Analysis of SPV-Diesel Hybrid System for Remote Area Application

Arjyadhara Pradhan
Assistant Professor
KIIT UNIVERSITY

S.M Ali, Ph.D
Associate Professor
KIIT UNIVERSITY

Puspapriya Behera
Research fellow
KIIT UNIVERSITY

ABSTRACT

Energy is a crucial input in the economic, social and industrial development of the country. The growth of world population coupled with the improved standard of living has increased the energy consumption considerably by the turn of 21st century. These areas specifically hilly, forest and tribal area, islands, in remote due to their varied geographic and demographic locations and generally have low load potential, low load factor and inaccessibility of national grid thereby making them unable to connect to the grid due to the involvement of heavy capital investment and therefore are also not expected to have power in the long run. In order to energize such area the renewable energy sources have been found to be most reliable, economic, ecofriendly and quickly installable as compared to conventional energy sources. The renewable energy sources like solar, wind, biomass, tidal etc the main sources of renewable/green power which can be used to electrify such areas in most appropriate and economic way. Out of these sources, SPV is considered reliable, pollution free and convenient power generation system.

Keywords: Homer, SPV, vipor, OSEB

INTRODUCTION

Energy is a crucial input in the process of economic, social and industrial development and is the key to industrial development for the promotion of economic and social wellbeing of the world population. The growth of world population, coupled with the improved standard of living, has escalated the growth of energy usage since the turn of this century. The consumption of world's fossil fuel is a pulse action of a relatively short duration in long history of human existence. It took millions of years for the earth to fertilize and to store fossil fuels in convenient forms, but the present human population may take only 300 to 400 years to use them up completely. The rapid increase in energy usage during the past 50 to 100 years cannot continue indefinitely as the earths finite supply are likely to exhaust. The fossil fuels have powered the tremendous industrial and economic development of the developed countries. The oil crisis of 1973 served the warning that fossil fuels were neither inexhaustible nor any cheaper. This holds true for oil and natural gas too. The developing countries, like India, were the ones who were the most severely hit by this crisis and added to their problems for rapid industrial development. Energy has become an integral part of development of a society, as it is required for agriculture, drinking water supply, lighting, healthcare, tele-communication, and industrial activities and for all aspects of everyday life. Provision of lighting and cooking energy for rural and remote areas is still a major issue in many developing countries including India. The overall electricity consumption in India is quite low, as evident from the national average per capita electricity consumption of about 350 kWh per annum. There is also disparity in the electricity consumption in the urban and rural areas. Owing to about 80% of the population live in rural areas and consume only 30% electricity in India.

1. SPV Diesel Hybrid System

The main constraint to implement the SPV system is its high cost of energy as well as have limited potential and limit its use large such power generation. The limitations of SPV power can be improved by using different combinations either of among renewable energy sources i. e. integrated renewable energy energy system or such as system like SPV-Biomass, SPV-diesel & SPV-Wind-diesel or conventional energy e. g. diesel engine generator system known as hybrid. Among the above combinations, a hybrid system is selected depending upon their energy resources availability, demographic data and load/consumption pattern. The study area in Orissa state, the SPV-hybrid energy system has been promising prospects for power generation. All the rural households in remote area are without access to grid electricity and as per recent Rural Electrification Bills 2003, the Govt. of India has fixed a target of electrifying all such areas by renewable electricity by 2012. The present study has been carried out to design a SPV-Diesel hybrid system for providing sustained power to a typical remote area in Kendrapara district of Orissa state. On the basis of energy resources data & load pattern of the area, HOMER (version-2.09) computer software has been used to optimization the SPV-hybrid system and it was found that the system design will consist of 70 % of SPV & 30% of DG generation with peak power of 160 kW. Accordingly, the system has been designed & unit cost of energy be calculated including cost of energy of all SPV & all DG power. It was also found that the DG-set is not suitable to electrify the selected remote area in comparison to SPV stand-alone system even if the unit cost of energy of former is very less. Further, the T & D network has been optimized using software VIPOR (version-0.9.22). The software calculated the different options viz all isolated, all centralized & mixed T & D network. The most economic T & D network has been found to be all centralized system. Finally the unit cost of energy of all the times options of overall system have been calculated and compared. It can be inferred that though the cost of SPV- diesel system is still higher than diesel & all SPV, but in coming future, due to the availability of cheap semi conductor material improved SPV cell efficiency & govt. incentives will further bring down the cost of the system to the level, where villages can purchase & use the system as packaged system. Among all renewable energy hybrid sources, SPV-diesel hybrid system is the most reliable and ecofriendly power generating system. The selected area at Orissa is electrified by this hybrid system, where the solar resources are basic source of power generation and it is combined with conventional DG set to supply regular power to the remote area. Based upon the existing energy sources, the daily hourly load is calculated and power plant shall be

designed depending upon the peak hourly demand and peak load of the study area. The unit energy cost is calculated based upon SPV stand-alone system and also DG system. The SPV unit energy cost is costlier than diesel generating system but due to non-availability of fuel and major pollution problem, the diesel generator system is not suitable in the remote area. Due to some constraints, the SPV-diesel hybrid system is selected to generate power at that remote area. Also the optimizations of both sources are made by HOMER computer software and the T & D network optimized by VIPOR computer software. Finally the proper mixing of SPV-diesel will be done by on least cost basis, the unit energy cost is comparatively less in comparison to SPV stand-alone systems.

