PLANNING ON WIND-DIESEL HYBRID MODEL FOR RURAL ELECTRIFICATION IN MYANMAR

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Abstract

Case study area, Wetkaik village (16° 54' N, 93° 27' E) is identified for economic feasibility in this paper. HOMER optimization model plan imputed from total daily load demand, 1167kWhr/day for current energy consuming of 850householdsandaverage wind speed, 3.7 m/s according to NASA data, 10m above the ground in this area is designed. This proposed system is storage wind-diesel hybrid system based on the cost and fuel availability, and resulting power quality for not only to optimize the energy cost but also to decrease the air pollution with effects the environment. Simulation results can be performed with HOMER micropower optimization tool. Special focus is put on sizing the optimal system which gives the lowest levelized cost of energy approximately 0.257 $/kWhr according to the village level priority. This project intends to access to a reliable supply of energy as wind-diesel hybrid system application that it is possible to supply of electricity to such remote locations where there is a wind energy source.

Keywords: Rural electrification, Wetkaik village, Wind-diesel hybrid optimal model plan, Wind energy

Introduction

Myanmar has very intermittent wind nature. It mentions that wind generation system may not be currently economically attraction. Nevertheless, it would be useful for potential hybrid situations such as remote area. On the other hand, generally 70% of the population lives in rural areas which are not commonly use electricity. In fact, this paper hands out hybrid system combination diesel generators with battery inverter subsystems and incorporating wind generators in the usage of rural electrification, Myanmar. The system design and control of operation was investigated depending on factors such as consumer requirement, site location, and system economic in the proposed area, Wetkaik village.

The purpose of this paper is not only to develop wind energy usage in Myanmar but also to provide electricity for rural people who couldn't access to connect to the national grid as a reference preliminary report for wind power application of renewable energy systems at other similar locations and villages in the remote area, Myanmar. The economic feasibility of the case study area, Wetkaik village is determined by HOMER model imputed from existing data: such as local status and resource availability. The selection component of wind-diesel hybrid system is apparatus based on optimal design. To ensure the feasibility target of this project, electrical demand in rural area and socio-economic development are provided, at the same time, additional benefits of this project are to reduce CO_2 and particulates entering into the atmosphere.

This paper describes in six sections. An overview of rural electrification in Myanmar presents in Section two. Generally, wind resource information based on NEDO and NASA data is discussed in Section three. Case study on Wetkaik village is highlighted in Section four including the village nature load and local status of this area respectively. In section five, simulation model and result outcome of proposed area are performed. The last section, Section six, summarizes the feasibility study of Wetkaik village in which a sample of wind energy application in remote area, Myanmar.

Rural Electrification in Myanmar

On extensive landscape of Myanmar, distribution pattern of villages scatter to far apart at remote areas. Also it is geographical nature of mountainous regions and many water ways barriers of rivers, creeks, lakes and delta zones make difficult to communicate. Accordingly, national grid lines reach only few village areas and most villages have no chance to use electric power from the grid. The national grid has an installed capacity of 1.7 Gigawatts and currently serves 220 of the 396 main towns and just 7000 of the 64,000 villages, translating to approximately 26% of the population. 46% of this electricity stems from hydropower, much of which is seasonal in performance resulting in limited and unreliable supply throughout dry months of the year, and leaving those connected to the grid energy insecure and seeking alternative sources of light. At the moment, national grid power distribution is priority to urban and industrial zone.

Generally, energy supply system to rural area, especially to the village people is almost entirely relying on direct usage of natural resource at their own arrangement. Majority of rural population depends on natural environment to get energy required for their daily living struggle. Cooking fuel comes from the tree or agricultural residue collected from the nearby forest or farm land. For lighting power source fossil fuel lamp or candle is still common, but it became very inconvenience since Kerosene shortage crisis in 1973. Lighting energy substitution by small battery applications evolved country wide by the effort of private sector but technical and knowledge backup is found to be very weak at the moment.

On the other hand, gradually growing rural socio-economic atmosphere is demanding the energy and governmental energy supply systems of national grid and other centralized power distribution arrangements are far to reach rural destinations at feasible scale for sustainable establishment. Regarding to energy issue cut down the problem of daily cooking fuel and fulfillment of night light need by renewable energy can be implemented successfully. But still there is a big question for sustainable development and urgently required knowledge, technologies, materials and initiative assistances are quite essential to fulfill [9].

