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Analysis of Wind-Diesel Hybrid System by Homer Software

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ABSTRACT

A hybrid power system is to avoid the use of depleting fossil fuels, improve the technical performance and reduce the greenhouse gases emission. Depending on the renewable energy sources, it is connected in the main grid or operates separately. Because of these reasons, operation, control and grid integration of renewable sources is a task of fundamental importance in modern power system. Hybrid power system modes must be studied.

The simulation was carried out using various combinations of optimization and sensitivity variables developed in HOMER. The economic parameters play central role of deciding the dimension, feasibility and optimization of a proposed system. In order to achieve lowest Net Present Cost (NPC), comparison of diesel generating system and wind-diesel systems were compares for (i) economic (ii) technical and (iii) environmental parameters.

KEYWORDS: *hybrid system, Homer software, costs, reliability and DG applications.*

I. Introduction

A combination of one or more resources of renewable energy, called hybrid, will improve load factors and help saving on maintenance and replacement costs as the renewable can complement each other. High initial capital of the hybrid is a barrier to adopt the system thus the needs for long lasting, reliable and cost-effective system. Designing of a hybrid system requires correct components selection and sizing with appropriate operation strategy.

Initial optimization and component sizing methods are based on worst month scenario leads to non-optimal design with excess capacity.

Software, Hybrid Optimization Model for Electric Renewable (HOMER) is to find optimum sizing and minimizing cost for hybrid power system with specific load demand. The National Renewable Energy Laboratory (NREL) has developed Homer as a optimization model that consider hourly and seasonal variations in loads and resources, simple performance characterizations for each of components, equipment costs, reliability requirements, and other site specific information. HOMER can be used for evaluating the design options for both off-grid and grid-connected power systems for remote, isolated, and distributed generation (DG) applications. Applications of hybrid systems range from small power supplies for remote households providing electricity for lighting or water pumping and water supply to village electrification for remote communities. Mixed combinations of renewable energy technologies are applied in one location without the systems being necessarily interconnected in one electricity grid. This thesis is a study on integration of wind generators into an existing diesel reliable system at the Wetkaik village ($16°37'N, 96°24\,E$), Kungyankon Township, Yangon region.

II. DESIGN OF WIND TURBINE

A wind-diesel hybrid power system is supplemented by three wind turbines each of 25 kW totaling 75kW to reduce dependency on diesel generating sets and to reduce the air pollution and finally encouraging the usage of clean and green energy sources in propose site. The wind turbine is the PGE 20/25 model of Energies PGE which is a three blade and it has 25 kW AC rated power. The Figure 1 shows the wind turbine while beside are the technical characteristics of the model. The lifetime is taken 25 years and hub height is 25 m for the wind turbine considered.

Rated power output	= 25 kW
Rated Speed	= 9 m/s
Cut-in speed	= 3.5 m/s
High cut-out speed	= 25 m/s
Rotor Diameter	= 20 m
Hub height	= 25 m
Air Density	= 1.225 kg/m
Total Capital cost (US$)	= 32500
Replacement cost (US$	= 29500
Annual maintenance cost (US$)	= 850
Life time (yrs)	= 25

Choice of Diesel Engine;

Diesel generators combustion engines are mainly used for off-grid generation. Low installed capacity, high shaft efficiency, suitable for start-stop operation, and high exhaust heat are some of the advantages of combustion engines. These engines convert heat from the combustion into work via rotation of shaft. The shaft is directly coupled to the generator and electricity is produced. They run at a speed defined by the frequency of supply grid. In this modeling, 40 kW and 30 kW diesel engines are used along with the wind turbine.

The 40 kW diesel generators;

Engine	= 4BTA3.9-G2
Capacity	= 40kW/50KVA
Rated Voltage	= 400V
Frequency	= 50/60Hz
Output Types	= AC Three Phase
Total Capital cost (US$)	= 20,457
Replacement cost (US$)	= 17,457
Annual maintenance cost (US$)	= 1.5
Lifetime (hrs)	= 17520

The 30 kW diesel generator parameters;

Engine	=404D-22TAG
Capacity	=30 kW/35 kVA
Rated voltage	=400 V
Frequency	=50/60 Hz
Output types	=AC Three phase
Total capital cost (US$)	=15343
Replacement cost (US$)	=12343
Annual maintenance cost (US$)	=1.2
Lifetime (hrs)	=17520

Power converter parameters;

Frequency	= 50/60Hz
Size (kW)	= 1.000
Capital cost (US$)	= 900
Replacement cost (US$)	= 850
Annual maintenance cost (US$)	= 20
Lifetime (yrs)	= 15

III. OPTIMAL DESIGN MODEL

The main components of a micro grid connected wind-diesel hybrid system are diesel generators, wind turbine, battery, and converter to link AC and DC bus. Figure 1 a typical wind-diesel hybrid system used in HOMER software. Choosing system devices represents an important step in the optimal sizing of wind-diesel hybrid 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.

