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Rural Electrification Challenges and Implementation Strategies through Micro Grid Approach in Ethiopian Context

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ABSTRACT- Accessibility of electrical power is one of the driving forces used for the development of any level of nations. Nearly 50 percent People in Ethiopians lack access to electricity which majority of them living in rural areas of the country. The average Electricity consumption of Ethiopia is 153Kwh/year. The current installed capacity is at 4228MW which is relatively better than neighbor's sab-Saharan countries. According to Ethiopian National Electrification program the road to electrification in country is either through grid extension and that of off-grid technologies such as standalone systems and microgrids. Given the abundant natural and vast geographical advantage, the potential for renewable energy sources is huge in Ethiopia. The main aim of this paper to present detailed overview on microgrid based rural electrification through renewable energy supported technology for rural Ethiopian community. It recommended detail some of the off-grid and microgrid developments. Challenges facing, good opportunities of this development was discussed. Finally, it concluded by reflecting on implementation strategies of the microgrid based rural electrifications using renewable technologies

KEYWORDS: Micorgrids; Renewable energy; Rural electrification; Implementation strategy

I. INTRODUCTION

Reliable access to electricity is a basic precondition for improving people's lives in rural areas, for enhanced healthcare, education, and for growth within local economies as well as to meet millennium development goal. At present, more than 50% people in Ethiopia do not have access to electricity in their homes [1]. Almost all of these people live in rural areas; most have scant prospects of gaining access to electricity in the near future. The Ethiopian Government tried to connect this rural location by using national grid extension for the last two decades. However, still the current electricity access is below 50% and the real connection is less than 30% [1]. In this scenario the rural people who have very low load demand with dispersed settlement will not get electricity in the near future. Better access to sustainable energy service for rural people in Ethiopia is prerequisite for the sufficient supply of lighting, communication systems, and the development of income generating activities as well as the improvement of the public health situation. Today it is widely accepted that Renewable energy system (RES) have a large potential to contribute to the strengthening and development of national sustainable energy infrastructures in many countries in the world by securing better energy independence through the mobilization of domestic renewable energy resources especially in rural areas

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II. ENERGY RESOURCE POTENTIAL AND INSTALLED POWER GENERATION CAPACITY IN ETHIOPIA

Table 1.Indigenous energy resources in Ethiopia (Report on Ethiopian Energy Sector [1])

Resource	Unit	Exploitable Reserve	Exploited Percent
Hydropower	MW	45,000	<5%
Solar/day	kWh/m^2	4 – 6	<1%
Wind: Power Speed	GW m/s	100 >7	<1%
Geothermal	MW	<10,000	<1%
Wood	Million tons	1120	50%
Agricultural waste	Million tons	15-20	30%
Natural Gas	Billion m^3	113	0%
Coal	Million tons	300	0%
Oil shale	Million tons	253	0%

Presently, Ethiopia has a total installed power generation capacity of around 4238 MW. About 90% (3807 MW) is generated by hydroelectric power plants. Additionally, 324 MW (7.65%), 7.3 MW (0.17%) and 99.17 MW (2.34%) are produced by the wind, geothermal and diesel power plants, respectively [1]. The percent division of production by different sources is shown in Figure

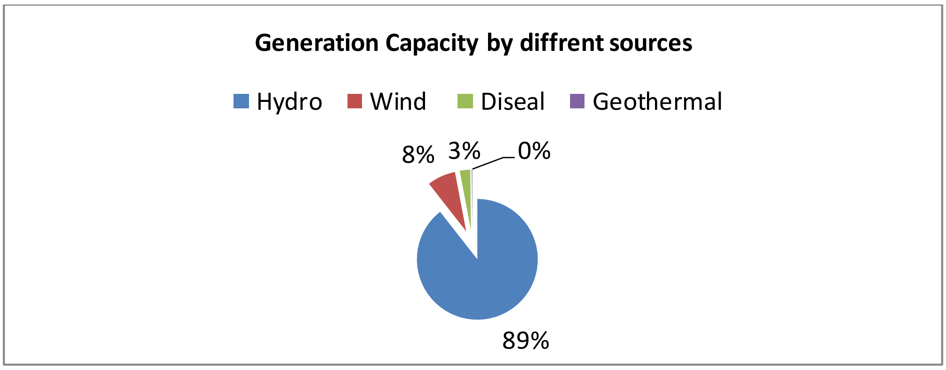

Figure 1.**Ethiopian energy generation by different sources**

The energy production of Ethiopia has been enhanced greatly by more than 250% between 2008 and 2018, with new hydroelectric and wind power projects such as Tekeze (2009, hydroelectric, 300 MW), Gibe II (2010, hydroelectric, 420 MW), TanaBeles (2010, hydroelectric, 460 MW), AmertiNesha (2011, hydroelectric, 97 MW), Gibe III (2015, hydroelectric, 1870MW), Ashegoda (2012, wind, 30 MW), Adama I (2012, wind, 51 MW), Ashegoda expansion(2012, wind, 90 MW), and Adama II (2014, wind, 153 MW). Additionally, one more project, the Grand Ethiopian Renaissance Dam is under construction with planned capacity of 6000 MW. The increased power generation is not efficiently utilized due to inadequate electricity grid.[2]

