

RURAL ELECTRIFICATION IN ETHIOPIA: OPPORTUNITIES AND BOTTLENECKS

By

Aklilu Dalelo (PhD)

Addis Ababa University,

College of Education,

Department of Geography and Environmental Education

P. O. Box 45, Code 1032, Addis Ababa, Ethiopia

akliludw@hotmail.com

Abstract

Rural electrification has long been top on the development agenda of many developing countries. Nevertheless, a vast majority of the population in these countries is still in the darkness. The proportion of rural population in the Sub-Saharan Africa that has an access to electricity is, for instance, as low as 4%.

Electric energy (electric light in particular) is still a luxury enjoyed only by a few in Ethiopia. The rate of electrification in the country is 10% and for rural Ethiopia it is almost nil (less than 1%!). There are 922 towns having more than 2000 households. The population living in these towns makes up only 15% the total. The remaining 85% live in scattered rural villages and have very remote chance to get electricity through the national grid. The only realistic approach to electrify the rural houses seems therefore to be the stand-alone (self contained) system. At present, diesel generation sets are popular and well known in the country. Renewable sources of energy like hydropower and solar energy are, on the other hand, less familiar and their contribution to electrification is minimal.

The aim of this study is exploring the opportunities and bottlenecks to rural electrification through stand alone or self-contained system. The main approach used to collect data was investigating a wide range of secondary sources of information on natural resource base relating to energy; and government policies, which could either encourage or hinder the utilisation of the natural resources for rural electrification.

Content Outline

Abstract.....	
1. Introduction.....	
1.1. Ethiopia: Country Background.....	
1.2. Pattern of Energy Utilisation.....	
2. Rural Electrification in Ethiopia: Potentials.....	
2.1. Resource Base.....	
2.2. Policy Backing.....	
2.3. Huge Market.....	
3. Bottlenecks to Rural Electrification in Ethiopia.....	
3.1. Willingness to Pay and Affordability.....	
3.2. Low Organizational and Managerial Capacity.....	
3.3. Misconceptions about the Private Sector.....	
3.4. Unfair Regulations.....	
4. Conclusions and Recommendations.....	
4.1. Conclusions.....	
4.2. Recommendations.....	
References.....	

1. Introduction

1.1. Ethiopia: Country Background

The Physical Environment

Ethiopia, a country located in the Horn of Africa, extends from 3-15 degrees north latitude and 33-48 degrees east longitude (see Fig.1). The country covers an area of 1.126 million square kilometre (about three times as large as the Federal Republic of Germany) and has a population of about 67 million, 85% of which living in the rural areas.

Fig 1: Ethiopia: Relative location in East Africa



Ethiopia is a highland country with 65% of its total area having an elevation of more than 1400 meters above sea level and a substantial area lying well over 3000m. It should, however, be equally stressed that there are extensive lowlands and conspicuous depressions, one of which having an elevation of about 120 m *below* sea level.

Geographically, the central parts of the country are dominated by highlands, which are divided into two by the Ethiopian Rift Valley. The altitude goes on decreasing from centre outwards almost in all directions. It is, therefore, essential to underline, from the outset, that the marked altitudinal difference (between the central highlands and the lowlands that surround them) has a noticeable effect on the overall state of the

country's environment (Aklilu, 2001). The highlands, just to mention one example, get an average rainfall ranging from 500-2000 mm per annum whereas most of the lowlands receive an amount too little to grow crops. The altitudinal difference also has an important implication to the generation of energy, particularly hydropower.

Pattern of Population Distribution

The Ethiopian highlands, owing to their moderate and friendly climate and absence of some of the most deadly tropical diseases that characterise the lowlands, have attracted most of the human and livestock population. Nearly 50% of the Ethiopian population lives in altitudes above 2200m and 89% in altitude of 1400m and over. It is thus only one tenth of the total population that is inhabiting areas with an altitude below 1400m.

Generally, the interplay between the physical environment and pattern of population distribution in Ethiopia explains, to a great extent, the ever-worsening problem of natural resource degradation as a whole and the problem of deforestation in particular (Aklilu, 2001). This has a direct relationship with the current state of energy utilisation in the country as will be presented in the succeeding sections.

