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Potentiality and Feasibility Study of a Hybrid Renewable Energy System for Remote Area Electrification in Jimma Zone, Ethiopia

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Abstract: **Renewable technology provides clean, abundant energy sources derived from self-renewing resources, with the rapidly increasing demand for electricity; it is quickly becoming the best option for electrification, particularly in rural areas. This paper shows that Potentiality and Feasibility Study of a Hybrid PV/Hydro/Biomass optimizing System for Remote Area Electrification, which is found in this area at high energy and has no electricity access from grid connection. The incoming average solar energy has been converted in to 5.16$\mathrm{kWh/m^2/d}$. The flow rate of Naso River was found 1.22$\mathrm{m^3/s}$ from the flow rate of Gigel Gibe I using through empirical area ratio method. Monthly average biogas feedstock (i.e. cow dung), the site is 1.35 $\mathrm{tonnes/day}$. To produce 18 KW from Solar PV system 416 modules, having 83$\mathrm{m^2}$ area and Solar insolation at the site during the worst month at July is 3.86$\mathrm{kWh/m^2/d}$ was used. From point of optimizing energies through homer software, the designed peak power demand at installed capacity is around 116 KW. Since EEPCO can sells for urban is $0.025\$/\mathrm{kWh}$ and for the rural is double price that is $0.05\$/\mathrm{kWh}$ by considering transmission line cost, maintenance cost and transportation cost. The hybrid system is cost would found around $0.031\$/\mathrm{kWh}$. So that from Economic Point of View the hybrid system is more feasible.**

Keywords: **EEPCO, Feasibility, Hybrid, Potentiality, Renewable, Sells.**

I. INTRODUCTION

Growing world population and industrialization increase the energy demand and world energy consumption is expected to grow by 50% from 2018 to 2050 [1]. Big portion of this energy demand is met by fossil fuels and therefore causing detrimental effects to the environment [2]. Rural electrification has long been top on the development agenda of many developing countries. Nevertheless, the vast majority of the rural population in these countries did not have access to electricity. Renewable Energy Sources (RESS) such as wind, solar, biofuels, hydro, and others are already at the backbone of the transformation process to a lower carbon dioxide (CO2) emission and greener energy system [3]. However, the COVID-19 pandemic has a significant impact on the power industry [3]. Most of population of Ethiopia lives in rural areas far from the national electric grid. So, it is not possible to satisfy the energy need of the population taking the current situation in Ethiopia [4]. Ethiopia has a huge renewable energy (micro-hydro power, solar, biomass and wind energy) potential that has not been used for rural electrification. Due to the remote location and the low population densities of the rural communities the traditional means of providing power have proven too expensive, undependable, difficult to maintain, and economically unjustifiable. Climate change enhanced greenhouse gas emissions, and the decline of non-renewable energy supplies has drawn attention towards retaining worldwide energy sources [5]. Kedemsa village is not rich in fossil fuel resources but it has plenty of renewable energy resources, in particular water that is running down. The sun's freely available and number of cattle reproduction also there. In this context renewable energy development continues to be a high priority program of government as it provides a least cost solution to remote, sparsely populated areas unviable considered for the hybrid system [6]. The main purpose of this paper found suitable component size and operation strategy for system which results would lead to the design and planning of optimal hybrid energy system. The main problem regarding renewable source-based power system networks is its uncertain nature. The hybridization of two or more renewable sources into the system might reduce this problem by offering system reliability and improved efficiency [7]. In coming time it would be a necessity as well as requirement to change from conventional sources to renewable energy resources to fulfill the energy demand. The main objective of this paper is to Potentiality and Feasibility Study of a Hybrid PV/Hydro/Biomass System for Remote Area Electrification in Jimma Zone.Many researches were conducted on the feasibility of hydro/solar/wind-based hybrid system. The author in paper [8], Hybrid power systems that combine wind and solar PV technology have been widely employed for power generation, particularly for electrification in remote and islanding locations, because they are more cost-effective and reliable than traditional power systems. This article intends to develop an environmentally friendly and cost-effective hybrid power system for selected critical loads in the Avu to community of Ghana. The author in papers [9], discussed the feasibility of the hydro/PV/wind/diesel system using homer simulation software, and others in [10]discussed the feasibility study and comparative analysis of hybrid renewable power system for off-grid. The author in paper [11], the fuzzy logic control system is designed, to monitor the resource availability and load demand. This controller was managing the demand and the available resources according to the rule. The author in paper [12], Optimization of Hybrid Renewable Energy System (HRSE) Using Homer good feasibility study analysis the author in paper [13], the study's detailed findings indicate that the majority of the power produced in both off/on grid situations is photo-electric solar power. In the off-grid environment, the renewable fraction is comparatively high, and it is varying from 92% - 100%, compared with perturbations around 63% - 80% in grid-tied systems. and simulations were performed using HOMER software. The author in paper [14], used HOMER as the optimization tool and used the optimality ranking technique as a second method while determining the best optimal hybrid distributed generation system. The author in paper [15], the author discussed the economic viability with the technical aspects to set up such a system via HOMER analysis. The author in paper [16], However, due to the lack of proper data collection, optimization methods, and use of old technology and devices in hydropower generation, the outcome of researches is still not enough to implement hybrid energy generation systems .In this research, the optimized Solar PV -Hydro-Biomass hybrid system is proposed using a new modified and feasibility study to increase the PV-generated power with a reliable power control supplied to loads in remote area Jimma Zone. The contribution of this research is as follows: a)The potential assessments of Solar PV -Hydro-Biomass hybrid energy generation system application was investigated with an actual situation in the selected one .b) Standalone hybrid Solar PV -Hydro-Biomass systems were developed to optimize the power generated and stabilize the energy supply to load demands.c) HOMER was used, and the optimize

II. METHODOLOGY

A Data collection

National Meteorological Agency, NASA &SWERA for solar irradiation, Ministry of Water Resources- for flow rate (discharge) of rivers. Direct measuring data from the site- Using GPS (Global Positioning System) to identify the exact location of the sites. Estimation & analysis of the consumer load by counting the homes and different websites-for estimation of the cost, hydro turbines and solar panel will be used.

