Cost Effective Analysis of Hybrid Energy System with Pumped Hydro Storage using HOMER Pro

Himanshi Koli, M.P.S. Chawla

Abstract*— As India is a developing country which demands in more power requirement for the population. The conventional resources are also not making the requirement upto the needs of the customers. This brings our attention towards the non-conventional resources which includes renewable energy resources i.e., natural resources like sun, wind, ocean, geothermal, tidal etc. are some of the resources. Using this resources with the help of latest technologies we are equalizing the mismatch between the power generation and power demand. As far as the conventional power generation our country is performing great in the non- conventional means also, which results in the cost reduction of energy, carbon emission from the environment which will help a lot in the reduction of global warming. This paper presents the hybrid renewable energy system which consist of solar PV and wind energy system as generation unit and for the change of same traditional storage system here we are working with the pumped hydro storage system. All the system is being analyzed on the software for hybrid system known as Hybrid Optimization Model for Electrical Renewable (HOMER Pro).

Keywords*— Renewable energy system, Solar Photovoltaic (PV)energy system, Wind energy system, Pumped Hydro Storage(PHS) System, Energy storage system, HOMER Pro.

I. INTRODUCTION

Human life is totally dependent on the usage of electricity. The development of nation and the individual growth depends on the energy. Thus the availability and accessibility is the main concern for the nation. Since use of electricity is the integral part of our modern lifestyle which means on the other hand its supply should be secure and sustainable at the same time it should be economical and eco-friendly to all[1]. The conventional resources are costing very high to the pockets as well as to the environment which draws our concern towards the non-conventional resources which are omnipresent, free of cost, apart from the conventional resources have longer life time. Thus the importance of renewable energy resources is of great importance for the future power generation and supply[2].One of the peculiar nature of the non-conventional energy system is that the amount of energy generates varies through-out the day which adds the requirement of the energy storage devices to the system. Though the non-conventional energy power generation has recently grabbed attention world widely. As the renewable energies are great sources for future in turns of absence of conventional resources. Energy storage devices also plays an important role in the energy generation. Various storage devices are present as per the requirement[3].

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This paper deals with the hybrid renewable system which includes Solar PV Power System, Wind Energy System and using Pumped Hydro Storage System[1]. India has total installed capacity of solar power plant about 7568 MW and the proposed target is 100000 MW by 2022. Simultaneously the total installed capacity of wind energy system is 7455.2 MW which is at fourth position in the world. The first operational PHS power plant was built at Nagarjunasagar in Andhra Pradesh in 1970 with installed capacity of 700 MW. The total operational capacity of the PHS power plant is 2.61 GW[4]. Therefore, hybridization of such system will definitely fills the gap of energy between the production house and customer part.

II. PHOTOVOLTAIC ENERGY SYSTEM

As India is situated to the north of the equator and between the boundary of the tropics and subtropics i.e. at the Tropic of Cancer, this phenomenon makes India relatively hot which turned out to be a great opportunity of using it for the energy production[5]. Solar PV power system is defined as the conversion of energy from sunlight into the electricity either directly using solar cells or using concentrated solar cells, or combination of both. This solar cells or PV cells converts light energy to electric current using photovoltaic effect[6]. Solar PV is now becoming an inexpensive low-carbon technology to affordable renewable energy system. The largest solar power plant is situated in Pavagada Solar Park, Karnataka, India with the generation capacity of 2050 MW[9].

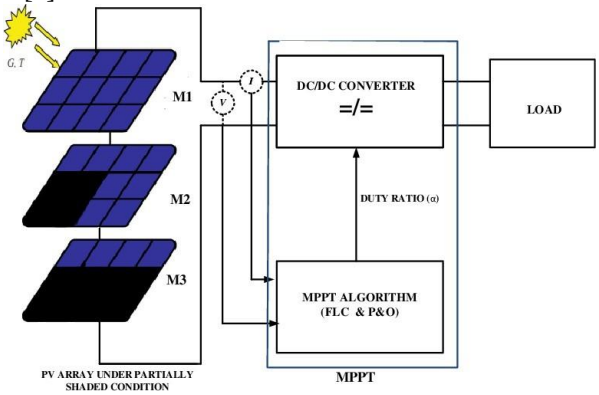

Figure 1- Solar PV Energy System

III. WIND ENERGY SYSTEM

Motion of air is known as Wind. Wind plays a significant role in the nature. In the recent years, the use of wind energy for production of electricity has increased. Wind turbines are capable of producing electricity with no bad impact on global environment. They neither releases harmful gases nor induce harmful pollutants in the environment[7].

