International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-1, February 2022
https://doi.org/10.55524/ijirem.2022.9.1.9
Article ID 22919, Pages 53-60
www.ijirem.org

Assessment of Hybrid Energy Facility for a Well Being Center in an Island

Sumaira Khan[1], Dharminder Kumar[2], and Krishna Tomar[3]

[1]M.Tech Scholar, Department of Electrical Engineering, RIMT University, Punjab, India,
[2]Assistant Professor, Department of Electrical Engineering, RIMT University, Punjab, India,
[3]Assistant Professor, Department of Electrical Engineering, RIMT University, Punjab, India

Correspondence should be addressed to Sumaira Khan; khansumairassk@gmail.com

ABSTRACT-According to World Bank estimation 65.07% of Indian population reside in rural areas. In such areas, the health and wellbeing centers are mostly supplied by a national grid. So the power supply in such areas is not continuous and the quality is also low. This affects the diagnosis process which subsequently leads to delay in the entire health care. The aim of this study is to provide continuous and adequate power supply to such health care centers by combining solar PV and wind mill. This hybrid combination is intermittent in nature. In order to alleviate this nature and to elevate the power quality, a large number of battery units are added. The proposed model examines the feasibility of such scheme by using HOMER software; optimize the size by keeping the economics of the scheme at the center.

Keywords- Solar energy, wind energy, hybrid energy, HOMER, optimization.

I. INTRODUCTION

The world's energy demand is increasing rapidly due to population explosion and innovation. So in future we need to go for strong, fast and continuously eco-friendly power hotspot [1]. Presenting non-environmental friendly power sources would certainly not meet the energy requirement as they are limited sources of energy [2]. The Sustainable Power Area currently accounts for 13.5% of the world's energy interest. Some long positions present a rapidly expanding portion of unbroken developments. Under such circumstances, with the appropriate approach and new innovation advances, renewable energy may combine to meet half of the energy interest by the middle of the 21st century. Despite this, its variance is a test of the use of eco-friendly electricity and is a time-subordinate trademark. The adaptable interest [3–5] of the executives and the brilliant energy of the board [6,7] may help, although they may not be able to fully take into account the harmony between creation and the request for power. An effective answer to overcome the discontinuity issue of sustainable power creation could be energy storage innovation [8]. It stores excess energy when creation of energy is more than requested and transmits stored energy when creation is less than requested. As utility electricity rates move up, the combination of a sun-based photovoltaic (PV) infrastructure with battery storage could guarantee a financial vulnerability to be overcome. Regardless of the batteries, load control innovation can reshape client load profiles to advance the use of PV frameworks. This half-and-half innovation offers a powerful answer to the tedious task of storing energy using most standard storage innovations [9].

II. MODELLING OF PV- WIND-HYBRID SYSTEM

The essential parts of the framework are shown in fig.1.
PV exhibition, wind plant, battery, balancing structure as inverter, converter and charge regulator. Sunlight-based PV operates during bright hours and the wind plant operates during high wind speeds to deliver electricity. If there is an overflow of energy, that energy will be stored in the battery bank which will be used when there is a power shortage.

