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Performance Analysis of Autonomous Hybrid Distributed Generation Based on Typical Control Strategies for Rural Electrification in Myanmar

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ABSTRACT

It is undeniable fact that even though fossil fuels are likely more to fulfill the requirements of energy, the rare of natural resources and their harmful contents for the environment have directed people to search for new energy sources like renewable resources such as hydropower, biomass, wind, solar and other types of clean energy. In order to highlight the proposed methodology, PV-Diesel generator (DG) with battery energy system (BESS) based on two typical control strategies, load following (LF) control strategy and cycle charging (CC) control strategy, have been analyzed by using HOMER Software to supply the Makyiyay village which is located at 22.02 north latitude and 96.56 east longitude in the Naungkhyo Township, Southern Shan State in Myanmar. The yearly average solar radiation of that area is 4.895kWh/m^2/day and it is very important to prepare a proper load data to meet the current situation of the target village which has 45 household numbers. By calculating the total load demand, the peak demand of that proposed village is 34kW. The fractions of energy production from PV array and diesel generator of the proposed PV-Diesel-BESS hybrid system using LF control strategy are 60% and 40% to meet the demand. Moreover, the proposed hybrid system based on LF control strategy provides the lowest TNPC, COE and carbon emission than the hybrid system based on CC control strategy according to the evaluation results. In contrast, the analysis of evaluation results shows that the PV-Diesel-ESS based on LF control choice is more economically possible than that system based on CC control.

KEYWORDS: *PV, Diesel generator, Hybrid system, HOMER software, BESS*

INTRODUCTION

Although fossil fuels are continually being formed via natural processes for using to produce energy, its harmful impact on the environment such as global warming and rising sea levels, makes people to find new energy sources [1]. In order to conserve and create a sustainable atmosphere, renewable energy sources (RES) have been considered as an alternative energy source due to its environmental friendly attributes. The significant energy security, climate charge mitigation and economic benefits can be made to get by the main application of RES such as hydropower, biomass, and wind, solar and other clean energy types and to decrease the environmental pollution [2]. Furthermore, RES can provide power efficiently at remote areas where construction of generation and transmission system can be costly. However, the composition of power sources within a system has to be determined optimally not only to reduce the overall cost but also to operate the system reliably and stably. The authors in [3] studied a multi-period mixed-integer linear program for planning and operation management of grid connected PV-battery systems.

The problem statement of this research is that the load center of non-electrified villages is located far away from the substation and the national grid. Therefore, these areas cannot access the electricity until now. Most of the people in these villages mainly depend on small petrol engine, batteries and some of people are using candle lamp for lighting, phone charger and other electricity appliances. The need of reasonable and reliable electricity is very much necessary to develop remote rural areas in developing countries [4]. In these regions, electric power is provided by various options. One is for extending the transmission network of existing system, and receiving power from a distant location. However this is not possible to practice because of high price transportation lines, their losses, and stability issue that may occur during long range power transmission [1]. Second is to use the standalone diesel generator to supply, but it is not reasonable due to its great amount of operating price, fuel transportation cost, short operational lifetime and intermittent support [5], and a distinct literature stands on the a lot of fuel-related obstacles of remote societies in the developing world [6]-[8]. Therefore, RE system can be a favorable solution due to its less installation, operation, and maintenance costs. According to the rural electrification organization, one of the most appropriate and environmentally friendly solution to supply electricity to those areas is RESs (Renewable energy Sources). Out of many RESs, photovoltaic (PV) generation has been one of the most favorable options because of its fewer prices and efficiency measured in other renewable energy solutions [2].

However, a system cannot be solely composed of RES due to its inherent intermittent characteristics, which increases the uncertainty and variability of the power system. Therefore a hybrid system, combination of both renewable and conventional energy sources, has been a promising result for the electrification of remote regions. To get the benefits of above solution, combining in a hybrid system- a diesel generator with renewable energy sources is so often the most optimal option [9]. Specifically, a medium to large scale PV and diesel generator system has been observed for rural electrificated systems in many countries throughout the global [10],[11].

The hybrid system is suitable for application in developing countries like Myanmar, where approximately 70% of the population live in rural areas, and electricity from the main grid is not yet available [12]. Additionally, Myanmar has many renewable energy resources, such as hydropower, biomass, wind, solar and other types of clean energy [12]. Therefore, Myanmar is well suited to apply the hybrid system.

A hybrid system composed with PV, DG, and battery energy storage system (BESS) has been suggested to meet the demand reliably and cost efficiently at an islanded rural area [13]. The prior studies have already chosen this PV-DG-BESS system for optimal sizing before they write the article, but have not focused on the selection of the optimal control strategy before they make the optimal sizing. So, in this paper, the possible micro grid system based on two typical control strategy have been carefully researched to confirm significantly that which one is the more optimal in cost minimization for a chosen rural area between these two control strategies by using the actual load data. Therefore, the main objective of this research is finding of the optimal hybrid solution based on optimal control strategy for proposed area. This problem has been solved by applying Hybrid Optimization Model for Electric Renewable (HOMER) software and Microsoft Office Excel. HOMER is a resource capacity optimization program that can be applied to different grid environments, such as standalone or grid connected systems. An excellent ability that HOMER offers is the capability to observe the optimum configuration based on both estimation of cost and performance sensitivity analysis to help understand tradeoffs between dispatch technologies and economic considerations. To get the best feasible solution, HOMER is based on three main functions: simulation, optimization and sensitivity analysis.