2. SPV Based Power System

The photovoltaic (PV) process converts sunlight directly into electricity. The equipment required for this process has no moving parts and as a result requires minimum maintenance. In addition, the electricity is generated with no emissions and no noise. The basic power-generating element is a photovoltaic module. Modules are made out of photovoltaic cells. A photovoltaic cell consists of semi conducting material, most commonly silicon. When the cell is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (d.c.). The electrical output from a single cell is around 0, 6 V d.c., therefore multiple cells are connected together to provide a more useful output. Photovoltaic cells connected in this way are encapsulated to form a weatherproof photovoltaic module. Multiple photovoltaic modules can be connected together, called a photovoltaic array, in order to provide sufficient power.

3. Rural Electrification in India

In India, about 55% households have access to electricity. Most of those who have access do not get uninterrupted reliable supply. Govt. of India is according top priority to electrify the remote rural area through renewable power.

Orissa state is situated on the Northeast in the geographical map of India. Bhubaneswar is its capital. Its geographical area is 1, 55,707 sq. km. and population is 36,706,920, with literacy rate of 63.61%, about 87% of Orissa's population live in villages. The state is surrounded by West Bengal on the Northeast, Jharkhand on the North, Chhattisgarh on the west and Andhra Pradesh on the south while the Bay of Bengal washes its shores on the east. Its total number of villages is 50,887, out of which 37,307 villages are electrified while 13,580 villages are unelectrified. Out of unelectrified villages, there are many villages in the state, where the normal grid supply is not available. The selected area of the state is more than 20 kms far away from grid supply, to which the grid supply is not economical and also T & D losses are maximum. Its climate is tropical, which is influenced by the Southwest monsoon and is characterized by high temperature from March to May and high rainfall from June to September. The state also receives a small quantity of rain from the retreating monsoon in the months of October-November when occasional cyclonic storms are experienced. The annual average rainfall is 1482 mm, out of which 76% is received from June to September. The maximum temperature in May is about 40^0 - 45^0 C. The low temperature in coastal district is usually between 12^0-14^0C .The district Kendrapara is situated at the northeast coastal region of Orissa (Bay of Bengal) and is surrounded by Bhadrak, Jajpur, and Cuttack and Jagatsinghpur districts. Its geographical area is about 2,548.0 sq. km, and one Sub-division, is sub-divided in like Tehasils-7, Blocks-9, Towns-2, Gram Panchayats-205, Villages-1, 532, Population-13, 01,856. The literacy rate is 77.33% followed by forest 248.05 km^2, Rainfall-1463.6mm (average). The main occupations of peoples are agriculture and fishing.The block selected, as study area is Rajnagar consists of 18-gram panchayats, 307 villages, Population of 1, 02,520, 273 villages are electrified and 34 villages unelectrified and is situated near river Brahmani. The main occupation of the peoples is agriculture and fishing. The villages of the study area belonging to Rangani Panchayat are located on eastern part of Kendrapara district on south side of river "Brahmani" and western side of Bay of Bengal. The distance of the village from Block and District headquarter is 51 and 91 kms respectively. Educational facility up to class 10th is available in the study village. College education up to graduation is available at Rajnagar. While the health center is located at the adjacent panchayat Talcahuano.

Figure 3.1 shows district map of odisha with demographic details.

3.1Demographic data

The demographic data were collected from village people, panchayat office, Revenue Inspector (RI) office, local market, tehsil office, block office, OSEB (Orissa State Electricity Board), Orissa Renewable Energy Development Agency (OREDA), and other local agencies. The data on population, number of families, number of domestic animals, local market, number of offices and schools, sources of drinking water, cultivation, occupation, level of richness, land area, available energy sources used for cooking and lighting, communication etc, load/consumption etc of the area.

4.Estimation of Load Pattern

Total average load 690 kWh per day for 6 hrs per day uses. As stated elsewhere, total population of the study area is 5935 constituting 1187 families including children and adults using different mode of energy consumption. The appliances like lights, fans, TV, and pumps are therefore arranged in hours of consumption of the families on of 24 hours per day. The

standard ratings of devices have been used for computing load pattern. This hourly load pattern, the maximum consumption in the families is between 18-20 hrs of the day. In this situation, all the appliances can be operated based upon the maximum load at the power station. This is one of the most critical parameter for operating the power plant very smoothly without any power failure.