The most common generating sources for the hybrid system are wind, solar, hydrogen, geothermal, biogas, micro-hydro and fossil fuels. Owing to the environmental impact of conventional sources such as coal, diesel and the nuclear emphasis are given to renewable resources. The hardship of laying down transmission lines to remote areas makes HRES most attractive option. Integrating more than one resource preferably with storage unit overcomes the issue of unreliable power production [3]. To promote green and clean energy production, research is in progress for optimization and control tools for the HRES [4]. Out of the various sources mentioned above, hydro and biogas are among the first-generation resources which have been in use since the 19th century. Further advancement in power electronic technology has led to solar and wind resources which comprise the second generation. Further research has

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led tothe third generation which includes bio-mass, geothermal, and tidal and oceanenergies [5].**Photovoltaic Cell (PV)**:-The power generated by PV cells depends on the irradiance and the ambient temperature can be obtained by,

$$P_{Pv} = P_{STG} x \frac{G_{ING}}{G_{STG}} x(1 + k(T_c - T_{ref}))[1].$$

Hydro Power System:-The first step in hydro modeling is to calculate the flow rate. The flow rate can be calculated if the catchment area of river is known in addition to the rainfall data (monthly, daily, and hourly). Catchment areas are the areas from which rain water flows into the river. The above procedure is for run off river type of hydro system. The hydro potential of a site is given by

$$Q_{site} = K \frac{A_{site}}{A_{gauge}} Q_{gauge} \qquad [2]$$

Where $A_{site}$is catchment area of power plant (m^2), A_{gauge} is catchment area of gauge (m^2), Q_{site} is discharge at site (m3/s), Q_{gauge} is discharge at gauge (m3/s), and K is scaling constant or function.
The mechanical power generated by the turbine is given by

$$P = \eta_{total} \rho g Q H \ [3]$$

Hence the contribution of DG scheme using micro hydropower with other forms of RE technologies in a micro grid network to electrify rural Ethiopia is practically feasible. It is even economically sound to distribute some of the funding used for big dam hydropower plants to be shifted to micro hydropower in order to efficiently reach the rural areas with minimal transmission cost and power loss.

Table2 Summarizes regional distribution of small hydropower potentials

Region	Approximate small hydro power potential
Oromiya	35MW
Amhara	33MW
BenshangulGumuz	12MW
Gambella	2MW
SNNP	18MW

Their development is aided by advancement in nanotechnology [21–22]. The drawback of RES is that power generation is completely dependent on the climatic condition and topography of the plant site and not on the load demand unlike other conventional power generation systems [23]. Therefore, there can arise a problem of power mismatch. Hence, storage system forms an important part of HRES in order to aid its reliability with a trade-off with system cost. This is most commonly used electric storage system. The excess energy from the HRES is stored in the form of chemical energy which can be converted to electricity when required. The most commonly used batteries are of four types, each having their own advantages and disadvantages. Sodium–sulphur (Na–S) gives the highest energy density, nickel–cadmium (Ni–Cd) has the longest life, lead–acid are the cheapest and lithium (Li)-ion is the most commonly used of all with the best trade-off of all properties [23]. Since batteries are the most commonly used storage system in HRES, following are certain constraints which should be satisfied for modeling of the battery source [24, 25, 26].

$$SOC_{t+1} = \begin{Bmatrix} (SOC_t x\sigma) + \frac{I_{bat}(t) x \Delta t x \eta_{ch}(I_{bat}(t))}{Q_n} & \text{charging} \\ (SOC_t x\sigma) + \frac{I_{bat}(t) x \Delta t}{Q_n x \eta_{ch}(I_{bat}(t))} & \text{discharging} \end{Bmatrix} \qquad 4$$

$$SOC_{min} \le SOC_t \le SOC_{max}$$

$$P_{max-char} \le P_{bat} \le P_{max-discha}$$

Where $SOC_t$is the state of charge of battery which should always lie between manufacture-defined maximum and minimum limits, σ is the self-discharging rate of the battery, $I_{bat(t)}$ is the current,which is positive during charging and negative during discharging of the battery, Δtis the period of sample and $\eta_{ch}[I_{bat(t)}]$ is the charging efficiency and $\eta_{disch}[I_{bat(t)}]$ is the discharging efficiency of the battery, Q_n is the nominal capacity of the battery in Ah. P_{bat} is the power extracted from battery, which should lie between maximum allowed charging power and discharging power of the battery for which P_{bat} is considered positive during discharging and negative during charging of the battery [26].

