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RENEWABLE ENERGY ASSESSMENT FOR SUSTAINABLE DEVELOPMENT AND POVERTY REDUCTION IN ETHIOPIA: REVIEW

AWASH TEKLE, SURESH PITTALA & RAMESH UDDAGIRI

HMKS & MGS College of Engineering & Technology, Kangal, Chrukupalli, Guntur, Andhra Pradesh, India

ABSTRACT

The present paper review work is the assessment of renewable energy potential for sustainable development and poverty reduction of the rural and urban location of the country. Ethiopia has huge energy potential almost from all renewable energy except tidal and wave energy. But, almost all the rural area does not have access to electricity and still 94% depend on biomass for cooking and 87% electricity source largely depends on hydro power stations to generate major portion of power. Electricity is one form of energy and easy to convert to other form of energy. Even though the country has high electricity demand but only 15% of the population have access to electricity. And this paper has also presented an option of rural electricity and other energy supply through energy extension system. Energy extension and high efficiency appliances are the best solution to solve energy shortage of pastoral, semi-pastoral and poor rural society. Since some of the eastern African countries are already facing power shortages, they need of electricity to power their economies. Ethiopian government should increase the expansion of the infrastructure in the energy sector and to export towards the sub-Saharan countries.

KEYWORDS: Assessment, Energy Extension, Ethiopia, Renewable Energy

INTRODUCTION

Energy development is basic part of enriched economic development of developing and developed countries. And sometimes defined as the vital thing to the existence of human beings because it plays a fundamental role in their economic and social activities. Renewable energy resources are referred to as an energy that comes from resources which are continually replenished; include hydro, wind, biomass, solar and geothermal. And this energy plays one of the basic needs and a means to increase productivity, enhance employment opportunities, improve the quality of life of people and promote socioeconomic development of a country. Conversely, a lack of access to energy contributes to poverty and scarcity and can contribute to the economic decline. Energy and poverty reduction are not only closely connected with each other, but also with the socioeconomic development, which involves productivity, income growth, education and health [5].Electricity is one form of energy and easy to convert to other form of energy. And it is very important factor in developing the economy and standard living of one country. Ethiopia is one of the countries which are on transition /developing/ process, but still with great problem of energy supply, however it has huge amount of hydropower, wind, geothermal and solar potential. Almost all the rural area does not have access to electricity and still depend on biomass for cooking. And electricity of the country largely depends on hydro power stations to generate major portion of power. Expanding electrification and scaling up electricity services is critical to both the social development and economic growth of Ethiopia.

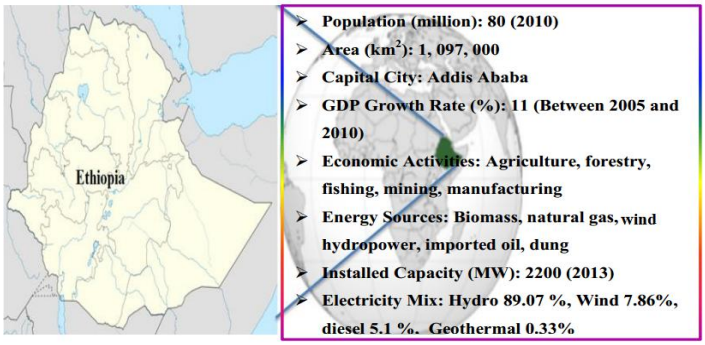


Figure 1: Country Profile of Ethiopia

The present total energy generation capacity is 2260 MW, with hydro-generation accounting for 87.07%. Each energy resources are 1960MW from hydropower stations and 113.1 MW widely distributed diesel capacity feed the Interconnected System (ICS), 173 MW from wind power and 7.3 from the Aluto-Langano Geothermal Pilot Power Plant.