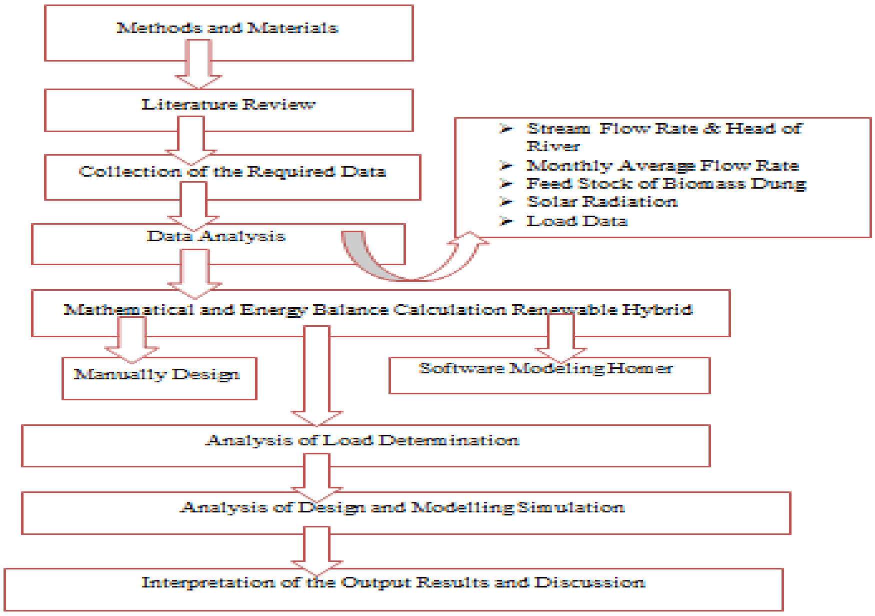

Figure 1: Flow chart of the research processes

III. ASSESSMENT OF RENEWABLE ENERGY

3.1 RENEWABLE ENERGIES

3.1.1 Solar energy resource assessment

The most common solar energy resource data collected in many of the meteorological stations (NMSA) throughout the country is the average daily sunshine hours. The available sunshine hour data from the National Meteorological Agency of Ethiopia (Jimma, and Agaro branch) was used to estimate the solar radiation energy of the sites.

The empirical formula used to the estimate monthly average day of solar radiation on horizontal surface is determined by Angstrom- equation and applying Eqn. (1).The parameters N, a, n, b, H_o and finally H were calculated [17].

$$H= H_o\left(a + b\frac{n}{N}\right) \quad (1)$$

Where H = is monthly average daily global solar radiation, H_o = is monthly average daily extraterrestrial solar radiation, a and b= is Angstrom's correlation parameter, n = is monthly average daily hours of sunshine from sunshine recorder, N= is monthly average of the maximum possible hours of sunshine

$$H_O = \frac{24}{\pi} \times 3600G_{SC}[1 + 0.033\cos(\frac{360 \times N}{365})] \times [\cos(L)\cos(\delta)\sin\Omega_{ss} + \frac{2 \times \pi \times \Omega_{ss}}{360} \times \sin(L)\sin(\delta)] \quad (2)$$

Where N= Day number starting from January 1*st*, G_{SC}= solar constant= 1367w/m^2, Φ= Latitude of the location, δ = Declination angle (°) and Ω_{ss}= Sunset hour angle (^{0})

The day length is twice the sunset hour, since the solar noon is at the middle of the sunrise and sunset hours. Therefore, the length of the day in hours is

$$N= \frac{2}{15}\cos^{-1}(-\tan L \tan \delta) \quad (3)$$

$$\delta = 23.45 \sin(360/365(284 + N)) \quad (4)$$

Where L= latitude angle north i.e. L=7.51^{0}N

$$\cos \Omega_{ss} = -\tan(L)\tan(\delta) \quad (5)$$

Where Ω_{ss} = the sunset hour angle, Ω_{ss}= $\cos^{-1}(-\tan(L)\tan(\delta))$

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Thus the regression coefficients "a" and "b" in terms of the latitude, elevation and percentage of possible sunshine for any location around the World (for 5° ≤54°) are correlated by Gopinathan with equation(6 & 7) below [17][**16**].

$$a = -0.309+0.539 \cos L -0.0693\ h +0.290\left(\frac{n}{N}\right) \quad (6)$$

$$b = 1.527-1.027 \cos L +0.0926\ h -0.359\left(\frac{n}{N}\right) \quad (7)$$

Where h = (is Altitude of a site = 5496ft = 1.6752 km for the specific study site) with an elevation of h

δ = is declination angle for the average day in the month, L= is Latitude of the site (7.51^{0}N and 36.35^0 E for the specific study), therefore the declination angle for each month calculated as summarized in table 1 below.

Table 1: Day Number and Recommended Average Day for Each Month [18].

Month	n_d for i^{th} day of the month	For the average day of the month		
		Date	Day of year (n_d)	declination (δ)
January	i	17	17	-20.9
February	31+i	16	47	-13.0
March	59+i	16	75	-2.4
April	90+i	15	105	9.4
May	120+i	15	135	18.8
June	151+i	11	162	23.1
July	181+i	17	198	21.2
August	212+i	16	228	13.5
September	243+i	15	258	2.2
October	273+i	15	288	-9.6
November	304+i	14	318	-18.9
December	334+i	10	344	-23.0

There is also tabulated table 2 as shows below global solar radiations from Jimma National Metrology Agency (JNMA) calculated for the select one site of village.

Table 2: Average solar radiations in $kWh/m^2/d$ village

Month	N	δ(^{0})	Ω_{ss} (^{0})	N (hours)	n hours	$\frac{n}{N}$	a	b	H_0 (kwh/ m²/d)	H (kWh/ m²/d)
January	17	-20.9	87.114	11.62	7.41	0.64	0.29	0.43	9.21	5.2
February	47	-13.0	88.26	11.77	7.58	0.64	0.29	0.43	9.84	5.56
March	75	-2.4	89.68	11.96	7.95	0.66	0.30	0.43	10.36	6.05
April	105	9.4	91.25	12.17	7.26	0.60	0.28	0.45	10.49	5.77
May	135	18.8	92.57	12.35	7.13	0.58	0.28	0.46	10.27	5.62
June	162	23.1	93.22	12.44	5.94	0.48	0.25	0.49	10.07	4.89
July	198	21.2	92.93	12.4	4.09	0.33	0.20	0.55	10.12	3.86
August	228	13.5	91.81	12.25	4.10	0.33	0.20	0.55	10.33	3.94
September	258	2.2	90.29	12.04	4.81	0.40	0.23	0.52	10.34	4.53
October	288	-9.6	88.72	11.84	7.22	0.61	0.29	0.44	9.94	5.55
November	318	-18.9	87.41	11.66	8.14	0.69	0.31	0.42	9.33	5.59
December	344	-23.0	86.79	11.58	7.96	0.69	0.31	0.42	8.99	5.39
Annual Average										5.16