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III. STATUS OF RURAL ELECTRIFICATION IN ETHIOPIA

Ethiopia has been making considerable progress in the electricity sector since the turn of the millennium. The grid-based Universal Electricity Access Program has made progress in connecting off grid villages and regions to the national electricity grid through public investment. Furthermore it has worked on expanding capacity of the national grid. The grid expansion program will continue in the GTPII.[4]

Table 3. Grid extension program [4]

	2002	Current estimate (2018)
National grid coverage to rural towns (electric access)	13%	55%
National electricity connectivity (percentage of households actually connected to grid)	7%	30%
Electrification rate	6 rural cent /Year	500 cete/year
Installed generation capacity	450MW	>2000MW
Urbanization rate	15%	17%
Per capital electricity consumption	21Kwh/Year	150KWh/Year

The impressive extension of the national electricity grid does not automatically mean that all rural households in those regions are connected. In many areas, grid is present, but limited villages or households have been connected, making actual grid connection in rural areas well below the 55% geographical coverage of the grid. Energy poverty is thus quite severe because of the limited ability to access adequate, affordable, reliable, quality, safe, and environmentally friendly energy services to support human and economic development.

Therefore the rural electrification effort in Ethiopia has to face up to new and existing challenges, including:

- Scaling up electrification capacity to levels unachieved to-date;
- Dealing with electricity supply sources outside the national grid;
- Scaling up connectivity in the rural areas to get electricity to the nearly 14 million rural homes that are currently without any supply;

Currently energy needs are mostly covered by the use of traditional biomass sources (e.g. fuel wood or agricultural waste for cooking and heating), kerosene (especially for lighting) or small battery or thermal generator units (for lighting, communication etc.), and diesel.

PV lanterns and solar home systems (especially small systems) are starting to gain momentum in Ethiopia with deployment and sales increasing (annual sales of 0.3 million units), but this concerns mainly small systems and do not fully cover the electricity needs of multiple households or whole villages [6].

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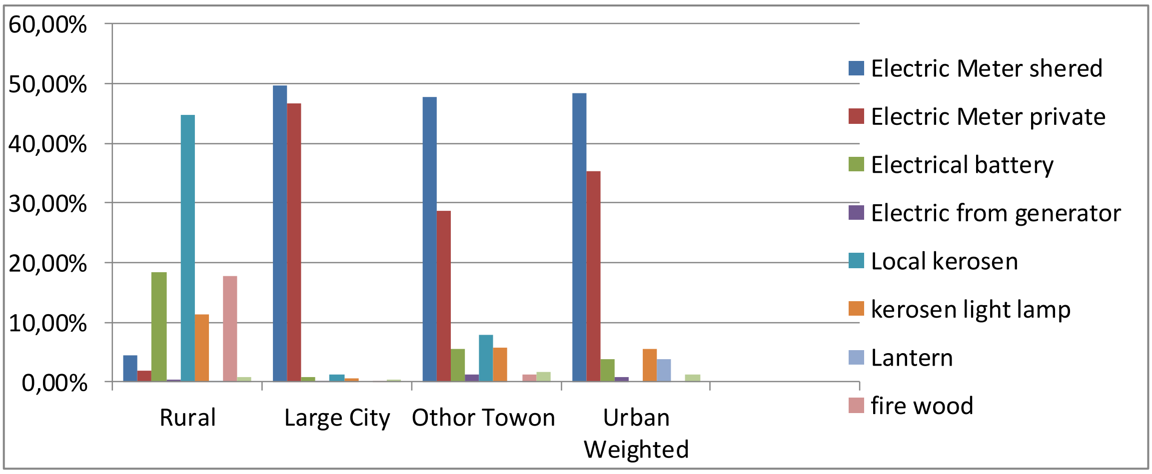

Figure 2. Energy used for lighting in Ethiopia, .[7]

Issues related to the use of these types of energy are for example health risks (e.g. flammability of kerosene, respiratory impacts of fuel wood burning), high costs and absence of constant

