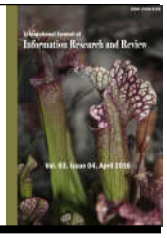
IJIRR

International Journal of Information Research and Review
Vol. 03, Issue, 04, pp. 2192-2197, April, 2016



Review Article

DESIGNING AND STUDY STANDALONE HYBRID ENERGY SYSTEM: FOR TECHNICAL INSTITUTES

***Rakesh sahu, Digbijoy mohanty, Tanushree maharana and Nishant pareek**

Department of Electrical and Electronics Engineering, Gandhi Institute of Engineering and Technology, Gunupur

ARTICLE INFO

Article History:

Received 16th, January 2016
Received in revised form
14th, February 2016
Accepted 29th, March 2016
Published online 27, April 2016

Keywords:

Hybrid Energy Systems,
Technical College,
PV-Solar,
Wind Turbine,
Optimization,
DG Set.

ABSTRACT

Hybrid energy source is becoming popular because it is composed of two or more energy sources. This combination of two energy sources is an efficient way of generating energy. Hybrid energy systems are used in remote Hybrid renewable areas for power generation. This project gives the design idea of a very efficient Hybrid Energy System in which solar energy with a conventional diesel generator operate together for producing sufficient power for a technical college (GIET, Gunupur). For this hybrid system, the required data of Solar energy, wind speed, are taken for Gunupur (the lap of the Eastern Ghat, India). It is located at 83˚13'E 19˚60'N. The pattern of load consumption of Gandhi institute of Engineering and Technology, Gunupur College are studied and properly modelled for optimization of the hybrid energy system using HOMER PRO software. This project gives the detail hypothetical study for standalone hybrid energy system for technical institute in five stages: 1) Recent electric bill of the college for the year 2015; 2) Studying the load demand for every month in a year; 3) Calculating the highest, lowest and the average load demand; 4) Introducing the solar data in HOMER PRO software; e) Designing the hybrid energy model. This system is very cost effective and more environmental friendly over the conventional diesel generator. It should reduced approximate 75% - 85% fuel cost over conventional diesel generator and also creates no pollution. The action plan is designed on the basis of cost effective modeling that is minimization of energy production cost in a long run.

INTRODUCTION

Energy is indispensable for sustaining life on earth. The most important energy is Electrical energy. It has also become a part of modern life and a world without it can't be imagined. So the demand of electrical energy has been increasing. The energy problem is thus synonymous to ecological and economical problems. The convention energy resources are exhaustible and limited in supply (Ashok, 2007). Therefore, generation of electricity by using conventional energy source is not sufficient to suffice the growing demand an alternative energy resources is required like solar energy , wind energy , hydro energy , biomass energy, etc. The hybrid energy system (HES) (Katti and Khedkar, 2007), has sought much attention over the past decades. It is a best alternative solution (Khan and Iqbal, 2004) as compared to system which relies entirely on hydrocarbon fuel.

Present energy scenario: India had total electrical installed capacity of 288 GW as of 31 January 2016. In which Renewable energy Power plants contributed 28% of total installed capacity and Non-Renewable Power Plants contributed the remaining 72%. The total electricity produced by utilities is 1,106 TWh (1,106,000 GWh) and 166 TWh by captive power plants during the 2014–15 fiscal. The net electricity generation includes auxiliary power consumption of power generation plants. India has conquered the third position as largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia.

****Corresponding author: Rakesh sahu,***
Department of Electrical and Electronics Engineering, Gandhi Institute of Engineering and Technology, Gunupur.

Hybrid Energy Systems

Hybrid energy systems consists of two or more energy conversion devices, or two or more fuels for the same device, that when connected to overcome limitation of each other. A hybrid energy system (Celik, 2002) is consists of two or more energy resources with fossil fuel powered genera-tor to give electricity where the electric energy (Yang and Burnett, 2003) is either directly fed to (Shaahid andElhadidy, 2003) grid or to energy storage i.e. battery. The main reason of integrating renewable energy sources into a hybrid system is mainly to save fossil fuel & to reduce the pollution due to emission. For that reason a diesel generator is mainly used as a backup. Hybrid energy system can be designed in three different ways: grid connected off-grid with distribution system and for direct

