Optimization of Solar-Wind Hybrid Power System for Distributed Generation

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Abstract---Solar and wind energy systems are omnipresent, freely available, environmental friendly, and they are considered as promising power generating sources due to their availability and topological advantages for local power generations. Hybrid solarwind energy systems, uses two renewable energy sources, allow improving the system efficiency and power reliability and reduce the energy storage requirements for stand-alone applications. The hybrid solarwind systems are becoming popular in remote area power generation applications due to advancements in renewable energy technologies and substantial rise in prices of petroleum products. This Paper presents simulation, optimization for the stand-alone hybrid solarwind energy systems with battery storage. Simulation and Optimization is done using HOMER (Hybrid Optimization Model for Electrical Renewable) software.Six different locations of Gujarat is selected for study with two different plant size i.e. 5 kWh/day, and 10 kWh/day. HOMER gives optimized rating of equipment except battery and calculation gives cost of energy.

Keywords: Solar-Wind hybrid system, cost optimization, Homer and suggested Algorithm

I. INTRODUCTION

A. Problem statement:

Over the last decade, it became apparent that the world's resources of fossil fuel are beginning to come to an end. Estimates of energy sources vary but oil and gas reserves are thought to come to an end in roughly 40 and 60 years respectively and coal reserves could only be able to last another 200 years .The rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present day's demand. Another key reason to reduce our reliance on fossil fuels is the growing evidence of the global warming phenomena. The potential of renewable energy sources is enormous as they can in principle meet many times the word energy demand. Renewable energy sources such as Biomass, Wind, Solar, Tidal, Geothermal, and Hydroelectric can provide sustainable energy service based on the use of routinely available individual resources. Of the many alternatives, Photo-voltaic and Wind energy have been considered as promising towards meeting the continually increasing demand for energy.

The Wind and Photovoltaic sources of energy are inexhaustible, freely available and it does not cause greenhouse effect in contrary to the fossil fuels .Solar and Wind energies sources are good complementary each other. They have been widely used as Hybrid combination for electricity supply in isolated locations far from the distribution network. From the several studies of Optimization preferred an attractive alternative energy sources. However, they suffer from the fluctuating characteristics of available Solar and Wind energy sources. Therefore, properly sized Wind turbine, Photovoltaic panel and storage unit provides high reliability and, low initial investments cost and maximize performance while minimizing the cost.

B. Objective of the Project:

Optimization of renewable energy hybrid system looks into the process of selecting the best component and its sizing with appropriate operation strategy to provide cheap, efficient, reliable and cost effective. Wind and Solar driven Stand-alone system have turned into one of the most promising ways to handle the electrical energy requirement of numerous, isolated consumer worldwide.

The main objective of this paper is to Optimize Stand-alone Solar and Wind Hybrid Power System configuration for distributed generation. And to maximize Hybrid renewable energy generation system while minimizing the total system cost.

C. Motivation:

The disadvantage of Stand-alone Power Systems using renewable energy is that the availability of renewable energy sources has daily and seasonal patterns which results in difficulties of regulating the output power to cope with the load demand. Also, a very high initial capital investment cost is required. Combining two or more renewable energy generation will enable the power generated from a renewable energy sources to be more reliable, affordable and used more efficiently.

This thesis focuses on the combination of Wind, Solar and energy storing systems for sustainable power generation. The Wind turbine output power varies with the wind speed at different conditions. The Solar energy also varies with the hourly, daily and seasonal variation of solar irradiation. Thus, a Battery bank (energy storage bank) can be integrated with the Wind turbines and PV-system to ensure that the system performs under all conditions. In the proposed system, when the wind speed is sufficient, the Wind turbine can meet the load demand. When there is enough energy from the sun, the load demands can be supplied from the PV-array system. Whenever there is excess supply from the RESs, the energy storage bank stores energy which will be used at times when there are insufficient supplies from the RESs.

II. ABOUT TOOL (HOMER)

HOMER means "Hybrid Optimization Model for Electrical Renewable". HOMER, the micro power optimization software developed by Mistaya Engineering, Canada for the National renewable Energy Laboratory (NREL) USA, simplifies the task of evaluating designs of both off-grid and grid connected power systems for a variety of applications.

HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal demand in the hour to the energy that the system can supply in that hour, and calculates the cost of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries.