Cost 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 and other accessories used in the installation including labors according to current market.

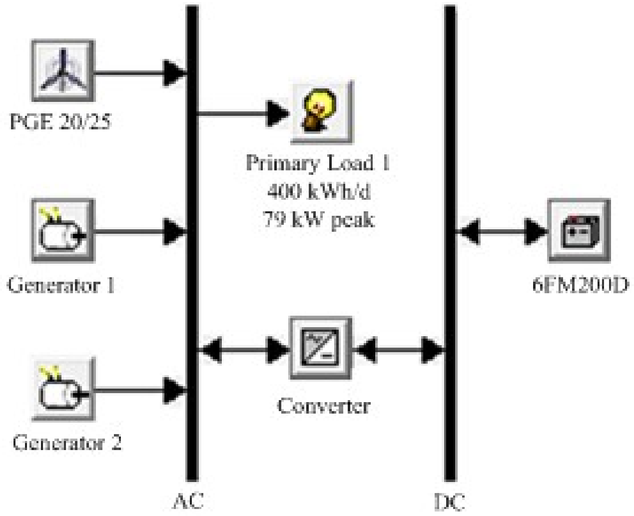

Figure2. Equipment of the Wind-Diesel Hybrid Energy System

IV. SIMULATION AND RESULTS

In Wetkaik village, there are about 550 households with 2000 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 and only one-third of the population in this region is higher income.

The propose site, Wetkaik, household lighting in this village is generated by three main sources; battery power 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 350 households with lower income, 170 households with medium household, 30 households with higher income and other public affairs such as (two monastery, one clinics, one public building, school, street light and two shops).

Therefore, the total daily load demand is used about 400 kWh/day for lighting as well as for domestic appliance such as TV, CD/DVD player, phone, fan, water pump, 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 2.

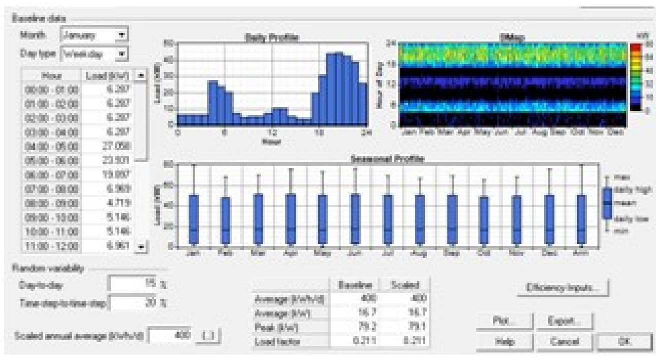

Figure 2. Load Data Input of Wetkaik Village

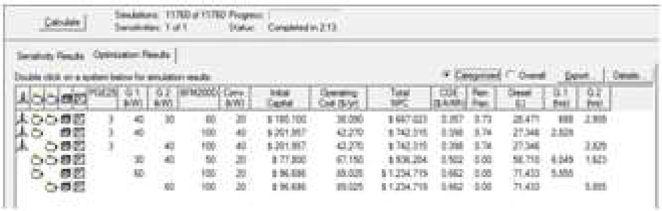

Figure3. Optimization Results with Sensitivity Variables

Simulation results obtained six different models. Model-I is three wind turbine, two generator, battery and converter, Model-II and III are three wind turbine, one generator, battery and converter, Model-IV is two generator, battery and converter, and Model-V and VI are only one generator, battery and converter.

Figure4. Monthly Contribution of Energy by Two Generators during the Year

The cost break down, including system capital, replacement, operation and maintenance, and fuel costs were 574,955 US$ and 246,746 US$ for two generators, 85,617 US$ for 50 batteries and 28,887 US$ for 20kW converter respectively. The fuel cost is dominant among all the components with minimum contribution of operation and maintenance part. The fuel cost was almost 7.7 times of the total system capital cost. This means any cut down in fuel consumption will have a great impact on the cost of generation and additionally will protect the environmental by reducing gases emissions.