supply. The first design model is able to rely on grid if the hybrid system has faced any problems. Supplying the power to the grid, so that, boosting the voltage and minimizing power cuts strengthens the grid. For off-grid design, the hybrid model can either be connected to many load centers or can act as a resource of supply for one or two loads, thus by avoiding the need of a distribution system. An isolated off-grid system is designed usually to charge storage devices or give powers to small rural industry/households. National Renewable Energy Laboratory (NREL)'s, Hybrid Optimization Model for Electric Renewable (HOMER pro 3.5.3) has been used as the designing and optimization software tool (https://analysis.nrel.gov/homer/). It contains a number of components for energy models and evaluates efficient techniques options based on cost and availability of resources. In this paper the system sizing (Elhadidy and Shaahid, 2004; Nema *et al.,* 2007) is carried out using HOMER PRO-optimization and simulation software tool. The hybrid system for technical college are implemented in HOMER PRO. Analysis with HOMER PRO requires information on resources, economic constraints, and control methods. It also requires inputs on component types, their numbers, costs, efficiency, longevity, etc. Sensitivity analysis and optimization could be done with variables having a range of values instead of a specific number.

Renewable Energy Resources for Hybrid System

The amount of renewable energy resources available at a technical collage site is an important factor to develop the hybrid system. In many parts of India a huge amount of wind and solar energy is available. These energy sources are naturally and intermittent available, due to these factor we first choose solar and wind as renewable energy sources to power the technical institute. Weather data are very important factor for pre-feasibility (http://eosweb.larc.nasa.gov/sse/; http://www.kirloskar-electric.com/gens.shtml.) study of renewable hybrid energy system for any particular site. Here the solar and wind energy resources data are taken from NASA (http://eosweb.larc.nasa.gov/sse/) for Gunupur-Eastern Ghats India(83˚13'E 19˚60'N). In Eastern Ghats India wind speed is an average and sun brightness is strong.

Solar Energy Resource

Data to consider the long-term average annual resource (5.12 kWh/m^2/d). The clearness index for the latitude and Average daily radiation in a year is shown. The solar power in summer is more than winter season. In rainy season clearness index and solar power availability is lesser than summer and winter season.

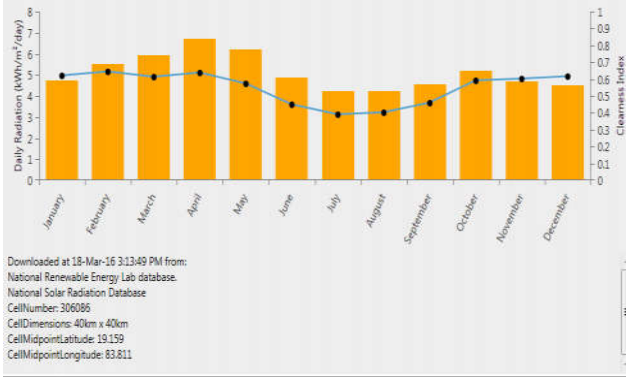


Fig. 1. Solar resource details

Month	Clearness Index	Daily Radiation (kWh/m²/day)
January	0.619	4.720
February	0.643	5.532
March	0.611	5.954
April	0.636	6.714
May	0.571	6.217
June	0.447	4.888
July	0.389	4.218
August	0.400	4.237
September	0.457	4.536
October	0.589	5.216
November	0.600	4.677
December	0.614	4.483

Annual Average (kWh/m²/day): 5.12

Fig 2. Solar date

Wind Energy Resource

For Gunupur area the wind data are taken, as it is present in the Eastern Ghats India so wind speed is an average. By using wind turbines which are generally mounted on a tower to capture more energy from wind. There are propeller like blades in the turbine which extract energy from wind.

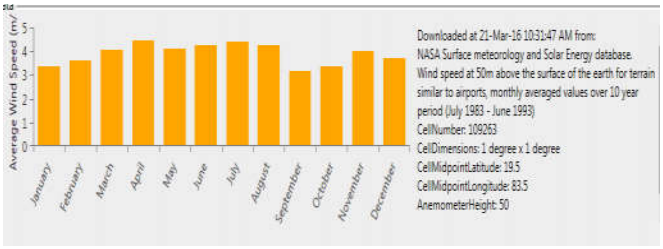


Fig 3. Wind resourse details

Month	Average (m/s)
January	3.390
February	3.630
March	4.080
April	4.460
May	4.100
June	4.240
July	4.390
August	4.280
September	3.160
October	3.380
November	4.010
December	3.730

Annual Average (m/s): 3.90

Fig 4. Wind data

Load Pattern for Technical Institute

The load demand is approximate 127 kwh/d and 53.38 kW peak.