ENERGY RESOURCES AND AVAILABILITY IN ETHIOPIA

Ethiopia has huge energy potential almost from all renewable energy except tidal and wave energy. The majority of the poor people live in the rural areas and they do not have access to modern energy. According CIA World Fact book (2012), the total electric production of Ethiopia was around 3.72 GWh and ranked 119 of 214.Evidences indicates that the nation has the potential to generate 1.4 million MW electric power from water, geothermal, wind and solar energy but it has only managed to utilize about 2,260 MW of it. Currently, the government is doing all it can at all levels of its administration to invest heavily on renewable source of energy all over the country. According Ethiopian Power Corporation (EEPCO), the construction of Ethiopian Grand Renaissance Dam, Gibe III, Genale Dawa (GDIII) and other Wind Farm Power Generation projects is being accelerated to realize the Growth and Transformation Plan energy sector goals and green energy economy.

The present total electricity distribution generated from hydropower is 87% and the other energy distribution include diesel and wind supply is only 13% (Figure 2). The potential and status of development of renewable and thermal energy resources are increasing at different investigations and technology options. In different perspective and years, the unexploited potential of renewable energy will increase from the current situation. But according the current feasibility study the potential of renewable energy was described by Ethiopian Power Corporation (Table 1).

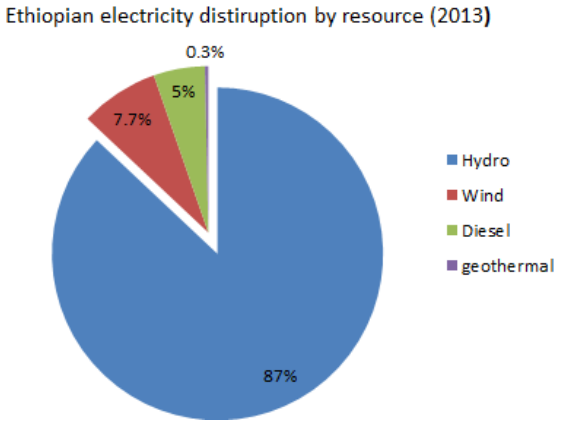


Figure 2: Current Energy Distribution of Ethiopia by Resource

Table 1: Installed, Ongoing and Planed Renewable Energy Projects in Ethiopia (EEPCO)

Source	Installed (MW)	Ongoing Project (MW)	Plan up to 2030 (MW)	Capacity (MW)	Exploited Percent (%)
Hydro Power Energy	1960	8124		≥ 45000	< 4
Wind Energy	170	154	6820	1300000	<0.013
Solar Energy (PV)	≈ 0.0	-----	135	≥ 252000	≈ 0.0
Thermal Energy	113.1	------	112	-	-
Geothermal Energy	7.3	75	1000	10000	< 0.07
Cogeneration	3.6			≥ 263	
Nuclear Energy	0.0	-	300-1200	-------	

Availability of renewable energy resources type varies by the geographical location of the country. For instance, geothermal potential in Ethiopia is located in rift valley where as huge hydro potential is found in Nile basin and the wind power is more competitive along the shores and on the mountain ranges. In the perspective of different geographical location, the power crisis of the local community can be solved by biomass, solar, hydro, wind, Cogeneration and geothermal energy.

Hydropower

Hydropower is an important renewable source of energy because it plays an important role in the country's energy system and its ecosystem stability. Ethiopia's first large hydroelectric generating facilities were constructed in the Awash River basin. The three plants are Awash I (Koka) with 54,000 kW, Awash II with 32,000 kW, and Awash III with 32,000 k W capacities were finished between l960 and l972 [11]. In l974 Fincha River facility in central welega opened with a generating capacity of 84,000 kW. Out of total hydropower potential (15,000-30,000 MW) only about 360 MW (i.e. less than 2 percent) has been exploited by 1997 and now around 1960 MW (Figure 3). Ethiopia has huge hydropower potential due to several long distance traveling rivers occur in the country and sometime calls mother of water (or African power house). Special properties of Ethiopian rivers are flowing almost in four directions of the country across the border to neighboring such as S. Sudan, Sudan, Eritrea, Kenya and Somalia(Figure 4). Hydro power constructing has economic and environmental applications including irrigation, tourism, and fishing. Beyond economic and environmental application, hydropower construction has vital benefit on unity strength of nation and nationalities of the country. Ethiopian renaissance dam-I(ERD-I) shows that the strength and unity of nation and nationality can construct many other projects (ERD-II, ERDII and more) on the Nile river basin to sustainable economic growth of multi nation owner.