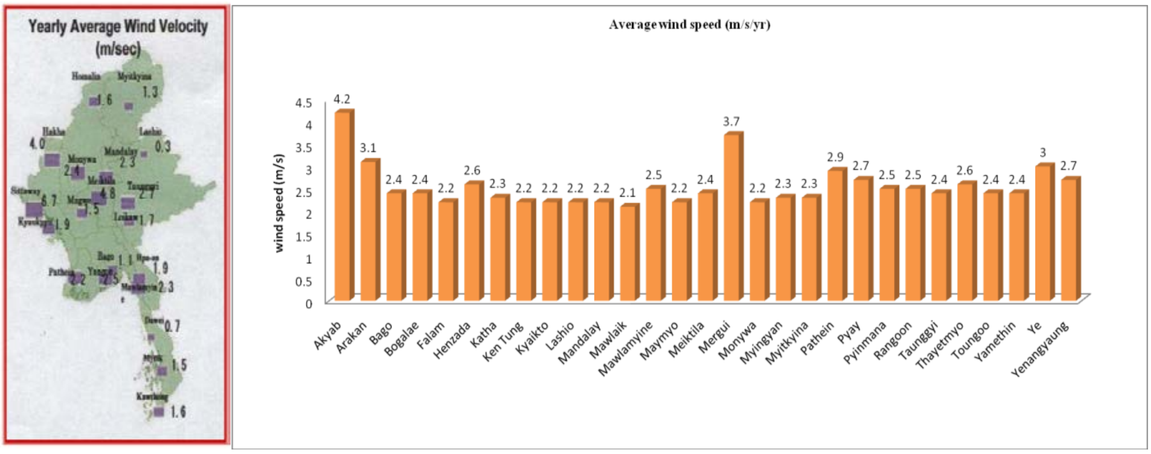
Wind Energy in Myanmar

Myanmar has vast measure of renewable energy resource in various kinds. Solar, Hydro, Wind and Biomass are at great potential to utilize easily for the benefit of the poor to fulfill their basic needs of fuel for cooking and lighting in rural area. Among them, wind pattern in Myanmar is generally not regular and low in capacity to produce sustainable energy at the current availability of technology.

The promising areas to harness wind energy sources are the hilly regions of Chin and Shan State, Coastal region of 2832 km facing the Bay of Bengal and the Andaman Sea and Central Myanmar region. The results from the data of NEDO, (New Energy and Industrial Technology Development Organization) of Japan indicate that the feasible area to harness wind energy are in locations an average wind speed of 5.6 to 7.4 meters per second, which would yield outputs ranging from 55kW to 225kW. Potential available wind energy along this coastal strip, with its southwesterly wind for 9 months and northeasterly wind for 3 months, is around 365,1 TWhr/yr[6]. However, wind energy development in Myanmar is only initial stage such as experimental and research phase because of the initial cost; therefore, install capacity is only 0.5194 MW.

Moreover, while Myanmar has no wind map for suitable site of wind power application, the data of yearly averaged wind velocity can be seen not only Figure 1. (a), NEDO data in accordance with States and Divisions but also Figure 1. (b), NASA data from selecting site area specified three highest wind speed such as Rakhine region at western part, Magway at central part and Ye township at southern part, Myanmar. These areas would be windy site for development of wind power project. From getting NASA data, the feasibility study can be approached to development and usage of wind power for rural electrification in Myanmar as a future extension study.

In this paper, Yangon region is focused on study area because Yangon is greatest electricity demand in Myanmar. In future expect of this project, excess electricity is supported to be extension Yangon load, 35% of national grid if the more getting power providing from wind energy resource in this area; especially there is very good wind resource site. Regarding to fulfillment of government policy, promoting to the rural electrification need by renewable energy can be implemented successfully from support one point.



(a) Source: NEDO, Japan [12] (b) Source: NASA [10, 11]

Figure 1. Yearly averaged wind velocity in Myanmar

Case Study on Proposed Area

Location of Wetkaik Village

In feasibility study, target location of the project is Wekaik village (16° 37' N, 96° 24' E), is a small village located in Kungchankon Township, Yangon region, coastal region of 2832 km strip which are promising areas to harness wind energy sources in Myanmar as shown in Figure (2). In current situation of this area, there are remaining remote places disconnected from the grid such as Ywathitkon, Kyahkat, Kanyashe and Wetkaik Villages because the provision of the electricity supply to this area is difficult and costly, extension of the main grid over difficult terrain, is not generally economic for small power loads.