IV. ELECTRICITY SECTOR CHALLENGES IN ETHIOPIA

The electricity sector in Ethiopia faces the following key challenges going forward, which necessitate the development of a sector reform roadmap:

a) Providing quality service to its current and future customers. A recent customer satisfaction survey (in 2019) concluded that more than 60% of customers who were consulted and interviewed expressed dis-satisfaction with the quality of service they are provided by the utility. Improving the quality of service would require institutional, regulatory and structural reforms encompassing regimes that mandate and enable the delivery of quality supply.

b) Achieving universal electricity access by the year 2025. The National Electrification Plan envisages to bring the on-grid access to 65% and the off-grid access to 35% households. This ambitious plan has already started with the ongoing IDA financed electrification project and the off-grid focused electrification project under preparation.
The financing prospectus shows that development partners (DPs) in addition to the World Bank need to be coordinated to enhance the financing plan (through syndication) to make the Plan a reality.

c) Maintain meaningful improvement in the energy mix. Ethiopia's hydro dominant power system experienced some challenges in the past due to climate change triggered draughts. The country fell into severe load shedding in 2009 due to water shortage in the dams. The hydropower vulnerability could be mitigated with appropriate energy mix by developing renewable energy sources – including solar, wind and geothermal energy.

d) Achieving the vision of becoming key electricity exporter in the region. Ethiopia with ts huge renewable energy potentials and considering the ongoing ambitious growth and transformation plan could emerge as a regional exporter of electricity which would contribute to national economic growth as well as earn valuable foreign exchange.

e) Maintaining strong credit worthy companies that can finance investment. This is a key issue that requires deep analysis for a forward-looking strategy while addressing debt sustainability. Although the government has recently decided to convert a portion of EEP's debt into equity, the utility is still far from being financially sustainable. EEP

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faces a large investment plan and will also become the off-taker for the large number of future PPP projects. Therefore sector revenues need to keep pace with the cost of service as well as sustaining the investment plans.

f) Establishing a strong, full-fledged and independent regulatory body. The government has only recently taken measures to adjust electricity tariffs after a period of 12 years. The regulatory body has great role in developing and monitoring tariff and other regulatory aspects of the sector. With the opening of the private sector, the regulatory body needs to be strong and independent to sustain its human resources capacity through creating conducive environment.

V. CHALLENGES OF RURAL ELECTRIFICATIONS IN ETHIOPIA

In many developing countries, rural areas offer opportunities to deploy power systems based on small-scale hydro power, solar energy and biomass. These areas offer an "electrification green field" where the selection of the technological option can be determined by the locally available resources, the financial situation, the features of the supply area, and the environmental impact. A general conclusion is that rural electricity supply has always been considerably more expensive than the supply to urban areas and, as a consequence, utilities have been reluctant to extend the service to rural areas. Table 1 summarises, for the purpose of mutual comparison, a number of features specific to urban/industrialised supply areas and rural supply areas. The combined effects of the specific features of rural power systems and their more problematic operation and maintenance, make the marginal costs of electricity supply to rural consumers high relative to that of consumers in urban areas.

Table 4. Typical features of industrial/urban and rural supply areas.

Feature	Industrial/urban supply areas	Rural supply areas
Area load density (kW/km²)	500 to 100,000	2 to 50
Consumer density (conn/km²)	> 500	1 to 75
Number of consumers per km line length(both MV and LV included)	> 75	1 to 75
Consumption density (kWh/km²)	> 2,000,000	5,000 to 200,000
Total costs/kWh (US/con)	10 to 15	Grid based: 12 to 50 Diesel based: 25 to 100 or more PV home systems based: 50 to 500
Investment costs per connection (US$), excl. gen &transm.	<500	500 to 7000, average 1200, extremes of over 100,000
Social aspects	limited	specific financial support and solutions needed
Technical/organisational aspects	large projects; often heavy power technologies on supply and demand side; reasonable load factors as a result of mixed loads	various technologies and small scale applications; low load factor because of dominant domestic and agricultural loads; intensive customer support needed; ratio of labour to capital high.
Socio-cultural aspects	seldom of importance	important
Economic aspects	profitable business opportunities	limited profitable business opportunities

If affordable tariffs are assumed, a cost-benefit analysis of a rural electrification project in itself will usually show a negative outcome. Figure 1 illustrates the high cost per connection in the case of small grid systems. Despite the abundance of natural resources, the difficulties (financial and in supply) of fossil supply and the absence of modern electricity sources, renewable energy micro-grids have not been widely deployed yet in rural Ethiopia. Several types of challenges can be identified which are obstructing the deployment of these renewable micro-grids:

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•Financial challenges;

•Privet sector investment;

•Institutional;

•Technical/technological;

•Informational and awareness.