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Graphically as shown Figure 2 and Figure 3 below global solar radiations from JNMA and NASA station respectively

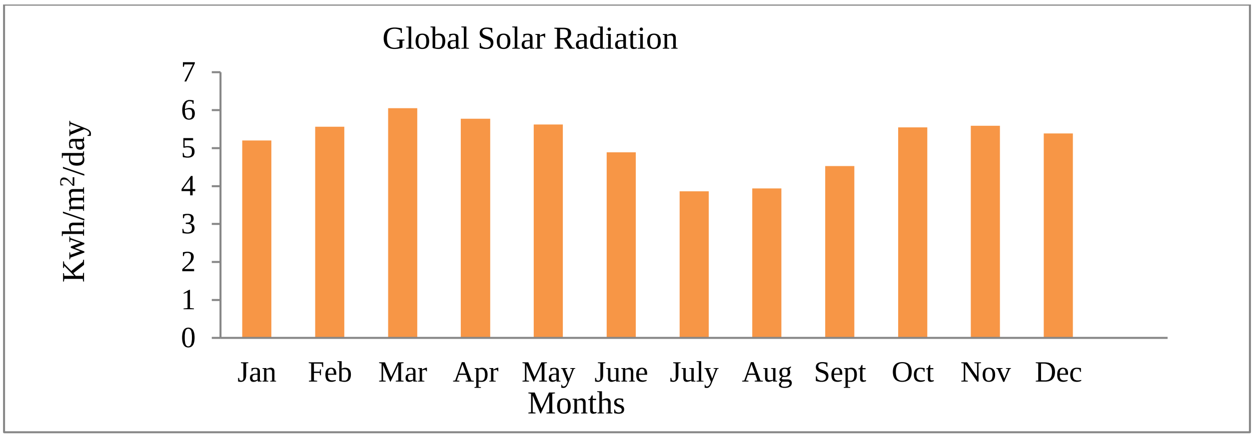

Figure 2: Global solar radiations from JNMA station

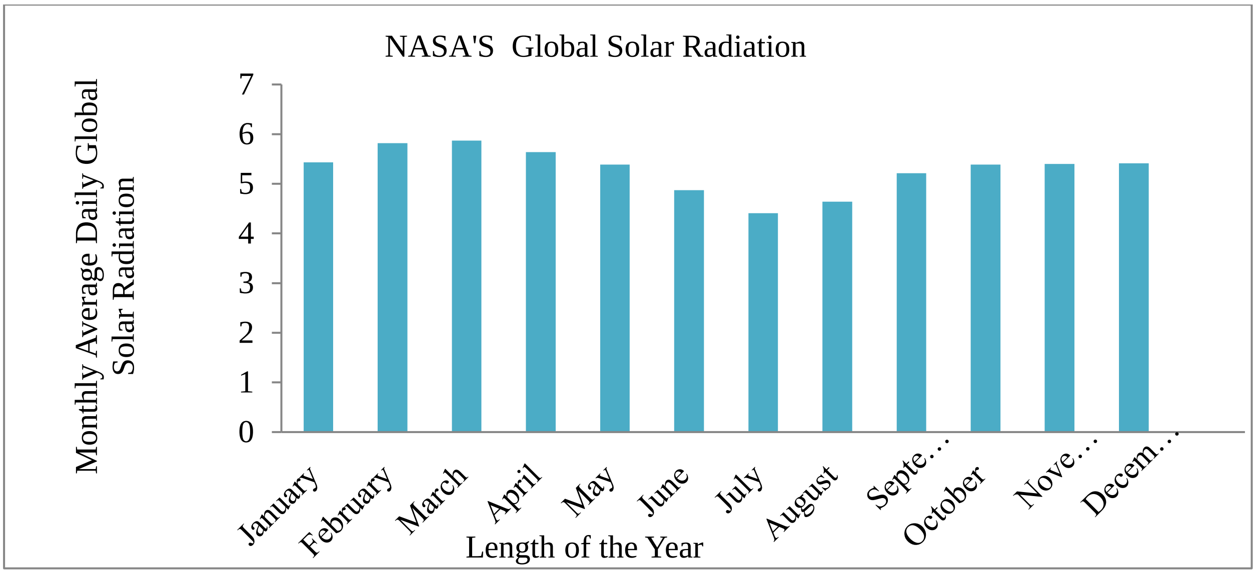

Figure 3: Global solar radiations from NASA

Table 3: compares between data taken from the JNMSA and NASA.

Sited Place													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Avg.**
NMSA	5.2	5.56	6.05	5.77	5.62	4.89	3.86	3.94	4.53	5.55	5.59	5.39	5.16
NASA	5.43	5.82	5.87	5.64	5.39	4.87	4.41	4.64	5.21	5.39	5.40	5.41	5.29

From above Table 3 the average global solar radiation of NMSA Jimma branch was 5.16kWh$/\mathrm{m}^2/$d, average global solar radiation of NASA was 5.29KWh$/\mathrm{m}^2/$d. And there was enough solar radiation to electrify the site from Solar system.

3.1.2 Assessment biomass energy system

Number of cows in the village in average are =135, cow dung discharge = 10 kg / cow-dung/day Total discharge for the village is TS_d= 135 × 10 =1350 kg / cow-day. Therefore, the daily biomass input is = 1350 kg.

The amount of biogas generated each day is calculated on the basis of the specific gas yield of the substrate and the daily substrate input. The estimation can be based on Eqn. (8 & 9) [19] .

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The volatile solids content VS

$$G_d = VS \times G_y \text{ (solids) } \left[{}^{m^3}/_{day} = kg \times {}^{m^3}/_{(day \times kg)}\right] \tag{8}$$

The weight of the moist mass

$$G_d = W_{biomass} \times G_y \text{ (moist)} \left[{}^{m^3}/_{day} = kg \times {}^{m^3}/_{(day \times kg)}\right] \tag{9}$$

Standard gas-yield values per livestock unit LSU

$$G_d = n_{LSU} \times G_y \text{ (species)} \left[{}^{m^3}/_{day} = number \times {}^{m^3}/_{(day \times number)}\right] \tag{10}$$

Where G_d = Daily biogas generated, G_y = Specific biogas yield, n_{LSU} = Number of Livestock Unit

So now it wills that a higher degree of sizing certainty can be achieved by comparing and averaging annually of the manure results in the Table 4 below.