1.2. Pattern of Energy Utilisation

Most of the developing countries are suffering from what many call the energy crisis, which is characterised by depletion of locally available energy resources and dependence on imported fuel. In fact, the energy crisis is believed to be the second most serious problem in these countries next only to the food crisis. What is more, the energy crisis is exacerbating the food crisis by increasing the rate of deforestation and thereby causing degradation of farmlands. Furthermore, dependence on imported fuel is weakening the capacity of the concerned countries to buy food whenever the need arises. All these situations apply to Ethiopia. Traditional fuels contributed 99.9% of the rural energy consumption, with fuel wood being by far the most important source (81.8%), followed by dung (9.4%), crop residues (8.4%) and small amount of charcoal (EPA, 1997a: 107).

On the whole, over 95% of the domestic energy needs are met from bio-fuels thereby contributing to deforestation, loss of soil nutrients and organic matter. Some reports raise this figure to 97% (Anderson et al., 1999:68). In any case, Ethiopia is one of the countries that rely extremely on the biomass (Table 1). According to the Table, 86% of the total and 97% of the household energy consumption depends entirely on the biomass. Furthermore, biomass is expected to retain its dominant position in the coming decades (Table 2). In fact, its contribution in rural areas is estimated to increase from 66% in 1992 to 68% in 2014.

Table 1: Household energy consumption as a percentage of total biomass consumption in a number of selected African countries

Country	Biomass energy consumption (% of total energy consumption)	Household energy consumption (% of total biomass energy)
Burundi	94	78.5
Ethiopia	86	97
Kenya	70	93
Somalia	87	92
Sudan	84	90
Uganda	95	78.6

Source: Karekezi and Ranja, 1997 quoted in Anderson et al. 1999:68

Table 2: Estimates for household energy consumption by source (percent of total energy consumption)

Energy source	Urban		Rural	
	1992	2014	1992	2014
Wood charcoal	62	42	66	68
Dung	16	8	20	13
Crop residue	11	5	14	7
Electricity	3	15	-	5
Kerosene gas	8	20	-	2
Coal	-	10	-	5
Total	100	100	100	100

Source: Ministry of natural resources, 1993 quoted in Tegegne (1995:103)

The three most important rural energy sources, in their order of importance, are fuel wood, dung and agri-residue; while the three most important end-uses are mitad-baking, other cooking and lighting. The implication of this is that, if rural households are provided with electricity, even for lighting, the gain in terms of environmental protection of rural areas is significant (EEA, 2002).

2. Rural Electrification in Ethiopia: Potentials

2.1. Resource Base

There is a huge energy resource potential in Ethiopia, which, if utilised, could minimise the present energy crisis prevailing in the country and enhance the process of rural electrification. The total exploitable renewable energy that can be derived annually from primary solar radiation, wind, forest biomass, hydropower, animal waste, crop residue and human waste is about $1,959 \times 10^3$ Tcal per year (EEA, 2002). Out of this, the share of primary solar radiation is about 73.08 percent, while the share of biomass resources is about 12.8 percent (Table 3).

Table 3: An Overview of Renewable Energy Resources in Ethiopia

No	Energy Resources	Energy in 10^3 Tcal per year			
		Potential	% share	Exploitable	% share
1	Primary solar radiation	1,953,550	99.7	1,954	73.08
2	Wind	4,779	0.24	239	8.94
3	Forest Biomass	800	0.005	240	8.97
4	Hydropower	552.1	0.03	138.00	5.16
5	Animal Waste	111.28	0.01	33.73	1.26
6	Crop Residue	81.36	0.0004	40.63	1.52
7	Human Waste	28.18	0.00014	28.18	1.05
Total		1,959,901.93	100.00	2,673.54	100

Source: CESEN and calculation by EEA (2002)

The most important energy resources available in the country are presented hereunder.

Solar Energy

Studies indicate that for Ethiopia as a whole, the yearly average daily radiation reaching the ground is 5.26 KWh/m^2 . This varies significantly during the year, ranging from a minimum of 4.55 KWh/m^2 in July to a maximum of 5.55 KWh/m^2 in February and March. On regional basis, the yearly average radiation ranges from values as low as 4.25 KWh/m^2 in the areas of Itang in the Gambella regional state (western Ethiopia), to values as high as 6.25 KWh/m^2 around Adigrat in the Tigray regional state (northern Ethiopia).