In the following section we will briefly address the types of barriers as presented above.

Financial barriers

Currently it will be difficult to operate micro-grid on renewable energy in an economically profitable manner. In rural areas, affordability is an issue, mostly because the willingness to pay is lower. The main driver for this is the fact that on-grid tariffs for electricity are currently very low, so all consumers (on and off grid) expect to be serviced for that same price. However if the grid tariffs would reflect real costs for supplying to remote areas, they would be a lot higher than the current grid tariff. Off grid solutions would be a more economically favorable solution if comparing to real grid extension costs(see ECA 2013, which indicates real connection costs for households to be in the range of $1000-$3000, micro/minigrids could be developed for lower costs per connection). Furthermore grid expansion is state financed, making the extension of grid to rural areas seem cheaper than construction of mini-grids, even if overall it is actually more expensive. If similar subsidies to grid extension would be applied to mini-grids, they would be able to operate in economically sustainable manner. Financial capacity and willingness to pay of rural households for modern energy services is growing fast. The development of economic activities in the region could be combined with the construction of modern energy services. So far the combined benefits of connections for household energy services and economic activities has not been looked into in detail.

Another aspect for private developers is the initial investment costs required for the development of a mini-grid, while income would only be generated during the lifetime of the mini-grids. Start-up finance (e.g. in the form of soft loans) would enable private developers to overcome this barrier. Marketbarriers: At the moment the involvement of private developers in the rural electricity sector, especially in mini-grids deployment is very low. This is due to two main reasons, namely uncertainty and quality assurance. The main source for uncertainty for private developers is due tothe'unknown' path of grid extension. The plans and areas targeted for grid expansion in the coming 5-15 years are not clear to private developers. Furthermore it is also uncertain what happens if grid is extended to an area where mini-grids arealready in place. Private developers' main questions and concerns include: Could they connect to the grid as a decentral producer, what would tariffs then be, what technological changes are then required, would it be allowed to continue off-grid operation etc. Regarding quality assurance, at the moment there is no clear system to label or certify certain systems to ensure quality, safety and efficiency in the deployment of mini-grids. Quality assurance will also create more confidence of consumers and private developers in the long term operation of their mini-grids.

Institutional barriers:The Rural Electrification Fundhas been set up as the entity responsible for coordinating all efforts on rural electrification. This is already a big step forward. Before the creation of this entity within the Ministry of Water, Irrigation and Electricity, there was limited coordination between different ministries and donors on their efforts to establish initiatives on rural electrification. This caused a sometimes weak integration in infrastructure planning among all sectors, leading to inefficiencies. At the moment thereareinsufficient capacity (technical and financial) and experiences at the Rural Electrification Fund available to actually steer the developments on rural electrification. Another barrier(mixture between institutional and financial barrier)is the challenge in Ethiopia to finance the energy sector programs. The energy sector is highly capital intensive, requiring substantial investment for energy sector development and for promoting the transition from traditional solid biomass fuels to modern energy

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services. The combination of new energy generation projects, grid extension and off grid options place quiet some financial burden on the Ethiopian government.

Technical/technological: Some regions in rural areas are remote and therefore difficult to reach (especially those further away of roads). Due to insufficient technology transfer and underdeveloped industry for manufacturing, most of the energy technological hardware is imported, which leads to high foreign exchange spending. Technical capacities, information and awareness:One of the major bottlenecks in the Ethiopian energy scene remains to be limited capacity in human, technical and lack of stable institutional arrangement. The development of a vibrant energy sector requires substantial development of energy sector management, investment, technical know-how, and institutional capacity. Information is scanty for investors on resource potentials, available provisions, tax regime, and possible benefits on mini-grids development, especially in the international arena, but also from pilot projects within Ethiopia experiences and lessons learned are available. These seem not to filter through to other possible developers. There is an absence of a central 'learning/knowledge platform' where new possible developers could turn for tips and lessons learned. If developers, or government would have better insights in what type of projects, business models or financing models would work, it would be easier and faster to deploy new projects.