Hybrid Energy System Components

The designed hybrid system consists of the following:

Photovoltaic System

The photovoltaic system is used to convert solar energy into electrical energy. Here we use generic flat plate pv.

Fig. 5. Load detail

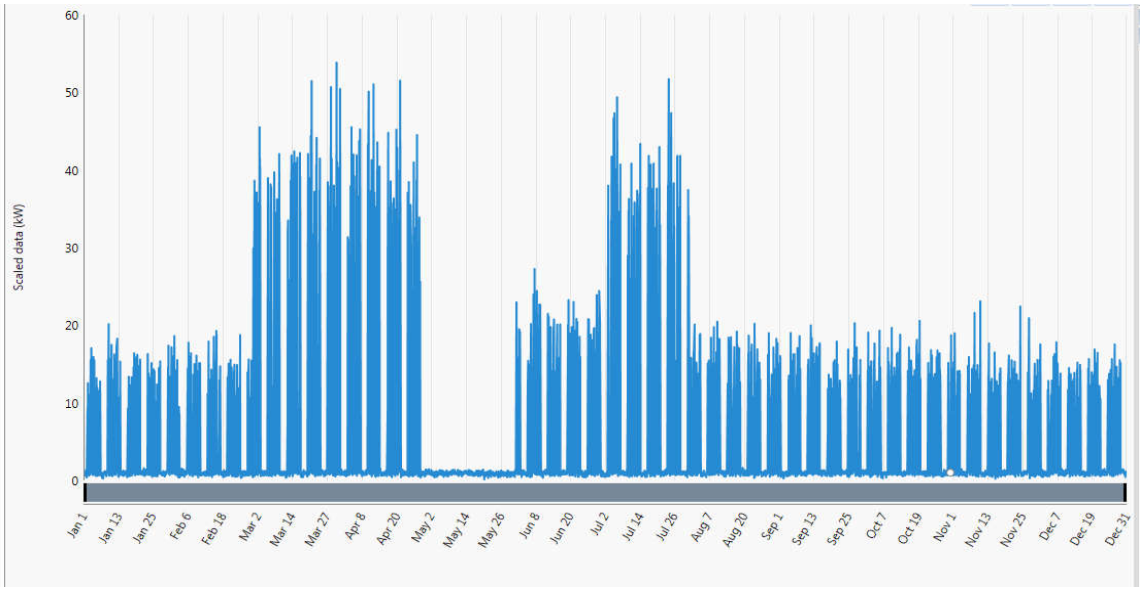


Fig. 6. Hourly load details

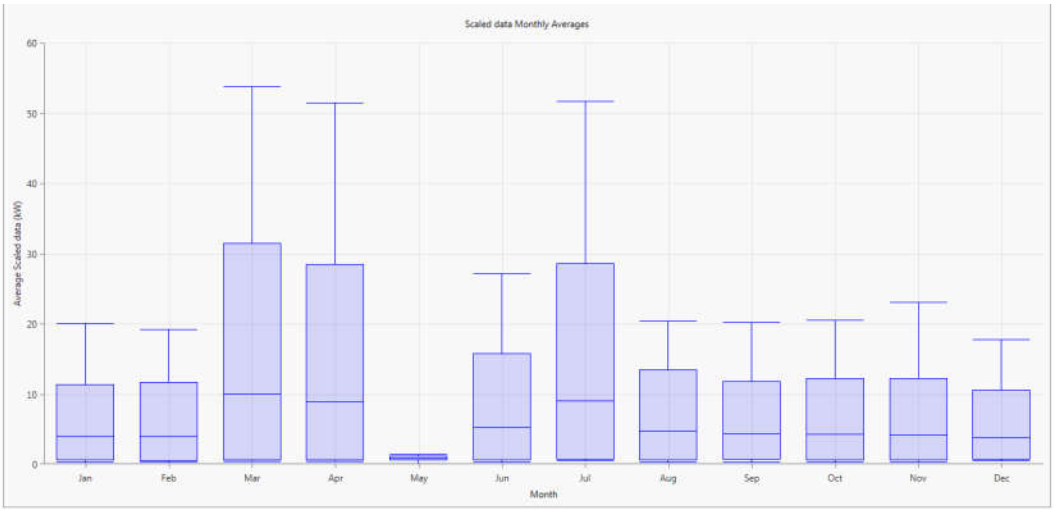


Fig.7. Monthly load detail

This pv system have silicon solar cells on the top surface. A 90 kW solar panel installation and replacement cost are taken approximate as Rs. 47, 57,480 and Rs. 48, 30,672 respectively the lifetime of the PV arrays are taken as 25 years.

