Optimal Design of Hybrid Microgrid for Off Grid Villages

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Abstract-The Microgrid is a small scale transmission and distribution of power. Microgrid is mostly implemented in the rural villages and remote places which are not accessed by the normal conventional grid. The generation capacity of the micro grids will be less compared to the conventional grids as the demand is also significantly less. The renewable energy source acts as the major generation source for the microgrid when compared to the non-renewable sources. Some of the renewable sources which are used for generation in micro grids are wind, solar, small hydro, biomass etc. Since the renewable energy sources are not instantaneous for the microgrid to supply the load more efficiently and continuously the hybrid sources are required. In hybrid sources two different types of sources are considered in which one will be the conventional source and another will be the non-conventional source. The present work describes the design of a hybrid microgrid system for a remote off grid village in Myanmar. The hybrid microgrid consists of locally available primary energy source (photovoltaic) and diesel generator as a backup source. The main objective of the project is to design a system based on the locally available renewable energy source to electrify the village. To design the system, the energy requirement of the village, the current energy consumption and future demand is estimated through door to door survey. Based on the survey data the system is designed and installed.

***Keywords—Renewable** energy; Hybrid Microgrids; Load Shedding.*

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I. INTRODUCTION *(HEADING 1)*

A Microgrid is a localized connection of available energy sources and electrical loads that operates normally connected to the traditional grid. The Microgrid is also capable to disconnect from the traditional grid and function autonomously based on economic and physical conditions dictate.

The Microgrid has become the most innovative topic in the electric power industry these days. In future the Microgrids may exist as the energy–balanced systems within existing traditional power distribution grids powering the small communities. It requires a logical way of approach to overview the purpose of installing the Microgrid considering the technical aspects, discussing the social, environmental and economic benefits of the system [1].

A Microgrid is referred as a 'normal' transmission and distribution grid same as the traditional conventional grid but of smaller scale. Microgrids are usually implemented in the remote rural locations where the transmission of power from the traditional conventional grid is not feasible and it is not economical.

The salient feature of the Microgrid is that they make use of locally available energy resources, such as wind, biomass and solar (photovoltaic) for the power generation. In order to install a Microgrid for a particular locality the current power consumption considering the future expansion need to be estimated. To estimate and develop the load profile the door to door survey of the households need to be done. Based on these details the electricity consumption pattern for the households over a time of 24 hours will be estimated and based on that the system will be designed [2].

Compared with traditional standard grid the generation in the Microgrid will be significantly less meanwhile the demand will also be less. Since the generation is less the integration of renewable energy sources such as solar photovoltaic, wind and biomass is more challenging. As a result, the Microgrid will be less advantageous when the generation available from the renewable energy resources is too low, so to make the system most reliable the hybrid Microgrid are implemented.

The Microgrid acts as a common component in the evolution of the electricity grids characterized by improved reliability, reduced cost for generation and increase in the penetration of the renewable energy sources.

Nikos Hatziargyriouet. al., [1] explains the contribution of the Microgrid in the electric power industry. Accordingly, the Microgrid will exist as the energy–balanced systems within existing traditional power distribution grids powering the small communities.

Abhishek Kumar et. al., [2] presented a Microgrid concept for a remote village in the foothills of Himalayas. The salient feature of the micro grid is that it makes use of locally available natural resources, such as wind, solar and biomass for the generation of power. In order to design the Microgrid first the load estimation needs to be done, to estimate the current load and the future demand the survey is done. Based on the load profile stand-alone system powered by renewable energy sources is selected and the same is modeled with the help of Simulink

Omar Hafez et. al., [3] explains that importance of Microgrid over the conventional grids in case of remote villages. When it comes to electrifying the remote villages around the word, extending the conventional grid is one of the option, but due to the long distance between the main grid and the remote location results in the increased transmission line cost.

Youssef Cheddadi et. al., [4] says that energy management system plays an important role in the optimal working of the Microgrid. When it comes to the clustering of the multiple energy sources to make the Microgrid more reliable the management of these energy sources is of great deal. This operation of the energy management systems will be usually carried out using the microcontroller board for acquisition the data, preprocessing the data and transmitting the same to a host computer and then the system in analyzed using Lab View Application.

Azah Mohamedet. al., [5] the optimization of the Microgrid refers to a design of a system that is capable of operating at minimum operating cost and the service should be available for a long period. The optimal design of the system is obtained from the mathematical models for all the system components such as the solar energy, wind speed and the temperature will be employed during the design. Such design shows that the optimal design requires the optimal ratios for all the energy sources which are integrated in the hybrid system. The results showed that for the optimal design of the hybrid system requires the sizing ratios battery; diesel generator, wind turbine and the PV array are 0.17, 0.22, 0.46 and 0.737. The results of the optimal design have been validated using the HOMER software.