VI. IMPLEMENTATION STRATEGY

In order to overcome the above mentioned challenges we have to do the following basics:-

A. Follow the appropriate methodology

To implement microgrid based rural electrification in rural area it is best way to follow the methodology described below

1. **Case study: -**To determine all necessary in put parameters it is better to do case study on selected rural area of the country. The case study include the following basic task

a) Data Collection

- For selecting a case study area, collecting general information about non-electrified rural villages in Ethiopia such as geography, climate, population, current electricity status of the village is required.
- Based on the existence of or distance of the community to the national distribution grid; Population and settlement density; Average income and purchasing power; Existing economic activity; Existing semi-industrials such as telecom towers; availability of sufficient solar radiation resources; flow rate head of the existing river and Accessibility and security.
- Various meteorological data sources need to be used as time series data inputs for the simulation of expected renewable energy generation potential at every potential micro-grid site. Typically, the most accurate data would be ground-measured meteorological data (Solar irradiation, water flow rate, wind speed and etc) covering multiple years, measured on site, using high accuracy instruments. If this kind of data is available for a micro-grid site under investigation from NMA (Ethiopia National Meteorology Agency) or NASA (National Aeronautics and Space Administration).
- Electricity demand data collection by measuring current for a detailed assessment of existing and potential of local demand for the selected case study area.

b) Sizing of renewable energy sources

The Sizing of the following renewable energy resources will be carried out

- ✓ The solar PV module
- ✓ Micro hydro generator and

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- ✓ Wind turbine
- ✓ Battery energy storage. For the specified case study area based on the modeled and forecasted loads.

c) Analysis of the different data's

The following basic analysis will be carried out

- Economic analysis
- Environmental analysis , and
- Sensitivity analysis

2. Design and Modeling of hybrid system

2.1 Proposed the appropriate model of isolated micro-grid

The modeling of renewable energy hybrid systems has to be made by knowing all types of renewable energy used in the model. For a good understanding of the system, equivalent models, based on large scale used components, should be considered. So if we consider Solar, micro hydro and Battery the appropriate micro-grid model is shown below.

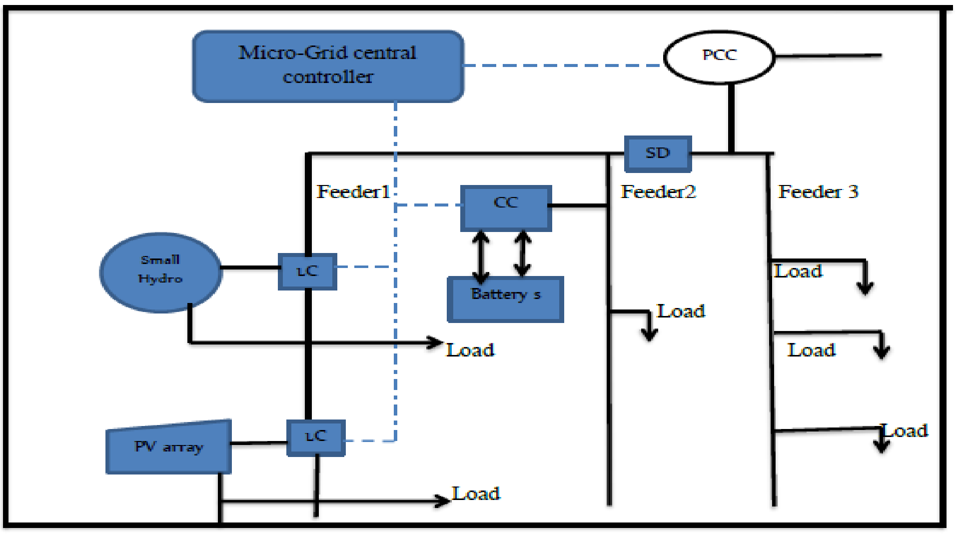

Figure 3.PV and Micro hydro based hybrid micro-grid

2.2 Design and optimal load flow study of Radial local distribution network

The most common form of primary feeder for local distribution at lowest cost for village electrification is radial distribution system with isolated hybrid micro-grid. In isolated Hybrid Micro-grid three phase supply if feeding into 3-phase or four wire distribution system and laterals its feed single phase supply to each home and 3-phase to common loads in the village. In distribution system current magnitude is the important parameters along with voltage magnitude, frequency and power factor. The voltage regulation in isolated hybrid micro-grid may restrict based feeder size, thermal capability and current carrying capacity of the feeder.