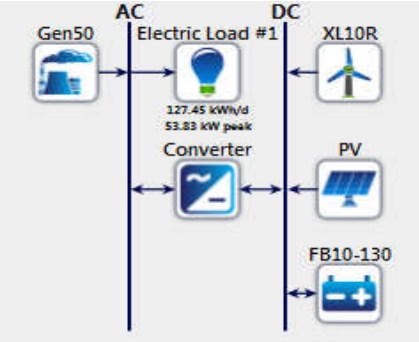


Fig. 8. Schematic diagram of project

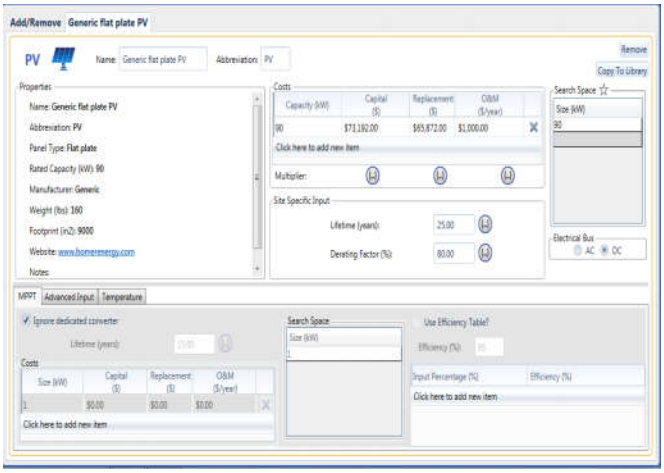


Fig. 10. Prpperties of pv cell

Wind turbine system

The Wind turbine system is used to convert wind energy into electrical energy. Here we use bergey XL 10R.This turbine has 7 nm diameter with HWT for 48VDC battery charging and typically production of 35-70 kwh per day. A 10 kw wind turbine is installed and replacement cost are taken approximate as Rs. 2925000 and Rs. 2892500 respectively. The lifetime of the PV arrays are taken as 25 years.

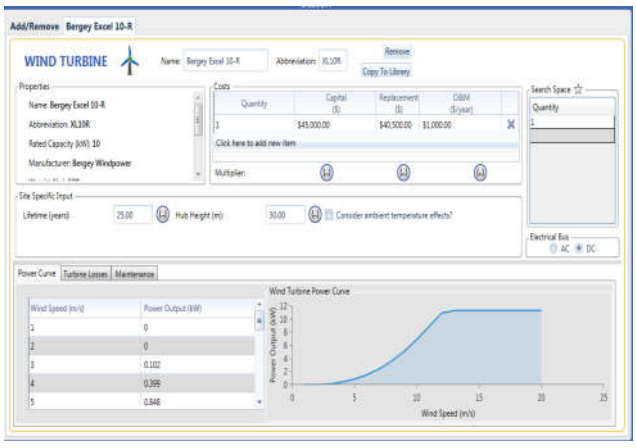


Fig. 11.Wind turbine properties

Diesel Generator Set (DG Set)

We have used one 50 kW DG set.which will be used as a backup to our hybrid system. , considered to be Rs. 700,000 and the operating and the maintenance cost are found to be Rs. 180/hr. The Diesel price is used for sensitivity analysis and three discrete values (Rupees 46, 47, and 48 per litre) were introduced. At present, diesel price is around Rs. 46/lt and for a very remote location this could increase up to Rs. 48/lt.

Battery

A battery bank is always used as a backup system and to maintain constant voltage across the load. For battery we are using CELLCUBE FB 10-130 (http://eosweb.larc.nasa.gov/sse/; www.rollsbattery.com). This battery is a 10kw-130kwh vanadium redox flow battery. As in AC bus system its round trip efficiency represents an AC-DC-AC conversion. The battery should be large enough to store sufficient energy to operate the loads at night and cloudy days. The nominal voltage of one battery is 48 V with nominal capacity if 2708 Ah and lifetime throughput 130 kWh. Cost of one battery is Rs. 48,840 with a replacement cost of Rs. 43,956.