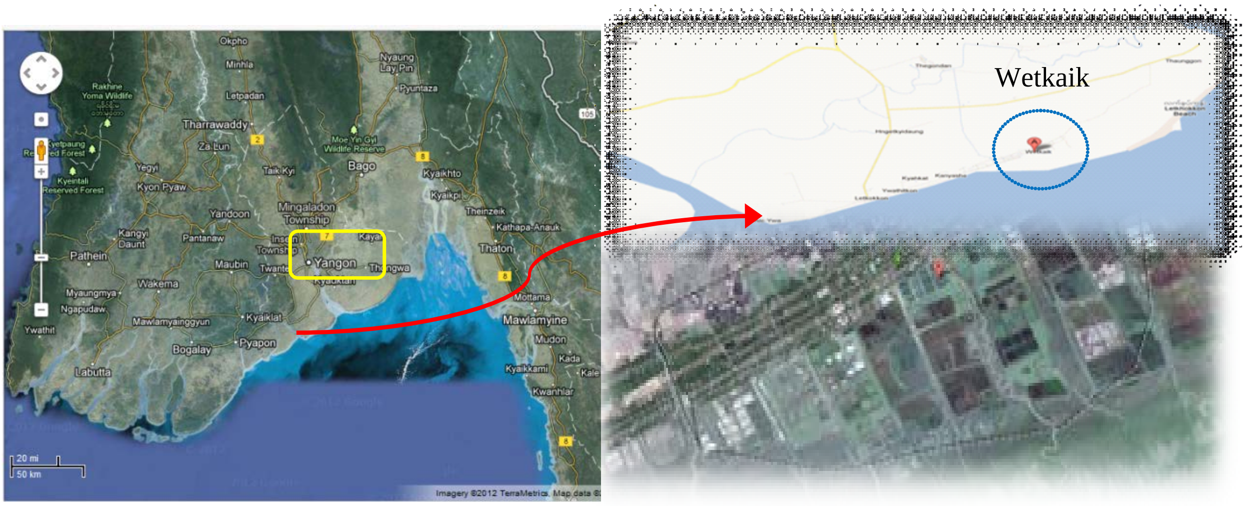


Figure 2. Wetkaik village [5]

Among them, Wetkaik village is far about 7miles from Lettkokkon village, connecting to the national grid, the last one at the end of the transmission line. Therefore, this area cannot connect to the electricity grid in case of conventional grid extension to such area seems physically impossible or economically unviable. On the other hand, Wetkaik is the nearest village of Letkokkon Beach where the wind blows constantly and also its geographical nature of coastal region for leading efforts to wind power available within this area. Annual average wind speed of this area is 3.7 m/s at 10m height reference by the NASA data using monthly averaged wind data from 22-years of weather data including global solar radiation, dew point temperature, mean temperature, maximum temperature, minimum temperature, relative humidity, and wind speed [5,10,11]. Although there is no reference wind atlas in Myanmar measured by high mast, this assumption data can be used as input wind resource for HOMER model in this study and then wind speed for each month can be seen in Figure3.