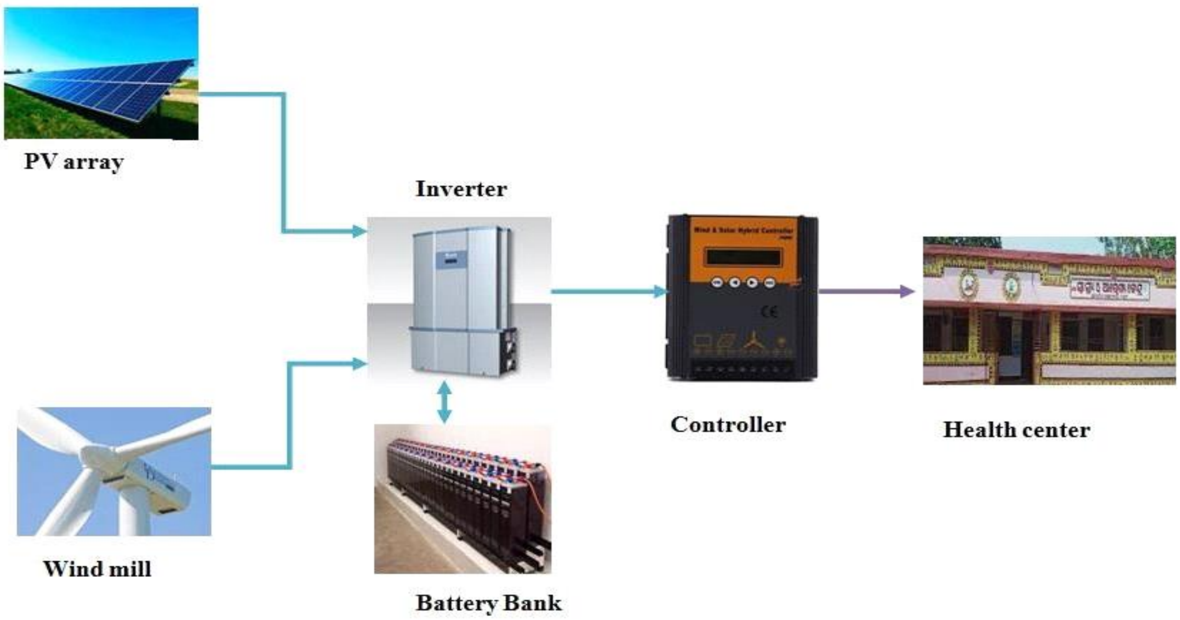

Figure 1: PV wind integrated model

III. LOAD PROFILE

The proposed structure aims to meet a daily load of 15 kW/day with a maximum demand of 1.9 kW. Nonetheless, this addresses the general burden of interest on the site GANGADHARPRASADDIA Village TRILOKYAPUR Panchayat RAJKANIKA Block Kendrapara, Odisha.. At the same time, it is also seen that the peak load is happening in the evening. The proposed plot is blended into Homer's programming by adding the irregularity of the day, to create a very sensible burden profile.

IV. SOLAR ENERGY SOURCE

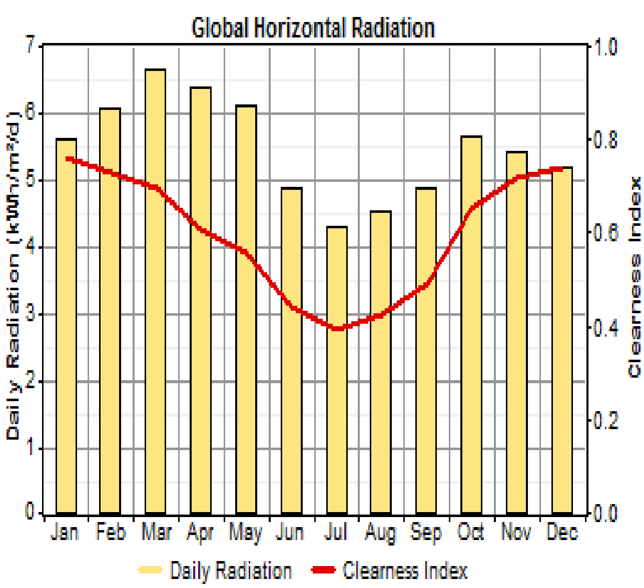

Figure 2 solar energy resource

As shown in fig.2 the regular variation of sun-powered radiation in India is believed to be 3-8 kWh/m2/day. The review is directed at 20.59 degrees scope and 86.45 degrees longitude. In addition, month to month normal every day sunlight based radiation observed for the proposed site is 5.464 kWh/m2/day with a clarity index of 0.583, the introduced limit of the PV cluster is 4 kWP

V. WIND RESOURCE

Fig.3 shows the wind resource at sight.The wind property is remembered for a proposed model for minimizing the energy present in the wind. The wind factory in this review is saved for exploratory purposes, so turbine size is limited to 1 kW, the generic 1 kW model has been chosen for the reason. The life expectancy of a breeze plant is believed to be 15 years. The annual mean normal wind speed at the proposed site is 4.956 m/s. Capital expenditure of INR 1, 45,000 and O&M of INR 3,000 is considered.