Hydropower

Ethiopia is often described as the water tower of northeastern Africa. It was estimated that the country has a hydropower potential of 40,000 MW (installable potential) (Förch, 1989). Not more than 750 MW has been utilised so far thus leaving more than 98% of the potential unused. Almost all of the power stations operating at present are big plants and meant to feed the national grid. The development of mini- and micro-hydro, which is more suited to rural electrification, is not practised yet. At present, there are only about ten small-scale hydroelectric plants (0.25-1MW capacity) in the entire country. The average annual potential (exploitable with small slope plants without reservoir) is estimated to be about 20 TWh/year. The electric energy generated from small slope plants, being smaller in capacity and geographically dispersed, is of great importance for rural electrification.

Wind Power

Ethiopia also has exploitable reserve of 10,000 MW wind energy with an average speed of 3.5 – 5.5m/s, 6 hours/day. Small towns, villages, farms and other scattered loads in remote areas provide ideal situation in which electricity generation from wind is convenient compared to conventional diesel generation or grid connection. The available information identifies two basic zones with homogenous periodicity separated by the rift valley. In the first of these, covering most of the highland plateaus, there are two well-defined wind speed maximal occurring, respectively, between March and May and between September and November, according to location (EEA, 2002). In the second zone, covering most of the Ogaden and the eastern lowlands, average wind velocity reaches maximum values between May and August.

Biomass Energy Resources

Wood, agricultural residues, animal waste and human wastes are considered as major biomass resources. The total energy that can be derived annually from these resources is estimated to be about 101,656.77 Tcal. Out of this, the share of the woody biomass is estimated to be 79%, followed by animal waste 11 percent, crop residue 8 percent and human waste 2 percent.

Fuelwood and tree residues provide the only means of lighting to the vast majority of the rural population located in areas remote from modern fuel supplies. The efficiency of fuelwood and twigs as a source of light, when compared to other sources of energy, is weak.

The contribution of dung and crop residues for the total energy consumption of rural households is around 18% of the total rural energy consumption. The total dung that can be produced annually from the current livestock and poultry population is about 27,835,022.62 tonnes. From this, about 111,284.42 Tcal of energy can be derived annually. Studies also indicate that from current population level of the country, 7,048,500 tonnes of human waste can be produced annually. In energy terms, this is equivalent to about 28,180 Tcal per year (EEA, 2002).

Others

Geothermal energy resources suitable for power production total about 700 MW. The natural gas reserve is also estimated to be 10 to 30 billion m³. Oil exploration is underway (EPA, 1997a: 110-111). Large amount of coal reserves are said to be available in the western regions of the country especially in Illubabor. Unfortunately, none of these enormous potentials for the development of energy resources has been utilised yet thus making the country's per capita energy consumption one of the lowest in the world.

2.2. Policy Backing

The Economic Policy

Regulation encourages investment by providing rules that are broadly perceived to be fair and that inspire confidence in the stability of the business environment. Regulation also supports efficiency by encouraging competition and market-based pricing and by requiring efficient pricing where competition alone is inadequate. The

new Ethiopian economic policy introduced in 1991 gives a wide-range of opportunities to both local and foreign investors. In accordance with the policy, building infrastructure, investing in specific strategic areas, and regulating the economy by means of rules and regulations are the main roles that the government plays, while the initiatives for agricultural and industrial promotion and development are left largely to the private sector.

The investment Law

Unlike the earlier investment law where the electricity sector was mainly left to the government holding, the 1998 proclamation liberalised the sector and created opportunities for the private sector. As far as the electricity generation from hydropower sources is concerned, both domestic and foreign investors can now invest in the sector with no capacity limit. With regard to electricity power generation from non-hydropower sources, there is limitation whereby 25MW and above capacity is left to the government (EEA, n.d.).

Electricity production, transmission and distribution have been prioritised as some of the private investment activities in the newly introduced investment law. It has, therefore, become an area where domestic and foreign investors enjoy the incentives and privileges that the law provides. Accordingly, those who invest in new projects will have the privilege of tax exemptions for a period of two-five years, depending on the regions where they invest. In case an investor incurs a loss within the period of income tax exemption, his loss will be carried over forward to the future, for a period of two-five years depending again on the regions where the investment is made.

Furthermore, machinery, equipment and related accessories, necessary for generating, transmitting and distributing electrical energy, and spare parts of 15% of their value are exempted from payment of customs duty. In general, the investment law allows the import of capital goods free of customs duty, if the same capital goods are not locally produced. Besides, a foreign investor who reinvests a minimum capital of 40,000 USD or its equivalent in Birr, that is drawn from an existing enterprise as a profit, for its expansion or upgrading, shall be exempted from payment of customs duty on machinery and equipment, necessary for the investment. The law also has incentives in the areas of remittance of foreign currencies and employment of qualified senior expatriate experts and managers.