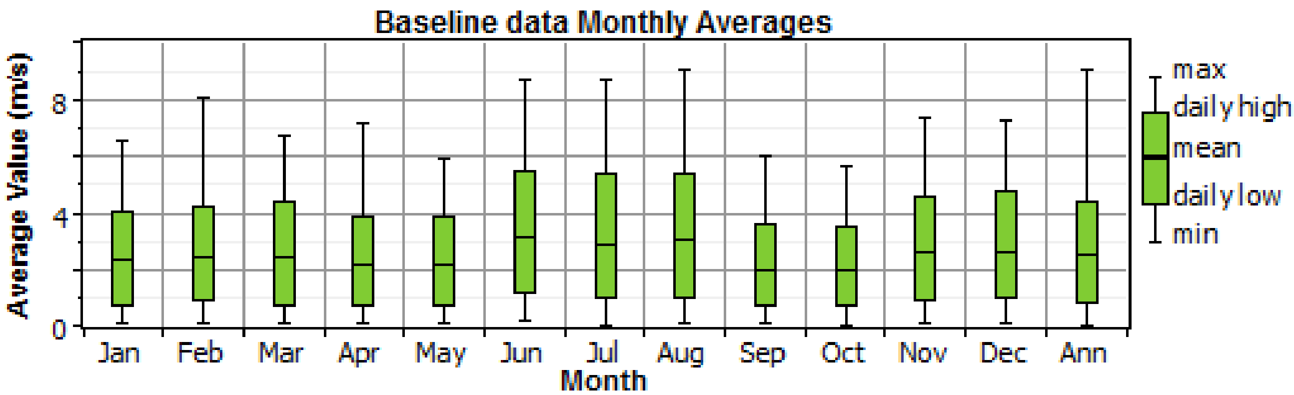


Figure 3. Wind data of Wetkaik [5, 10, 11]

In fact, this area is possible for rural power application from very good wind resource. Furthermore, wind resource is better generation electricity than solar, biomass and others. In effect, the most important factor enhancing social and economic development of Wetkaik village is a reliable supply of electricity by wind energy resource. Based on NASA data, a feasibility study for wind-diesel hybrid system at Wetkaik is prepared to optimal design model in this paper.

Socio-Economic Characteristics of Wetkaik Village

In Wetkaik village, there are about 1450 households with 5000 of local people. Majority of rural population in this area depends on natural environment to get energy required for their daily living struggle. Fishing is the dominant source of income for rural households in this region. The remaining primary income source is farming, shop owner, petty trader and casual labor. Half of the population in this village is low income household. The main sources of their energy usage for cooking and lighting are firewood, candle and battery. Remaining households are medium and high income. Some of them are used for few private diesel-generating sets. Diesel and petrol are used in cars, trucks, and motor boats for transportation purposes. The communication system is bad because of poor roads. Battery-operated radios are the only entertainment gadgets. Facilities likes school, clinic, government office are inadequate. There is a chronic shortage of power. Renewable energy project can change the lifestyle of the people of the Wetkaik. It is true that villagers will never get grid power due to its difficult terrain and remote location, but villagers hope to the power of wind.

Load Power Demand

The proposed site, Weikaik, household lighting in this village is generated by three main sources: battery powered lantern, diesel generator generated electricity and candle. The current energy consumption for each household is assumed to be constant and broadly classified with village load patterns for which 500 households with lower income, 300 households with medium household, 50 households with higher income and others public affairs such as (two clinics, one public building, school, two workshops, two primary schools, street light, five restaurants and two shops).

Consumers are categorized into two classes: domestic and commercial. Commercial load in this village typically consists of cold storage to keep the daily catch fish, and small motorized loads floor mill, grinder and so on. The rice mills and workshop driven 2hp engine power observe in power consuming of this area. Domestic load consists of mainly lighting and power for viewing television. The high household level consumer can be used domestic appliance such as lighting, TV, CD/DVD, electric pan, freezer and fan. Other public affairs can also use domestic applicants like high level consumer. But poor people of Wetkaik need only few lights and at best a television sets. Therefore, for total electricity demand of Wetkaik, village load data can be gathered for each different load pattern and then estimated by using Microsoft Word Excel. The total daily load demand is used about 1167kWh/day for lighting as well as for domestic appliance such as TV, CD/DVD player, electric pan, freezer and fan motor is also encountered as local facility of this village. The demand side management has to calculate the daily energy consumption in kWh for load consideration input data in HOMER model seen in Figure 4. The high use during the evening hours is about 380kW which reflects the high demand for Wetkaik village based on rural energy system. Almost the same energy consumption pattern is observed in monthly average variation load.

A present, absence of power had been hindering economic growth in this village. Under such a situation, availability of renewable energy is boon. To fulfill the expectation of people, the model plan can be investigated implementation of wind-diesel hybrid system for this village.

