Electricity Generation in Ethiopia

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Abstract

Ethiopia is considered by many to be one of the most under-developed nations in the world. In 2017, population is estimated with approximately 104.96 million, which ranks 14th in the world. With almost 34% of its population is under the poverty line, Ethiopia is projected to higher economic growth brought with it positive trends in poverty reduction in both urban and rural areas. The energy sector is one of the fast-growing sectors in the country. With regards to electricity, Ethiopia is generating around 4284 MW from hydro, diesel, geothermal and wind power plants, and this generation is projected to increase to 45,000MW by 2065, with the new Growth and Transformation Plans (GTP1 and GTP2) and increasing utilization of wind and solar in generation electricity in mainly rural areas. In this project, we have briefly studied the state of affairs in Ethiopia with major regards to electricity generation in Ethiopia. The study was focused on the North Gondar zone in Ethiopia being one of the most economically backward zones of the country facing major electricity shortage problems. The study covers the current situations and proposes feasible solutions to tackle the problems based on interviews conducted with experts and data available on the internet.

Introduction

Ethiopia, also known as the Federal Democratic Republic of Ethiopia, is in east-central Africa. Its capital, Addis Ababa, serves as the headquarters for most of the global NGOs focused on Africa, including the African Union, the Pan African Chamber of Commerce and Industry, the United Nations Economic Commission for Africa, the African Standby Force, and many more. Ethiopia is home to approximately 100 million people, making it the world's most populated landlocked country. Although currently considered one of the poorest countries in the world, it is developing rapidly. The government is a federal parliamentary republic headed by a Prime Minister, and has been making significant efforts to increase electricity production to keep up with growing energy demand [1].

Figure 1. Map of Ethiopia [14]

Ethiopia lies in the Horn of Africa, a peninsula bordered by the Indian Ocean, the Red Sea, and the Gulf of Aden; however, it is completely landlocked. Near the coast to the east, it is bordered by Somalia, Djibouti, and Eritrea. To the west lie Sudan and South Sudan, and Kenya is to the south. Ethiopia is divided into several administrative regions, each with its own unique terrain and climate. The Somali and Afar regions near the Somali and Eritrean borders are deserts, while the Sobat region in the lower basin is swampy, with high heat and humidity. The mean temperature range across Ethiopia is 15 - 25 ◦C. The capital, Addis Ababa, is in the center of the country in the Oromia region. This region is higher above sea level than the others and has a more temperate climate. The western side of the country has a tropical climate. A mountain range runs through the central part of the country, divided by the Great Rift Valley, which is volcanically active, as well as being subject to earthquakes and droughts. Natural resources include small deposits of precious metals, as well as reserves of natural gas, and plenty of hydropower. 36.3% of the country's land is used for agriculture, with a little more than half of that utilized as pastures for livestock. The main crops are cofee, sorghum grain, and castor beans, but water shortages due to raising these crops are causing the deserts to expand. Deforestation is also a big problem [2,3,9].

As of 2015, the population of Ethiopia was estimated to be around 100 million with an estimated growth rate of 2.89% per year. The energy demand per capita is estimated to be less than 100 kWh/yr and the present annual growth rate of the demand for energy is approximately 20%. Based on an estimate taken in 2015, 43.94% of the population is in the age group of 0-14 years.

The working age group (15-64 years) is the largest demographic, amounting to 53.07%. The working population being high indicates a significant demand for energy resources. In addition, the literacy rate in Ethiopia is about 49.1% according to the 2015 estimate. The literacy rate is on the rise and an increase in literacy rate would help advance the idea of energy conservation and proper use of energy throughout the country. 19.5% of the total population lives in urban areas. The rate of urbanization in Ethiopia was estimated to be 4.89% per year over the period of 2010-2015. An increase in urban population indicates an increase in energy consumption as urban lifestyle demands better technology and infrastructure for comfortable living. The most widely spoken languages are Oromi, Amharic (the national language) and Somali. English is the foreign language taught most in schools, but is only spoken by less than 1% of the population [3,9].

