the town is more rural than the others. As a result, the level of free collection is in the order of 60 % for wood, 99 % for BLT, and 100 % for dung.

Efficiency losses relate to the amount of useful energy that has been actually utilized in the process of burning a specific fuel. Efficiency losses for fuel-wood using the traditional three-stone stove are as high as 90 percent, as proven in repeated efficiency measurement tests in Ethiopia.

In Ankober area, farmers stock compost throughout the year and in the middle of the summer spread it on their fields using communal labour, with every farmer providing labour on a rotational basis. This tradition has been long established and is one of the very few places in Ethiopia where dung is composted for use as fertilizer in lieu of its use as fuel. As a result, the use of dung as fuel in Ankober area is as low as 4 percent.

Years of electricity access were: 0 for Gosh-Bado, 5 for Ankober, 3 for Kotu, and 1 for Shola Gebeya.

The most commonly used commercial fuels are kerosene, liquefied petroleum gas (LPG), and batteries. The latter is excluded from the study as it is not utilized in rural towns.

It is very common in rural towns for people to use flashlights powered by dry-cell batteries while moving around at night in the absence of electricity based street lighting.

Productive benefits of RE include the use of electricity for businesses that in return provide income and employment. Small businesses and investments are all treated under productive benefits.

For simplicity and for minimizing repetition of logistic regression result tables of non-efficient models, all model results consisting of five independent variables are shown in an appendix while improved model results are presented in the discussion.

One year after the field survey, it was learned that Shola-Gebeya showed remarkable progress in the one year after being connected to electricity services and Gosh-Bado was also in a state of visible socio-economic change immediately after connection to electricity services.

Soccer is a very popular game in Ethiopia with most urban residents watching European soccer leagues, usually on pre-paid TV channels subscribed by bars and public places for customers’ entertainment.

Data on education related changes in the study areas were collected primarily from the survey. Further discussions were held with representatives of educational establishments. Persons contacted were Mr. Aklilu Yirgu (Head, Department of Education, North Shewa Zone, Debre-Berhan), Mr. Desta Ergete (Principal, Gosh-Bado Elementary School), Mr. Simech Lette (Principal, Kotu Elementary School), Mr. Mesfin Asseffa, (Principal, Ankober Elementary School), and Office of Education at Shola –Gebeya.

Interviewed health officers in the study areas include Mr. Dejene Mekitie, Nurse, Kotu Health Centre, Kotu; Mr. Endeshaw H. Michael, Nurse, Kotu Health Centre, Kotu; Mr. Mohammed Said, Expert, Office of Health, Ankober; Mr. Mohammed Adem, Office of Health, Shola-Gebeya; Mr. Fikade Tekle, D. Head of Department of Health, Debre-Berhan.

Of the four rural study towns, Kotu and Shola-Gebeya use water supplied through electric pumps. Ankober does not use electric pumps as water is supplied using gravitational means from a source located at higher
ground. Gosh-Bado uses a diesel powered pump for supplying water to residents, and could not shift to an electric pump due to prevailing acute shortage of electricity services.

A separate kitchen is very common in Ethiopia, even for urban households, as burning solid biomass fuels is customary and causes high levels of pollution with gradual accumulation of carbon deposition on roofs and walls.