The simulation environment was constructed by modeling a small village called Makyiyay village which is located at 22.02 north latitude and 96.56 east longitude in the Naungkhyo Township, Southern Shan State in Myanmar. The demand of 450 households has been estimated by calculating the power consumption of a single village in the area. Furthermore, the climatic data for PV energy has been found through NASA's website [14] and the average solar radiation for the region is observed as 4.895kWh/m^2/day. The cost for each system component was obtained from different publications and websites. And then, the proposed system, PV-Diesel with BESS, has been analyzed based on two typical control strategies for supplying the proposed area economically.

PROPOSED SYSTEM

In the past, hybrid power system had been applied to various sites including:

A. extremely remote site,
B. telecommunication site,
C. village power (rural electrification), and
D. environment protection project [15]

For an extremely remote site, the priority is on fuel saving, where the priority of telecommunication site has power quality. In rural electrification, cost minimization is the main priority on the other hand in environmental protection project; pollution reduction is the main priority. In this paper, the proposed hybrid system has been applied for village power supply (Rural Electrification). So, in rural electrification, the first priority situation is minimization of costs and then second priorities are power quality and fuel saving. For system economic concerns, preventing the choosing of under-sizing of the system can minimize the system costs as well as preventing the choosing of over-sizing of the system can improve the system reliability in power quality concerns.

A. PV-DG-BESS Hybrid System

In Fig. 1, all energy sources to feed the total load as well as at peak loads from combined sources by synchronizing the inverter with the alternator output waveform are permitted by the parallel configuration. When overflow energy is obtainable from the engine-driven generator, as well as act as a DC-AC converter (inverter operation), the battery bank can be charged by the bidirectional inverter (rectifier operation). Besides, the bidirectional inverter may provide "peak shaving" as part of the control strategy when the engine-driven generator is overloaded [16].

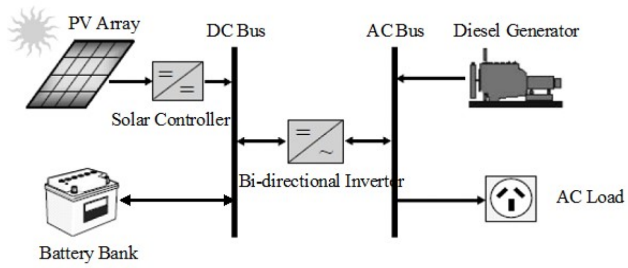


Fig. 1 PV-DG-BESS Hybrid System

B. PROPOSED HYBRID SYSTEM CONTROL STRATEGIES

In general there are two main control strategies of hybrid PV-DG-BESS system. These strategies are load following strategy and cycle charging strategy. In this paper, two models are presented for hybrid PV-DG-BESS system considering both strategies.

1. LOAD FOLLOWING STRATEGY

Fig. 2 shows the flow chart of proposed model of hybrid PV-DG-BESS system with load following dispatch strategy.

Firstly, the source files of load meteorological data (solar radiation and ambient temperature) must be obtained. Secondly, system specifications need to be defined such as PV array, battery storage and DG capacities, PV module efficiency, charging efficiency and the allowable depth of charge.

The simulation process starts by calculating the produced current (I_{PV}) by the PV array and compare this current with the load current (I_L). The maximum state of charge of the battery SOC_{max} is set as an initial capacity of the battery. In addition to that, matrices are defined so as to contain the results of battery state of charge (SOC), Load current (I_Load), Battery charging current (I_Charge), Battery discharging current (I_Discharge), Battery current (I_Battery), Deficit current (I_Deficit), Damped current (I_Damp), DG current (I_Diesel) and DG fuel consumption cost (F_C). After that, a "For loop" is initiated in order to handle the PV array and load currents. The resulted net current (I_{net}) represents the deference between the PV current (I_{PV}) and the load current (I_L).