Economy and Technology

While Ethiopia is still heavily impoverished today, it is considered one of the fastest growing members of the IMF. The major occupation in Ethiopia is agriculture and it contributed to approximately 40.5% of the GDP and 85% of the labor force as of 2015. The other major occupations in Ethiopia include mining, manufacturing, transport, telecommunication and tourism. The manufacturing sector includes food processing, beverages, textiles, leather, garments, chemicals, metals processing, cement, etc. of which foods and beverages constitute a good 40% of the sector. Textiles and garments contribute mainly towards exports. In an estimate taken in 2016, the GDP of Ethiopia was estimated to be $ 177.5 billion and a per capita GDP of $ 1900 with a growth rate of 8% in 2016, the fourth highest in the world. Chief exports are coffee, oilseeds, vegetables, gold, flowers, and live animals. Chief imports are machinery and aircraft, metals, electrical materials, petroleum products, motor vehicles, and chemicals and fertilizers. Approximately 24% of the population has access to electricity, mostly in Addis Ababa and the other urban areas. About 1% of Ethiopians have access to landline telephones, and about 50% have access to cell phones. There are 6 public television stations, and about 15% of the population has internet access. There are 17 airports and an inventory of 75 aircraft operated by one carrier. There is also a single electric railway from Djibouti to Addis Ababa, run by a Chinese contractor [4,11].

Government and Policies

Ethiopia, being one of the least and slowest developing countries in the past, with approximately 34% of its over 100 million population being below poverty line, as well as was one of the countries with lowest rates of access to energy services. However, in the last decade, along with new policies and strategies, the figures have taken a change. In 2016, Ethiopia's economy was one of the fastest growing in the world, with an average economic growth rate of 10.8% since 2005. The Ethiopian Government has announced two plans to transform the country to a middle-income country by 2025; The first plan is the Growth and Transformation Plan (GTP1), which is a five-year-plan which started in 2011, aiming to achieve the Millennium Development Goals (MDGs) with a rapidly growing GDP growth rate of 11-14% per year, with investments

throwing light on agriculture sector, industrial development, and infrastructure. The second Growth and Transformation Plan (GTP2), which started in 2015, is expected to sustain economic development, guarantee social justice and increase income per capita to elevate from an underdeveloped country to middle income country by 2025. To achieve these goals and achieve stability and sustainability of resources, challenges are bound to be faced. The GTP includes the Blue Nile Dam which is expected to have an electricity generation capacity of 5,250MW. The GTP also aims to improve and develop the solar, wind and biofuels energy sector. [1,3]

Ethiopia Electric Power (EEP) is assigned the responsibility of maintaining hydroelectric plants and wind farms in various locations of the country. Also, the Grand Ethiopian Renaissance Dam (GERD) capable of generating 6,000MW is currently being built and is 60% completed. The completion of this project will enable export of energy to Djibouti, Sudan, South Sudan and Kenya. Another strategy to expand electricity generation from renewable sources of energy has been set up which is known as the Climate Resilience and Green Economy (CRGE) strategy. In 2012, the Electricity Feed-in-Tariff Law was introduced with the objective of diversification of power sources to improve availability of electricity regardless of weather and to reduce reliance on hydropower alone [2,5].

Another initiative by the Ethiopian government was the National Biogas Programme (NBP) of Ethiopia which was established in 2007. This program works with the Ethiopian Rural Energy Development and Promotion Centre (EREDPC) to promote biogas by working with investors and donors on a cost sharing basis. The programme has been fruitful and over 1200 biogas plants have been implemented in over 37 wards. Another important body in the political framework of energy in Ethiopia is the GiZ Energy Coordination Office (ECO) which has been working with the Ministry of Water and Energy (MWE) to promote renewable energy in Ethiopia. The MWE is the federal institution responsible for all energy planning including development and management of energy. It also creates policies, strategies, programs, and implements laws and regulations for the energy sector as well as provides technical support to energy bureaus all over the country. The combined efforts of the ECO and the MWE have yielded a significant achievement via the installation of photovoltaic solar systems in hundred off-grid public health centers and four community centers [5,13].