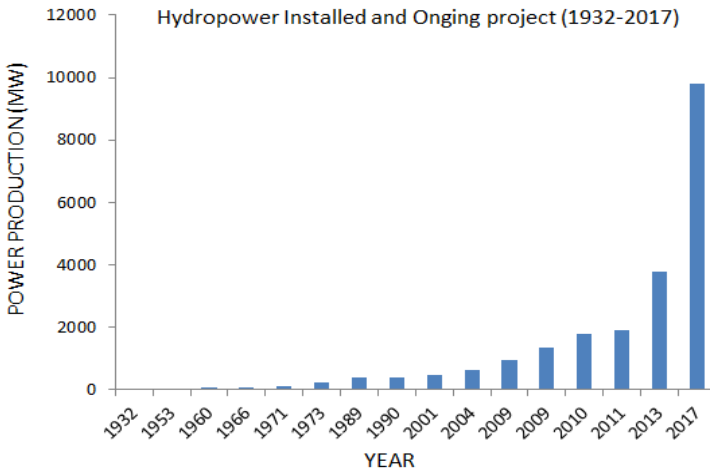


Figure 3: Hydropower Installed and Ongoing Projects in Ethiopia (1932-2017)

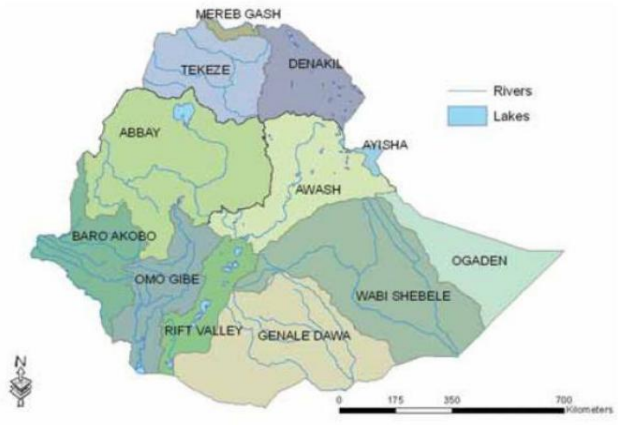
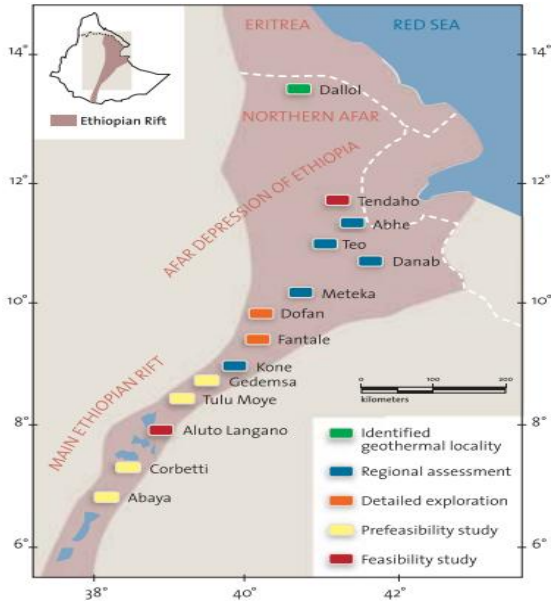


Figure 4: Ethiopian Water Basins (Source: Awulachew Et Al., 2005)