Maria Kalogeria et. al., [6] describes the role of Microgrid in electrifying the remote villages. The hybrid Microgrid is considered as the topmost solution for meeting all the requirements of the offshore platforms. But the renewable energies are characterized by fluctuation and intermittence and they are directly dependent on local meteorological conditions. As a result, the energy storage system is must and should to supply to the load at such conditions.

Shailendra Kumar Jha et. al., [7] the hybrid Microgrid in the remote areas will be designed depending upon the availability of the resources and considering the demand. The type of generation to be used, the prime mover, technologies and interconnection issues are resolved depending on the availability energy sources, local technology. The communities' health, income generation, education, information exchange and women empowerment will be benefited by the installation of the Microgrid

II. PROPOSED WORK

As per Myanmar government official's survey and the private organization survey shows that in Myanmar only 34 percent of people are having access to grid quality electricity and remaining 66 percent of people no access to electricity. Because those who have leave in remote locations have no access to electricity. The Myanmar government took an ambitious project to electrify such remote villages with the help of Microgrid.

Kanti is a remote village located in Tanintharyi region, Myanmar. It has an approximate population of 1500 people allocated in 250 households. The main economic activities carried out by the people are fishing, farming and livestock rearing. Since the village is located in the remote island they have no access to the conventional grid.

Currently the village is electrified with the help of 50kVA generator which is owned by a private personal. The village people have the access to electricity only at night time from 6 P.M to 10 P.M from the generator. The current tariff rate paid by the villagers is too high about 650 Kyat's (30.89 Rupees) per unit and they need to pay a minimum of 6500 Kyat's (308.9 Rupees) per month regardless of their usage.

The objectives of the project are to:

- To conduct a survey of the village and study the current energy scenario, capture the present and future energy demand, load details, hours of operation and prepare the load profile for the village.
- To design the hybrid Microgrid system as per the requirement based on the data collected during the survey.
- To install and commission the hybrid Microgrid system.

A. *Priliminary Survey*

The preliminary survey is the most important part in the design and installation process of Microgrid in rural areas. This is the best tool to gain the information of the site, insight and the perspective needed for supporting the design and installation process.

B. *Location of the Site*

Kanti is the remote village in the Tanintharyi region, Southern Myanmar, Myanmar. The latitude and longitude of the village Kanti are 13°09'44.6" N and 98°32'35.9" E. The distance to Kanti village to the equator is about 1458 km north to the equator.

C. *Village Details*

The village Kanti is located in Tanintharyi region, southern Myanmar consists of total 250 households with a population of 1500 people. The main source of income is the fishing, farming and livestock rearing. The village is composed of only 15 percent of semi-permanent houses which are made of concrete walls and remaining houses are built using wooden planks. The entire village is located next to sea shore and most of the houses are built above the sea with the support of wooden poles as shown in Fig 4.3. The village consists of primary health center, three temples and three schools in which two of them are primary school and another is a secondary school, for high school the students to travel to the next village.

D. PV Data

The experimental PV data measurements shows that solar irradiation intensity in Myanmar is greater than 5 kWh/m² /day and it was during the dry season of the year. The solar irradiation intensity varies from 4 to 6 kWh/m² throughout the year. The sizing of the PV based Microgrid will be based on considering the lowest irradiation of the month in a year. In addition to this to ensure that the Microgrid system operates economically over the year the average yearly values of the solar irradiation are considered.

The Yangon is the nearest city to the village Kanti (Proposed Project). Table 1 indicates that the average monthly irradiation from the month January to December.

Table 1 Average Monthly Radiation of Selected Cities

Sl. No	1	2	3	4	5	6	7	8	9	10	11
Location	Kauthaung	Dawei	**Yangon**	Sittwey	Myithyina	Pyay	Mandalay	Lashio	Magwey	Meikhtila	Monywa
Jan	5.07	5.06	**4.92**	4.65	4.16	4.79	4.5	4.45	4.9	4.55	4.45
Feb	5.52	5.82	**5.77**	5.68	5.05	5.88	5.65	5.71	5.52	5.64	5.63
Mar	5.93	6	**6.04**	5.84	5.56	6.12	6.06	6.07	6.06	6.25	6.11
Apr	6.09	6.29	**6.4**	6.49	5.82	6.19	6.33	6.07	6.5	6.64	6.47
May	4.71	4.85	**4.92**	5.42	5.48	5.61	5.97	5.71	5.91	5.98	6.09
Jun	3.61	4.68	**3.7**	3.78	4.07	4.45	5.45	4.91	5.08	4.97	5.45
Jul	3.3	3.42	**3.41**	3.4	3.69	4.22	4.88	4.34	4.83	4.84	4.93
Aug	3.27	3.33	**3.5**	3.73	4.18	4.21	4.64	4.29	4.79	4.79	4.66
Sep	3.85	4.04	**4.05**	4.4	4.31	4.56	4.7	4.52	4.9	4.79	4.75
Oct	4.72	4.86	**4.63**	4.7	4.15	4.58	4.34	4.23	4.69	4.55	4.37
Nov	4.7	4.94	**4.52**	4.29	3.83	4.35	4.07	4	4.16	4.21	4.11
Dec	3.54	4.84	**4.47**	4.31	3.78	4.28	3.99	3.84	4.31	4.05	4.05