Energy Resources

The energy resources in Ethiopia can be classified into two major components: traditional sources and modern sources. Biomass fuel is the traditional energy source composing 92.4% of Ethiopia's energy supply, which is mostly composed of wood, animal remains and agricultural residues. Modern sources are mainly composed of oil and electricity, making up approximately 5.7% and 1.6% respectively of Ethiopia's energy supply [2]. Since above 80% of the country's population is engaged in agricultural activities in rural areas, the traditional energy sources represent the cornerstone of energy in Ethiopia. In urban regions, access to petroleum fuels like kerosene and electricity have enabled a portion of the population there to utilize these for cooking and other domestic energy usage. Moreover, access to biomass fuels has significantly dropped in

many regions of Ethiopia and drastically in other parts, varying from one region to another. Reduced access to woody biomass has extended developmental and social effects; less access to wood indicates that more must come from other sources of biomass fuels in order to meet the demand. Besides, the excessive dependence on biomass energy involves a trade-off in agricultural productivity, where crop residues and animal remain are being diverted from farms to provide energy need instead of supplementing soil nutrition in farms. Similarly, as scarcity of wood fuel has become serious, rural households who collect wood freely must travel longer to get it, thus causing loss of human capability availability for productivity at work. Furthermore, fuel wood scarcity will increase deforestation rates and lead to environmental degradation and extension of deserts. [1,2]

As for electricity, Ethiopia is generating around 4284 MW from hydro, diesel, geothermal and wind power plants. The hydropower resources, which are distributed in nine major river basins are remained the main source for electricity 95%, followed by wind energy 3.5%, of which 11% is exported. By 2065, Ethiopia aims to generate 45,000MW from hydropower, geothermal, solar and wind [3].

The highlands and mountains in some parts of the country make many of the nation's hydro resources suitable for energy generation of varying sizes, ranging from small and large hydropower plants. Small scale schemes are suitable in remote areas, which are not connected to national grid. The total potential for micro hydropower schemes is 100 MW. Like other natural resources, Ethiopia's rainfall is in relative abundance in the western and southern parts, and moderate in northern and central plateaus [5].

Ethiopia has a vast amount of natural resources, but utilization is currently highly ineffective. The government has been making significant efforts to improve this, as well as providing an impetus for switching from the traditional biomass fuel sources to more modern and renewable sources such as hydro, solar, and wind power. The widely varying landscapes of Ethiopia's nine regions, shown in figure 1, each provide their own potential in this area. Known as the" Water Tower of Eastern Africa," Ethiopia holds about 86% of the waters in the Blue Nile in the 12 river basins covering almost the entire country. Studies by the Ministry of Water Resources (MoWR) estimate that the annual run-off from the major river basins totals to approximately 122 billion cubic meters [13]. Currently, hydro resources are mainly distributed in the north, central, western and south-western regions, where rains are moderate (especially in the north) and the land conditions are suitable for hydro-generation. Major developments in this area are currently underway. Ethiopia's Growth and Transformation Plan (GTP) is the most important ongoing plan which outlines a 15-year long plan with three 5-year phases starting from 2010. In the first phase GTP-1, major hydropower projects were completed increasing the capacity of the installed plants from 2,000 MW to 10,000 MW. The second phase GTP-2 from 2015 to 2020 is ongoing with the objective of increasing the installed capacity to over 17,000 MW. Although hydropower constitutes over 90% of the generation capacity, the Government of Ethiopia introduced the Electricity Feed-in-Tariff law, taking measures to increase the diversity of energy resources by incorporating more projects on solar, wind and geothermal energy into the mix. This would help

to reduce the effects of drought and other water shortage problems on electricity generation. The Great Ethiopian Renaissance Dam (GERD) is planned to have a 6,000 MW capacity and was reported about 60% complete in June 2017. The GERD is expected to allow Ethiopia to export electricity to Djibouti, Sudan, Kenya and Tanzania by the end of 2018. The GTP is strongly backed by the Government of Ethiopia, as it is one of the major initiatives aimed at making Ethiopia self-sufficient in electricity generation. In 2007, the National Biogas Program (NBP) was introduced in collaboration with the Ethiopia Rural Energy Development and Promotion Center (EREDPC) to promote utilization of biogas by working with donors and investors on a sharing basis. In the western regions, where the land is flat and arid, wind power is the primary future resource. Throughout the country, there is also a predicted annual total of 2.199 TWh of solar reserves [1,10].

The government also emphasizes the involvement of Independent Power Producers and Ethiopia Electric Power (EEP) is selecting producers by a competitive bidding process. Crowns Agents International is assisting with building a procurement manual for EEP in collaboration with US Trade and Development Agency. The government is also developing a feed-in-tariff bill which would enable independent producers to sell electricity from renewable sources to the national grid at specific rates. Power Africa is assisting EEP with development of documentation and the regulatory framework for independent power producers [5].