Geothermal Energy

Ethiopia is among the few countries in Africa with a significant amount of geothermal resources. These resources are found scattered in the Main Ethiopian Rift valley depression that covers an area of 150,000 Km^2.Ethiopia could possibly generate more than 10000 MW of electric power from geothermal resources alone. Ethiopia started a long-term geothermal exploration in1969 [6].Along the Ethiopian Rift Valley about sixteen geothermal prospect areas are judged as having potential for electricity generation. Those are Dalol, Tendaho, Abbe, Teo, Danab, Meteka, Dofan, Fantale, Kone, Gedemsa, Tulu Moye, Aluto Langano, Corbetti and Abaya) were investigated for their geothermal energy potential which extends some 400 km NNE from latitude of 60N to latitude of 90N [12]. From these sites, EEPC Oowns and operates the Aluto-Langano geothermal plant. A feasibility study on geothermal power development at the Aluto Langano geothermal field has been conducted in March 2010. In order to meet the increasing demand for electricity in Ethiopia, EEPCO has established a project named Aluto Geothermal Power Plant Expansion Project Phase III to generate70 MW electric Power[12].



(Source: Geological Survey of Ethiopia)

Figure 5: Location Map of the Geothermal Prospect Areas with in Ethiopian Rift Valley

Table 2: Ethiopian Geothermal Projects Scheduled to be Executed before 2018 (Source: EPA, 2010)

No.	Geothermal Project	Generating Capacity (MW)	Planned Year of Commissioning
1	Aluto Langano	75	2012
2	Tendaho	100	2018
3	Corbeti	75	2018
4	Abaya	100	2018
	Tulu Moye	40	2018
6	Dofan Project	60	2018
Grand		**450**	

Solar Energy

Solar energy is an ideal alternative source of energy because of its potential in the region. In Ethiopia, solar energy is abundantly available in most parts of the country. The semi-arid and desert areas in the eastern and northern-central part of Ethiopia have the highest radiation intensity 6.5 -7.5 kWh/m^2/day, while the other parts of the land have radiation in the range of 4.5 -6.0 kWh/m^2/day. Solar energy availability is fairly constant (less than10% of average) throughout the year in the lowland areas of the country but varies substantially in the highlands (more than 25% of average).The theoretical potential of solar energy is huge: 500MWt/$km^2$and 100MWe/km^2.

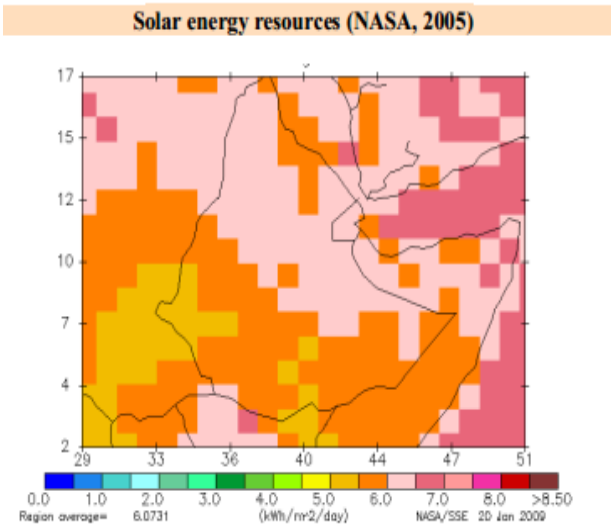


Figure 6: Solar Radiation Distribution in Ethiopia (in Kwh/M2/Day)

Even though, the country has huge amount of solar energy, but the exploited power from this renewable energy is almost none. But for the future, it will be one of the vital solutions for energy supply to sustainable economic development of the country.