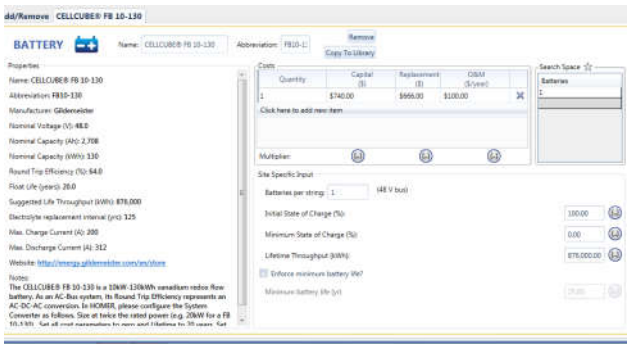


Fig. 12. Properties of battery

Converter

A power electronic converter is generally used to convert AC to DC. For a 100kW system the installation and replacement costs are taken as Rs. 19,800 and Rs. 17,820, respectively. Lifetime of a unit is considered to be 15 years with an efficiency of 85%. Consider for this hybrid system 100 kW converter.

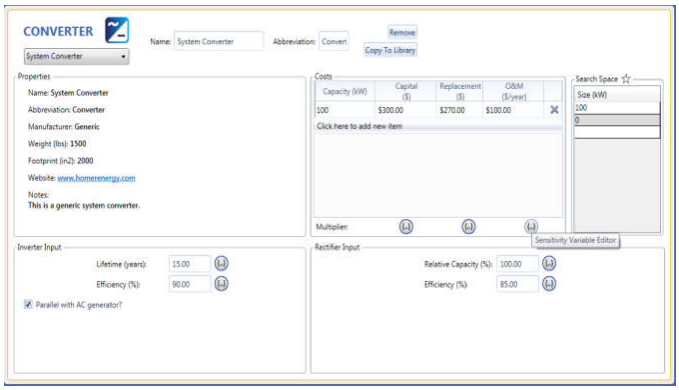


Fig. 13. Properties of converter

RESULTS AND DISCUSSIONS

The above proposed hybrid energy system supplies the power to the Technical Institute continuously throughout the year.

Fig.14. Optimization result

Fig.15. Simulation result

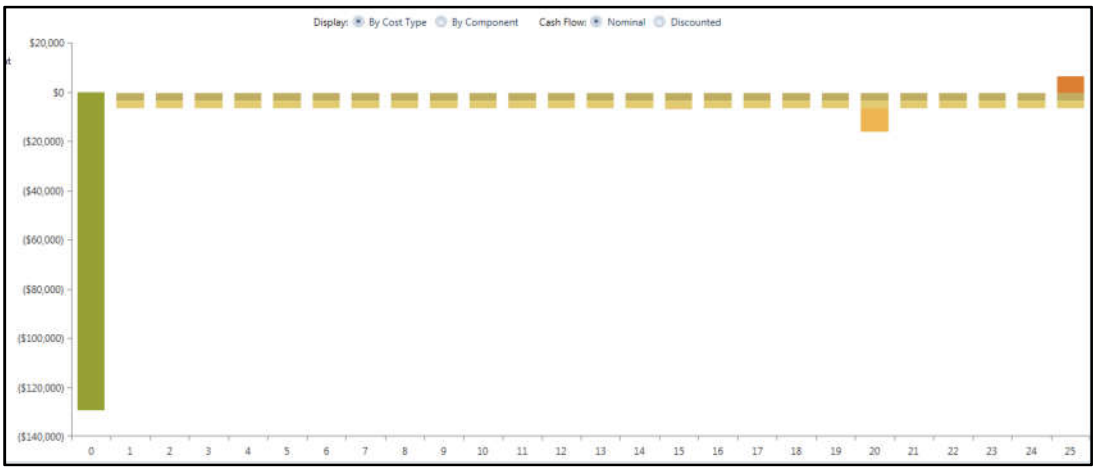


Fig.15. Cash flow result

Fig.16. Monthly average electric production

For the analysis of this hybrid system we have considered four variables (wind speed, solar irradiation, fuel cost and Battery cost). For each of the four sensitivity values simulate all the systems in their respective. An hourly time series simulation for every possible system type and configuration is done for a 1-year period.

An optimal system is defined as a solution for hybrid system configuration that is capable of meeting the load demand of the technical institute.

Optimization Result

From the optimization results the best optimal combination of

energy system components are 90 kW PV-Array and 10kw wind turbine and one 50 kW diesel Generator. Total net present cost (NPC), Initial Capital cost and cost of energy (COE) for such a system is Rs. 1,37,92,480 Rs. 84,00,080 and Rs.22,398/kWh, respectively for one year.