Ethiopia Electric Power has presented details about the upcoming tenders for energy resource utilization which is presented below.

Table 1. Upcoming Tenders – Ethiopia Energy [6]

Projects	Capacity (MW)	Status	Energy Source
Tekeze II	450	Under Tender Preparation	Hydro Power
Gojeb	150	Under Tender Preparation	Hydro Power
Lower Didessa	550	Under Tender Preparation	Hydro Power
Lower Dabus	250	Under Tender Preparation	Hydro Power
Additional Solar	500	Under IFC scaling solar program	Solar
Additional Wind	1000	Under discussion to collect data	Wind
Biomass	420	Under early stage	Biomass

Therefore, it could be argued that the distribution of Ethiopia's hydro resource is in contrast with that of its wind energy, since the former decreases while the latter increases as we go to the lowlands. The country is currently considering multiple other hydropower projects across the whole country, with hope of exploiting the country's hydropower potential as well as exporting electricity to neighboring countries. However, the Ethiopian government faces other serious challenges in expanding the country's energy system, and that includes the urge to rehabilitate an outdated distribution system with 23% high leaks and losses [2]. It also must ensure more efficient operation of the expanded system, as it must become a creditworthy purchasing client of electricity from Independent Power Producers. It is important as well to address foreign exchange constraints, and reform customs and tariffs to allow full cost recovery, and deliver more electricity to the majority of the population [4].

Energy Demand

As the country's economy is rapidly growing, the demand for electric power has widely increased. Consequently, more than 40% of the electricity generated is to be used for industrial purposes, while the rest is used for the consumption of enterprises and households. Addressing questions concerning electric power export, Ethiopian authorities stated that it plans to use the power generated for domestic consumption as well as to sell surplus power to neighboring countries. Ethiopia is now exporting about 60 MW to Djibouti. In addition, it also agreed with Sudan to export power ranging from 50-100 MW and now a portion of the deal is being exported. However, this is executed in a manner that does not affect the local power demand. [5]

According to the Electric Power Research Institute (EPRI), depletion of resources, emission of waste and other environmental changes are all challenges facing the energy sector, and the demand for discovering of alternative paths to achieve sustainability for power industry is becoming crucial. Ethiopia, as it aspires to become the main powerhouse and supplier of Africa, highly advocates green development strategy and the development of renewable energy advocates for a carbon free economy in Africa and the world. The unavailability of modern energy in the rural areas has caused lack of opportunities for basic human amenities like clean water supply, health services and educational facilities for which modern energy sources are essential. Generally, the apparent pattern of energy supply and consumption shows much resemblance of unsustainability. It is evident that the energy problem in the country arises not from just excessive reliance on nonrenewable energy sources, but rather the main source of energy for the population – fuelwood - is being consumed at an unsustainable rate, while the potential of other forms of renewable energy (solar, wind, geothermal, hydropower, etc.) remains underdeveloped [1].

Case Study: Electricity Generation and Access in North Gondar

The North Gondar area of the Amhara region in Ethiopia is economically lagging in comparison to other areas of the region. While experiencing a similar population growth rate to that of the rest of the country, the area lacks roads and other infrastructure, making power distribution to the area difficult [12]. We propose to perform a case study on electricity generation to North Gondar. Since there is only one year of concrete data on the area from 2007, we propose to perform a semi-comprehensive review of case studies performed on generation in other rural areas with characteristics and demographics like those of North Gondar. Many such studies exist on rural areas of India, Cambodia, Vietnam, and even other regions of Ethiopia. We analyzed these studies and made direct comparisons to our region of interest. We analyzed the current state of other rural regions in Ethiopia, as well as their state over the last decade to provide a hypothetical plan for infrastructure development, choice of primary resources, and investment strategies for the North Gondar zone. To provide a complete picture, we looked at data concerning energy demand, population demographics, economic development, resource usage and depletion, distance from urban centers, and state of infrastructure.