Table 4: Monthly average cattle's manure assessed (tonnes/day) at the site

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cattle manure (tonnes/day)	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35

3.1.3 Assessment of micro-hydro energy system

Stream flow estimation for un-gauged catchments by transposing gauged stream flow data from an analogue catchment is a widely use technique requiring the rescaling of the flow region to the un-gauged target catchment [20]. These techniques all take by the following formula in eqn.11 below.the potential assements three consecutive years of Average value of mean monthly flow at Gilgel Gibe I River shows in Table 5 below.

$$QX_T = K\left(\frac{A_T}{A_A}\right) QX_A \tag{11}$$

Where QX_T = the flow in the target un-guaged catchment T, QX_A= the corresponding flow in the analogue guaged catchment A

A_T = the catchment area for the unguaged catchment T, A_A= the catchment area for the analogue gauged catchment A, k = a scaling constant or function

Table 5: Average value of mean monthly flow at Gilgel Gibe I River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	17.4	7.76	6.43	44.26	70.07	181.61	187	279.18	185.68	122.77	324.73	143.09
1998	76.12	38.96	43.58	30.32	55.16	78.13	226.85	458.64	257.03	226.38	88.51	39.91
1999	26.9	14.21	19.56	15.68	44.39	92.15	213.17	291.11	154.38	194.37	67.40	29.49
Avg.	40.1	20.31	23.25	30.08	56.54	117.29	209.00	342.97	199.13	181.17	160.21	70.83

The desired result is the development of a technique which finally allows an estimation of the hydropower potential of an un-gauged site of Naso river shows under table 6 below.

Table 6: Average value of monthly flow rate of Naso River

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Naso (m^3/s)	2.41	1.22	1.39	1.39	3.39	7.04	12.54	20.57	11.94	10.87	9.61	4.25
Naso (L/s)	2410	1220	1390	1800	3390	7040	12540	20570	11940	10870	9610	4250

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Generally, Naso river is 20% of the GGR-I water flow area, Catchment area of GGR-I = 2966km^2 and Catchment area of Naso river = 593 km^2

Designed parameters were indicated as per power requirements of the system, generally empirical of any hydro system's power output is described in Eqn. 12 below and it has been preferred for this study [21].

$$P = \rho \times \eta \times g \times Q \times H \tag{12}$$

Where; P = Power output (KW), ρ = Density of water, η=Efficiency of small turbine, g = Gravity due to acc. and H= Head in meter

3.1.4 Load determination of the site

In table 7 below shows the potential Load estimation of village that is the processes of finding electrical demand/consumption that must be met by the power system at a specified moment is known as primary load. The principal load is often described as the electrical demand for things like lights, radio, TV, Enjera Methad, home appliances, computers and industrial activities.

Electrical load that can be satisfied at any moment within a set time frame, without regard to exact timing, is referred to as deferrable load. Deferrable loads include things like pumping water and charging batteries because they each have storag e that affects when the system may use them [22].

Table 7: Load estimation of village

Appliance		Quantity	Power rating(W)	Daily hours(hr.)	Daily energy demand
	Lamp(salon)	1	11	4	44
	Lamp(bed room)	1	11	2	22
	Socket outlet	1	60	8	480
	TV receiver	1	80	8	640
House Hold	Toilet Lamps	1	11	1	11
	Refrigerator	1	100	24	2400
	Kitchen Lamps	1	11	2	22
Irrigation	Pump drive	2	350	4	2800
	Florescent Lamps	3	60	2	360
Church	Socket outlet(speaker players & cell phone)	2	60	1	120
	Lamps(class)	8	60	3	1440
Schools	Toilet(lamp)	1	11	1	11
	Verandah(lamp)	1	60	12	720
	Toilet Lamps	1	11	1	11
	Class (reception room)	1	11	3	33
	Class (laboratory)	1	11	8	88
Health Center					
	Class (bed room)	1	11	2	22
	Verandah	1	60	12	720
	Socket out let	2	60	10	1200
		Total			11144 wh

It is necessary to display each appliance's energy/load estimation for selected village use in kW over the duration of a 24-hour period shows in table 8 below.

Table 8: Daily demands of village

Morning		Afternoon		Evening		After midnight	
Daily Hour	**Energy(KW)**	**Daily Hour**	**Energy(KW)**	**Daily Hour**	**Energy(KW)**	**Daily Hour**	**Energy(KW)**
00:00-1:00	63.400	6:00-7:00	65.700	12:00-13:00	102.900	19:00-20:00	37.500
1:00-2:00	75.900	7:00-8:00	63.400	13:00-14:00	102.900	20:00-21:00	37.500
2:00-3:00	63.400	8:00-9:00	63.400	14:00-15:00	102.900	21:00-22:00	37.500
3:00-4:00	63.400	9:00-10:00	63.400	15:00-16:00	102.900	22:00-23:00	37.500
4:00-5:00	63.400	10:00-11:00	63.400	16:00-17:00	102.900	23:00-00:00	37.500
5:00-6:00	80.000	11:00-12:00	63.400	17:00-18:00	102.900	19:00-20:00	37.500

IV. RESULTS AND DISCUSSIONS

4. Configuration

4.1 Configuration of overall hybrid systems

Hybrid power system consists of a combination of renewable energy resources such as solar photovoltaic (PV), biomass and micro hydro to charge batteries, converter and provide power to meet the energy demand, considering the local geography and other detail of the place of installation of the hybrid. Therefore, Figure 4 shown below Configuration of Overall Hybrid Systems with each component generated from HOMER software.