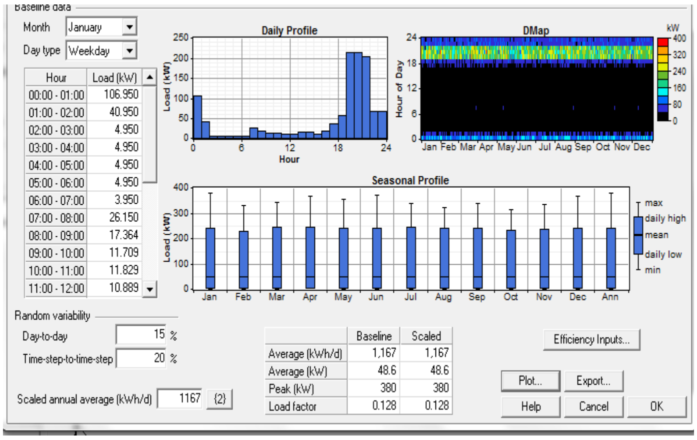


Figure 4. Load data input of Wetkaik village

Simulation Model of Wind-Diesel Hybrid System

This paper presents the results of village-level fieldwork carried out to fulfill electricity supply for rural people by building wind-diesel hybrid system as planning HOMER model. Diesel generators are used back-up power applications in this area when wind velocity is poor. The costs associated with the diesel generators are dominated by the costs of fuel delivery and the on-going maintenance. This contrasts with the wind turbines where cost are dominated by upfront capital investment, but have low maintenance requirements. Further, a diesel generator provides good reliability and when combined with wind, the renewable energy reduces fuel consumption and emissions from the diesel [7, 8].

Operation problems with wind-diesel systems can be overcome to a significant extent with inclusion of energy storage element. With diesel generation shut down and wind speed falling suddenly, battery can meet the power demand before the diesel generator is started again. Another advantage of battery backup lies in its ability to improve wind energy utilization. During low wind, the battery can meet the load demand, and when wind speed is sufficient, the excess wind energy can be used to recharge the battery, thereby saving diesel fuel. Likewise, during times of low wind and low demand, when the diesel unit is brought into service, the battery bank can provide an additional dump load to the diesel generator, enabling it to maintain a minimum generation [14].

To achieve reliability of supply, wind-diesel hybrid system is considered combination with rechargeable batteries for energy supply during peak load periods. Therefore, this project can be hopefully to provide electricity to more households, commercial establishments, and education and health centers. This move is expected to lead to social and economic development of this area, where electricity was a distant dream.

Software Input

The optimal system combination will lead to the optimal system design with the lowest levelized cost of energy. For this purpose, the HOMER software tool is preferred rather than other hybrid softwares such as Hybrid2, RETScreen, etc. This software application is used to design and evaluate technically and financially the options for off-grid and on-grid power systems for remote, stand-alone and distributed generation applications. HOMER can optimize the system configuration, and perform sensitivity analyses, and therefore, the designer can make the right decision when the supplying load is needed to optimize with minimization of energy cost. The input data including wind resource data, electricity usage of the Wetkaik village and the components of wind-diesel system are put in HOMER software tool built as a model plan shown in the following.

Primary Load

- 60 minutes time step
- 15% of day to day random variability
- 20% of time to time step random variability
- 1167 kWh/day of minimum daily load consumption-scaled annual average
- 0.128 Load factor

Wind Resources

- 3.7 m/s annual average wind speed [5,10,11]
- 60 minutes time step
- 10m of anemometer height
- 0.3m of surface roughness length to corrected variation wind speed with height from ground
- Weibull parameters of k = 2
- 0.85 factor for 1hr autocorrelation factor
- 0.25 (no unit) of diurnal pattern strength
- 15 hours of peak wind speed

Wind Turbine

- PGE 20/25, 25 kWAC rating, 20m of rotor diameter, Available tower 24/30/36m, 25m of hub height, 25 years of lifetimes
- Cost based on turbine current cost
- Range of turbine number to consider: 0, 8, 12

Diesel

- Cost based on dollars per 1kW
- 15000 life time operating hours
- 30% minimum load ratio
- 100 kW

Battery

- Trojan battery type with 6V, 225Ah, 1.35kWh
- Cost based on dollars per one battery
- 2 Batteries per string for 12 V of DC bus
- 100% of initial state of charge
- 5 years of minimum battery life
- Strings to considered: 1 to 500

Converters

- Cost based on dollars per 1kW rating
- Size to consider in kW: 0 to 400
- 15 yrs of life times
- 90% of inverter efficiency
- 100% of capacity relative to inverter
- 85% of rectifier efficiency