Wind Energy

Wind energy is not exploited that much in most of the East African countries. It has been estimated that the resource is exploitable in the range 2.5 – 6 m/s [13]. Average wind power density distribution of Ethiopia varies from 25-800W/m^2, (Height: 50m, 1980~2009) with exploitation potential of 1,035 GW [9].From central to eastern part of Ethiopia (38^o-48^o longitude) has good wind energy distribution potential varies from 200W/m^2 up to above 800W/m^2.

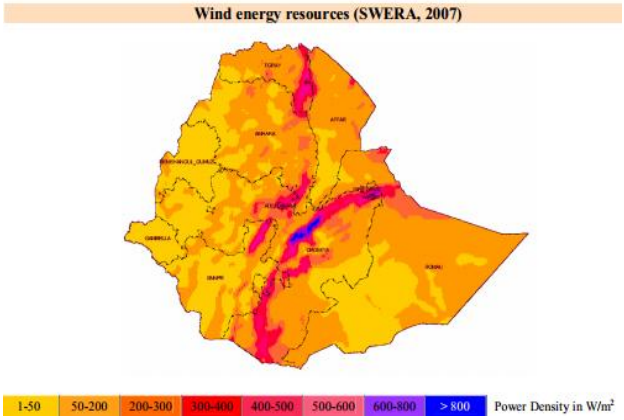


Figure 7: Wind Energy Distribution in Ethiopia (NASA, 2005)

Ethiopia has huge renewable energy from wind but until today the exploited potential is almost 0.13%and the third rank energy exploited by resource. Though, the current installed energy is very low relative to the potential available but now a day there are a lot projects under plan (Table 3).

Table 3: Ethiopian Wind Energy Projects Scheduled to be Executed before 2018 (EEPCO)

No.	Geothermal Project	Generating Capacity (MW)	Condition of the Project	Planned Year of Commissioning
1	Ashegoda	120	Complete	2012 (complete)
2	Adama I	51	Complete	2011 (complete)
3	Adama II	154	Construction on the way	2013
4	Messobo	42	MoU signed	2012
5	Ayisha	300	Feasibility Under way	2018
6	Debrebrhan	100	Feasibility Under way	2018
7	Assela	100	MoU under way	2018
Grand		**867**		

Cogeneration

Co-generating is an energy production in agro-processing industries including sugar, cotton, coffee, and etc. Currently, there are four main sugar factories in Ethiopia on production, all located downstream of hydroelectric power plants. Three factories (Wonji, Shoa and Metahara) are on the Awash River, below the hydro power plants at Koka, Awash II and III. Since the irrigation always simple at downstream of the damp and the factory should near to sugar cane cultivation [8].The fourth factory is40 km below the Fincha a hydro power plant. Each plant is strategically and conveniently located within short distances from the interconnected grid of EEPCO and some of these industries already use their agricultural residue in cogenerating plants to supply their own thermal and electricity energy needs. At the Shoa Sugar Factory, there are two 3.2 MW cogenerating units, from which only 2 x 1.42 MW capacities is being utilized for internal processing. There are also plans to increase sugar cane production and extend generation capacity extending to 18 MW, out of which 10 MW is to be exported [8]. Currently, there are 10 ongoing mega projects of sugar factories and sugar cultivation area to increase the production of sugar and export it. The expansion of sugar factories has many applications in addition to sugar exporting. These are: To increase biofuel energy and increase cogeneration energy from the bagasse. Presently, Ethiopia has an estimated power potential above 263 MW from bagasse.

Biomass

Ethiopia has about 990billion tons biomass energy excluding Addis Ababa and Somalia. Woody biomass constitutes 95% of total potential supply. Animal dung and crop residues account mainly for 3% and 2% respectively. Regional distribution reveals that Oromia supplies about 40% of biomass resources followed by SNNPR (24%) and Amhara (15%). Remaining regions own insignificant share of national biomass fuel resources[2].Traditional household energy sources are renewable, but the rate of consumption is much greater than the rate of cultivation. As the result, it increases the rate of deforestation and land degradation, which in turn can lead to excess soil erosion and loss of soil fertility. This further contributes to the decline of agricultural productivity and production, perpetuating the vicious cycle of rural poverty [1]. By adoption the technology energy conversion, it is possible to use the energy for rural and remote location of the country. Since those locations are out of grid connection, it is the best way to simplify the burden of the society using biogas electrification and cooking.