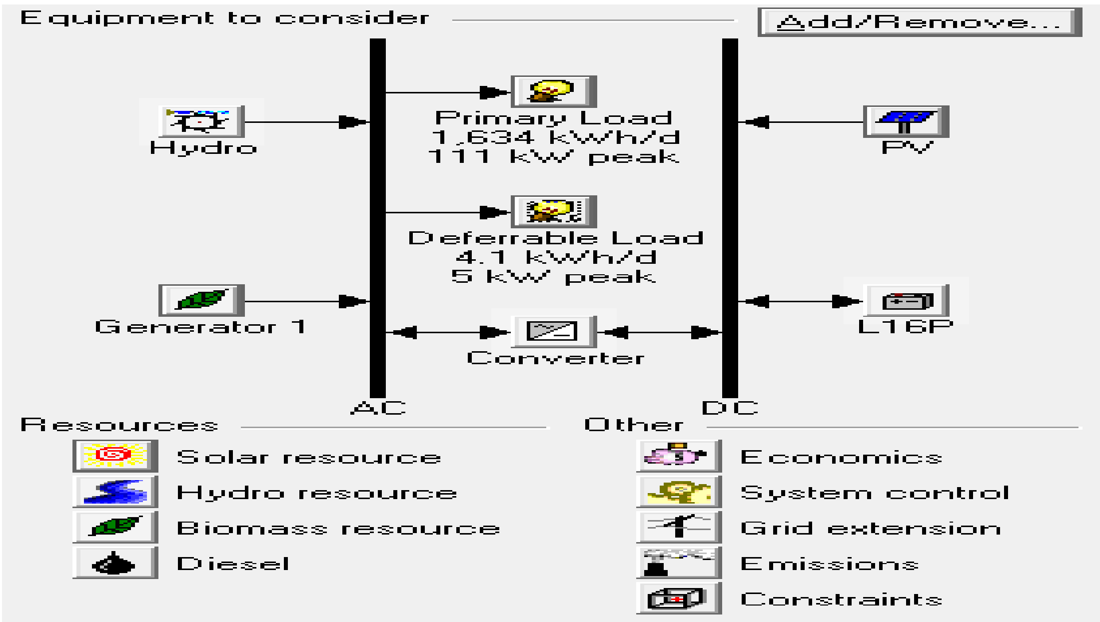

Figure 4: Configuration of hybrid system

4.2 Modeling and input of each component to software

For this results the capital cost is considered which is 9500$/km, EEPCO's average COE is 0.025 $/kWh, estimated operating and maintenance cost is 285 $/yr/km.therefore, micro hydro power systems input for homer are flow rate of 1220L/s, minimum flow ratio of 75, maximum flow ratio of 150, gross head is 9m, absolute head loss is 0.9m or relative

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head loss is 10%,100m of pipe length, efficiencies is 65 % and steel pipe is entered as a selected input for homer. Solar PV power systems input for homer are lifetime 15 year, de-rating factor is 90% and ground reflectance is 20%.Biomass generation input for homer will be for biomass source I have select biogas for generation system, life- time operation system is could be 40000 hours and the minimum load ratio is 30% and also average monthly biomass energy around 1.35 tonne/day input to homer software. A battery of Trojan L16P flood lead -acid type, 6V, 1156Ah, 6.94 kWh has been chosen for this site. The minimum life time of the battery is set to be 4 years and the battery per string is one. The converter is used as inverter and rectifier. The remaining inputs for the software to Kedemesa village are described in Table 9 below. The estimated cost only for 33kV single circuit transmission line without consideration of transformer, insulation, mounting pole, wire costs is $9500/km. Estimated operating and maintenance cost is 3% of the capital cost ($/km) that is $285/yr/km and EEPCO"s average COE is $0.025 /kWh for domestic and general application [23].

Table 9: Size, cost, quantity and life time input for homer software [23]

Component Type	Size(kw)	Capital ($)	Replacement Cost($)	O&M Cost($/year)	Quantities	Life time (year)
PV Module	1	2000	1500	20	0,5,10,15,20,20,30	15
Biomass generator	1	200	150	0.05	0,5.10,20,30,35,40	4-5
Hydro	1	20000	6000	50	-	25
Trojan L16P	1	360	250	5	0,5,10,15,20,20,30 40,50.60,70,80	4
Converter	1	200	150	20	0,5,10,15,20,20,30	15

4.2.1 Connected Electric Load

From Figure 5 below shows the Daily load requirement of the intended village group is found to be 1634 kWh per day and the peak load is found to be 111 kW.

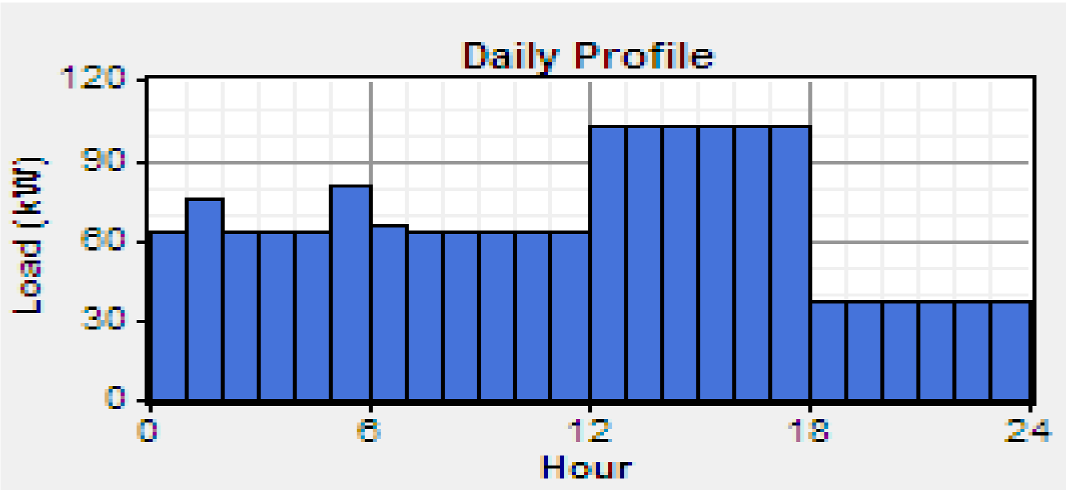

Figure 5: Hourly load consumptions

4.2.2 Simulation Results

From the overall optimization result the first rank and other selected overall optimization results, grid breakeven distance, annual electrical energy production, annual electrical load served, excess electricity, renewable energy fraction, and capacity shortage are evaluated in Figure 6 below.

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Double click on a system below for simulation results.