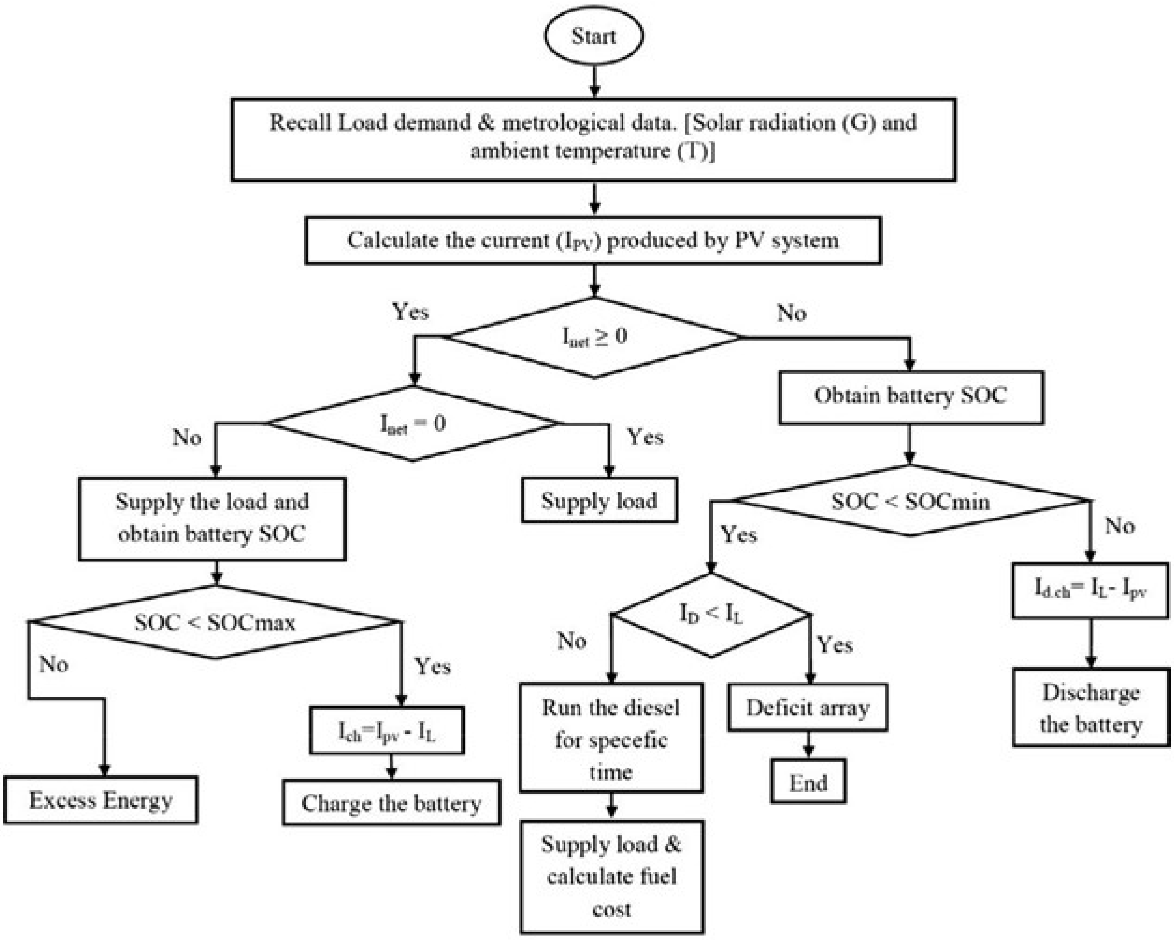


Fig. 2 Flow Chart of PV-DG-BESS System with Load Following Dispatch Strategy [17]

With this model, system operation can be described intro three cases. The first case is when the generated current by the PV array (I_{PV}) is equal to the load current (I_L) ($I_{net} = 0$). In this case, the load demand is totally fulfilled by the PV array's current and there is no current drawn neither by the diesel generator nor the battery. Moreover, there is no deficit and excess energy in this case.

The second case represents the case when the generated current by the PV system is more than the load current. In this case, the load demand is fulfilled by the PV array's current while an excess amount of energy is resulted. Here if the battery is fully charged, all of the excess energy will be damped and consequently there is no current drawn by DG and battery. Moreover, there is no energy deficit in this case. Otherwise, if the battery is not fully charged, battery will be charged by (I_{net}) and the new battery state of charge (SOC) is calculated.

The final case is when the generated current by the PV system is less than the load demand current. In this case, there are two main subcases,

I. If the battery is not used before ($SOC = SOC_{max}$) or the battery has been used before and the SOC is still higher than the minimum SOC ($SOC > SOC_{min}$).
Then, the battery will provide the required current together with the PV system to fulfill the load demand current. At this point, the new SOC is calculated and store in the defined array.
II. If the battery SOC is less than the minimum state of charge (SOC_{min}). In this case, the DG must provide current to fulfill the load demand current and here also there are two scenarios:

A. The first scenario is when the load demand current is less than the maximum diesel generator current. .

In this scenario, the diesel generator will run and supply the load demand. Meanwhile, the fuel consumption will be calculated and stored in the defined matrix. Moreover, in this case, there is no deficit current. In addition, the current that is generated by the PV system during this period will be used to charge the battery and again the SOC will be calculated and stored in the defined matrix. Here, there is no damping current in this scenario until the SOC of the battery reaches the maximum level and at this point, the damping current will be equal to I_{PV}.