Diesel

- Prices range in $/L -1.4
- No fuel limit consumption

Economic

- 12% of annual real interest rate

System Control

- 60 minutes of simulation time step
- Cycle charging with 80% of setpoint state of charge
- Generator control to allow systems with multiple generators operated in simultaneously, and to allow systems with generator capacity less than peak load

Constraints

- 0% of maximum annual capacity shortage
- 40% of minimum renewable fraction
- 10% of load in current time step
- 50% of wind power output for operating reserve

Optimal Design Model

This section examines the economic and operational results from the optimization modeling of wind-diesel hybrid system in Wetkaik village using the Homer model as shown in Figure 5. Choosing system devices represents an important step in the optimal sizing of wind – diesel system. Small amount of wind turbine is much more possible than the higher rating of wind turbine selection in this wind condition. In addition, only diesel generator supply is expensive design comparing with wind-diesel hybrid system, and this hybrid system is more reliable than only diesel supply. Storage battery for energy supply is optimal design which can support not only wasting energy if the wind is strong but also using back up if the wind is weak for this area.

Costs of hybrid system include: components initial costs, components replacement costs, system maintenance costs, fuel and operation costs, and salvage costs or salvage revenues. Initial costs include purchasing the equipment required by the hybrid system: wind turbine, batteries, diesel generator, converter, management unit, cables, and other accessories used in the installation including labors according to current market. Operating and maintenance costs typically account for 20% to 25% of the total Levelised Cost Of Energy of current(LCOE) wind power systems (EWEA, 2009)[8].

In this study, applying the baseline assumptions for wind resources, the use of 8 wind turbines, one for PGE 20/25 wind turbine estimated $ 32500 for capital cost plus 15% for installation and 10-years maintenance, and market observed fuel prices, 100 kW diesel genset combined with battery storage for Wetkaik village at average wind speeds of 6 m/s and $ 1.4/L for diesel fuel. And 1167 kWh/day is used as total demand for primary load in the model based on rural energy studies.

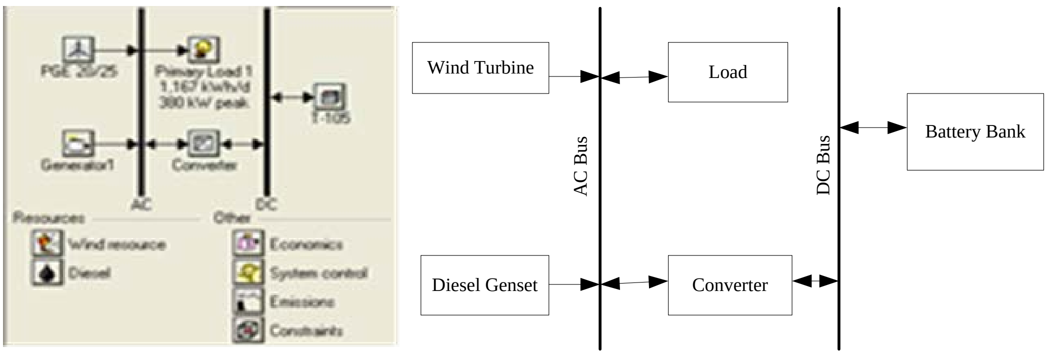


Figure 5. Wind-diesel hybrid system

Optimal Result Data

The optimal system design graphic shows the range within specified fuel prices and load varied for which various system types are most economical. After running the selection model, the results show that wind-diesel system becomes the most optimal configuration to meet the load requirement. According to the optimization results, wind penetration is 236%. Therefore, this system is high penetration wind-diesel system and 0.987 of renewable energy friction. When fuel consuming is 4,879L/yr, diesel generator can generate electricity about 3,593kWh/yr. And the electrical production of eight wind turbines (8×25) is 1,004,000kWh/yr at average wind speed 6m/s. According to this generation source wind-diesel hybrid system, total electrical production is about 1,017,595kWh/yr. On the other hand, total load consuming is about 425,956kWh/yr. Therefore, excess electricity would be about 49.9%. In fact, storage wind-diesel hybrid system can be performed in the model. In cost summary chart, the battery cost is highest investment in this system. However total net present cost is 1,494,031$, the cost of energy is about 0.274$/kWh and system is no capacity shortage. These simulation results data can be seen in Figure 6. Therefore, the storage wind-diesel hybrid system is optimal design to achieve the lowest cost of energy comparing with no storage system in final result of this study.