HOMER performs these energy balance calculations for each system configuration that you want to consider. It then determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the conditions that you specify, and estimates the cost of installing and operating the system over the lifetime of the project. The system cost calculations account for costs such as capital, replacement, operation and maintenance, fuel, and interest. After simulating all of the possible system configurations, HOMER displays a list of configurations, sorted by net present cost (sometimes called lifecycle cost), that you can use to compare system design options. When you define sensitivity variables as inputs, HOMER repeats the optimization process for each sensitivity variable that you specify. For example, if you define wind speed as a sensitivity variable, HOMER will simulate system configurations for the range of wind speeds that you specify.

HOMER can be used for three different purposes, which are:

- To analyze the cost of a hybrid system before installation.
- To find out the cost effective sizes and combinations of the necessary components in the system.
- To analyze the cost of an already built or existing system

III. RESULTS AND DISCUSSION

A. *Experimental Parameters*

Six different locations are selected form Gujarat State i.e. Ahmadabad, Vadodara, Surat, Mundra, Khambhat, Junagadh. Solar insolation and wind speed of six location are obtained from NASA meteorological department.

a) Input details

Components used for Solar-Wind Hybrid Power System:

- Wind Turbine: 1KW
- Solar PV panel: 1KW
- Converter:1KW
- Battery: Vision 6FM 200D of 12V and 200Ah

b) Monthly avg. wind speed (m/s) and solar insolation (kwh/m²/day) on a horizontal surface

CITY	Avg. Wind Speed (m/s)	Avg. Solar Insolation (kwh/m2/day)
Surat	2.33	5.22
Vadodara	2.42	5.28
Ahmedabad	3.56	5.22
Mundra	2.96	5.50
Khambhat	2.51	5.26
Junagadh	2.80	5.27

Table.1: Monthly avg. wind speed (m/s) and solar insolation (kwh/m^2/day)