PV (kW)	Hydro (kW)	Bio (kW)	L16P	Conv. (kW)	Disp. Strgy	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage	Biomass (t)	Bio (hrs)
18	63.0	20	50	50	CC	$ 116,000	8,465	$ 213,091	0.031	1.00	0.02	196	3,076
18	63.0	20	60	40	CC	$ 117,600	8,340	$ 213,261	0.031	1.00	0.02	197	3,076
18	63.0	20	61	40	CC	$ 117,960	8,354	$ 213,782	0.031	1.00	0.02	197	3,078
18	63.0	20	62	40	CC	$ 118,320	8,361	$ 214,222	0.031	1.00	0.02	197	3,077
18	63.0	20	63	40	CC	$ 118,680	8,368	$ 214,660	0.031	1.00	0.02	197	3,075
18	63.0	20	65	40	CC	$ 119,400	8,383	$ 215,556	0.032	1.00	0.02	197	3,073
18	63.0	20	70	40	CC	$ 121,200	8,400	$ 217,552	0.032	1.00	0.02	197	3,061
18	63.0	20	60	50	CC	$ 119,600	8,543	$ 217,588	0.032	1.00	0.02	196	3,063
18	63.0	20	50	60	CC	$ 118,000	8,691	$ 217,680	0.032	1.00	0.02	195	3,063
18	63.0	20	61	50	CC	$ 119,960	8,554	$ 218,070	0.032	1.00	0.02	196	3,064
18	63.0	20	62	50	CC	$ 120,320	8,560	$ 218,503	0.032	1.00	0.02	197	3,063
18	63.0	20	63	50	CC	$ 120,680	8,566	$ 218,934	0.032	1.00	0.02	197	3,061
18	63.0	20	75	40	CC	$ 123,000	8,399	$ 219,334	0.032	1.00	0.02	197	3,046
18	63.0	20	65	50	CC	$ 121,400	8,580	$ 219,815	0.032	1.00	0.02	197	3,059
18	63.0	20	70	50	CC	$ 123,200	8,595	$ 221,779	0.033	1.00	0.01	197	3,047
18	63.0	20	60	60	CC	$ 121,600	8,769	$ 222,184	0.033	1.00	0.02	196	3,042
18	63.0	20	50	70	CC	$ 120,000	8,918	$ 222,289	0.033	1.00	0.02	195	3,063
18	63.0	20	61	60	CC	$ 121,960	8,780	$ 222,663	0.033	1.00	0.02	196	3,043
18	63.0	20	62	60	CC	$ 122,320	8,786	$ 223,094	0.033	1.00	0.02	196	3,042
18	63.0	20	63	60	CC	$ 122,680	8,792	$ 223,523	0.033	1.00	0.02	196	3,040
18	63.0	20	75	50	CC	$ 125,000	8,590	$ 223,530	0.033	1.00	0.01	196	3,032
18	63.0	20	65	60	CC	$ 123,400	8,806	$ 224,399	0.033	1.00	0.01	196	3,038
18	63.0	20	70	60	CC	$ 125,200	8,819	$ 226,352	0.033	1.00	0.01	196	3,026
18	63.0	20	60	70	CC	$ 123,600	8,997	$ 226,792	0.033	1.00	0.02	196	3,042
18	63.0	20	50	80	CC	$ 122,000	9,145	$ 226,897	0.033	1.00	0.02	195	3,063
18	63.0	20	61	70	CC	$ 123,960	9,007	$ 227,271	0.033	1.00	0.02	196	3,043
18	63.0	20	62	70	CC	$ 124,320	9,013	$ 227,702	0.033	1.00	0.02	196	3,042
18	63.0	20	75	60	CC	$ 127,000	8,814	$ 228,093	0.033	1.00	0.01	196	3,011

Figure 6: Homer overall simulation results

4.2.3 Breakeven Grid Extension Distance

According to the simulate from figure 7 below shows important better use the stand alone hybrid system for a distance greater than 3.29 km, but grid distance is less than 3.29 Km. The estimated distance for selected site is about 37 km therefore, it best to use the stand alone hybrid system. consequently, the hybrid system is more economical than a grid extension.

Figure 7: Breakeven grid extension distance in the first optimal result

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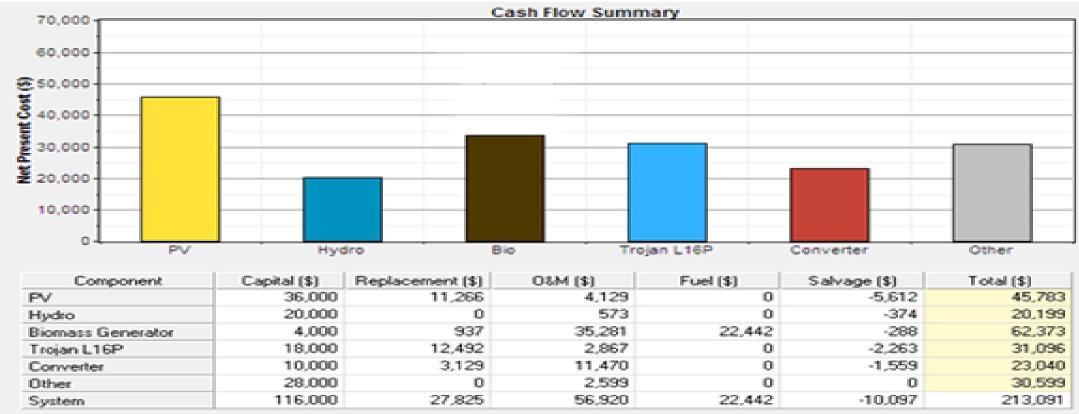
4.2.4 Cash flow summaries

The first rank overall optimization result (row 1) in Figure 8 below has 50kw lead acid batteries, 50 kW convertor, 20 kW biomass generations, 18kw PV and 63kW hydro. The total NPC of 213,091$ is the least cost for site in this simulation.

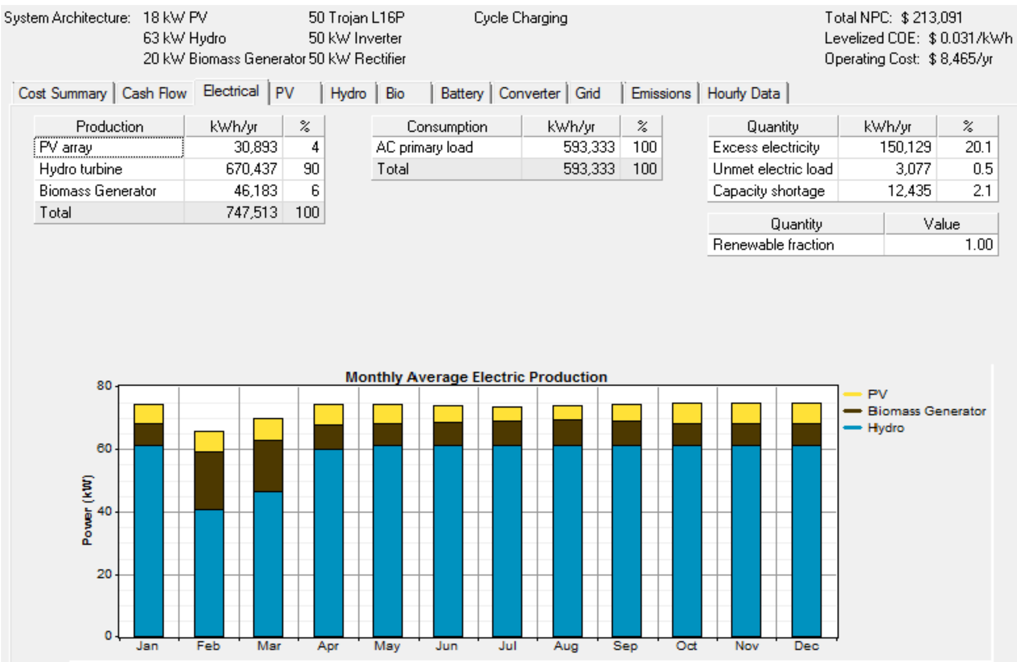


Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	36,000	11,266	4,129	0	-5,612	45,783
Hydro	20,000	0	573	0	-374	20,199
Biomass Generator	4,000	937	35,281	22,442	-288	62,373
Trojan L16P	18,000	12,492	2,867	0	-2,263	31,096
Converter	10,000	3,129	11,470	0	-1,559	23,040
Other	28,000	0	2,599	0	0	30,599
System	116,000	27,825	56,920	22,442	-10,097	213,091