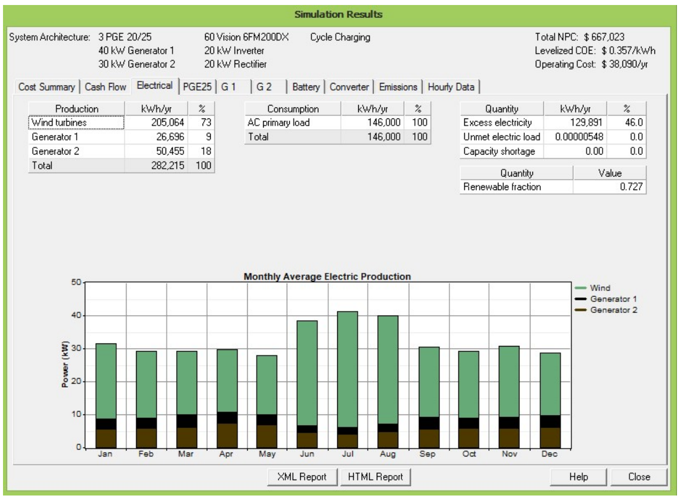

Figure5. Monthly Variation of Energy Yield from Wind and Diesel Generating

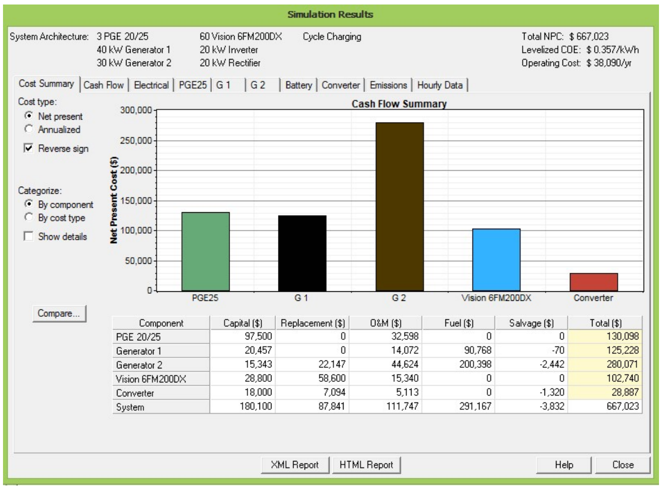

Figure6. Cost Break Down of Wind-Diesel Hybrid Power System

To check the effect of additional wind power capacity, a sensitivity analysis was performed with 3, 5, 8, and 10 wind turbines with total wind power installed capacity of 75, 125, 200 and 250 kW and keeping all the costs and the input parameters the same. The simulation results of different wind power penetration are summarized. With the above mentioned number of wind turbines the wind power penetration obtained was 73%, 84%, 89% and 91% corresponding to 3, 5, 8 and 10 wind turbines. The COE of the hybrid power system was found to be increasing with increasing wind power penetration. For 73% wind penetration the COE were 0.357 US$/kWh while for 8% and 10% wind penetration the COE were 0.419 US$/kWh and 0.452 US$/kWh.

V. DISCUSSION AND CONCLUSION

The simulation results work is a detailed simulation on the output system size, initial cost, net present cost, operational cost and cost of energy. In addition to the sizing process and economic analysis, a daily production on fossil fuel consumption and the generator operation hour over one year are included in the results. The simulation graph shows the results of the average monthly electricity production for the energy sources included in very configuration. Due to these findings, further work analysis is performed on the financial part of the project and more detailed information on power production, fuel savings and CO2 emission reduction is provided. The financial simulation result is based on the actual market component price, the purchase price per kWh for subscribers connected to the grid as well as to the diesel 48generator. The electricity from diesel generating system, at 0.502 US$/kWh and the wind-diesel hybrid system shows a cost of electricity (COE) of 0.357 US$/kWh compares to diesel generating system. The result of this project related to greenhouse gas (GHG) emission strengthens the argument of the plan to increase the share of renewable energy. This system hassignificantly reduced the pollutant gas production.

Future recommended work would be a further study on the rest of diesel generators to cover the whole village. In addition to this, it would be interesting to collect yearly load data from the household's electricity consumption for accurate profile load estimation. This information is very useful to implement similar projects across the country and decrease the diesel generator operation hours and size.

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