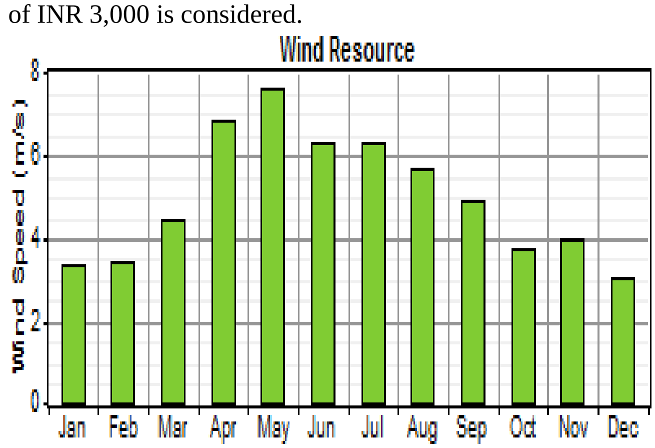

Figure 3 Wind resources at sight

VI. BATTERY

The age in power manufacturing diversity for PV exhibition is unreal. In order to moderate the irregular properties, work on the nature of the force battery with the PV framework has been included. To demonstrate the scheme 4 unit of Surrette 4KS25P batteries are used. The capital expenditure of the battery sub-structure for the proposed conspiracy has been taken as INR 56,000 with O&M cost of INR 2,800/year.

VII. CONVERTER

The proposed concentration is accepted in AC at stack and the force yield from sun based PV and wind plants is DC. So for this scheme inverter is used instead of converter. The size of the inverter used is 2 kW and its lifetime is set as 15 years and efficiency of 90%. The capital expenditure for the proposed conspiracy is taken as INR 11,600 and the O&M cost is 800 each year [10].

VIII. MATHEMATICAL FORMULATION

- **Solar Energy**

Shockley diode equation is used to express relation between voltage and current of PV cell, expressed as

$$I = N_p I_{ph} - N_p I_0 \left(e^{\frac{1}{V_t}\left(\frac{V}{N_s}+\frac{I_{RS}}{N_p}\right)} - 1 \right) - \frac{N_p}{R_p}\left(\frac{V}{N_s} + \frac{I_{RS}}{N_p}\right)$$

Iph is the photo current in A; I0 is the saturation current od diode in A; Rs is the series resistance and Rp is the parallel resistance in Ω; Vt= nKT/q is the thermal voltage of diode; n is the diode ideality factor; T is temperature in Kelvin; K is Boltzmann's constant and q is the charge: Np is the module connected in parallel and Ns denotes modules in series

The Power equation of PV array is expressed as

$$P = VI = VN_p I_{ph} - VN_p I_0 \left(e^{\frac{1}{V_t}\left(\frac{V}{N_s}+\frac{I_{RS}}{N_p}\right)} - 1 \right) - V\frac{N_p}{R_p}\left(\frac{V}{N_s} + \frac{I_{RS}}{N_p}\right)$$

The important parameters are calculated under STC. The paramaters like Iph, I0, Vt, Rs & Rp are specified by the manufacturer.

- **Wind Energy**

The energy production from the wind mill depending upon equation wind speed v in m/s and the intercepting area A is given as

$$Power = \frac{1}{2}\rho v^3$$

where ρ is the density of air in kg/m3, which also depends on pressure and temperature difference. The above equation is in simplified form.

IX. SIMULATION METHODOLOGY

The United States-based NREL Lab has developed a Hybrid Optimization Model for Electric Renewables (HOMER) [11] which is used to simulate the proposed scheme. It can be used to simulate various renewable energy sources including solar, wind, biogas etc. In simulation, conventional and non-conventional energy sources are used as per the requirement. The feasibility and economic viability of the plan can be ascertained by analyzing the reliable data of the simulation [12].