The environmental policy

The recently issued policies on the environment give alternative sources of energy their due place in the future of energy development in the country (EPA, 1997a; EPA 1997b). The need for the use of alternative energy sources (e.g. solar power, wind, biogas, agricultural bio-fuel, liquid bio-fuel or small hydroelectric plants) for towns and villages remote from the national grid has also been well recognised. The following are some of the policy guidelines set for the development and management of the country's energy resources in general and use of alternative sources of energy in particular (EPA, 1997b:83-85).

1. To adopt an inter-sectoral process of planning and development which integrates energy development with energy conservation, environmental protection and sustainable utilisation of renewable resources;

2. To promote the development of renewable energy sources and reduce the use of fossil energy sources both for ensuring sustainability and for protecting the environment, as well as their continuation into the future;
3. To develop alternative energy sources for towns and villages remote from the national grid;
4. To place an increasing reliance on energy efficient technologies, sustainable use of renewable resources, and the development of indigenous energy resources;
5. To acquire, develop, test and disseminate appropriate and improved energy use technologies (e.g. improved stoves, charcoal kilns, solar powered cookers and heaters);
6. To demonstrate and support the use of other energy sources (e.g. geothermal, solar, etc.) in the various economic sectors where it is currently little used such as in transportation, irrigation, crop-drying, food processing, fish drying, and thermal heating;
7. To promote and assist the private sector to assemble and manufacture energy development facilities and end-use appliances.

2.3. Huge Market

As indicated earlier, Ethiopia has 67 million population making the country the second in the sub-Sahara Africa next only to Nigeria. More than 99% percent of the rural population are yet to get electrified. This forms a huge market for investors in the area of rural electrification. And the huge market could be taken as the other opportunity for the development of the energy sector in general and rural electrification in particular.

3. Bottlenecks to Rural Electrification in Ethiopia

3.1. Willingness to Pay and Affordability

The consumers' willingness to pay for a product is an appropriate basis for deciding on pricing and investment policies for rural electrification. In extending electrical power to low income areas where domestic consumers are poor and the demand of electricity for productive purposes is absent; low levels of demand, low revenues, and high initial costs are obstacle to investment. Studies indicate that the key constraint to energy supply for rural communities is access to the initial capital needed to buy the equipment to harness the resource (Anderson et al., 1999:18). This forced rural communities to choose energy options that are cheap on a day-to-day basis, but offer poor quality energy and are expensive over the longer term.

It is obvious that electricity from the grid is cheaper when compared to, for instance, that generated by photovoltaic (PV) system. One projection (for a period up to 2010) regarding unit cost of various electricity technologies (coal, natural gas, oil, nuclear energy, photovoltaic, wind, and energy crops) substantiated that the photovoltaic option is the most expensive (Anderson et al., 1999). The latter, on the other hand, is known to be more appropriate for rural situations where grid connection is often problematic due to poor infrastructure and dispersed pattern of most of the rural settlements. It must also be underscored that comparison of cost between the grid and stand-alone systems of electricity supply is totally irrelevant for those pockets of remote areas that can barely or never be connected to the grid.

Though it is evident that the stand-alone system is most appropriate to rural electrification in Ethiopia, the affordability of the price to people living in rural situations remains the major bottleneck to the dissemination of the technology. In general, people in the rural areas have low purchasing power owing to the abject poverty prevailing in the country.

3.2. Low Organizational and Managerial Capacity

In Ethiopia, the low organizational and managerial capacity and experience for mobilizing communities and potential investors to develop resources are the other limiting factors for rural electrification. On the positive side, technical capacity for the development of such technologies as micro hydro systems and manufacturing of wind pumps is believed to be within the reach of institutions in the country.

3.3. Misconceptions about the Private Sector

The widespread misconception about the private sector is the other hindrance. The private business is likened with "negade" (meaning merchant) in Ethiopia. Traditionally "negade" is alleged to be not honest, strives only for too much profit, etc. The generally harsh attitude towards private investment could, at least, be explained in terms of the socialist culture that prevailed for about two decades in the country.