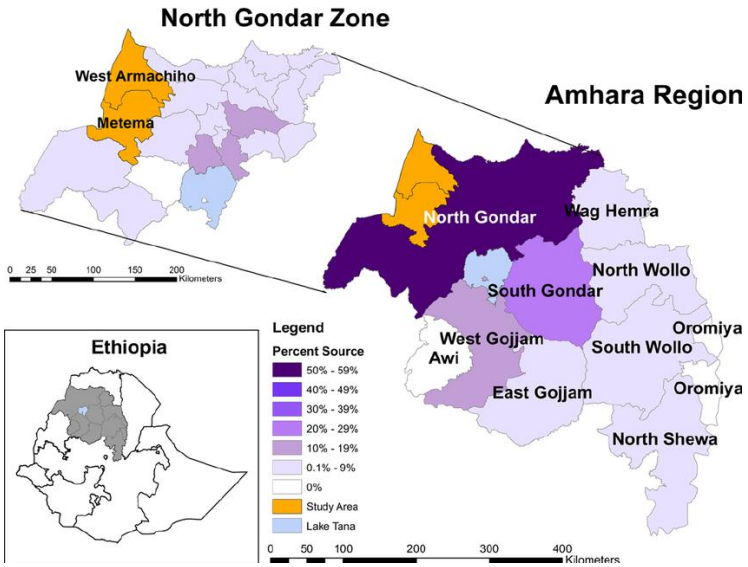

Figure 2. North Gondar Zone in Amhara Region in Ethiopia [16]

The North Gondar zone in the Amhara region of Ethiopia is noted to be considerably behind the remaining part of the region. Although the growth rate of the population is similar throughout the country, the North Gondar zone is facing significant problems with infrastructure, transport, etc. making the distribution and access to electricity difficult. Only 10-12% of the population of North Gondar has access to electricity [12]. Our case study was focused towards understanding the situation in the North Gondar zone and finding potential solutions to address the issues pertaining to electricity shortage in the region. The case was studied with online resources from the Government of Ethiopia, Ethiopia Electric Power and the World Bank as well as interviewing professionals working in energy related fields and have firsthand experience related to Ethiopia.

We had a very informative meeting with Mr. Christopher Arderne who works at the World bank as an energy analytics specialist at the World Bank. Christopher's work pertains to energy access more than the generation aspect where they map our possible grid solutions for energy access in various regions without considering the supply of the same. They create strategies based on the demand and need of energy either in the form of electricity or any other form based on the region and work with the government and other private providers to create sufficient supply. Chris has been working in developing energy projects in Africa as part of the United Nations Development Programme and has been to Addis. Recently, he published an article about off-grid electricity solutions in Tanzania. Based on experience from his past projects, Chris believes that off-grid generation might be a viable solution for a place like North Gondar, owing to its low population. He emphasized that solar and wind can prove to be very useful sources to cover the demand of energy, but they cannot be in operation throughout the day when sunlight is unavailable. So other sources such as hydro power, biogas, and other available sources must be utilized efficiently to ensure adequate and continuous supply. Although Christopher did not work directly with the energy generation aspect, our conservation with him was very informative with regards to how the entire energy schematic for a location is laid out before its implementation.

We also had the opportunity to have a conversation with Mr. Sudhir Patil who works as a Sr. Electronics Engineer and the Head of the Engineering Department at the Ethiopian Textile Industry Development Institute (ETIDI). He had visited North Gondar for a brief period on a project and provided us with some valuable references. Sudhir clarified that the only sources of energy used for electricity generation in the North Gondar zone at present are solar and wind power. The populace in Semien Gondar continue to face a shortage of electricity. Less than 15% of population in Gondar has access to electricity at present although the situation is improving with time. The Ethiopian government is encouraging the participation of private sector companies for development of solar mini-grid solutions to energy shortage problems. Transmitting electricity from the major dams to the North Gondar zone does not seem to be a very viable solution. Wind energy is also being promoted by the government and major subsidies are being introduced in the Gondar zone to ensure that the entire populace has access to electricity.

We also contacted Mr. Sisay Filate who worked as an Energy Engineer at the District of Columbia Sustainable Energy Utility (DCSEU). Sisay has worked in Ethiopia in the past but has no direct involvement in North Gondar but was strongly in favor of promoting solar mini-grid solutions for the area to overcome the current situation and make electricity accessible to the populace.

One of our sources is a new research, which is funded by Addis Ababa University, along with the National Meteorology Service Agency (NMSA) and Ministry of Water, Energy and Irrigation Office made Feasibility study of a solar photovoltaic water pumping system for rural Ethiopia. The research was based on 3 different regions: in Amhara, Tigray and Oromia. The monthly average solar irradiation values on horizontal surface for the three sites was measured and found that Ethiopia has immense potential for solar energy; because it is located near the equator with an average daily solar radiation of 5.25 kWh/m^2 [13].