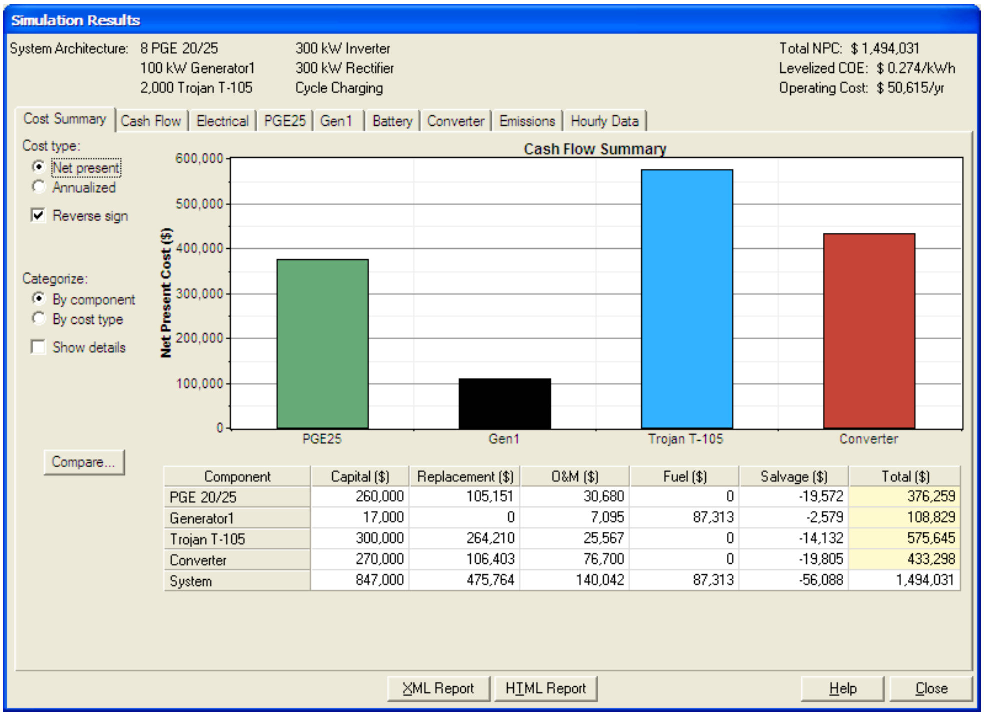


Figure 6. Simulation results of wind- diesel hybrid system for Wietkaik village

The power produced by the wind and diesel generator set over the course of the year is displayed in Figure 7. According to the weather condition, the best wind resource can get during the raining season, June, July and August, support to nearly wind only system resting the diesel generator to save fuel cost. This system generates 57.3% of its energy from renewable resources. The total yearly energy production from its component of wind sources are of 99%, and 1% from the diesel generator. Therefore, the aim in designing any wind-diesel hybrid system is to minimize the use of diesel, or in the other words, to maximize the wind power penetration. The recommended system provides 507,850 kWh/yr (i.e.49.9%) of excess energy with nearly zero percentage of unmet load and zero percentage of capacity shortage.