III HOUSEHOLD SURVEY AND LOAD PROFILE

In order to design the renewable energy based Microgrid for a remote village the estimation of the load is very important. To estimate the total load of the village is carried out from door to door survey. The loads in the rural area can be broadly classified into household loads, agricultural loads and the commercial loads.

A door to door household survey of 250 households is carried out in Kanti village.

During the household survey the house location is marked and a unique identification number is given to the house. The household customer details with total number of members and the total income is noted. The existing load and future load details of each house is noted down. The Fig 5.1 shows the marked GPS location of each household with the unique identification number assigned. The unique identification number assigned to each household helps the operator of the Microgrid to track the information of the customer. The Table 5.1 shows only 10 households survey data. During the survey it is observed that the household customers are mainly using Fluorescent Lamp for lighting, Television, Fan and Mobile Chargers. All the loads are powered by the 50kVA generator from evening 18:00 to 22:00 Hrs.

The main problem faced by the villager is restricted electricity usage and tariff. The householders need to pay a minimum tariff of 6500 Kyat's (308.9 Rupees) per month in spite of their usage. During the day time the villagers have no electricity to run the public and commercial loads.

The Table 2 indicates the total household, community and commercial loads.

Table 2 Household Information

Sl. No		1	2	3	4	5	6	7	8	9
Village		Anpur	Kanti	Anpur	Anpur	Kanti	Anpur	Anpur	Kanti	Kanti
Name		U Min	U NSoe	U Kaing	UMiThu	UNaing	UNing	U NTun	U LSoe	UMyint
Total members Family		3	5	8	4	8	7	7	8	6
Monthly income		100,000	1,000,000	300,000	1,000,000	300,000	300,000	150,000	300,000	100,000
Qty	Fluorescent Lamp	2	3	9	10	3	3	3	3	4
Power (W)		21	21	21	21	21	21	21	21	21
Qty	CFL	0	0	0	0	0	0	0	0	0
Power (W)		10	10	10	10	10	10	10	10	10
Qty	Fan	0	0	0	1	1	0	0	0	0
Power (W)		20	20	20	20	20	20	20	20	20
Qty	TV	0	1	1	1	1	1	0	0	0
Power (W)		40	40	40	40	40	40	40	40	40
Qty	Mobile Charger	1	1	1	1	1	1	1	1	1
Power (W)		5	5	5	5	5	5	5	5	5
	Total Load (W)	**47**	**108**	**234**	**275**	**128**	**108**	**68**	**68**	**89**

Load Profile

The load profile describes the variation of electrical load with respect to time. The load profile will vary from customer to customer and it depends on the customer type. The customers may be broadly classified into household, community and commercial customers. The Microgrid designer uses this information to plan the schedule of power with respect to time. The Microgrid operator ensures that the customers operate their loads according to the schedule designed as per the survey.

The Fig 1 shows the variation of the household load during the duration from 1:00 to 23.59 Hrs. The graph shows that the household load is high during night that is due to lighting and the television. During daytime there are not much household load expect the fan load running at afternoon.

The Fig 2 shows the variation of the community load during the duration from 1:00 to 23:59 Hrs. The graph shows that the community load consisting of the lighting load remains the same throughout the day (9:00 to 17:00 Hrs). The lighting load is also used during day time in monastery and school.

The Fig 3 shows the variation of the commercial load during the duration from 1:00 to 23:59 Hrs. The graph shows that the commercial load is high during day time that is due to water pump and the rice mill. During daytime no provision is given to run the commercial loads as the storage battery is used to power the grid.