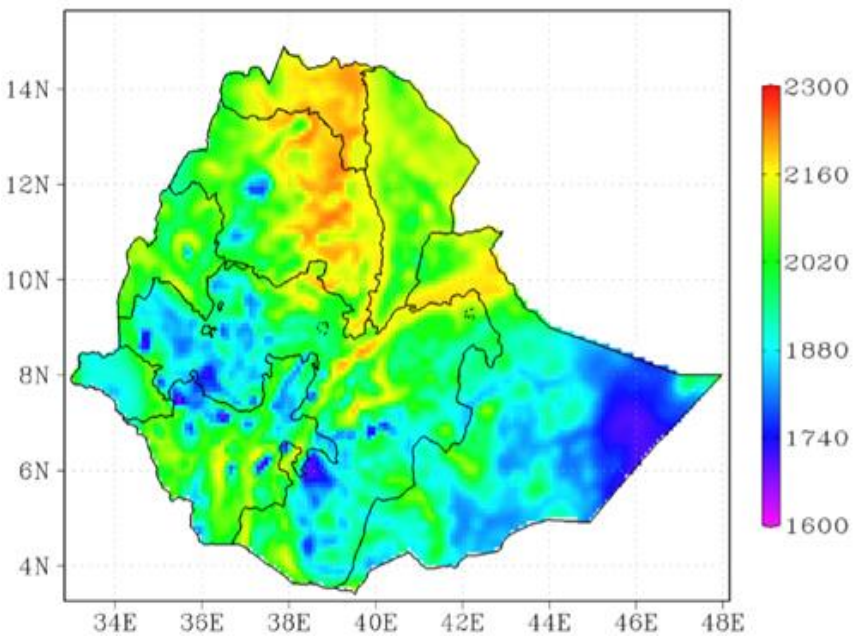

Figure 3. Distribution of average annual total solar radiation in kWh [11]

In collaboration with the Chinese, the government of Ethiopia prepared solar and wind master plan for the whole country. This plan identified the gross amount and distribution condition of wind and solar energy resources in the country, and found that Ethiopia has a capacity of approximately 1350 GW of energy from wind and annual total solar energy reserve of 2.199 million TWh/annum [3].

In developing countries like Ethiopia, generally composed of several villages sparsely located and with different topography, it is very difficult to extend the electric grid to every location where it is required. The trend of increasing fossil fuel price and its high contribution to environmental problems makes fossil energy sources unpromising. A lot of research has been conducted and the results invariably indicate that renewable energy is the best alternative to replace the fossil fuels.

Results

In this project we propose two solutions to solve electricity problems in North Gondar; Solar photo-voltaic power Hydro Power (GERD) for electricity generation. In Ethiopia, the development of the main power supply is not yet sufficient. Therefore, auxiliary power promotion with solar panels is not the priority. On the other hand, this could be ideal for rural electrification where the national grids do not reach. Therefore, many NGOs (Non-governmental Organizations) and are utilizing this type of solar energy generation in remote areas [11]

In Solar, there are two types of solar energy generation; to convert photovoltaic energy directly to electricity, or to heat water and create process steam to run a turbine. Recently, Solar PV generation costs are reduced all over the world. However, the capital cost of a solar photovoltaic water pumping system is still higher than the conventional diesel engines water pumping system. The capital cost of PV water pumping system can be considered as the major barrier for the application of the system in a developing country like Ethiopia.

The feasibility of solar photovoltaic water pumping system has been investigated for three selected sites in Ethiopia. It is found that the system can provide a daily average of 10.5, 7 and 6.5 m3/day for 700, 467 and 433 rural communities in Siadberand Wayu, Wolmera and Enderta sites, respectively, with average daily water consumption of 15 liters per day per person. And the cost of water, without any subsidy, are approximately 0.10, 0.14 and 0.16 $/m3for Siadberand Wayu, Wolmera and Enderta sites, respectively. If a 20% subsidy is considered during simulation, the cost of water would reduce to 0.09, 0.13 and 0.15 $/m3, respectively [11].

Therefore, optimization efforts are mainly focused on minimizing the capital cost of the system. While converting photovoltaic energy directly to electricity is very expensive and not suitable for a large-scale area like North Gondar. Direct converting is suitable for small application like houses or offices.