X. RESULTS AND DISCUSSION

A. Solar Radiation with power output

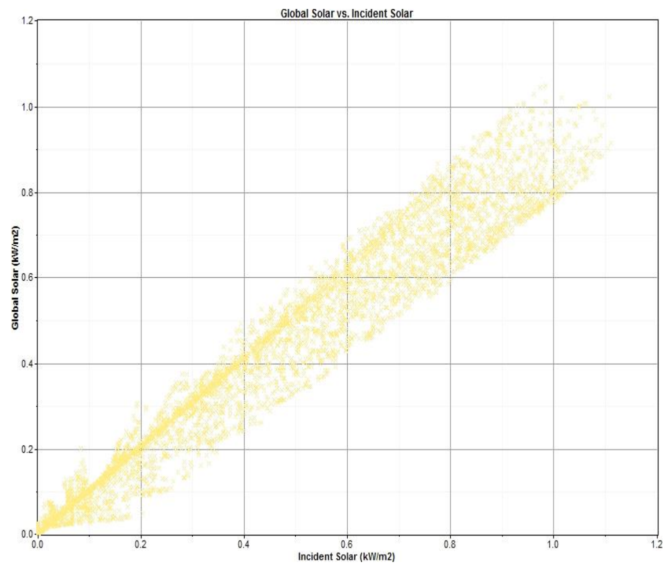

Figure 4 Solar PV output with radiation

Fig.4 shows the variation of PV power generation with the change in global solar irradiance. It is observed that the maximum output of 7.04kWh occurs at an average irradiance of 0.333kW/m2 throughout the day.

B. Generation Mix

The two sources of energy employed in this scheme are complementary in nature. Due to this complementary nature both sources are combined. In fig.5 the blue bar shows the power generation from PV and the orange bar shows the power generation from the windmill. Since the installed capacity of the PV is high, the maximum share of the load is also taken care of by the PV.