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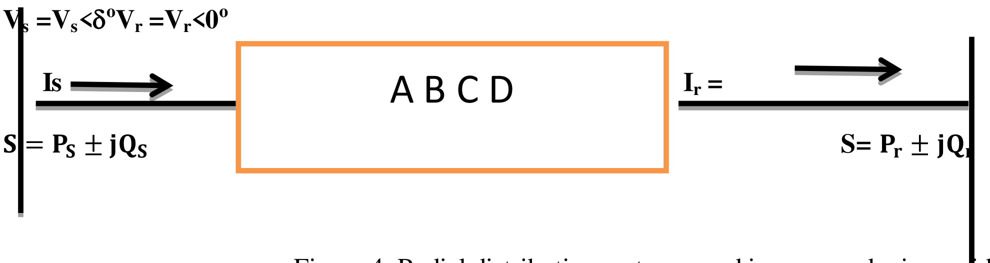
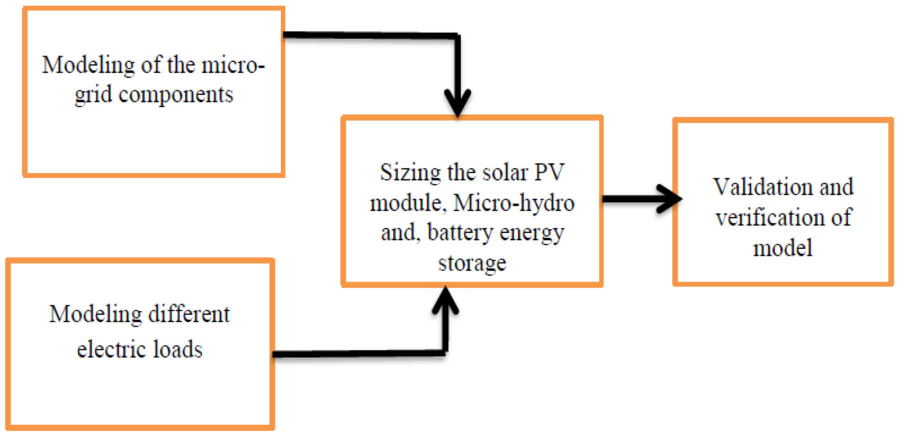


Figure 4. Radial distribution systems used in proposed micro grid

A planned and effective distribution network is the key to cope up with the ever increasing demand for domestic, industrial and commercial load. The load-flow study of radial distribution network is of prime importance for effective planning of load transfer. Optimal load flow methods which are widely used for distribution systems load flow solution is analyzed on 33-bus radial distribution systems using backward - forward sweep method and direct load flow approach.

2.3 Verification and Validation

a) To validate the optimized size of the solar PV module, micro Hydro and battery energy storage by using suitable software's.



b) **Modeling and simulation the overall system**

- ✓ Simulate the RES based distribution network using different appropriate soft ware
- ✓ Develop an algorithm using different optimization method inmodern software for verification of optimization the generation and load.
- ✓ Compare different Modern optimization methods (PSO, GA, Anelling game theory and etc)
- ✓ Design appropriate control method for improving a power quality for proposed isolated micro grid..

c) **Reliability Evaluation**

There are two reliability assessment techniques, viz., analytical methods and stochastic methods. Analytical techniques represent the system by analytical models and evaluate the indices from these models using mathematical solutions.

B. PROBLEM FORMULATION

The major consideration here is

- ❖ To determine the size of each of the components in the Hybrid isolated micro-grid so that the load can be supplied at minimum cost and high reliability. Individual power has different overall impact on cost, performance and

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reliability of Hybrid isolated micro-grid. Therefore, optimal sizing and economic power dispatch strategy needs to be considered. The decision variables are the number of hydro turbines (NSHP), number of the PV modules (NPV), and number of battery banks, (NBATT).

- The main objective function is to improve the reliability of the proposed Hybrid isolated micro-grid as well as minimizing the annualized cost of the system and cost of energy while satisfying the consumers' power requirements and the system constraints. This objective can be achieved with the integration of the RERs and ESS units in a MG power system. The objective function of the proposed power system is expressed as:-

$$F = \min \sum_{i=1}^{n} (RI + ACS + COE) \qquad (5)$$

Where:-

RI: Reliability Indexes

ACS: Annual Cost of the system

COE: Cost of Energy

- Comparison of the different control methods which performed by different researchers Compare contrast each of them in terms of rapidity, stability, harmonic elimination, robustness against parameter variation and unbalanced compensation. It is highly difficult to specify a particular control method is superior to others, as each method has its own merits and demerits.Though there are many discussions in the literature about the control strategies for the power quality improvement in a micro grid system, no control technique provides solution to address all the power quality issues like voltage unbalance, voltage sags and swells, harmonic distortion and power sharing issues at the same time. So based on proposed model it better to design different controlling mechanism which is fulfill different requirements of power quality limits.