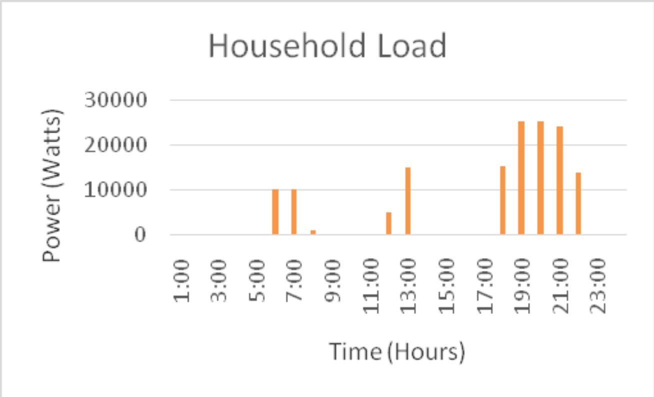

Fig. 1 Load Profile for Household Loads

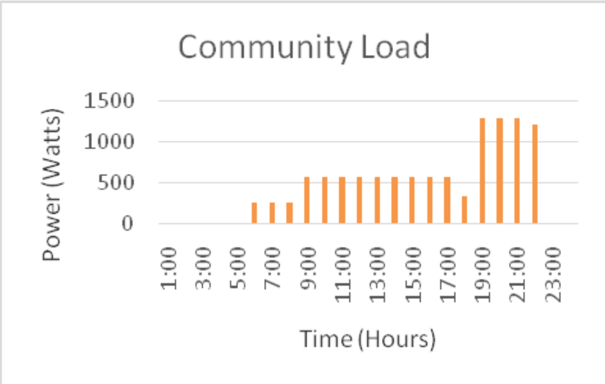

Fig. 2 Load Profile for Community Loads

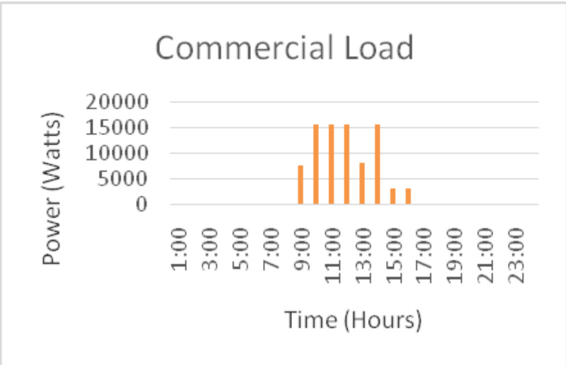

Fig.3 Load Profile for Commercial Loads

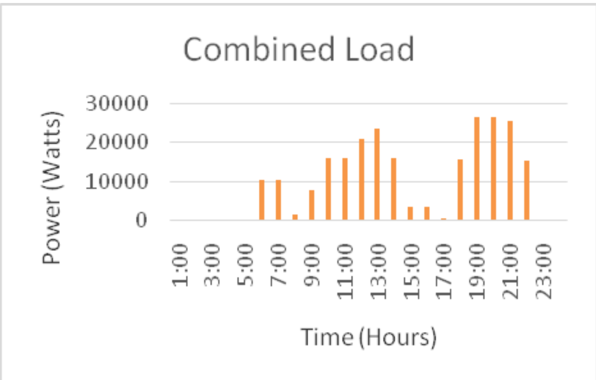

Fig. 4 Load Profile for Combined Loads

The Fig 4 shows the variation of the combined load during the duration from 1:00 to 23:59 Hrs. The graph shows that the total load is high during night time since the lighting load is dominating the other type of loads. The peak load is observed to be 26.53kW and it is during night time. The Table 3 shows the overall summary of the load profile for all the combined loads.

Table 3 Summary of Load Profile

Device	Rating (Watts)	Quantity	Hours of operation	Energy (Wh)	Time (Hrs)
Water Pump	800	10	5	40000	10:00-15:00
Rice mill	2200	2	5	22000	9:00-13:00 / 14:00-15:00
Workshop	1000	3	7	21000	9:00-12:00 / 14:00-17:00
Lighting	9000		7	63000	6:00-8:00 / 18:00-23:00
TV	10000		4	40000	13:00-14:00 / 19:00-23:00
Fan	5000		7	35000	12:00-14:00 / 18:00-23:00
Mobile charging	1250		6	7500	6:00-9:00 /18:00-21:00
Street Light	20	60	4	4800	19:00-23:00
School	81	3	9	2187	9:00-18:00
Clinic	81	1	13	1053	9:00-22:00
Monastery	81	3	13	3159	6:00-19:00
Total Energy Required (kWh)				239.699 ≈ 240	
Energy Required during non-sunshine hours (kWh) (17:00Hrs to 6:00 Hrs morning)				131.0	

III. DESIGN OF MICROGRID

The design of the Microgrid is based on the load data obtained from the household survey. The consolidated daily energy consumption Table 4 is used to design the Microgrid system components.

Table 4 Consolidated Daily Energy Consumption of Village

Total Daily Units Consumed (kWh)	240
Daily Units Consumed from 17:00Hr to 6:00 A.M (kWh)	131
Total Peak Load (kW) in a day	26.531

A. Solar Panel Array

The solar panel array capacity required is calculated by considering the total daily energy consumption of all the connected loads in the Microgrid.