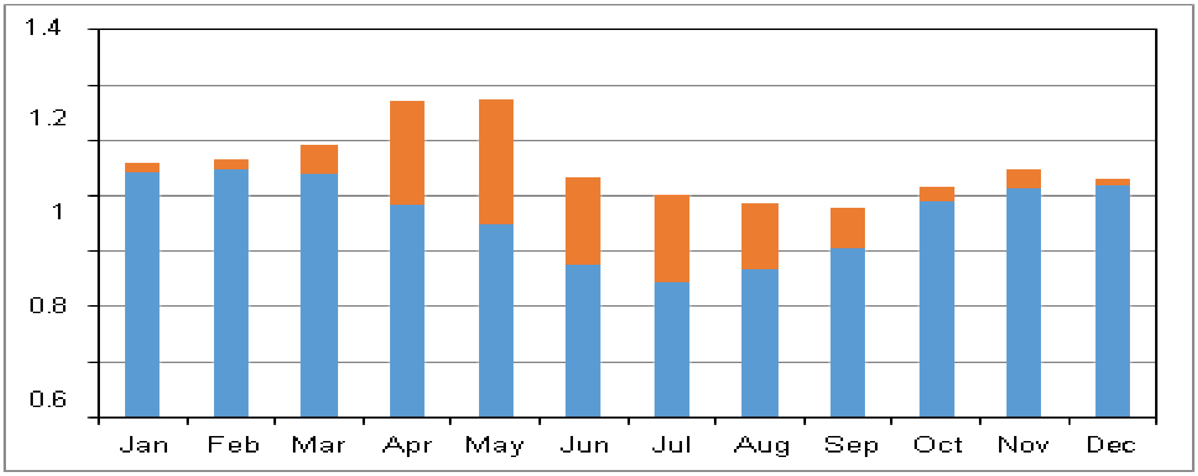

Figure 5: Energy mix from different sources

C. Battery Output

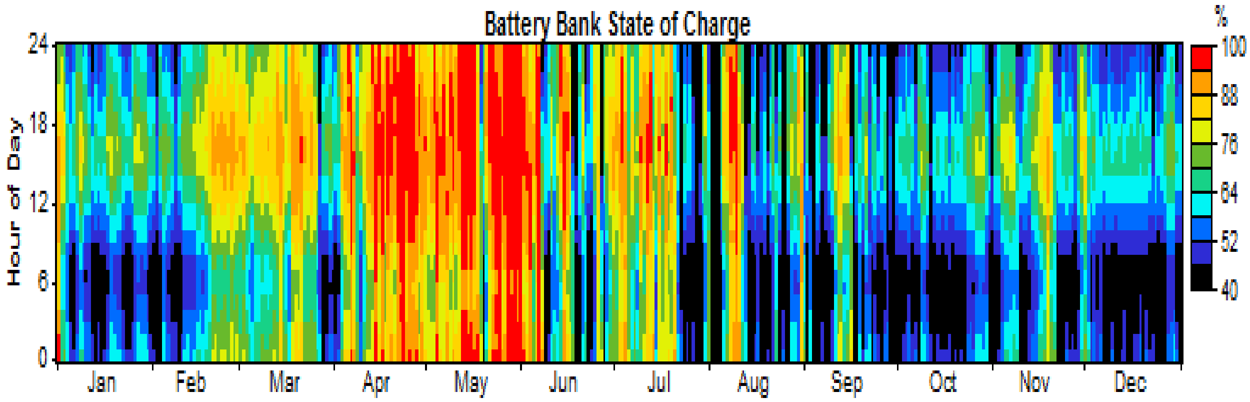

Figure 6: Battery State of Charge

Fig. 6 shows the battery state of charge. In this scheme batteries are used to improve the reliability of the supply. The total energy output from the battery over its lifetime is 42,274 kWh

D. Daily means Energy Production and Load Demands

In fig.7 the blue bar shows the power generated from the PV array and the magenta part shows the power generated from the windmill. HOMER established that PV takes care of the maximum part of the load. Estimated power reduction of 6%.

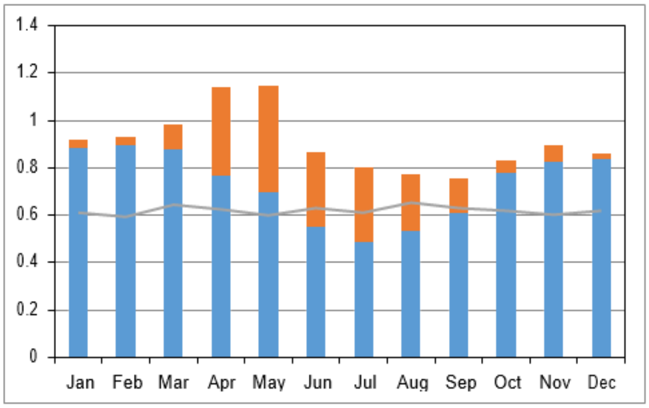

Figure 7: Daily Mean Renewable Energy Production and Load Demand.