Current Electricity Situation and its Future Solutions in Ethiopia

Uninterrupted energy supply is a vital issue for all developed and undeveloped countries. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. Security, climate change, and public health are closely interrelated with energy [6].In spite of having plenty of energy resources and potentials, Ethiopia suffers a very low supply of electricity. Presently, greater than 85% of Ethiopian's population has no access to electricity.

Ethiopia electricity is facing a serious energy crisis despite strong economic growth during the past decade and consequent rising demand for energy, worthwhile steps have been taken to install new capacity for generation of the required energy sources. Only 15% of the Ethiopian households have electricity connection and there are some rural parts which will not get the access of electricity connection from the national grid within next two or three decades. The current installed capacity of electrical power is about 2260 MW (Hydro 87.07 %, Wind 7.86%, diesel 5.1 % and Geothermal 0.33%) and this production is equal to 10% of the demand. For this reason, the country is dependent on the imports of petroleum to meet its requirements [3].Since Ethiopia is one of the fastest growing countries in the world likewise energy demand also increases exponentially. Using nine year energy demand percentage data formulated a correlation of Ethiopian energy demand percentage per each year with R^2=0.82.

$$Y = \frac{1.202\,e^{0.1298X}}{10^{-112}} \quad (1)$$

Where: Y=Ethiopian Electricity Demand (%) and X=Year

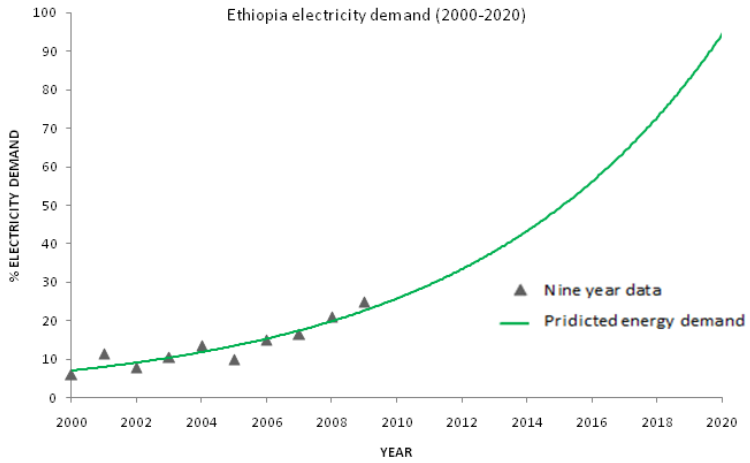


Figure 8: Historical Background and Predicted Electricity Demand in Ethiopia

Ethiopian energy access for rural and urban poor society is very low or almost none. To solve this energy crisis can use different form of renewable energy to generate power. Energy extension and high efficiency appliances are the best solution to solve energy shortage of pastoral, semi-pastoral and poor urban society. The goal of this paper is to propose a set of policy levers that can aggressively reform all two of these issues at once. The new energy extension policy has created favorable conditions for the rural community, private sector and encourages appliances manufacturing investments which entails heavy investment burden in the energy sector.

Energy Extension

It is well known that in most rural parts of the country is highly dependent on fire wood for cooking purposes. For this reason, the rural area is highly exposed to deforestation and for several eye and breathing related diseases. Health extension is adopted so money year in the country where as energy extension is almost none. This energy extension is the vital program to introduce self-energy supply to the rural and urban community.