With the total capacity of 7455.2 MW, Tamil Nadu is the largest for energy generation following Maharashtra (4450.8 MW), Gujarat (3654.4 MW) and Rajasthan (3307.2 MW). Most of the wind power plant belongs to the Maharashtra state with the adequate capacity from around 75 MW to 528 MW. Working on standalone wind energy system may increase installation costs and require more land area to ensure sufficient power generation[11].

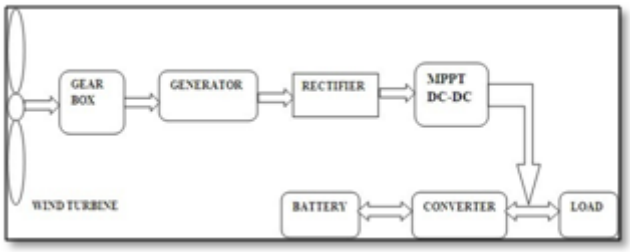

Figure 2- Wind Energy System

IV. PUMPED HYDRO STORAGE SYSTEM

Energy storage is the key issue for any generation system. Storage system should be flexible on-demand peaking capacity for all types of needs and to balance the low cost highly recommended nature of the energy generation[10].
Pumped hydro storage system plays a central role. As PHS works by storing energy water in the upper and lower reservoir. At the time of operation of PHS system, when there is excess of power in the system then the water is pumped from second reservoir at a lower elevation, and when there is demand for the energy the water in upper reservoir is released and as it falls , it turns the turbines ON which generates the power[13]. PHS system works in the generating and the pumping mode as shown in below figure.

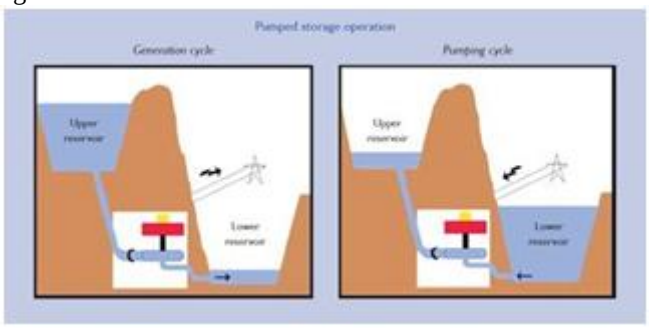

Figure 3- Pumped Hydro Storage System

V. HYBRID ENERGY SYSTEM

Hybridization is defined as the fusion of different orbits which in turn influences their geometrical and bonding properties and also it redistribute the energy of the different orbits to get the required amount of product we requires. Here Hybridization is done in the case of two standalone system which have their own drawbacks so to overcome this issue fusion of the system has done to get the required energy output. Hybrid energy system consist of the Solar PV and the Wind energy system. It has been investigated to counteract the fluctuations in the system and improve the reliability of the system. The policy named " hybrid wind-solar with storage" amended to clarify that any form of storage could be used in the hybrid projects including PHS, compressed air and flywheels. Its an enormous plans for new low cost, deflationary, domestic renewable energy also comes with an associated critical need to accelerate the deployment of storage devices[12].

VI. HOMER PRO SOFTWARE

HOMER Pro is a micro-grid software by HOMER Energy Solution is setting the worldwide grades for realizing micro-grid designs in every fields, remote island applications to rural power solutions, Off-grid and grid-connected sites and also military bases. The software is designed at the National Renewable Energy Laboratory, enriched and dispensed by HOMER Energy, HOMER roosted three robust tools in a single software package, so that economics and engineers works together. The main purpose of Homer software is to get optimal analysis of any system whether working or not. It provides all the factors summoned up at a single place to work, covers all the database quantities at a place[8].

VII. METHODOLOGY

In present work, we have introduced a collaboration of pumped hydro storage system with Solar PV-Wind energy production. The primary aim of this type of topology is to reduce losses and store energy through pumped hydro storage system. Thus, it is the great replacement of batteries and diesel engines or generators via use of renewable energy. Pumped hydro storage system has the potential to provide persistent power to system with the round trip efficiency of 75% to 80%. The study also directs that the renewable hybrid energy system with pumped storage will be price profitable alternative for energy storage[1].

VIII.HYBRID MODEL

The model consist of Solar PV collaborated with Wind energy system having some required converters with the pumped hydro storage system.

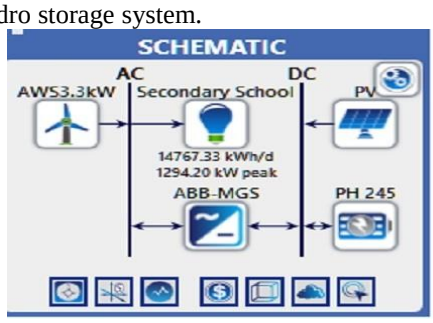

Figure 4- Schematic of the system in HOMER Pro.