The Table 6.1 shows that the total energy consumed during a day and it is found to be 240 kWh. The solar array capacity required is calculated as follows

The total units consumed (kWh) = 240 kWh

Assuming the system efficiency = 86%

Total unit required is calculated as:

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$$Units\ Required\ (kWh) = \frac{Total\ units\ consumed}{System\ efficiecy}$$

$$Units\ Required\ (kWh) = \frac{240}{0.86} = 280\ kWh$$

Sunshine hours in Kanti village = 4.5 hrs

The required PV capacity is calculated as:

$$PV\ Capacity\ (kW) = \frac{Units\ Required}{Hours\ of\ Sunshine}$$

$$PV\ Capacity\ (kW) = \frac{280}{4.5} = 63\ kW$$

Selecting the 250 Wp panel the total number of panels required is calculated as:

$$Number\ of\ Panels = \frac{Total\ PV\ Capacity}{Selected\ PV\ Panel\ Capacity}$$

$$Number\ of\ Panels = \frac{63 * 1000}{250} = 252\ Panels$$

The required solar PV capacity to power the connected loads is 63kW. The 250Wp capacity PV module is selected to develop the required PV capacity. The Table 6.2 indicates the panel information of 250Wp PV module at standard conditions of 25°C at 1000 W/m² irradiation, this information will help in arrangement of solar panels.

The characteristic of 250 Wp panel are stated below:

- High efficiency solar cell used in the module to keep the total module efficiency near to 15.5%.
- Characterized with positive tolerance which results in higher output.
- Excellent performance of the module even under weak light.
- All the PV module combination and packing through the stepping current to reduce the loss due to mismatch.

Table 5 Module Details of 250Wp PV Panel

Model No.	LUM250P
Maximum Power (P_{max})	250W
Max-Power Voltage (V_{mp})	31.2V
Max-Power Current (I_{mp})	8.01A
Open-Circuit Voltage (V_{oc})	37.6V
Short-Circuit Current (I_{sc})	8.53A
Module Efficiency	15.5%
Operating Temperature	-40°C to +85°C
Maximum System Voltage	1000 Vdc
Maximum Series Fuse Rating	16A
Power Tolerance	0 to +5W

The required 252 number of 250Wp panels are installed using8 in 1 module mounting structure.

The total number of structure required is calculated as:

The total number of panels = 252 Panels

Selected mounting structure = 8 in 1 structure.

The total number of structure is given by:

$$Number\ of\ structures = \frac{Total\ Number\ of\ Panels}{8}$$

$$Number\ of\ structures = \frac{252}{8} = 32\ Structures$$

The installation of 32 module mounting structures arrangement of all the module mounting structure in the selected solar panel installation area. The structures are tilted with an angle of 30° and facing south direction.

B. Charge Controller

The charge controller is designed to regulate the available power from a PV source.

The number of solar MPPT charge controller required is calculated as below:

The PV capacity installed (kW) = 63 kW.

Considering the Schneider Electric MPPT 80 600 charge controller

(MPPT 80 600 refers to 80A and 600V charge controller).

The charge controller rating (kW) = 4.5 kW.

The number of charge controllers required is given by:

$$Number\ of\ charge\ controller = \frac{Total\ PV\ Capacity}{Charge\ Controller\ Capacity}$$

$$Number\ of\ charge\ controller = \frac{63 * 1000}{4.5 * 1000} = 14\ Nos.$$

C. Inverter

The inverter is designed to convert the available DC power from a PV and battery to AC. In our project the selected inverter is also designed to convert the AC power from other types of power sources such as generator or grid to DC. This converted DC is used to charge the battery when the PV is not available.

The solar inverter required is calculated as below:

The peak load without losses (kW) = 26.53 kW.

Assuming system losses = 18%

$$Total\ Load\ with\ losses\ = \frac{Peak\ Load\ with\ Losses}{Percentage\ of\ Loss}$$

$$Total\ Load\ with\ losses\ = \frac{26.53 * 1000}{0.18} = 31.307\ kW$$

Choosing the Schneider Electric XW+8548E inverter, with the rating of 6000W at 40°C.