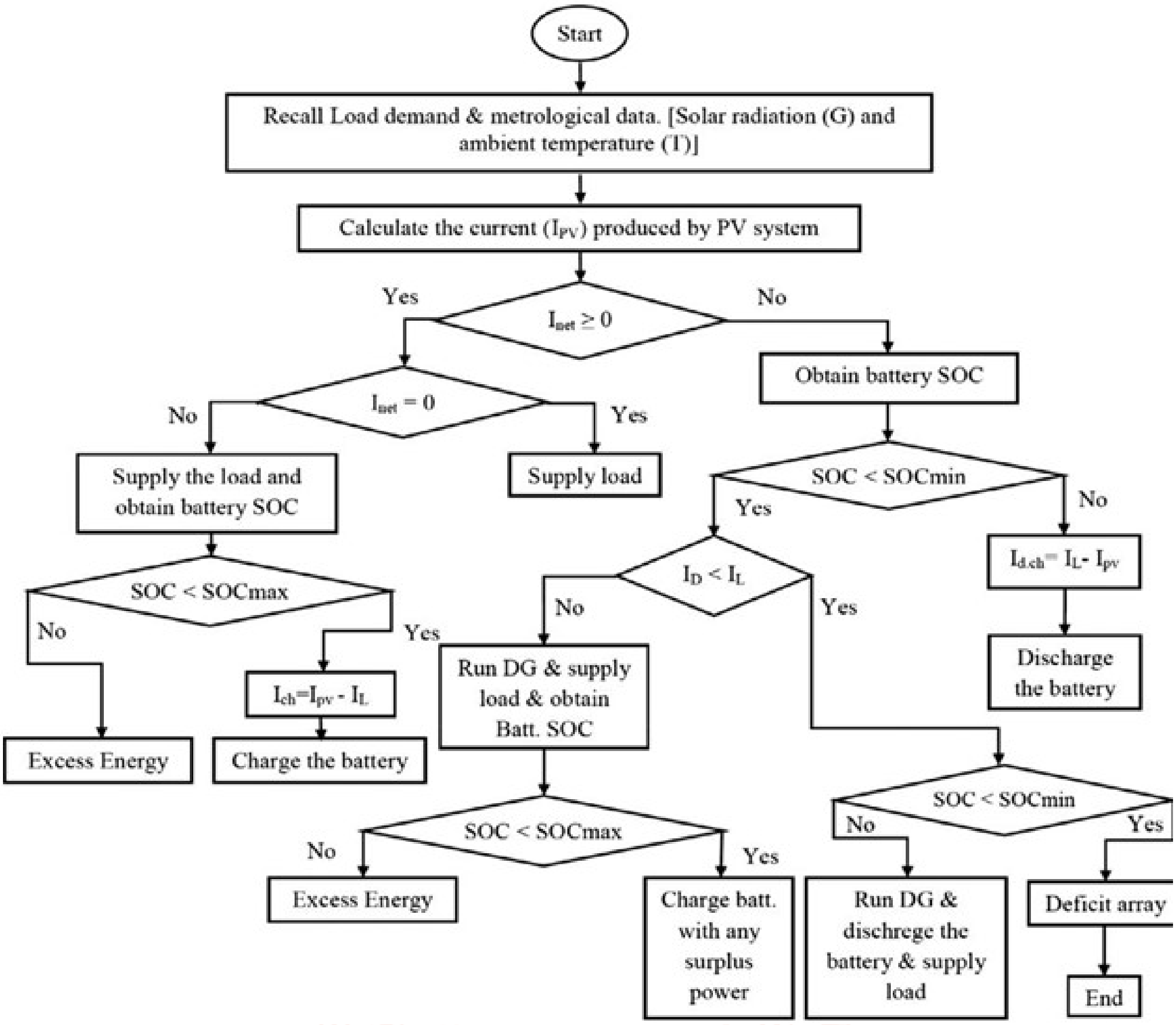


Fig. 3 Flow Chart of PV-DG-BESS System Model with Cycle Charging Dispatch Strategy [17]

B. The second scenario is when the maximum diesel generator current is less than the load demand current. Here, the diesel generator is not able to cover the load demand current and the deficit current is equal to the load demand current.

2. Cycle Charging Strategy

Fig.3 shows the flow chart of the proposed model of hybrid PV-DG-BESS system with cycle-charging dispatch strategy. In this model, system operation strategy is the same as the operation strategy in the load following dispatch. However, there is a difference in the case when the battery is not able to fulfill the load demand ($SOC < SOC_{min}$). In this case, there are three scenarios.

A. The first scenario is when the load current (IL) is less than the diesel generator current (I_D), the diesel generator will run and generate its rated power, or as close as possible to supply the load and to charge the battery with any surplus energy until the battery SOC is equal or less than the SOC_{max}.
B. The second scenario is when the load current (I_L) is more than the maximum diesel current (I_D) and the battery is fully charged or $SOC > SOC_{min}$. Here, both DG and the battery will contribute to fulfill the load.
C. The final scenario is when the load current (I_L) is more than the maximum diesel current (I_D) and the battery SOC is lower SOC_{min}. Here, the DG is not able to cover the load demand and it is not able to charge the battery as well. Consequently, the deficit current is equal to the load demand current.

MATHEMATICAL MODEL FOR EVALUATION

The performance of the hybrid system can be analyzed based on the goals of cost minimization, system reliability improvement, and reduction of greenhouse gas emissions [18]. The net present cost is calculated by discounting the annual, quarterly, and monthly financial flows [19]. The net present cost of a system is the present value of all costs minus all values over its lifetime, and it includes capital costs, replacement costs, operation and maintenance costs, and fuel costs. The levelized cost of energy is calculated by dividing the total life-cycle cost by the total energy output during the project lifetime [19]. The mathematical equations are formulated for the simulations using the HOMER, as follows [19], [20], [21].

$$C_{NPC} = \frac{C_{anntot}}{CRF(i,n)} \tag{1}$$

$$i = \frac{i_{nom} - f}{1 + f} \tag{2}$$

$$LCOE = \frac{TLCC}{\sum_{n=1}^{N} \frac{Q(n)}{(1+r)^n}} \quad (3)$$

$$TLCC = \sum_{n=1}^{N} \frac{C(n)}{(1+r)^n} \quad (4)$$

$$S = C_{rep} \cdot \frac{L_{rem}}{L_{comp}} \quad (5)$$

$$f_{es} = \frac{E_{sc}}{E_{tot}} \quad (6)$$

$$CRF(i,n) = \frac{i(1+i)^n}{i(1+i)^n - 1} \quad (7)$$

The parameters in (1)–(7) are defined as follows.

C_{NPC} : net present cost ($)
C_{anntot} : total annualized cost ($/yr)
$CRF(i,n)$: capital recovery factor
i : annual real interest rate (%)
i_{nom} : nominal interest rate (%)
f : annual inflation rate (%)
n : index for the year
N : project duration (yrs)
$LCOE$: levelized cost of energy ($/kWh)
$TLCC$: total life cycle cost ($)
$Q(n)$: energy output of power generation system in the specific year of n (kW)
$C(n)$: total cost in the specific year of n ($)
r : annual discount rate (%)
S : salvage value ($)
C_{rep} : replacement cost of the component ($)
L_{rem} : remaining life of the component (yrs)
L_{comp} : lifetime of the component (yrs)
f_{es} : capacity shortage fraction
E_{sc} : total capacity shortage (kWh/yr)
E_{tot} : total electric (kWh/yr)

SYSTEM MODEL PREPARATION FOR SIMULATION

In order to prepare for simulation, the following parameters are needed.