Figure 8: Cash flow summaries in the first optimal result

4.2.5 Monthly average electric energy productions

From Figure 9 as shows below there is total electrical production that is produced by all the renewable sources amounts to 747,513kWh/yr; which encompasses 30,893kWh/yr or 4 % from solar PV, 670,437kWh/yr or 90 % from hydro and 46,183kWh/yror 6 % biomass generation electric production, which covers large amounts of electric production. It has excess electricity generation of 20.1%, no unmet electric load is 0.5% and capacity shortage is 2.1%.



Production	kWh/yr	%
PV array	30,893	4
Hydro turbine	670,437	90
Biomass Generator	46,183	6
Total	747,513	100

Consumption	kWh/yr	%
AC primary load	593,333	100
Total	593,333	100

Quantity	kWh/yr	%
Excess electricity	150,129	20.1
Unmet electric load	3,077	0.5
Capacity shortage	12,435	2.1

Quantity	Value
Renewable fraction	1.00

Figure 9: Monthly average electric energy productions

4.2.6 Solar PV energy system

The available sunshine hour data from the National Meteorological Agency of Ethiopia (Jimma, and Agaro branch) was used to estimate the solar-radiation energy of the site. As it is seen in figure 10 the maximum average sunshine hour occurs during October, November, December, January, February, March and the minimum average sunshine hour occurs during June, July, August and September.

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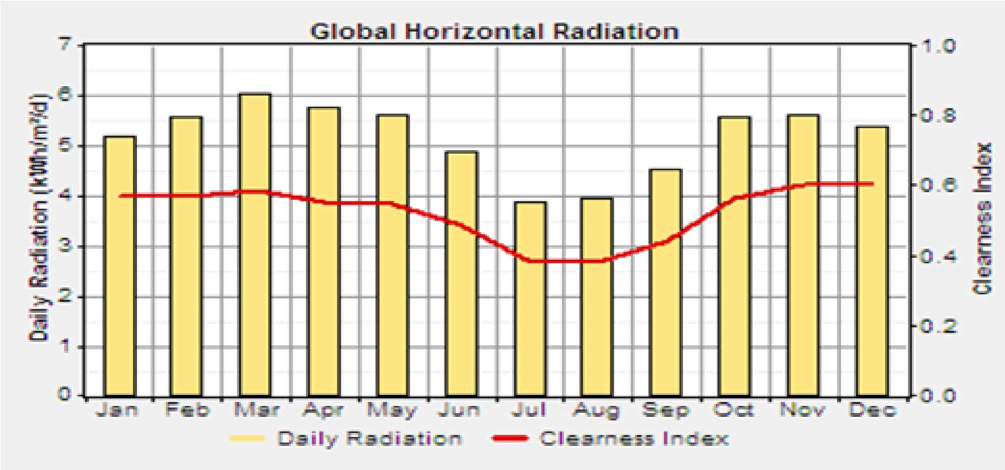

Figure 10: Monthly average solar resources

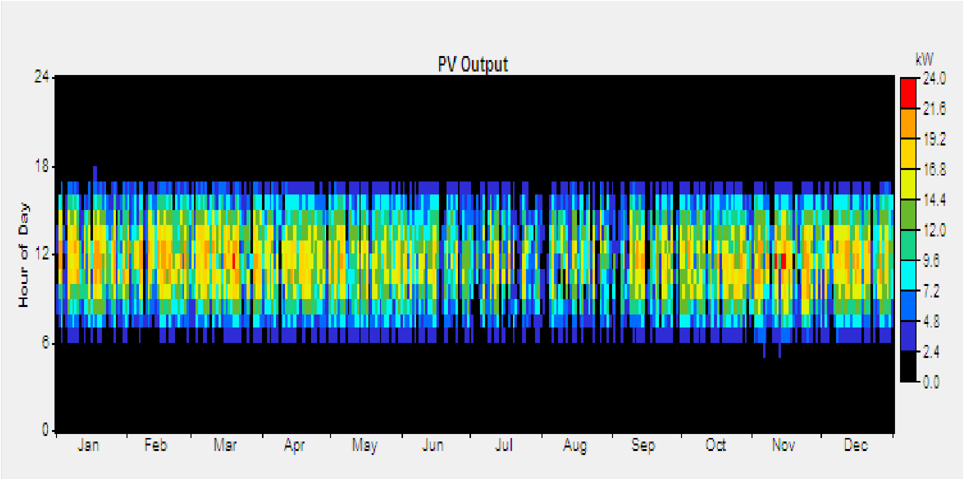

Figure 11: Annual electric energy productions by PV system

From Figure 11 above shows that difference of sunlight available throughout the hours of the day, with the minimum values registered in the beginning and the last hours of the times and the available peak during midday.

4.2.7 Hydropower energy system

From Figure 12 the average flow rate of Naso River from January – May and December is less than 5,000L/s, whereas the average flow of this river from July-October is greater than 10,000L/s.