The number of inverters required is calculated as below:

$$Number\ of\ Inverters\ = \frac{Total\ Load\ With\ Losses}{Inverter\ Capacity}$$

$$Number\ od\ inverters\ = \frac{31307}{6000} = 6\ Nos.$$

D. Battery Bank

The solar powered based Microgrids are affected by the power fluctuation due to varying weather. Since the solar energy is only available during day time, the energy storage is very much required. From the Table 4

Daily units needed from battery (kWh) = 131 kWh

Considering system efficiency = 90 %

Units to be stored in battery (kWh) = 144.8 kWh

Battery depth of discharge = 50%

The installed battery capacity is calculated as:

$$Installed\ battery\ capacity\ (kWh) = \frac{Units\ to\ be\ stored\ in\ battery}{Battery\ depth\ of\ discharge}$$

$$Installed\ battery\ capacity\ (kWh) = \frac{144.8}{0.5} = 290\ kWh$$

Selecting the system voltage 48V, the battery bank is given by: $Battery\ bank\ Capacity\ (Ah) = \frac{Installed\ battery\ capac}{Battery\ System\ Voltag}$

$$Battery\ bank\ at\ 48V\ (Ah) = \frac{290}{48} = 6000\ Ah$$

The total battery capacity required is 6000Ah and the selected battery bank is of capacity 3000 Ah. The Figure 6.8 shows the arrangement of two numbers of 3000Ah battery banks, inside the control room.

E. Cluster Box

The cluster box is a basic low voltage switchgear electrical panel which provides an interface for the XW+ inverters, loads, AC sources and/or PV inverters. The cluster box can be configured as a simple combiner box for the outputs of the XW+ inverters which are connected to the loads with no generator and PV inverters.

In hybrid coupled off grid system in addition to XW+ inverters, will be coupled with generator. In such design care should be taken that the inverters and generator should never run parallel and when solar energy is not available then generator should charge the battery.

The cluster box Fig 5design containing diesel generator interfaced with an AC contactor that protects against the back feeding to the generator and in addition a manual bypass switch is added to isolate the entire system and run it on diesel generator during the maintenance.

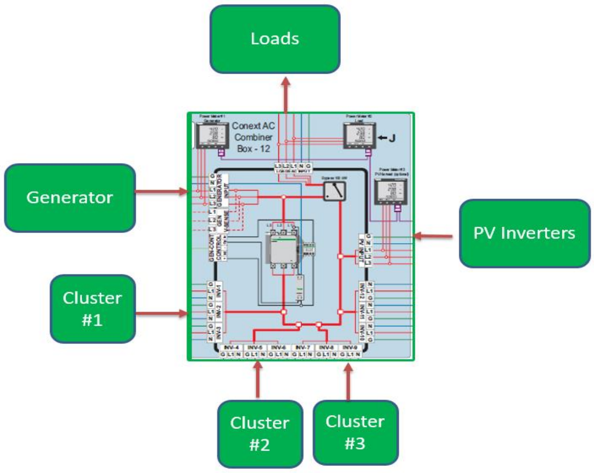

Fig. 5 Cluster Box Design

During the day time when PV is available, the PV will charge the battery and supply the load. Once the battery is completely charged then the complete generated power from solar will go to the loads as shown in Fig 6

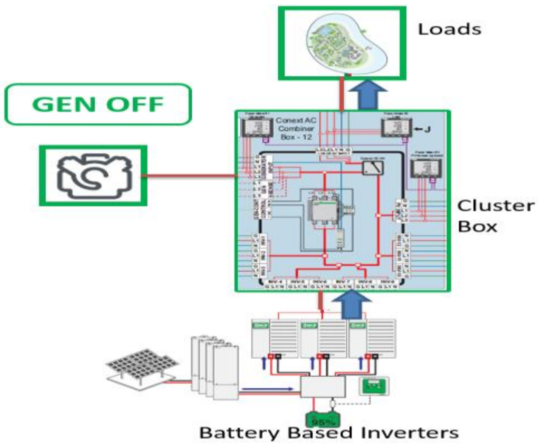

Fig. 6 Cluster Box Power Flow when Generator is OFF

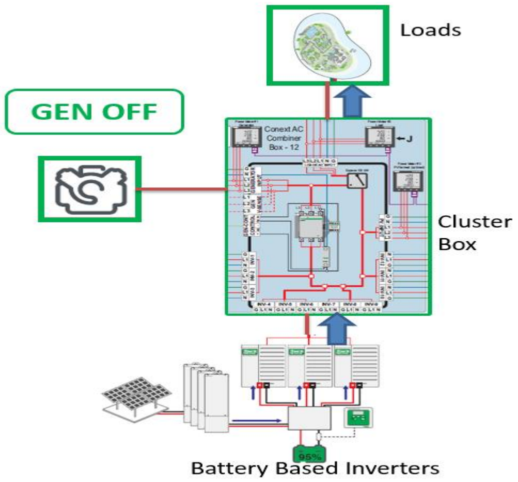

Fig. 7 Cluster Box Power Flow when Generator is ON

If the load is greater than the generation during a day in a particular time, then the extra demand will be supplied by the battery with the PV as shown in Fig 7 If the charge level in the battery goes below the set value, the Automatic Generator Start (AGS) will start the generator. During this time the inverter will act as the charger and the generator will charge the battery.