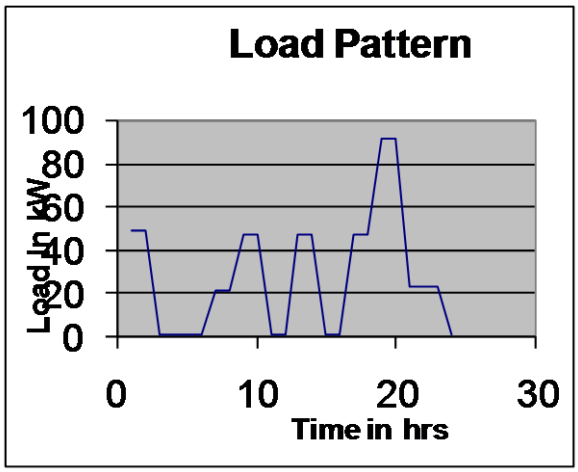

Figure 4.1 shows the load pattern

The fig. 4.1 indicates that, the peak demand of 92 kW is in between 18-19 and 19-20 hours of the day. This indicates that there is during 18-20 hrs i. e. evening time and hence maximum peak load on the plant. This will be the basis for further designing the proposed SPV-Diesel hybrid power plant for meeting the energy demand of the study area in effective manner.

5. Results and Discussions

Based upon the optimization, the breakdown of the costs and revenues associated with the optimal solution of all the systems have been evaluated for the study area using VIPOR .VIPOR displays a breakdown of the costs and revenues associated with the optimal solution. The above figure shows the distribution cost details i. e. Net Present cost of Rs. 12.04 lacs, Initial capital cost is Rs. 8.03 lacs, and annual O & M cost Rs. 0.16 lacs of all centralized T & D system.. The net profit is Rs. 12.04 lacs. As VIPOR searches for the optimal system, it remembers not only the overall optimum, but also the optimum at each different value of grid load (the total load on the centralized grid). In other output, the total centralized load points are 19 and isolated load points are zero. It also shows the total length of M V line (red line) of 6077 m and number of bus bar as 19, which is equal to total number of load points. Similarly the explanation of all isolated and mixed T & D system can be done by following the fig-5.21, where the distribution cost are different from the all centralized distribution systems. The above results are reported in the table-5.3, showing the costs of all type of T & D network .

6. Conclusion

The selected area is located at the North-East of geographical map of India. The study area includes nine villages of population 5935, families 1187, lands 3100 acres and covering 8 km^2 areas. Where 60% peoples are depending upon cultivation and others are fishing, trading and commercial works. Existing energy sources are wood, cattle dung and crop residue. The resources available with the study area are solar, biomass (gasifier & biogas), wind and tidal. More than 60% peoples are below level of richness, hence the minimum energy requirement of that area is lightning, and hence only domestic loads are taken into account to that area. The daily total load pattern is 800 kWh/day (including 15% losses) under the assumption of average 6 hrs usages by each family of each appliance of the study area. Peak load at any moment is 93.60 kW and hourly peak load is 92 kW in between 18-20 hrs of season and any emergency demand by the people of that area, the peak load situation will come on overall plant, this adjustment will made by generating unit accordingly.

The dissertation topic is based on SPV-diesel hybrid system based power generation. In the chapter-3 & 4, the unit energy cost of only SPV stand-alone power generation system and DG set is calculated, its values are Rs. 20.00 (including T & D) for SPV and Rs. 11.00 for generator set. But due to some constraints like more unit cost, pollution problem and not reliably throughout the year, both the isolated system are not preferred in the selected study area. Hence the SPV-diesel hybrid system is selected for power generation in this area. Also the various mixing of SPV and diesel generator done in this chapter. Since manually it is a tedious work to mix in different type of optimization results, hence the computer software like HOMER (version 2.09) for power generation and VIPOR (version 0.9.22) for T & D systems applied to this hybrid system to optimize on least cost basis. By applying this optimization procedure, finally the unit energy cost is Rs. 30.00 and including T & D cost, its value is Rs. 38.84 per kWh.

In this Dissertation, the study area is selected at eastern costal region of Orissa due to its topography and non-availability of regular grid supply. Based upon survey demographic data, the existing energy consumption pattern, energy resources and its potential and load pattern made for the study area. The unit energy cost of SPV stand-alone and DG set power generation system is calculated. Since there are many constraints to implement this system in the selected study area. Hence the SPV-diesel hybrid power generation system is selected for this area. Besides this, the optimization analysis on least cost basis of the same system done by HOMER (version 2.09) and analysis of T and D systems by VIPOR (version 0.9.22) computer model. The optimization will be done on the basis of mixing SPV and diesel generator power generating systems.

Based upon the above study the following conclusions can be drawn:

a) SPV-Diesel Hybrid system is more reliable and economical in comparison to all SPV stand-alone system.

b) The optimization system may be able to supply the reliable power continuously depending upon the load pattern and hence will help to improve the living standard of the people of the area.

c) In the design of such a hybrid system, the lower size inverter and battery may reduce the installation cost of the system.

d) The continuous supply of power through SPV-Diesel will improve the living standard and enthused to do extra work during nighttime.

e) The unit generation cost of hybrid system is less compared to SPV stand-alone and DG set generation system.

f) It will create relatively less air and noise pollution and hence provide cleaner atmosphere.

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