The system architecture shows the proposed analogy with all the units with respective quantities and the graphical analysis of the system with respect to the cost type and cash flow in the nominal form, and the discount considered in it 6% and inflation rate is 2% of the system.

IX. RESULTS AND DISCUSSION

All the results obtained from the system architecture are discussed in this chapter with their performance evaluations using HOMER Pro software.

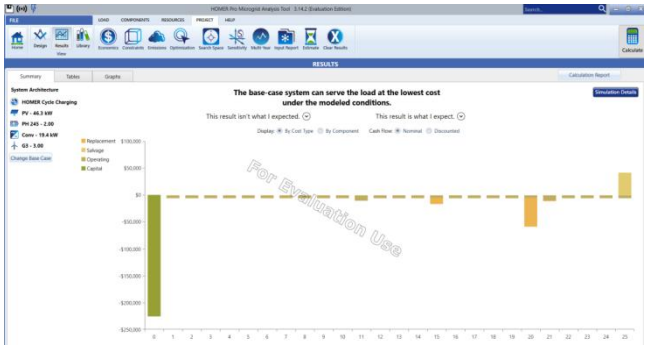

Figure 5.1- System architecture

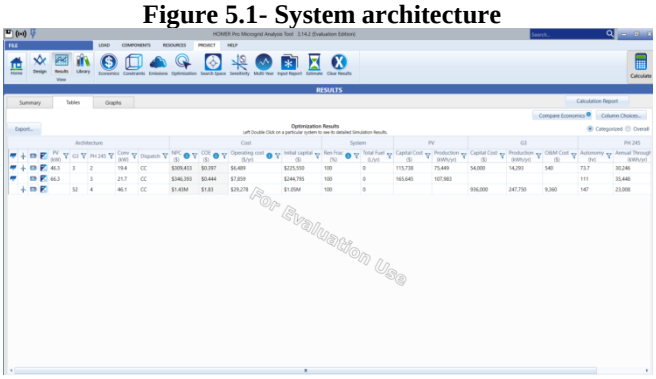

Figure 5.2- Optimization Result A

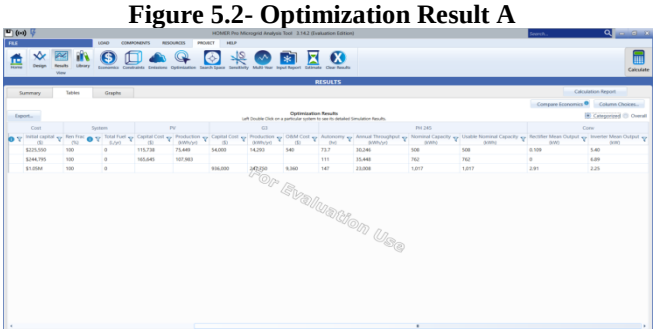

Figure 5.3- Optimization Result B

Figure 5.2 & 5.3 shows the various case studies regarding to our proposed system. In this it is cleared from the table that our proposed system is profitable with respect to other given systems. From both the figures of the optimization results it is clear that the cost of energy is lesser as compared to others while the net present cost, O&M cost is also lower in the proposed system. The main advantage is that the cost of fuel and the carbon emission is comparatively reduced due to renewable resources usage. The renewable fraction is almost 100% for the system.

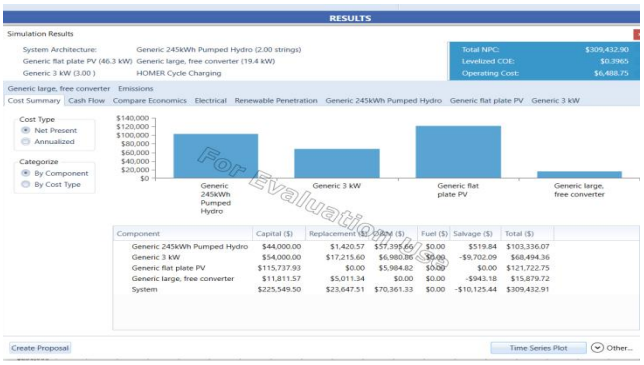

Figure 5.4 Cost Summary

The graph represents all the basic parameters like NPC, CoE, Initial cost, O&M, Replacement cost, Salvage cost.