The cluster box will help in combining all the AC sources and loads; it makes sure that the load is supplied at any time without any power outs by managing the available sources.

F. Distribution Network

The distribution is the last stage of the power system network. The distribution network carries the power generation to the individual consumers.

The distribution consists of 6 primary feeders running from the main feeder junction box. These feeders are designed considering distribution losses in each feeder and the distribution length.

The distribution network Fig 8 shows the 6 primary feeders containing the following electrical parameters listed in Table 6.3.

a. Distribution Feeder Loss Calculation

The distribution feeders are designed considering the power loss in the feeder. The power loss in the particular feeder depends on the following quantities:

- Peak power
- Voltage
- Current
- Length of conductor
- Material of conductor
- Cross section of conductor

Considering all the above quantities the feeders are designed as explained below:

For feeder-1 from the Table 6.3, peak power is 4762W at 415V then the current in the feeder is given by:

$$Current\ in\ feeder-1=\frac{Power}{\sqrt{3}*Voltage*Cos\Phi}$$

$$Current\ in\ feeder-1=\frac{4762}{\sqrt{3}*415*0.9}=7.33\ A$$

Considering the 2 core aluminum cable, cross sectional area of 16 Sq.mm for a feeder length of 40m. The resistance offered by the conductor is given by:

$$Resistance=\frac{\rho*Feeder\ Distance}{Area\ of\ cross\ section}$$

$$Resistance=\frac{((1.74*10^{-8})*2)*40}{(16*10^{-6})}=0.0870\ \Omega$$

The voltage drop in the feeder is given by:

$$Voltage\ Drop\ Feeder-1=Current*Resistance$$

$$Voltage\ Drop\ Feeder-1=7.33*0.0870=0.63771\ V$$

The power loss in the feeder considering the 2 core cable is given by:

$$Power\ Loss\ Feeder-1=2*[I^2*R]$$

$$Power\ Loss\ Feeder-1=2*[Current*Voltage\ Drop]$$

$$Power\ Loss\ Feeder-1=2*[7.33*0.63771]=\ 9.43\ W$$

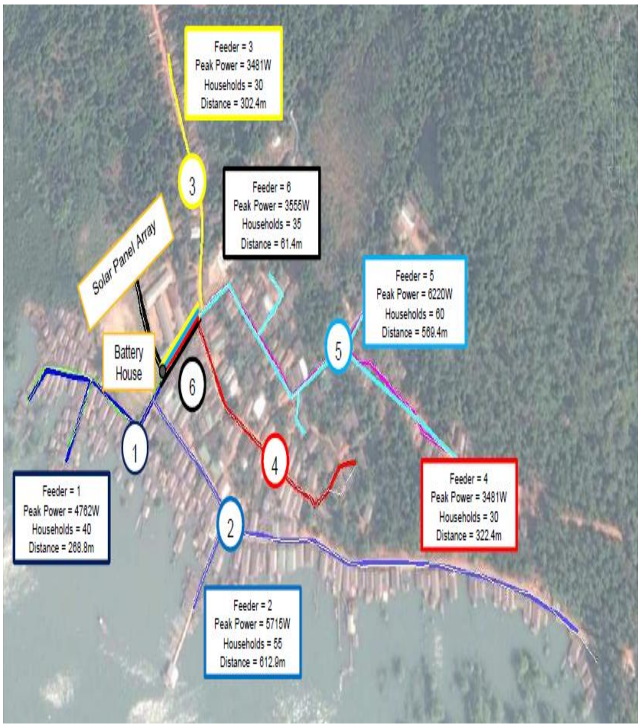

Fig.8 Distribution Network

Table 6.3 Feeders Loss Calculation

Feeder No.	F1	F2	F3	F4	F5	F6
Dist. line color in the layout	Dark Blue	Purple	Yellow	Red	Blue	Black
Peak Power(W)	4762	5755	3481	3562	6260	3735
Feeder Distance(Mts)	40	612.9	302.4	322.4	569.4	61.4
Dist. Voltage (V)	415	415	415	415	415	415
Wire Diameter	16	25	25	25	25	25
Conductor Material (Aluminum/Copper)	Al	Al	Al	Al	Al	Al
Current(A)	7.361239	8.896247	5.381031	5.506244	9.676891	5.773672
Resistance	0.087	0.8531568	0.4209408	0.4487808	0.7926048	0.0854688
Voltage drop(V)	0.640427762	7.589893653	2.265095679	2.47109641	7.669950082	0.493468822
Power loss(W)	9.428683	135.0431	24.3771	27.21292	148.4425	5.698254

G. Load Shedding Panel

The Solar based micro grid comes with centralized generation and storage. This type of micro-grids is used to electrify the remote off-grid villages. During day time the PV charges the battery and powers the grid. During night time when PV is not available the battery supplies power to load. During night time operation when battery is powering the load care should be taken that the battery bank is not drained below 50% DOD. To ensure such operation the generator will be used to charge the battery. If the generator is not available or under maintenance the loads should be disconnected. This disconnection of loads when battery DOD=50% is achieved an external mechanism known as PLC based load shedding mechanism. Fig 9 shows the block diagram of PLC based mechanism.