E. Energy Distribution Pattern for a Typical Day

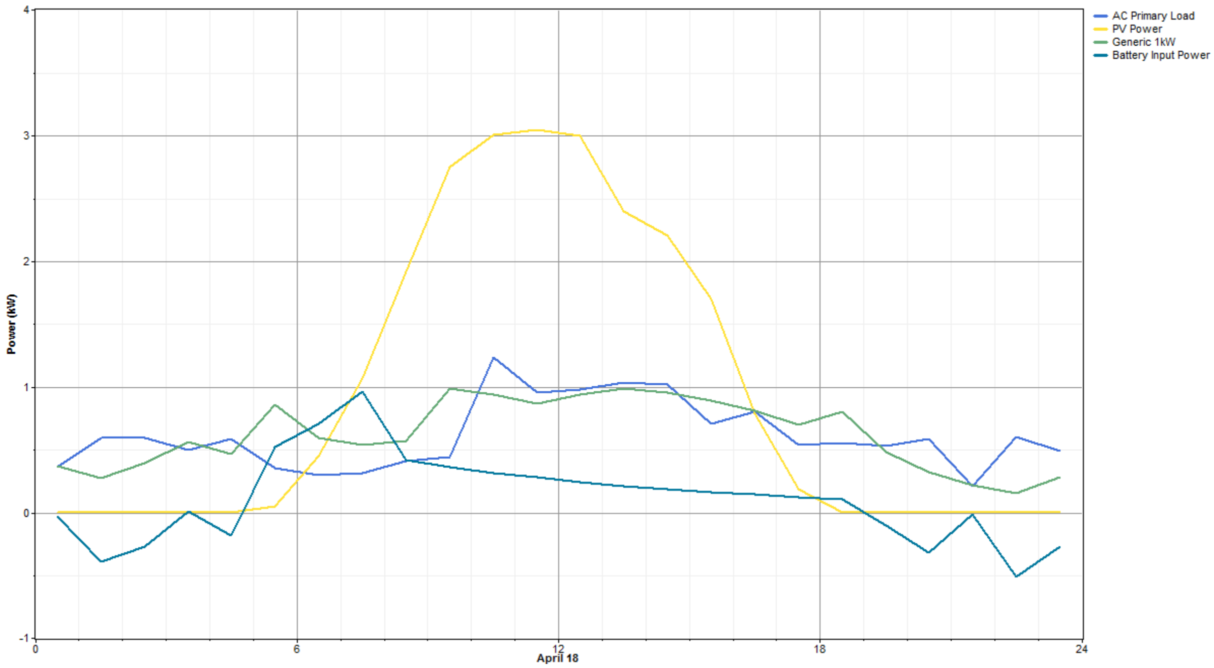

Figure 8: Energy Distribution Pattern

Fig.8 shows April 18th of the year is chosen to be driven to the analysis. Yellow line shows PV power generation and green line shows windmill power generation. Blue line shows load. The battery is shown above zero line during discharging and below zero line during charging hours. The battery gets discharged during the night and the windmill alone is not able to meet the load.

F. Renewable Fraction

Two sources of energy used in this scheme are completely renewable. This scheme satisfies the objective as the renewable fraction of one is attained.

G. Typical Load Curve Smoothed by Battery Integration

There is always variation in load in any network. The battery works well to handle these variations. Earlier charge controllers were used for this purpose. So a combination of charge controller and battery is used to smooth the load curve.

H. Emission from the System

Table 1: Emission from the system

Pollutants	Emissions (kg/yr.)
CO2	0
CO	0
Unburned hydrocarbons	0
Particulate matter	0
SOX	0
NOX	0

I. Seasonal Variation of Load

Load analysis is very important for designing any plan. One day from each season is selected for this analysis. In fig.9 Blue line shows load on January 10 which represents winter load, orange line shows load on March 10 which represents spring load, gray line shows load on May 10 which represents summer load and yellow line Shows load on 10th July which represents monsoon load.

Figure. 9 Electricity Consumption of four typical days in a year

J. Sensitive Analysis

Sensitivity analysis is done to estimate the project cost. PV panels, wind turbines, battery banks and inverters are components that can make a difference in energy costs.Fig.10 shows that in this analysis we found that a 10% drop in the price of PV panels alone would result in a 5.05% reduction in cost of energy (COE), a 10% reduction in capital cost and a 15% reduction in replacement cost but a 3.07% lower COE Will be Reduction in windmill capital cost and replacement cost of battery and inverter will result in a COE reduction of 1.74%. The total cost has come down by 8.68%.