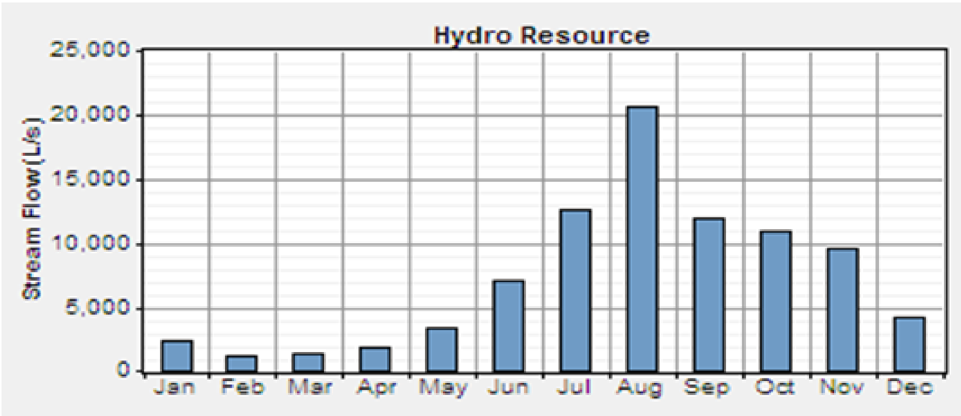

Figure 12: Average monthly flow rate of Naso river

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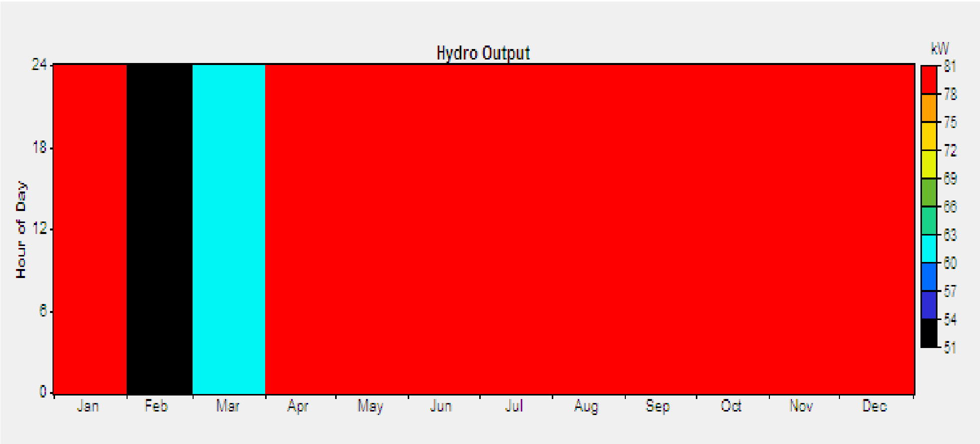

Figure 13: Annual electric energy productions by hydropower system

From Figure 13 above the potential electric generation over months of the year with the minimum amount of flow rate will be at (Black color) February month happened.

4.2.8 Biomass energy system

The main energy source for biomass is waste of animal manure (i.e. cow's dung). Looking at the number of estimation of animal residues for Biomass resources as shown in Figure 14 below will be the same through all time. The carbon content is the net amount carbon released per unit of feedstock consumed. The average price per tonnes of the biogas feedstock is taken 12 $ [24].

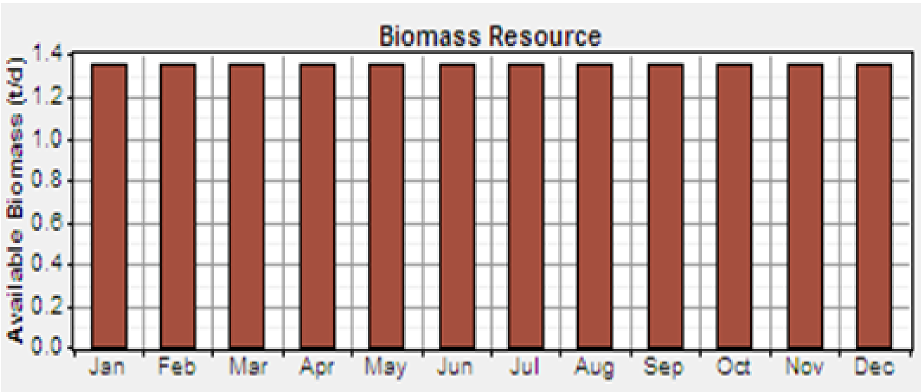

Figure 14: Monthly average biogas feedstocks

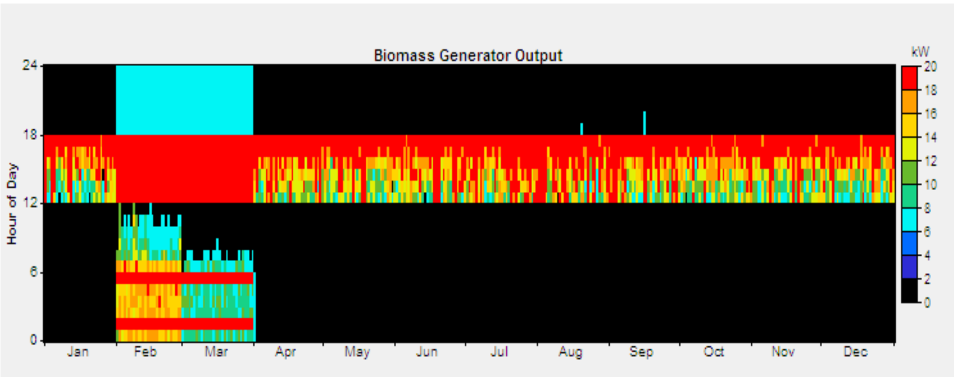

Figure 15: Annual electric energy productions by biomass generator system

One can learn from Figure 15 above the potential electric generation over months of the year almost will be the same except February and March.

V. CONCLUSION

In this paper, the conclusion is strategies for optimizing and using hybrid renewable energy systems. The main purpose of this paper is to show that renewable energy can play a satisfactory role in the electricity supply of rural localities. Minimize long-term system costs and energy per kWh by integrating and designing available renewable energy into hybrid energy systems. The paper presents a hybrid micro hydro, biomass and solar energy system for Kedemesa village. Opportunities have arisen to generate electricity in selected village using available resources such as micro-hydro, biomass and hybrid solar PV systems. Small hydropower plants account for 60% of the installed capacity, 20% biomass and 20% solar energy. The plant is designed to supply electricity to a total of 530 households. This improves their standard of living by providing access to night classes and laboratory medicine. The systems design and model are using HOMER to find the most optimal renewable energy for the village. The total electricity production is 747,513 kwh/yr per year. The total net cost is $213,091 and the annual operating cost is $8,465. The optimization results show that most of the energy is hydropower, which accounts 90%, pv modules 4% and biomass 6% of the total consumption. Economically, the cost of a hybrid system is about $0.031 kWh, much lower than the $0.05/kWh capital cost of extending the grid system to rural areas. This is lower than Ethiopia's current grid price of $0.025/kWh. EEPCO can sell $0.025 kWh for cities and for rural areas double the price is $0.05 / kWh due to transmission line costs, maintenance costs, and transportation costs. From an economic point of view, it is possible to choose a hybrid system. From an environmental point of view, the renewable energy share of the research is 100%, which means that almost all of its energy comes from renewable sources. This research contributes to the promotion of clean energy and the reduction of pollutant emissions in the environment.

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