A. Load Profile

The Makyiyay village is located at 22.02 north latitude and 96.56 east longitude in the Naungkhyo Township, Southern Shan State in Myanmar. In order to estimate the load consumption, the electricity loads are divided into three groups-from residences, from communal facilities, and from commercial facilities. The residence group consists of 450 households in the low-, medium-, and high-income ranges. The electricity demand in the low-income range is limited to the requirements for lighting and TV, and the annual growth rate of electricity consumption is small. The households in the medium-income range may additionally use electric fans, and their annual growth rate of electricity consumption is increasing rapidly. The households in the high-income range may use refrigerators. The communal facilities include schools, public offices, hospitals, and street lighting. The commercial facilities consist of shops, markets, and restaurants. The detail load components are shown in Table 1. From the consumption pattern of each load component, the daily and monthly load profiles for the village are calculated, and are shown in Fig.5 and Fig.4, respectively. The average and peak loads are 4.19 kW and 34 kW, respectively, which correspond to a load factor of 0.123. Mid peaks of approximately 9 kW occur in the evening, and high peaks of approximately 18 kW occur in the early morning. In contrast, a low demand of approximately 2 kW is observed during the day and in the early morning except at 6am. It is assumed that the determined load profiles do not change during the project life span of 25 years, that is, from 2018 to 2043.

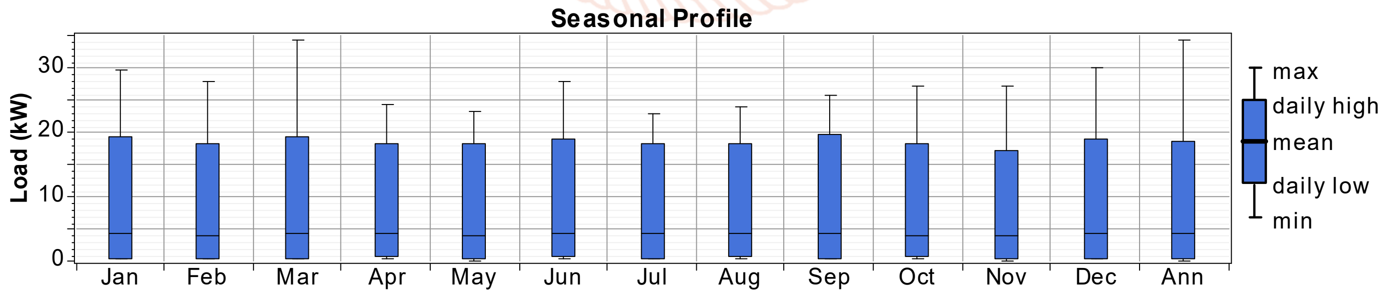


Fig.4 Monthly Load Profile for the Makyiyay Village

TABLE1. LOAD COMPONENTS FOR THE MAKYIYAY VILLAGE

Components		Numbers	Power consumption (kWh/day)
Residence	Low income	10	5.25
	Medium income	15	27.7
	High income	10	38.43
Communal Facilities	School	1	4.06
	Monastery	1	3.9
	Rural Health Clinic	1	3.3
	Street lighting	10	0.6
Total Power consumption per day			83.24

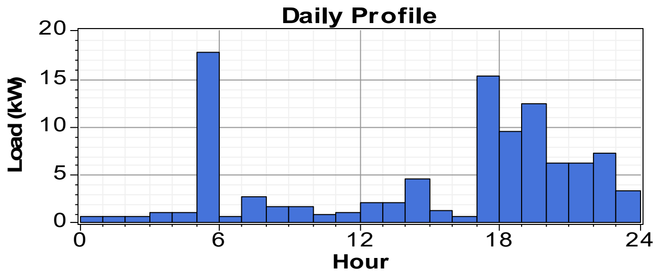


Fig. 5 Daily Load Profile for the Makyiyay Village

B. Solar Radiation Profile

The average solar radiation in Myanmar is more than 5 kWh/m2/day during the dry season [12]. It varies from 2.3 to 3.2 kWh/m2/day in the extreme north and south regions, while most parts of Myanmar, including the central area, receive a good amount of solar radiation ranging from 3.6 to 5.2 kWh/m2/day [12]. Therefore, government and private sector organizations have been promoting and piloting solar PV systems for rural electrification [12].

The specific daily and monthly solar radiation profiles for the selected village are shown in Fig. 6 and Fig. 7, respectively. The annual average is 4.895 kWh/m2/day. The highest and lowest solar radiation occur in April and August, respectively. In April, the PV array can satisfy the entire load during the day, and the load in the evening and night can be satisfied using the energy stored in the battery energy storage systems. On the contrary, in June, July, and August, the diesel generators may have to operate and charge the batteries, to support the PV generation system.