Table 2. Cost comparison using LCC for Siadberand Wayu site. [11]

SPV and DP system cost comparison using LCC for Siadberand Wayu site		
Costs	PV System ($)	Diesel Generator ($)
Capital Cost: pump cost is not included	1126.72	200
Maintenance Cost	225.34	400
Fuel/Energy cost for 20 years	0	7052
Replacement cost for generator	0	200
Total Cost	1352.06	7852
Salvage Cost	56.34	40
Life cost cycle	1295.72	7812

Many NGOs started solar projects in some parts of Amhara Region. A company called GTZ International is implementing a project of electrification of schools and health centers (to keep fridges working to maintain vaccines) in the north-east. Several other NGOs are working in the field, but considering the geographical size of Ethiopia, it is not enough to electrify the whole country.

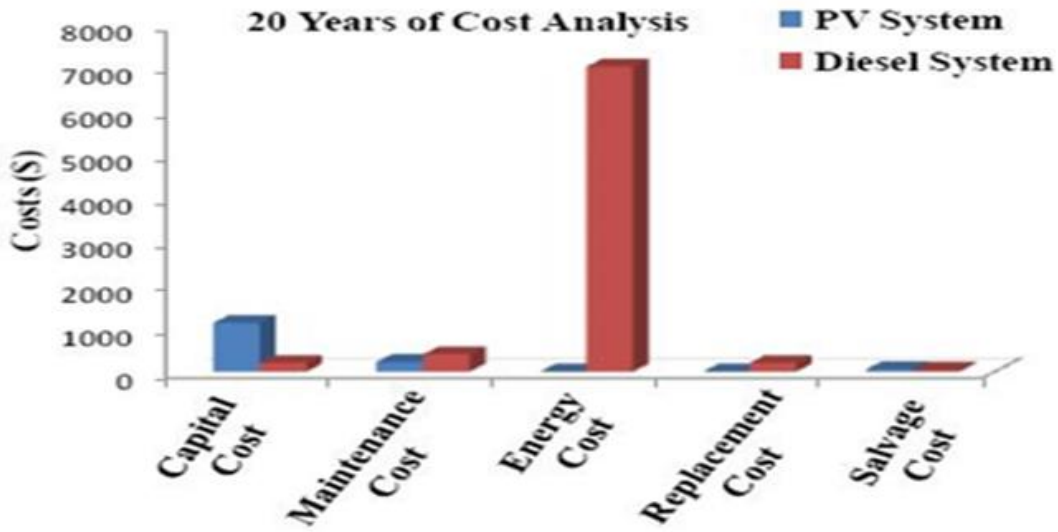

Figure 4. Cost Comparison PV and Diesel Systems [11]

To ensure the supply needed for growth, Ethiopian government has started, and should continue to promote private sector investment in the energy sector in addition to their own huge investment so far. IPP promotion is the new trend the Ethiopian government has started to promote. This will open the space for the world's private companies to invest in the Ethiopian energy sector [4].

A prospective solution for the electricity problem in Ethiopia the North Gondar zone is the hydro-electric power generation. The costs to explore hydropower energy are relatively low in Ethiopia. In fact, hydro installation in Ethiopia cost $1,200 per installed kW, about half the cost of most other plants in eastern Africa. Thus, generation cost of planned hydropower plants is calculated to be no more than $0.05 per kWh. The levelized cost for transmission is estimated to approximately kWh. Therefore, the leveled cost of power supply for planed power plants is estimated at $0.067 per kWh, making it one of lowest in the World. The additional power will cover both local and export demands, since most of Ethiopia's neighbors will use mainly conventional generations having average generation costs ranging between $0.15 and $0.24 per kWh [10].

It is estimated that Ethiopia is endowed with about 140,000 Mm3/yr. of freshwater resources, of which about 86% are surface freshwater resources. The Blue Nile constitutes the largest river basin in the country, where about 70% of its surface freshwater resources can be found. GERD dam has been under construction since 2011. It is in the Benishangul-Gumuz Region of Ethiopia, which is directly south of the North Gondar Zone, which allows easier connection of the North Gondar zone to the newly available grid upon completion of the project [11].