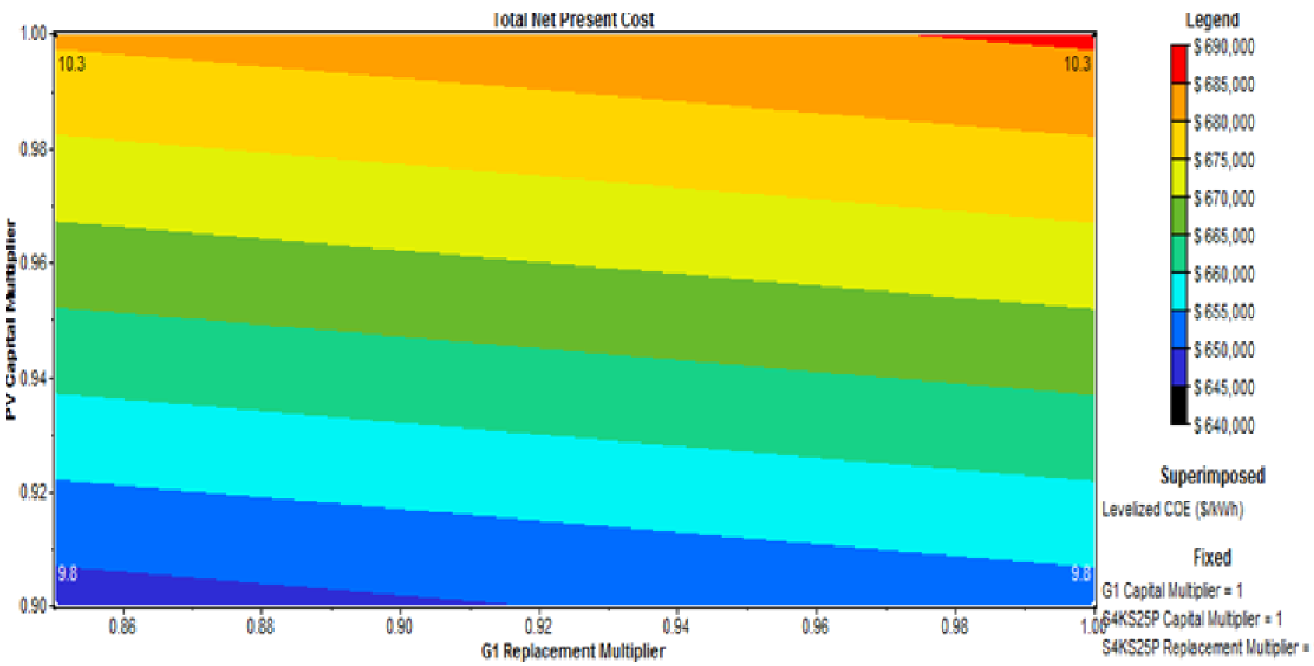

Figure 10: Surface Plot of Electricity Charge

K. Economic Analysis

Table 2: Present Cost

Component	Capital (INR)	Replacement (INR)	O&M (INR)	Fuel (INR)	Salvage (INR)	Total (INR)
PV	332,000	0	0	0	0	332,000
Generic 1 kW	145,000	41,727	38,350	0	-7,767	217,310
Surette 4KS25P	56,000	26,782	35,793	0	-7,689	110,887
Converter	11,600	4,840	10,227	0	-901	25,766
System	544,600	73,349	84,370	0	-16,357	685,963

Table 3: Present Cost

Component	Capital (INR)	Replacement (INR)	O&M (INR)	Fuel (INR)	Salvage (INR)	Total (INR)
PV	25,971	0	0	0	0	25,971
Generic 1 kW	11,343	3,264	3,000	0	-608	16,999
Surette 4KS25P	4,381	2,095	2,800	0	-601	8,674
Converter	907	379	800	0	-70	2,016
System	42,602	5,738	6,600	0	-1,280	53,661

Fig.11 shows the total amount spent on the system per year. The cost goes up a bit with any replacement. Large capital is required in the first year. The battery needs to be replaced in the 12th and 24th year. Need to replace converter and wind turbine in 11th year.