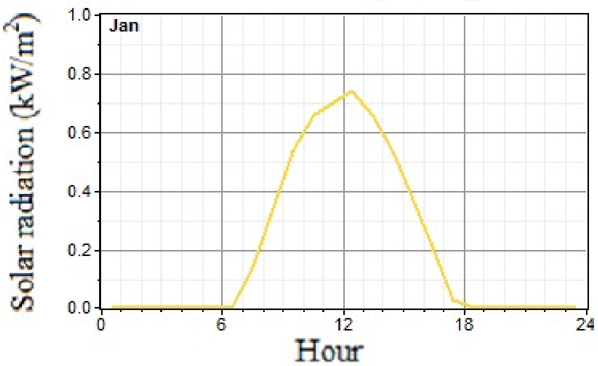


Fig.6 Daily Solar Radiation Profile for the Makyiyay Village

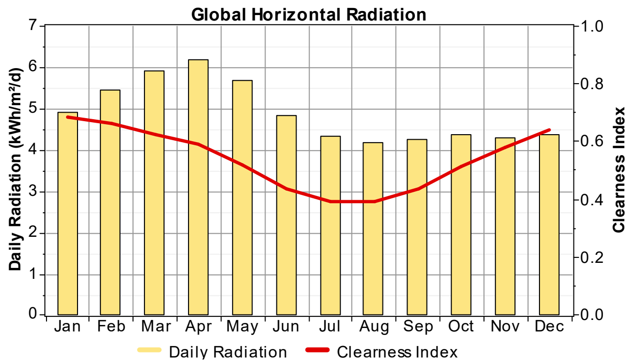


Fig.7 Monthly Solar Radiation Profile for the Makyiyay Village

C. Proposed System Components

The hybrid system proposed in this paper consists of solar PV arrays, DG, BESS, and converters, to obtain efficient and cost-competitive system for improving the system reliability of energy supply especially in rural areas. The configuration of the hybrid system is shown in Fig. 8.

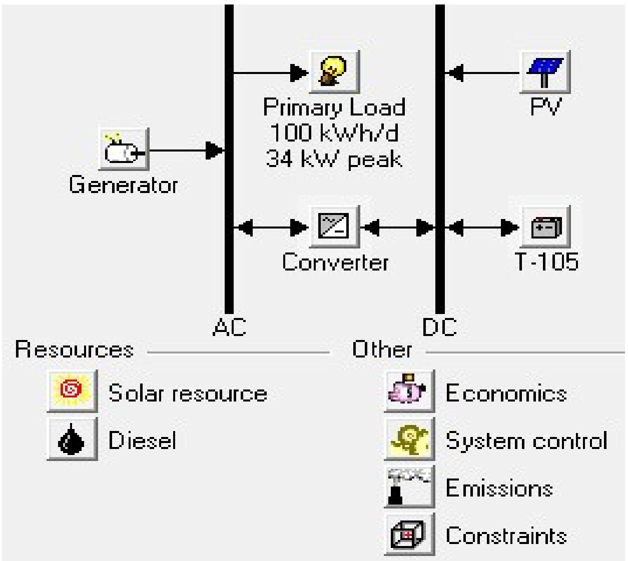


Fig.8 Structure of the Proposed Hybrid System

1. Solar Panel

The capital cost for the PV amounts to $400 with considering other auxiliary components of the system. The module life time is estimated to be 25 years. The photovoltaic system has no tracking device. The technical and economical parameters of the PV system are listed in Table 2.

TABLE2. TECHNICAL AND ECONOMIC PARAMETERS OF THE PV SYSTEM

Parameter	Value	Unit
Capital cost	400	$/kW
Replacement cost	0	$/kW
Operation and maintenance cost	10	$/yr
Lifetime	25	years
Derating factor	80	%
Tracking factor	N/A	N/A
Ground reflectance	20	%
Slope degree	20.03	degree
Temperature effect	N/A	N/A

2. Diesel Generator

The power rating of the diesel generator is selected as 35 kW to cover the peak load. The diesel generator is used as a backup system, which is operated when the output from the PV system fails to satisfy the entire demand, and the state-of-charge of the battery energy storage is not sufficient. The technical and economic parameters of the diesel generator are listed in Table 3.

TABLE3. TECHNICAL AND ECONOMIC PARAMETERS OF THE DG

Parameter	Value	Units
Size	35	kW
Capital cost	7200	$
Replacement cost	6500	$
Operation and maintenance cost	0.03	$/yr
Lifetime (operating hours)	15,000	hours
Minimum load ratio	30	%
Fuel price	0.8	$/liter

3. BESS

The battery type used in this paper is Trojan T-105 with a string size of 12. The battery energy storage system operates at a nominal voltage of 6V. The specific parameters of the battery system are listed in Table 4.

TABLE4. TECHNICAL AND ECONOMIC PARAMETERS OF THE BESS

Parameter	Value	Unit
String size	12	–
Capital cost	420	$/battery
Replacement cost	400	$/battery
Operation and maintenance cost	10	$/yr
Lifetime	10	years
Nominal capacity	225	Ah
Round trip efficiency	80	%
Minimum state-of-charge	40	%
Nominal voltage	6	V

4. Converter

The converter can operate as both an inverter and a rectifier, according to the direction of power flow. The specific parameters of the converter are listed in Table 5.

TABLE5. TECHNICAL AND ECONOMIC PARAMETERS OF THE CONVERTER

Parameter	Value	Units
Capital cost	340	$/kW
Replacement cost	300	$/kW
Operation and maintenance cost	10	$/yr
Lifetime	20	years
Inverter efficiency	90	%
Rectifier efficiency	85	%

SIMULATION RESULTS

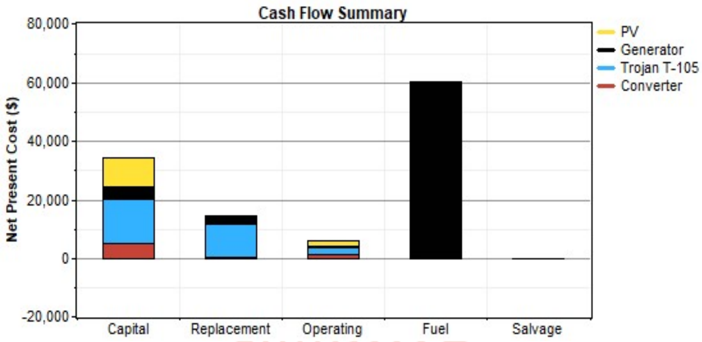
Simulations are performed for three cases. In case study I, the PV-Diesel-BESS hybrid system based on LF control strategy has simulated the entire demand as a stand-alone system. In case study II, that system based on CC control strategy is considered. In the simulations, the parameters presented in Tables 1, 2, 3, 4, and 5 and the above model shown in Fig.8 are used.