The load shedding panel placed near to the main feeder junction box. The PLC placed inside the load shedding panel will operate the contactor based on the Battery State of Charge (SOC). During battery SOC>50% Figure 10 the PLC closes the contactor and the loads will be connected to the Microgrid. During battery SOC<50% Fig 11 the PLC will open the contactor disconnecting the loads from the Microgrid until the battery will be charged.

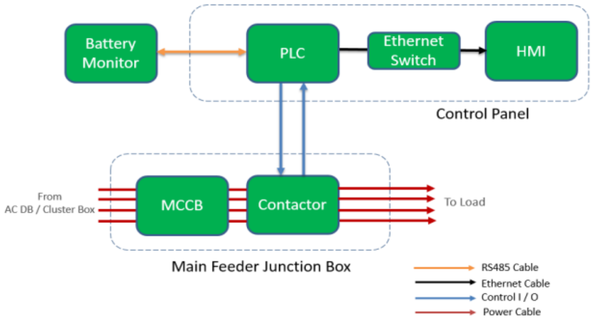

Fig. 9 Block Diagram of Load Shedding Panel

H. Power Room

The dimension of the control room is decided considering the components to be mounted and their dimensions. The power room is constructed near to the solar panel array area it contains all the required electrical and electronics components mounted inside the control room in which some components are wall mounted and some are floor mounted.

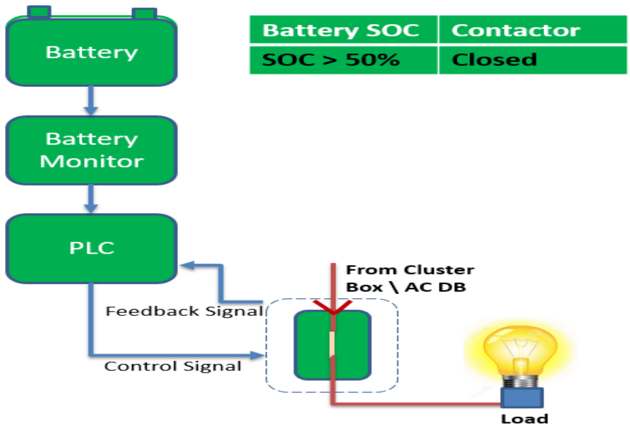

Fig. 10 Operation of Load Shedding Panel for Battery State of Charge (SOC) >50%

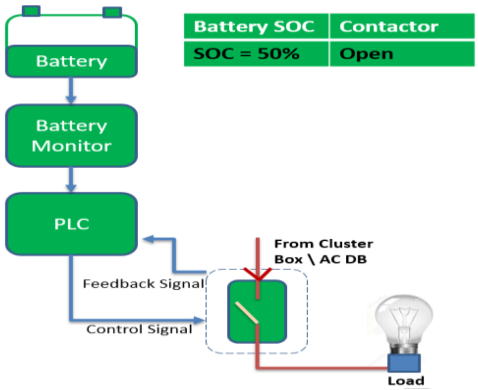

Fig. 11 Operation of Load Shedding Panel for Battery State of Charge (SOC) <50%

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CONCLUSIONS

In this work, optimal design of hybrid Microgrid for a remote village Kanti, Myanmar is designed. Based upon the load profile of the village, hybrid Microgrid system containing PV and diesel generator is designed.

The islands like Kanti represent a big market for the application of renewable energy sources for power generation. The newly designed and installed system hybrid system will provide a very good opportunity to showcase the importance of renewable energies using photovoltaic modules, power electronics and control technology for the remote locations. After the design of the hybrid Microgrid system, following points were concluded.

- The survey of the village plays an important role in designing the system. The survey has done by using GPS device which captures the location of household, unique number is assigned and the loads were entered against the assigned number. This approach of survey will help in optimizing the feeder losses by manipulating the households.

- The hybrid Microgrid has designed with the help of cluster box which combines all the AC sources and loads. The cluster box will make sure that the main preference is given to the solar and if PV is not available the generator will charge the battery.

- The load shedding panel designed will make sure that the battery is not over discharged when generation is not available. Once the generation is available, battery is charged it connects the loads to the Microgrid. It also makes sure that the commercial loads are not powered by the battery during night time. The use of power electronics devices such as the battery monitor, automatic generator start, system control panel will make the system to work more efficiently.

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