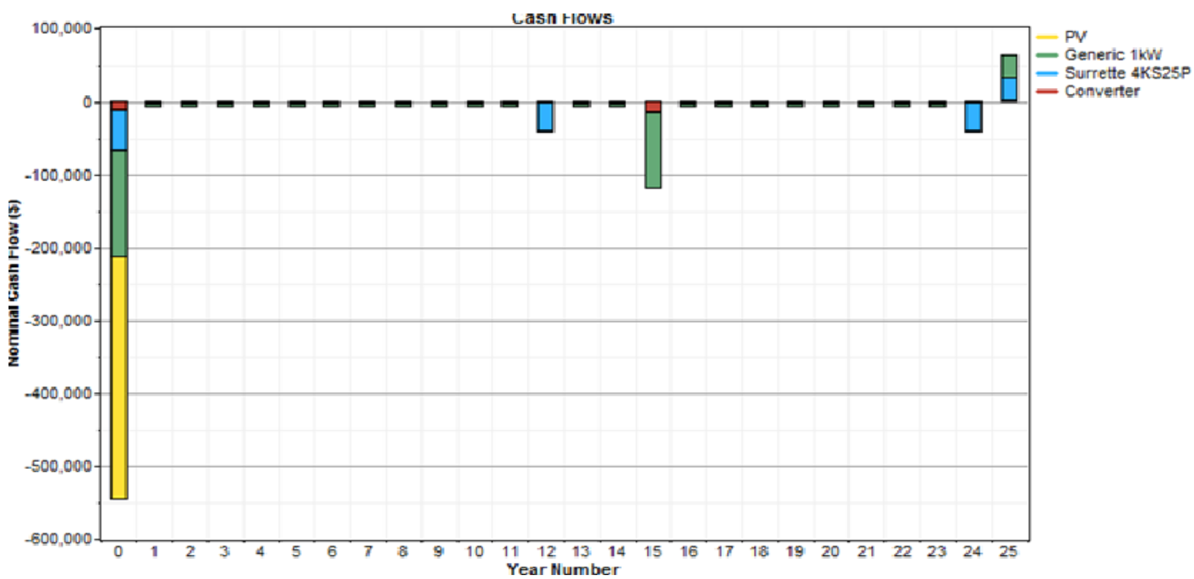

Figure. 11 Cash flow information of the scheme

XI. CONCLUSION

We investigated the hybrid PV wind system for the Center for Health and Wellness in this study. The result is inspiring. With the help of batteries improve power quality and power output, the power resources used are complementary in nature. Since the capacity storage is 0.06%, the reliability of the scheme has improved with level cost of energy as 10.33 INR/KW. The proposed plan has zero emissions.

REFERENCES

[1] Kannan, N., & Vakeesan, D. (2016). Solar energy for future world: - A review. Renewable and Sustainable Energy Reviews, 62, 1092–1105.

[2] Koroneos C, Spachos T, Moussiopoulos N. Exergy analysis of renewable energy sources. Renew Energy 2003;28(2):295–310.

[3] Lund H, Munster E. Management of surplus electricity-production from a fluctuating renewable-energy source. Appl Energy 2003;76:65–74.

[4] Droste-Franke B, Paal B, Rehtanz C, Sauer D, Schneider J-P, Schreurs M, et al. Demand for balancing electrical energy and

power. Balancing renewable electricity. Berlin, Heidelberg: Springer; 2012.
[5] Ostergaard PA, Lund H. A renewable energy system in Frederikshavn using low- temperature geothermal energy for district heating. Appl Energy 2011;88:479–87.
[6] Fraunhofer-Gesellschaft. Managing renewable energy intelligently. ScienceDaily. www.sciencedaily.com/releases/2014/03/140325094814.htm [accessed 07.4.21].
[7] Ostergaard PA. Comparing electricity, heat and biogas storages' impacts on renewable energy integration. Energy 2012;37:255–62.
[8] Ma T, Yang H., Lu L., &Peng J., (2015). Pumped storage-based standalone photovoltaic power generation system: Modeling and techno-economic optimization. Applied Energy, 137, 649-659.
[9] O'Shaughnessya Eric, Cutlera Dylan , Ardania Kristen, Margolisa Robert, (2018) Solar plus: Optimization of distributed solar PV through battery storage and dispatchable load in residential buildings . Applied Energy, 213, 11-21.
[10] "Balance of system", Solar energy technology programme, U.S.Department of energy. 5thJanuary 2006 archived from the original on 4th May 2008. Retrieved 31st March 2021.
[11] Lambert T, Gilman P, Lilienthal P. Micropower system modeling with homer. Integration of alternative sources of energy. John Wiley & Sons, Inc.; 2006. P.379–418.
[12] Bhattacharjee S., & Acharya S. (2015). PV–wind hybrid power option for a low wind topography. Energy Conversion and Management, 89, 942-954.