Energy self-supply co-operatives program support rural farmers and pastorals in developing locally available sustainable energies for electricity generation, heat production and producing sustainable fuels [4].As the result, in the short term developing a self-energy supply for local people and then in the longer term developing renewable energy for exporting to the neighboring countries. In order to meet energy demand of the community, the government should introduce energy extension using different renewable energy like biogas, biofuel, solar and wind energy in micro level. Using hybrid principle (or biogas, solar and wind) can solve energy shortage in rural Ethiopia. The following options are proposed to solve energy crisis of the local community (Figure 6).

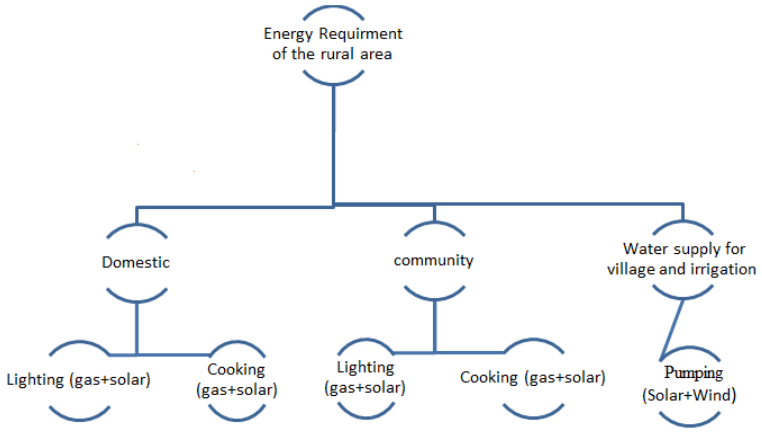


Figure 9: Energy Requirement and Proposed Plan for Ethiopian Rural Area

Energy Efficiency Improvement Options

Power Distribution Losses

According to the World Bank, Transmission and Distribution (T&D) losses in Ethiopia have risen from 9.4% in 2007 to around 10% in 2011. Power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage. Ensuring low power distribution losses are a reliable supply of energy without interrupt and it helps to sustainable agricultural and industrial development strategies of the country.

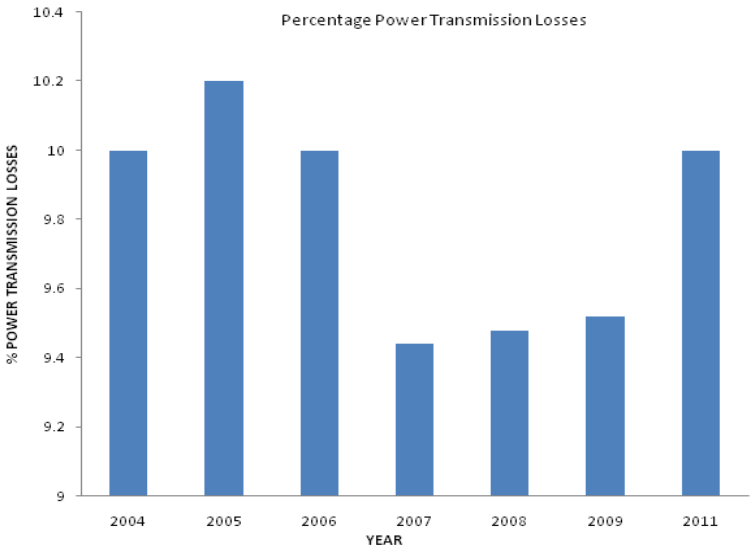


Figure 10: Percentage Power Transmission Losses in Ethiopia

Household Appliance and Different Sectors

Increasing energy efficiency is the quickest and least costly way of addressing energy security, environmental and economic challenges. To raise the efficiency of the energy sector, develop the necessary institutional and manpower capabilities building by introducing appropriate incentive measures. To help it'srural and urban community achieve the benefits of energy efficiency across their local and global economies. The International Energy Agency (IEA) developed (in 2008) a set efficiency policy recommendations for seven priority areas. Those are: cross-sectorial, buildings, transport, industry, and appliances equipment, lighting and energy utilities [10].