c) HOMER Simulation for different location

Fig..1: (A) 5 kWh/day for Surat location

Fig..1: (B) 10 kWh/day for Surat location

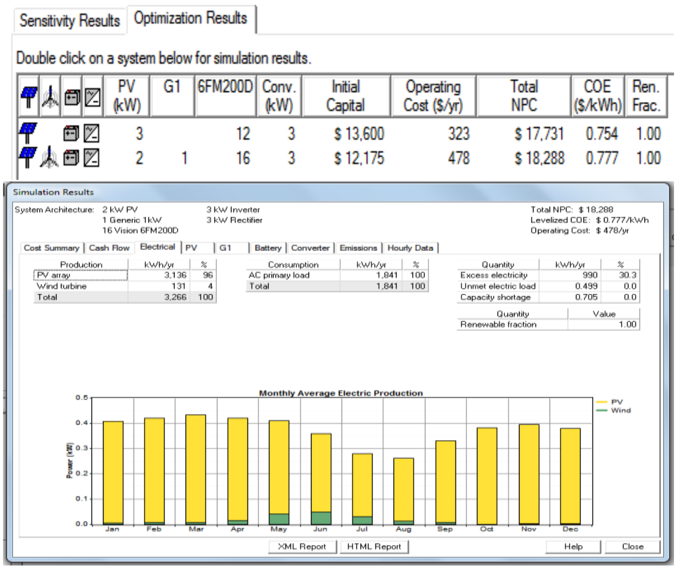

Fig. 2: (A) 5 kWh/day for Vadodara location

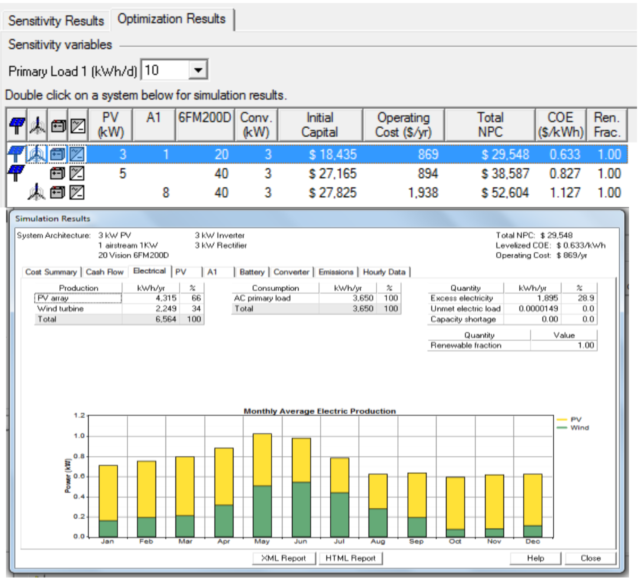

Fig. 2 :(B) 10kWh/day for Vadodara location

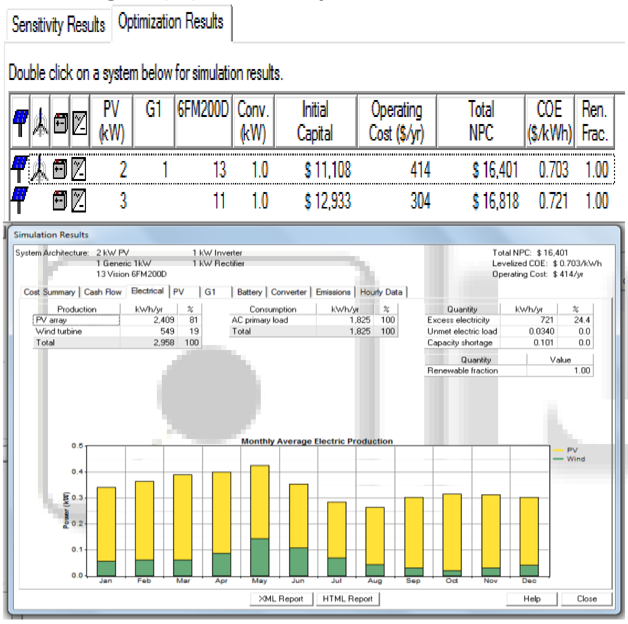

Fig. .3: (A) 5kWh/day for Ahmedabad location

Fig. 3:(B) 10kWh/day for Ahmedabad location

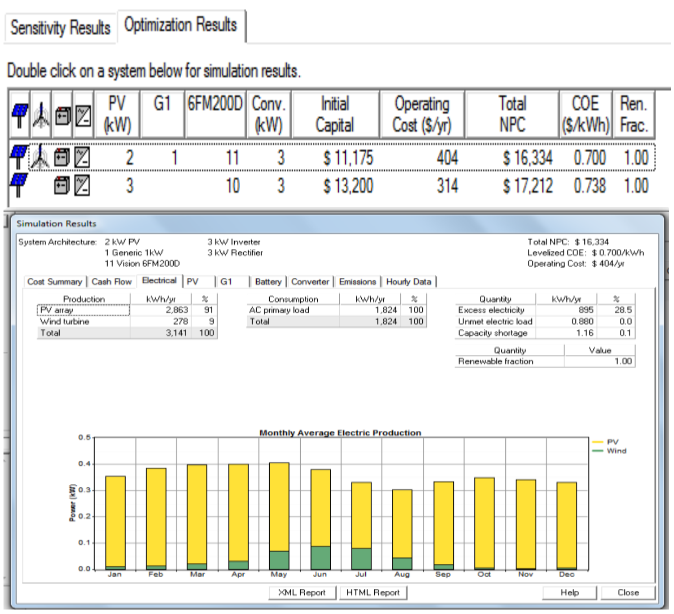

Fig. 4 :(A) 5kWh/day for Mundra location

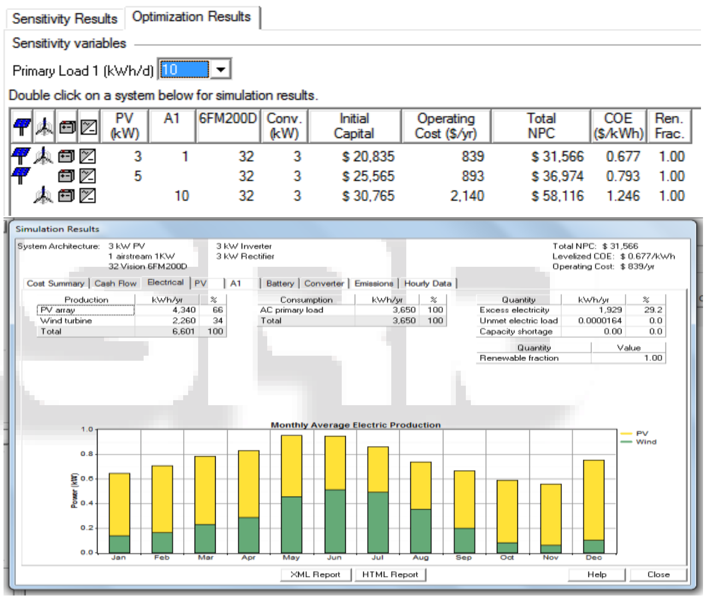

Fig. 4:(B) 10kWh/day for Mundra location

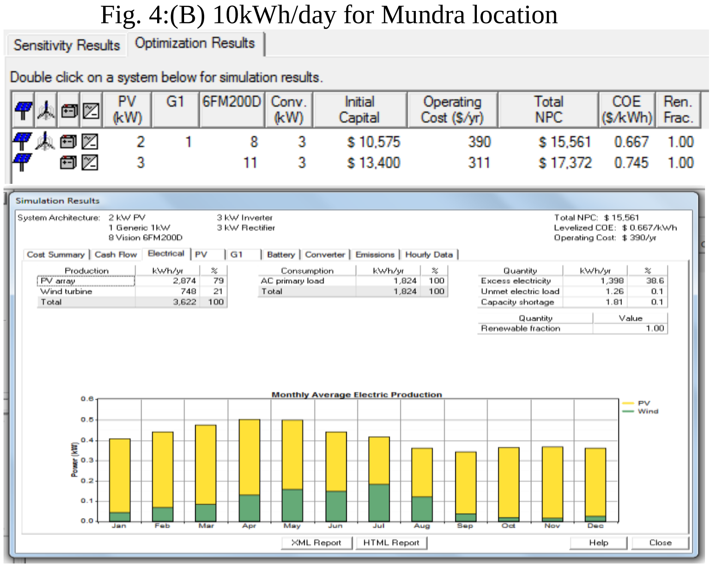

Fig. 5:(A) 5kWh/day for Khambhat location

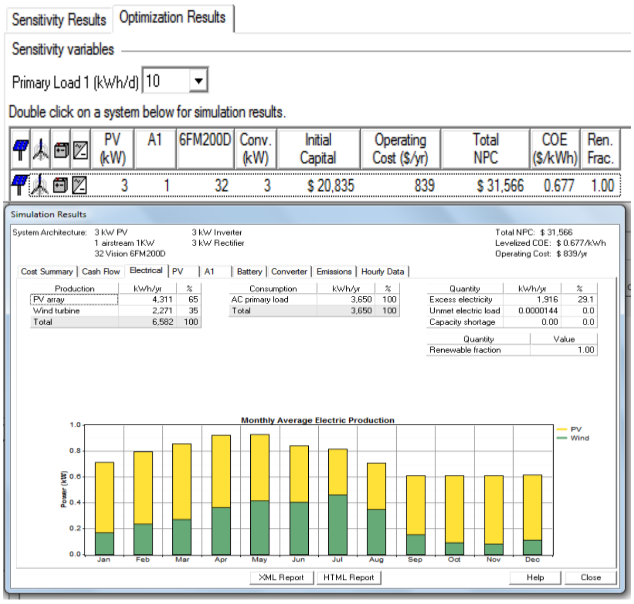

Fig. 5: (B) 10kWh/day for Khambhat location

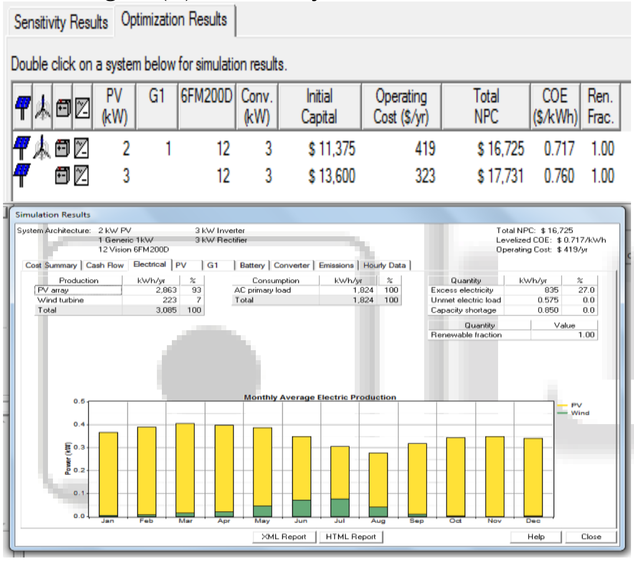

Fig. 6 :(A) 5kWh/day for Junagadh location

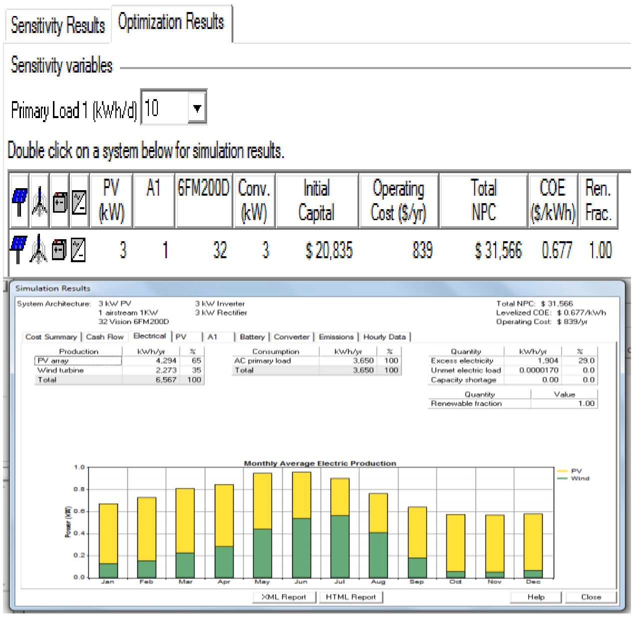

Fig. 6:(B) 10kWh/day for Junagadh location

d) Cost analysis of solar-wind hybrid power system for all location

	Surat	Vadodara	Ahmedabad	Mundra	Khambhat	Junagadh
PV	3	3	2	2	2	2
WT	0	0	1	1	1	1
Battery	11	12	13	11	8	12