3.4. Unfair Regulations

The inaccessibility to services like electricity in rural areas is also aggravated with unfair regulations that discriminate against technologies that are especially suited to rural areas. One of these is duty charged on imports of renewable energy technologies especially solar electric generators.

4. Conclusions and Recommendations

4.1. Conclusions

Rural areas in Ethiopia are characterized by either low-density settlement with relatively large distances between households, or villages with fewer inhabitants. This has hindered the use of modern sources of energy. Leaving rural inhabitants, to continue on the course of the current use pattern of traditional energy sources, is bound to have highly negative consequences for the rural economy at large, as well as the environment and the ecosystem balance. Fortunately, the natural resource base for the generation of modern sources of energy is plenty. There are also favourable economic, environmental and energy policies.

The following points summarise the issues that could be considered as opportunities for rural electrification in Ethiopia:

- Ethiopia has several rivers that carry huge amount of water (the country stands only second in Africa next to the Democratic Republic of Congo). The country has exploitable potential of 40,000MW hydropower of which only 2% has been utilized so far.
- Ethiopia has exploitable resource of 10⁶GW solar energy with an average insolation of 5kwh/m²/day.
- The country has exploitable reserve of 10,000MW wind energy with an average speed of 3.5-5.5m/s, 6 hours/day.
- The economic, environmental and energy policies issued recently encourage use of renewable sources of energy and attract the private sector.
- The huge market (Ethiopia has 67 million population making he country the second in the sub-Sahara Africa next to Nigeria).

There are also factors that hinder rural electrification in the country. These include the following.

- Low purchasing power owing to the poverty prevailing in the country.
- Low managerial capacity and experience for mobilizing communities and potential investors.
- The widespread misconception about the private sector.
- Unfair regulations that discriminate against technologies that are especially suited to rural areas.

4.2. Recommendations

Assessment of Ethiopia's natural resource base and government policies relating to the use and management of energy resources indicates that the country has a huge potential for rural electrification through the stand-alone system. There are, however, formidable challenges like low purchasing power, unfavourable public attitude towards the private sector and unfair regulations that work against development and dissemination of renewable energy technologies. It is thus recommended that the government, non-governmental organisations and the public make concerted efforts to overcome this challenges by using more flexible approaches to improve the current dreadful state of rural electrification in Ethiopia.

Since the government cannot simply afford to electrify rural areas of Ethiopia where 85% of the total population reside, maximum effort must be exerted to change the prevailing attitude towards the private investors and help the private sector in all possible ways beyond designing policies. The following statement is worth remembering: “The most promising way forward for self-sustaining dissemination of PV systems in Ethiopia is through private sector promotion of solar lanterns and solar home systems (SHSs) as has happened in Kenya” (ESMAP, 1996). The statement applies also to the dissemination of other technologies for rural electrification.

References

- Aklilu Dalelo, 2001. Natural Resource Degradation in Ethiopia: Assessment of Students' Awareness and Views. Flensburg Regional Studien, Band 11, Flensburg 2001
- Anderson, T. et al., 1999. Rural Energy Services: A Handbook for Sustainable Energy Development. IT Publications
- EEA (Ethiopian Electric Egency), 2002. Rural Electrification Symposium Proceedings, March 1-5, 2002
- EEA, n.d. Power Sector Policy and Legal Framework, Project Profile, Licensing Information and Procedure. Addis Ababa
- EPA (Environmental Protection Authority), 1997a. The Conservation Strategy of Ethiopia Volume I: The Resources Base, Its Utilisation and Planning for Sustainability, Addis Ababa
- EPA (Environmental Protection Authority), 1997b. The Conservation Strategy of Ethiopia Volume II: Federal Policy on the Environment, Addis Ababa
- ESMAP (Energy Sector Management Assistance Programme), 1996. Ethiopian Energy Assessment, Report No. 179/96
- Förch, G., 1989. Wasserwirtschaftliche Probleme eines Entwicklunglandes, aufgezeigt am Beispiel Äthiopiens, Wasserwirtschaft 79 (1989), 10
- Tegegne Gebre Egziabher, 1995. Population and Renewable Resources in Ethiopia: With Emphasis on Forest, Water and Rangeland Resource. – In AKLILU KIDANU (ed.): Proceedings of a Workshop on Integration of Population, Environment Equitable and Sustainable Development Issues into the Curriculum of the Demographic Training and Research Centre of the Institute of Development Research at Addis Ababa University, April 18-19, 1995, Addis Ababa