Ethiopia Foreign Energy Policy and Poverty Reduction

According to EEPCO, Ethiopia has an estimated hydro-power potential of 45,000 MW, a geothermal potential of 10,000 MW and an estimated 1.3 million MW from wind. And the new EEPCO policy will enable Ethiopia to generate 37,000MW of energy by 2037. Insufficient energy access can limit GDP growth by 2-5% per year and businesses cannot grow, neither can new jobs be created or critical services provided, without affordable and reliable access to lighting and power. The majorities of people in sub-Saharan Africa heat their homes and cook using traditional fuels like wood.

As the result, indoor inhalation of the smoke and fumes produced from wood burning results in over three million deaths per year, mainly among women and children. Ethiopian government should increase the expansion of the infrastructure in the energy sector to export towards the sub-Saharan countries. Ethiopia's current power production stands at around 2,260MW and exports 60MW of electricity to neighboring Djibouti and around 100MW to Sudan.

It is providing a considerable boost to the country's income. And S. Sudan, Kenya, Somalia and Eritrea are the countries available market for hydro-electric power demand within the region. Hence some of these countries are already facing power shortages they need of electricity to power their economies. In the present world energy crisis, interconnection of the regional electric energy networks is the best alternative to displace expensive thermal generation in regional as well as international power markets.

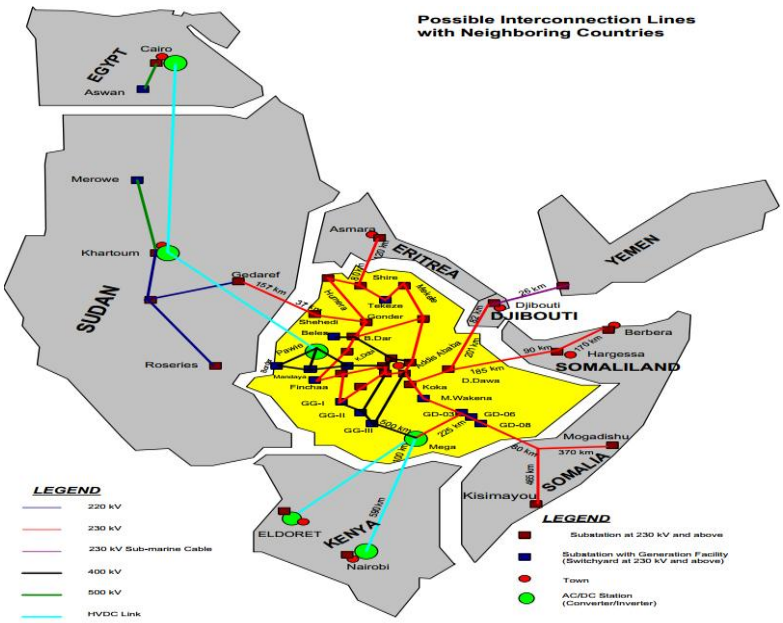


Figure 11: Ethiopian Energy Policy Connection to Supply for Neighboring Countries (EEPCO)

In harmony with this belief, Ethiopia has devised a strategy for accelerating cross-border electricity trading with the neighboring countries and further to other nearby countries to spur regional economic growth through developments of the untapped hydro resources for electricity.

CONCLUSIONS AND RECOMMENDATION

The present paper review work was the assessment of renewable energy potential for sustainable development of the rural and urban location of the country. And this paper has presented an option of rural electricity and other energy supply through energy extension system. Hydropower is the most important source of electricity for Ethiopia, the largest

contributor in power generation and additionally used for irrigation, tourism and Fishing. Ethiopia is one of the fastest growing countries in the world likewise energy demand also increases exponentially. Therefore, the Government and the Private sector should work hand in hand to emphasize more on energy extension to produce electricity and thermal energy to solve our power crisis problem. In addition, Energy extension is the vital program to introduce self-energy supply to the rural and urban community.

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