TABLE6. SIMULATION RESULTS FOR TWO CASE STUDIES

PV (kW)	Gen (kW)	T-105	Conv. (kW)	Disp. Strgy	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Gen (hrs)
25	20	36	15	LF	$ 34,334	10,960	$ 114,671	0.429	0.60	10,251	2,398
15	15	48	15	CC	$ 34,346	11,222	$ 116,602	0.436	0.45	10,632	2,942

A. Case Study I

For case I, 25 kW PV Array, 20kW diesel generator, 36 numbers of Trojan batteries and 15 kW converter based on LF control strategy are used for supplying the proposed area. The simulation results for the net present cost, nominal cash flow, and monthly average of generation for Case I are shown in Figs. 9, 10, and 11 respectively. The generations from the PV arrays and the diesel generator are 60% and 40%, respectively, of the total generation.



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	10,000	0	1,832	0	0	11,833
DG	4,114	2,909	301	60,111	-1	67,435
Trojan T-105	15,120	11,226	2,639	0	-13	28,972
Converter	5,100	391	1,099	0	-159	6,431
System	34,334	14,526	5,872	60,111	-173	114,671

Fig.9 Net Present Cost for Case Study I

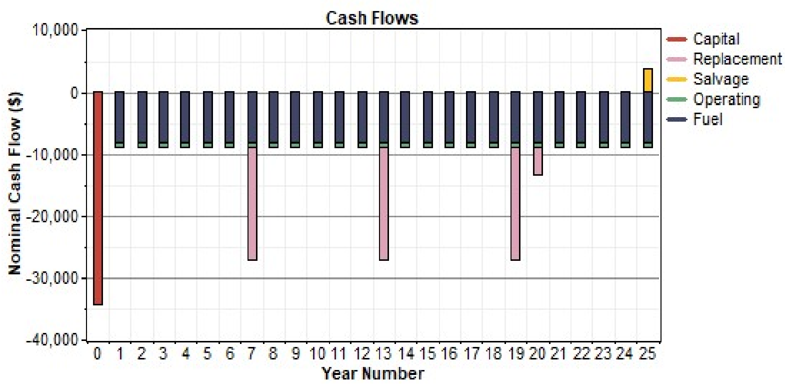
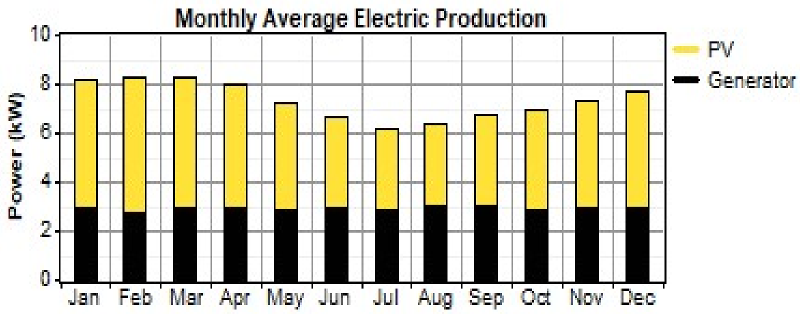


Fig.10 Nominal Cash Flow for Case Study I

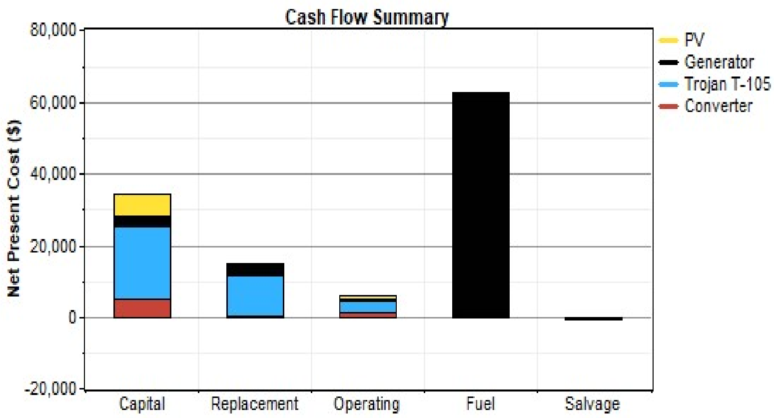


Component	Production (kWh/yr)	Fraction
PV array	38,524	60%
Generator	25,656	40%
Total	64,181	100%

Fig.11 Monthly Average Generation for Case Study I

B. Case Study II

In case study II, the proposed system contains 15 kW PV Array, 48 numbers of Trojan T-105 battery, 15kW diesel generator and 15kW converter for proposed area. The simulation results for the net present cost, nominal cash flow, and monthly average of generation for case study II are shown in Figs. 12, 13, and 14, respectively. The PV generation decreases to 45%, from the value of 60% in case II. This is because the battery energy storage can manage the variations in PV generation, which results in increased utilization of the PV.