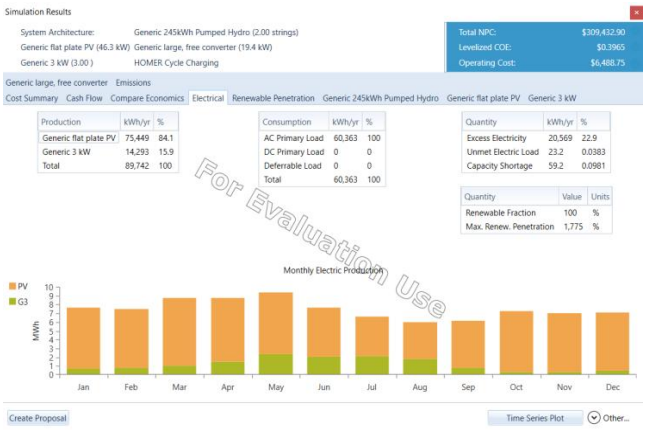

Figure 5.5- Simulation results for the electrical load on the basis of the production , consumption and quantity of the system.

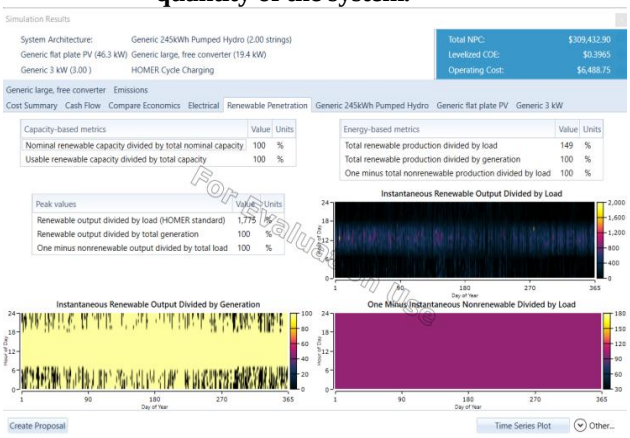

Figure 5.6- Simulation results for Renewable Penetration.

The renewable penetration is explained through the capacity-based metrics, energy-based metrics and peak values of the considered system. Renewable capacity metric is considered on the basis of nominal and useable renewable energy capacity. Energy metrics explains the production of energy considering by load, generation unit and non renewable load.

Figure 5.7- Simulation Results for Generis 245kWh PHS System

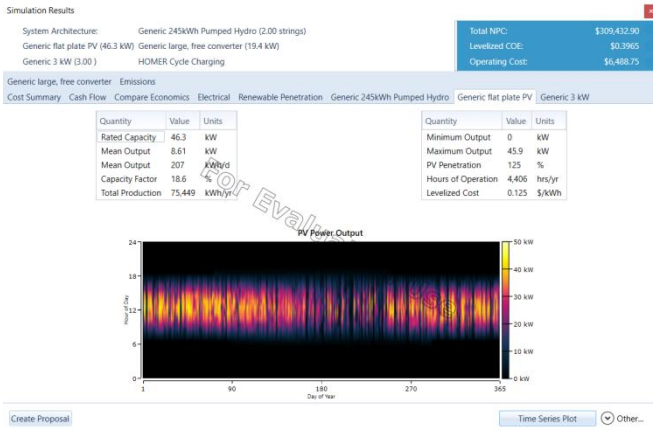

Figure 5.8- Simulation Results for Generic Flat PV System

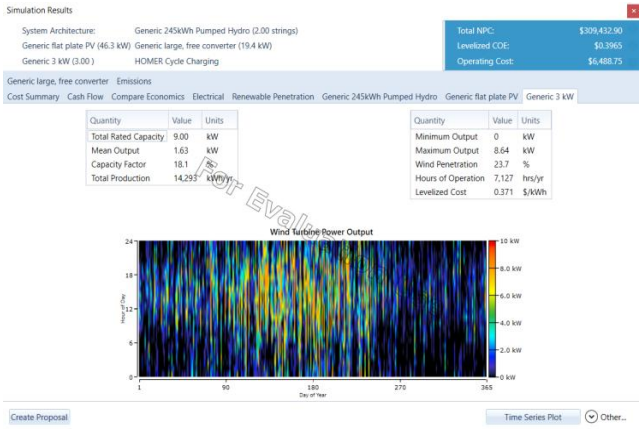

Figure 5.9- Simulation Result for Generic 3kW Wind System

X. CONCLUSION

The main issue is the designing of own energy storage strategy that enhances the need of energy at the peak time of load demand, storage of energy along with the cost reduction withstands the highest degree of flexibility, and deals with the feasible study of hybrid energy system and profitable output of the pumped hydro storage system rather than the battery backup system on the basis of net cost. Thus, for cost effectiveness, the studied hybrid scheme finds more profitable option available for residential loads. Energy generation and electricity market result suggests that huge energy demand from residential load doesn't occur at the peak time or critical hours. Time of use tariff plan and most of the energy sales is seen in industrial and commercial utility sector. Therefore, it will be the major revenue generating source because of the maximum sales of energy. Future scope of the work will include more of the feasibility of hybrid system enhances the overall energy output, attenuates the individuals shortcomings, reduces the need of storage system and reduces the need of components.

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