Inverter	3	3	1	3	3	3
IC (In Lac)	6.7	6.8	5.5	5.5	5.28	5.68
OC (In Lac)	0.2	0.2	0.2	0.2	0.19	0.2
NPC (In Lac)	8.7	8.9	8.2	8.2	7.78	8.36
COE (INR)	37	38	35.2	35	33.4	35.9

Table. 2: HOMER simulation result 5 kWh/day for six locations

Table. 2 shows summary of six locations for the plant size of 5 kWh/day. HOMER suggests that for lower plant size solar power plant is better than Hybrid power system. In table PV and inverter shows that rating of PV panel and inverter. And battery shows that number of battery of capacity of 200 Ah each. And Initial Capital cost (IC) and Net Present Cost (NPC) is in rupees, operating cost (OC) is in rupees per year while Cost of Energy is in rupees per unit. From below table it can show that for lower plant size or for solar power plant Khambhat location is batter, as it cost 33.35 INR per kWh as per simulation.

	Surat	Vadodara	Ahmedabad	Mundra	Khambhat	Junagadh
PV	3	3	3	3	3	3
WT	1	1	1	1	1	1
Battery	32	20	32	32	32	32
Inverter	3	3	3	3	3	3
IC (In Lac)	10.4	9.21	10.4	10.4	10.4	10.4
OC (In Lac)	0.41	0.43	0.41	0.41	0.41	0.41
NPC (In Lac)	15.7	14.7	15.7	15.7	15.7	15.7
COE (INR)	33.8	31.6	33.8	33.8	33.8	33.8

Table. 3: HOMER simulation result 5 kWh/day for six locations

Table. 3 shows summary of six locations for the plant size of 10 kWh/day. HOMER suggests that plant size of 10 kWh/day hybrid plant is economical. In table PV and inverter shows that rating of PV panel and inverter. Wind turbine shows that rating of it. And battery shows that number of battery of capacity of 200 Ah each. And Initial Capital cost(IC) and Net Present Cost (NPC) is in rupees, operating cost (OC) is in rupees per year

While Cost of Energy is in rupees per unit. For plant size of 10 kWh/day Vadodara location is batter as compared to other selected location as it costs 31.65 INR per kWh.

IV. CONCLUSION

With the help of simulation, the cost of energy production is calculated for Ahmedabad, Vadodara, Surat, Mundra, Khambhat, Junagadh.It can be concluded that for loading condition of 5 units per day and 10 unit per day, the cost of energy production reduces. So it is proved that as loading condition increases per day, the cost per unit will reduce.

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