Figure 5. The Great Ethiopian Renaissance Dam [15]

A recent study by Science Policy Research Unit of the University of Sussex found that Ethiopia has ambitious plans for bolstering economic growth and aims to fulfil much of the associated energy requirements by exploiting its large estimated domestic hydropower potential. There are highly optimistic projections for future hydropower generation in Ethiopia estimating between 71 and 87 TWh/yr. by 2050 in a stringent climate change control scenario. Ethiopia is expected to contribute substantially to global efforts following this scenario to reach the 2°C target fixed in the Paris Agreement [10].

Conclusion

Ethiopia is a country undergoing major transition. While still recovering from over usage of natural resources and a bloody revolution, it is one of the most rapidly developing countries in the world. Aggressive energy policies are being enacted to keep up with rapid urbanization and growth in energy demand. While some natural resources are abundant, others are in dire shortage. As far as government is concerned, the ways of a new democracy are coming into effect, but a fair amount of political violence and human rights violations are not uncommon. The government is taking initiative and initiating major schemes to facilitate the all-round development of the country in all the sectors. Yet the times are still rough for most of the country, but the future of Ethiopia is looking bright.

References

1. Bureau of Economic and Business Affairs, “Investment Climate Statement”, April 2013, Web. https://www.state.gov/e/eb/rls/othr/ics/2013/204639.htm
2. Samson Tsegeye, “Highlights of the Ethiopian Energy Sector”, Solar Energy Foundation. June 2016. Web. https://sustainabledevelopment.un.org/content/documents/21986Ethiopia.pdf
3. U.S. Central Intelligence Agency, “The World Factbook”, Web. https://www.cia.gov/library/publications/the-world-factbook/geos/et.html
4. Focus Economics, “Ethiopia Economic Outlook”, September 2017, Web. https://www.focus-economics.com/countries/ethiopia
5. Renewable Energy and Energy Efficiency Partnership (REEEP) Policy Database, 2014, Web. 2014. www.reegle.info/policy-and-regulatory-overviews/ET
6. Ethiopia Electric Power, Tenders, 2016, Web. http://www.eep.gov.et/tender/
7. U.S. International Trade Administration, 2017, “Ethiopia – Energy”, Web. https://www.export.gov/article?id=Ethiopia-Energy
8. Embassy of Ethiopia, “Hydroelectric Dam Development in Ethiopia”, Brusells, Belgium, 2017, Web. http://ethiopianembassy.be/en/2016/07/01/hydroelectric-dam-development-in-ethiopia/
9. Ethiovisit, “Ethiopia - Historical Attractions, Regions, Cities and Population”, 2017, Web. http://www.ethiovisit.com/ethiopia/ethiopia.html
10. Bob van der Zwaan, Agnese Boccalon, Francesco Dalla Longa, “Prospects for Hydropower in Ethiopia: An Energy-Water Nexus Analysis”, Transrisk, May 2017.
11. Misrak Girma, Abebayehu Assefa, Marta Molinas, “Feasibility study of a solar photovoltaic water pumping system for rural Ethiopia”, AIMS Environmental Science, Vol 2, No. 3, 2015, pp. 697-717
12. Kibru Aschalew and Tesfaye Gedyon, “An Assessment of Competitiveness of North Gondar Zone, Ethiopia as a Tourism Destination from the Suppliers’ Perspective”, Developing Country Studies, Vol 5, No. 15, 2015, pp. 66-82
13. Ministry of Water and Energy, “Ethiopia's Renewable Energy Power Potential and Development Opportunities”, June 2013, Web. https://www.agora-parl.org/sites/default/files/africa_cec_session_3_ministry_of_water_and_energy_ethiopia_beyene_220613.pdf
14. https://www.voanews.com/a/at-least-32-killed-in-ethiopia-oromia-somali-regions/4028238.html
15. https://www.trtworld.com/mea/life-in-ethiopia-the-grand-renaissance-dam-143243
16. Schicker RS, Hiruy N, Melak B, Gelaye W,Bezabih B, Stephenson R, et al., “A Venue-Based Survey of Malaria, Anemia and Mobility Patterns among Migrant Farm Workers in Amhara Region, Ethiopia”, PloS ONE, Vol 10, No. 11, 2015
17. Embassy of Japan, “Study on the Energy Sector in Ethiopia”, September 2008, Web. http://www.et.emb-japan.go.jp/electric_report_english.pdf
18. International Energy Agency, “World Energy Outlook”, 2016.