Simulation Result

The simulation result eliminates all infeasible combinations and ranks the feasible systems according to increasing net present cost. It also allows a number of parameters to be displayed against the sensitivity variables for identifying an optimal system type. In this system the total production of electrical energy is fulfilled by PV array, wind turbine and the DG sets. 90% is covered by PV, 7% by DG and the remaining 3% by wind turbine.

Conclusion

According to the load data of "Gandhi Institute of Engineering and technology" the yearly tariff including the output and maintenance cost of a DG set is around Rs. 6,61,310. On the hand the output and maintenance cost of in the new hybrid energy system is Rs. 25,09,910. The initial capital needed for this kind of hybrid energy system is very high so it can be considered as the only disadvantage but only in the beginning. In the long run this hybrid energy system will be more profitable and as well as environment friendly solution. What we have seen so far here in this design, we can conclude that this technology is the need of the future. Solar powered based sites benefit the environment as well as the business persons, whether they are located in highly populated or remote areas. Due to use of renewable energy source this hybrid system emits very less amount of polutated gases into air hence our environment is non polluting and our future generation will get a pollution free environment. This kind of technology is a step towards continuous development. Though it has high cost of installation but in a long run it is more profitable because it has a less operating and maintenance cost. It can be fitted to the needs of end use market. It is employed to enhance the economic development and standards of living of remote area. This can be upgraded to the need if required in the future. Hence this is an essential step to avoid energy crisis in the near future.

Acknowledgements

The authors acknowledge gratefully the director of GANDHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, GUNUPUR for providing the load data used in this study.

REFERENCES

Ashok, S. "Optimized Model for Community-Based Hy-brid Energy Systems," *Renewable Energy*, Vol. 32, No. 7, 2007, pp. 1155-1164. doi:10.1016/j.renene.2006.04.008

Celik, A. N. "The System Performance of Autonomous Photovoltaic-Wind Hybrid Energy Systems Using Syn-thetically Generated Weather Data," *Renewable Energy*, Vol. 27, No. 1, 2002, pp. 107-121. c

Elhadidy, M. A. and S. M. Shaahid, "Role of Hybrid (Wind + Diesel) Power Systems in Meeting Commercial Loads," *Renewable Energy*, Vol. 29, No. 12, 2004, pp. 109-118. doi:10.1016/S0960-1481(03)00067-3

http://eosweb.larc.nasa.gov/sse/

http://www.kirloskar-electric.com/gens.shtml.

https://analysis.nrel.gov/homer/

Katti, K. and M. K. Khedkar, "Alternative Energy Facili-ties Based on Site Matching and Generation Unit Sizing for Remote Area Power Supply," *Renewable Energy*, Vol. 32, No. 8, 2007, pp. 1346-1362. doi:10.1016/j.renene.2006.06.001

Khan, M. J. and M. T. Iqbal, "Pre-Feasibility Study of Stand-Alone Hybrid Energy Systems for Applications in Newfoundland," *Renewable Energy*, Vol. 30, No. 6, 2004, pp. 835-854. doi:10.1016/j.renene.2004.09.001

Nema, P., R. K. Nema and S. Rangnekar, "Integrated De-sign Approach for Stand Alone PV-Solar and Wind Hy-brid Energy System: For Rural Electrifications," *Interna-tional Conference on Advance Energy Systems (ICAER-2007),* IIT Bombay, 12-14 December 2007, pp. 354-359.

Nema, P., R. K. Nema and S. Rangnekar, "Sizing and Methodology of PV-Solar/Wind Hybrid Energy Sys-tems," National Conference of Power Electronics & Intel-ligent Control, Malaviya *National Institute of Technology Jaipur* (Rajasthan), 17-18 March 2007, pp. 291-294.

Shaahid, S. M. and M. A. Elhadidy, "Opportunities for Utilization of Stand-Alone Hybrid (Photovoltaic + Diesel + Battery) Power Systems in Hot Climates," *Renewable Energy*, Vol. 28, No. 11, 2003, pp. 1741-1753. doi:10.1016/S0960-1481(03)00013-2

www.rollsbattery.com

Yang, H. X., L. Lu and J. Burnett, "Weather Data and Probability Analysis of Hybrid Photovoltaic-Wind Power Generation Systems in Hong Kong," *Renewable Energy*, Vol. 28, No. 11, 2003, pp. 1813-1824. doi:10.1016/S0960-1481(03)00015-6

****