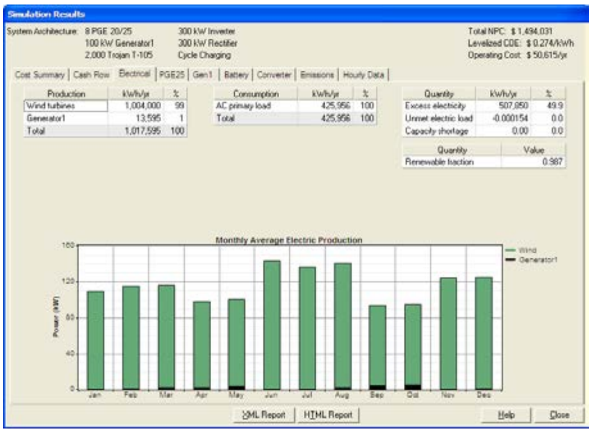


Figure 7. Power generation by source with 6m/s wind regime

By using the Homer software with appropriate considerations and actual data, the optimized design of wind-diesel hybrid System can be managed for villagers, Wetkaik village in rural areas of Myanmar in this study. Depending on the load demand, size and rating of the local wind-diesel hybrid system is reviewed for the supply side of the system while the cost of energy is minimizing. This study focuses on the lowest energy price for the village power priority. Especially, storage wind-diesel hybrid model can be arranged to the lowest cost of energy comparing with wind and diesel only as well as no storage system. The optimal design can perform the lowest levelized cost of energy is 0.274 $/kWh. The other advantage of a hybrid system is the fuel saving, the fuel usage is savings of more than 35% compared to diesel only systems. These savings reflect the renewable fraction that displaces the diesel in each case. Another beneficial of fuel saving is reduction of CO_2 emission, 12,847kg/yr. In fact, the model supports to migrate the air pollution so that environmental point of view. For the excess electricity, the battery storage system supports to the increasing the village loads during the near future. While the current energy usage of this village is estimated in this study, the generation forecasts for increasing load in coming 10 years.

In this study, HOMER model can be arranged optimal condition including cost benefit, system reliable and environmental effect. However, if this region is implemented to build wind power project as a realistic picture, other cost factors such as transmission and distribution cost, road access, etc. would be managed to be recovery at the lowest levelized cost because HOMER model is only intended to the selection of component for system configuration.

Recommendation on Result Data

In Myanmar, electricity prices currently stand at 75 kyat/kWh (US$.07) for industry and 35 kyat/kWh (US$.03) for consumers. For private diesel sector and other energy sources, the tariff is variation briefly from 100kyats/kWh to 300 kyats/ kWh disconnected to the national grid, the remote area [6]. In the proposed model of Wetkaik village, cost of energy, the tariff can be defined about 250kyats/kWh (US$ 0.274). In this system model, the priority is minimum cost for village power, rural electrification application. Otherwise, people in this village earn in around 3000kyat/day and above over. From these factors, the proposed system model of Wetkaik village is applied as a realistic picture, especially; the wind resource is free for electrification in this area.

The aim in designing wind diesel hybrid system is to be minimum the use of diesel. In this system, fuel savings on account of wind energy are million liters per year. In fact, CO2 emission can be reduced 12,847 kg/yr. Generally, diesel generator is only purposed both for backup system and storage battery. The other interesting result is that the diesel genset-only configuration is optimal at low combination load level only, which supports the claim that wind power is an economical part of the generation mix, even with lower wind speeds.

Consideration of storage type tends to not only protection to the waste of energy but also supporting excess electricity needed the electricity for others villages, nearly located villages, Ywathitkon (273 households with 1057 of local people), Kyahkat and Kanyashe (970 households with 3499 of local people), are not possible to connect to the national grid and also lack of electricity source. Therefore, the proposed system model can also provide electricity for these villages with battery storage system. Primary use of the generated power is for lighting, domestic use, schools, and power supply to small industries in these area.

Thus, the plant can contribute to improve the socio-economic conditions in this region. Otherwise, the proposed area, Wetkaik closely located at Letkokkon beach, can also provide extension sides of the wind power generation not only for growing electrical demand in coming years but also for supplying to the national grid and supporting to the Yangon load, 35% of the national grid.

For this area, village-level power plant along with their localized grids of low-voltage distribution network, based on wind-diesel hybrid technologies is used for meeting electricity needs of the people. The optimization model employed in this study allows for the selection of a hybrid system under uncertain conditions by using sensitivity analysis. Thus, robust conclusions can be drawn about the chosen system.

Conclusions

In Myanmar, most of the areas in the remote still do not have access to electricity. There is diesel-based grid systems set up by the private sector. There exists little or no reliable access to commutation systems, television, and health facilities, all of which require electricity. It is felt that application of renewable energy might be appropriate in the form of distributed electricity supply system to the rural area. The supply of adequate and reliable energy is quickly incorporated into everyday life. Rural areas that can be influenced are health, education, entertainment, income generation, social status, gender issues, migration, and the environment among others.

For this purpose, wind diesel hybrid system optimization model built in HOMER software tool is found out the expected outcomes, technical and economic, from different types of system architectures for the actual load demands in Wetkaik village. This paper evaluates the best wind resource site for wind power application in the remote area and the optimal model is supported to rural electrification. Therefore, view point of this project hopes to be supportive in programming the strategic plan for Myanmar.

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