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	6,000	0	1,099	0	0	7,099
DG	3,086	2,955	277	62,343	-13	68,648
Trojan T-105	20,160	11,447	3,518	0	-702	34,423
Converter	5,100	391	1,099	0	-159	6,431
System	34,346	14,792	5,995	62,343	-873	116,602

Fig.12 Net Present Cost for Case Study II

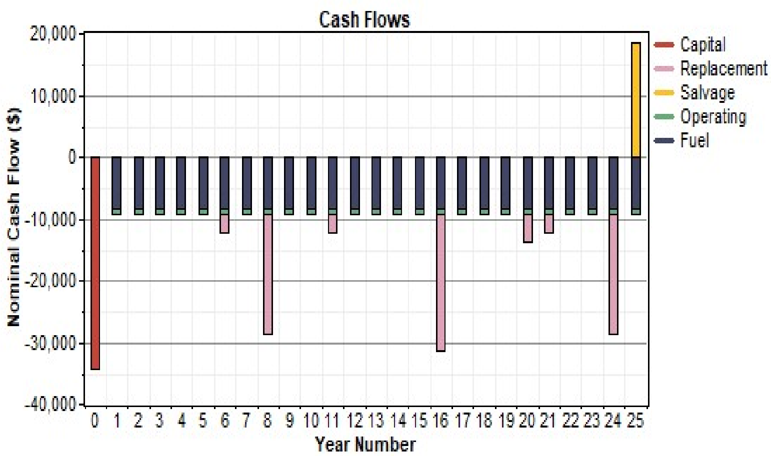
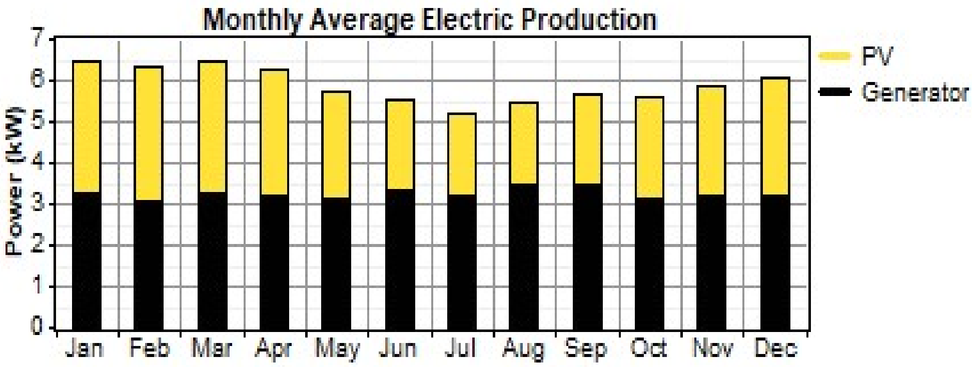


Fig.13 Nominal Cash Flow for Case Study II



Component	Production (kWh/yr)	Fraction
PV array	23,115	45%
Generator	28,404	55%
Total	51,519	100%

Fig.14 Monthly Average Generation for Case Study II

COMPARISON RESULTS

The results of case studies I and II are listed in table 7 for comparison. It can be seen from Table 7 that case study I, or the hybrid system with the PV, diesel generator, battery energy storage, and converter using LF control, is the better choice than case study II in terms of cost. The emissions of CO_2, SO_2, and NO in case study I are lower than in case study II, which means that case study II is better in terms of environmental effects also.

The fuel consumption decreased from 10,632 L/yr in Case II to 10,251L/yr in case I because of LF control strategy.

In terms of the unmet load and capacity shortage, there are no significant differences between the two cases, which means that the two cases are feasible for the village. This means that the hybrid system, particularly that in case study I, can achieve the benefits of reduced cost and lesser greenhouse gas emissions, without sacrificing reliability. Consequently, it can be concluded that, for the selected village in Myanmar, the hybrid system with both PV, diesel generator and BESS based on LF control can decrease the net present cost and mitigate the environmental problems while maintaining reliability.

TABLE7. COMPARISON RESULTS OF CASE STUDIES I AND II

Description	Case Study I	Case Study II
Total net present cost ($)	114, 671	116,602
Levelized cost of energy ($/kWh)	0.429	0.436
Capital cost ($)	34,334	34,346
Operation cost ($/yr)	10,960	11,222
PV penetration (%)	106	63.3
CO_2 emissions (kg/yr)	26,994	27,996
Renewable fraction (%)	60	55
Fuel consumption (L/yr)	10,251	10,632
SO_2 emissions (kg/yr)	54.2	56.2
NO emissions (kg/yr)	595	617
Unmet load (kWh/yr)	11.13 (0%)	3.99 (0 %)
Capacity shortage (kWh/yr)	31.1 (0 %)	14.2 (0 %)

CONCLUSION

Distributed generation model of hybrid PV-DG-BESS system was proposed in this paper. Two types of the most typical control strategies have been used in the proposed model namely, Load following and cycle-charging. To simulate the proposed model, two tests have been done for the hybrid system using real metrological data and load demand. Myanmar, being a country that has many renewable energy sources and non-electrified rural villages, was found to be suitable for the implementation of hybrid systems. Thus, in this paper, a village in Myanmar is selected and supplied from the hybrid system with economic feasibility, considering the specific local conditions and resource availability for the village. The evaluation results in this paper suggest that government and private sector organizations in Myanmar should consider the hybrid system as a highly suitable alternative, when promoting and piloting solar PV systems for rural electrification.

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