VII.CONCLUSION

Energy poverty is the number one factor in deterring economic development in developing countries like Ethiopia. This has been as a result of continued political instability, poor infrastructure system, lack of expertise in the area of energy technologies and weak policies and regulations encouraging the utilization of innovative off-grid technologies. Renewable energy technologies and microgrids are the next direction for the lack of energy access to countries like Ethiopia. The Ethiopian government has a plan toexploit the potential of their RES to secure energy for all sub-Sahara countries. In rural and remote arid regions where it is even harder and costly to get power, microgrids supported by different RES. Microgrids are cost effective compared to the grid extension investments. Finally, renewable energy supported microgrids are poised to make a huge impact in giving access to the rural electrification challenge for countries like Ethiopia and other developing countries are facing. If the government and privet investors are potentially participate on micro-grid based rural electrification it is possible to improve the electrfiction problem of rural community with in near futures.

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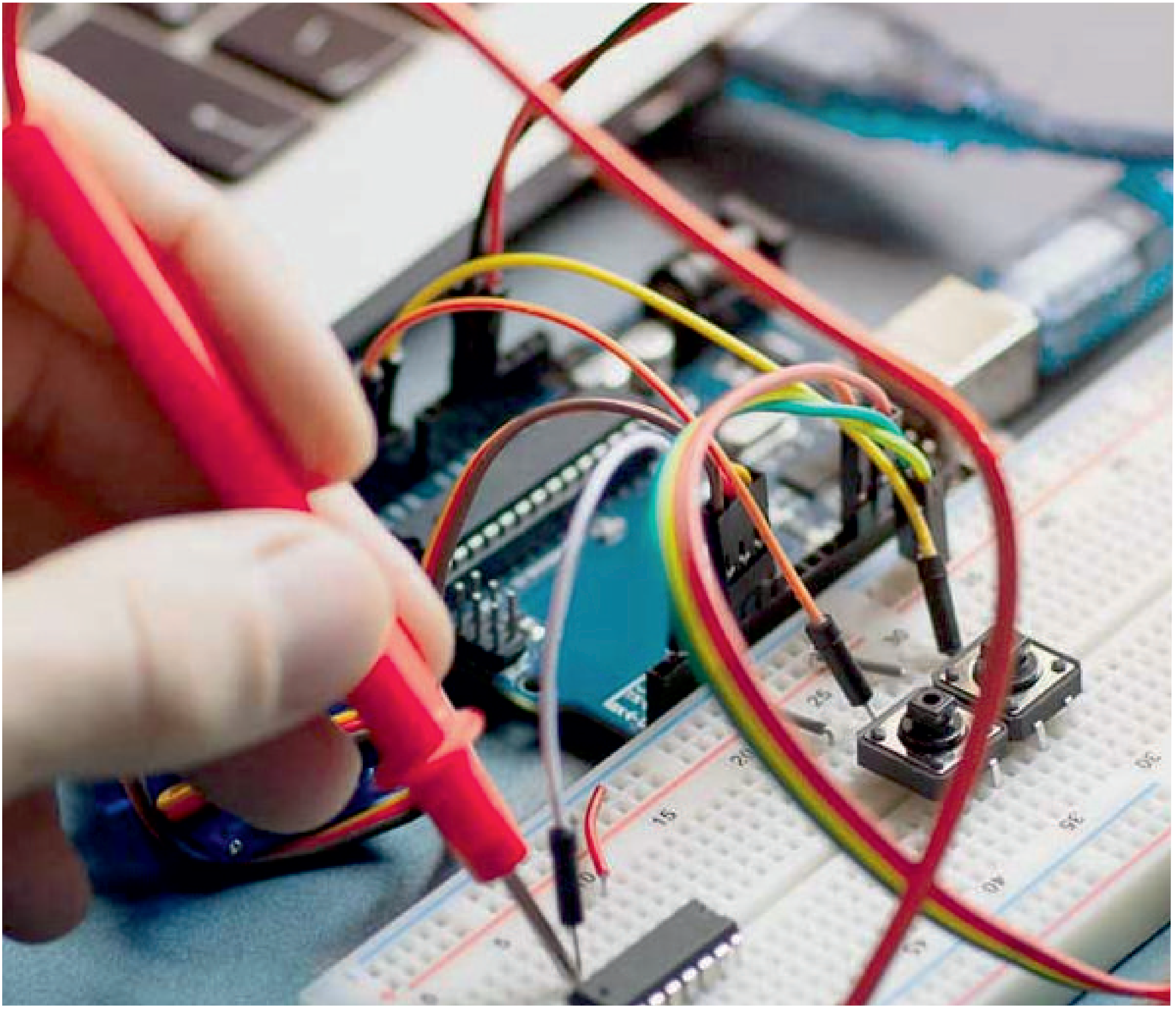

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