

Optimization analysis of solar photovoltaic and wind turbine hybrid system: Based on different defuzzification methods

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Abstract— *The expansion in electrical energy request has made sustainable energy source assets more attractive. Major sources of renewable energy such as solar energy, biomass energy, wind power and small hydro systems are gaining importance day by day. The progress of reliability of the energy source and electricity power supply in the hybrid system has reached to new height. Hybridization of two sources, such as solar photovoltaic and wind turbine for the supply of electrical power demand in Energy Park RGPV, Bhopal have been considered in this paper. This site is located at 23° 31' N latitude and 77°36'E longitude. The optimization of the hybrid energy system (HES) components using fuzzy logic algorithm and Hybrid optimization model for multiple energy resources (HOMER 3.11.6) pro software have been carried out. The ideal outcome is accomplished as for the minimization of the cost of energy (COE) over a lifetime of 20 years with different sensitivity parameters.*

Keywords— Solar photovoltaic; Wind turbine; Fuzzy logic; HOMER; Optimization

I. INTRODUCTION

Nowadays, the growth of political and financial crisis, stagnant material reserves, environmental concerns, the population or the difficulty of financial development utilizes renewable power resources. [1]. The basic problem with renewable energy is the obedience of the sources according to the climate conditions. Therefore, there is a change in their output at that place. To correct the problem, the generation of devices gets aged together. In recent years, considering various combinations of renewable and non-renewable energy sources an effort has been made in this regard. Generally specific types of hybrid energy structures for the use of solar photovoltaic, wind power, diesel generators, and hydroelectric resources have been tried, even if renewable energy is accessible [2]. A system regarding the combination of its distinctive sources has the skills on the stability or longevity. To date, the viability and performance studies of hybrid energy systems have been investigated in a number of research studies, based on the techno-economic and environmental analysis. Khan MJ and Iqbal MT [3] author used HOMER software to solve the optimization problem. a remote house having a vitality utilization of 25 kW h/d with a 4.73 kW crest control request zone was situated at Canada. The consequences of this work add up to net present cost (NPC), capital cost and cost of energy (COE) for such a framework are \$48,454, \$28,450 and 0.497\$/kWh, separately. Solar photovoltaic (PV) - wind turbine (WT) - fuel cell (FC) - battery bank (BB) was found as the most achievable arrangement in their work in light of current expenses. Karakoulidis K. et, al. [4] In this paper SPV-diesel generator (DG)-FC and BB HES for stand-alone (SA) applications proposed demand area which was located in Greece. Energy consumption was of 48 kW h/d with a 16 kW peak power demand (PPD). The results of this work using SPV and DG system, the COE value rises up to 0.65 €/kWh, whereas in the SPV-FC, the COE reaches 1.92 €/kWh. Turkeys BE, and Telli AY [5] A pilot district was chosen and cost investigation of utilizing renewable vitality sources with a hydrogen framework for that locale's vitality request is presented in a techno-monetary point of view in this paper. The pinnacle stack request 239 kW. The consequences of this work cost of creating vitality from this hybrid configuration was observed to be 0.307 \$/kWh. The area was proposed work at Turkey. Margaret Amutha W and Rajini V [6] This paper estimates the domestic, industrial, agricultural, BTS load in a remote village in India. SPV, WT, FC, BB the primary load demand is approximately 250 kW h/day and 25 kW h/day and 12.7 kW peak. It has a load factor (LF) of 0.984. The normal conceded load is 15 kW h/day and has a capacity limit intended for 25 kW h. The normal telecom load is 1.2 kWh/day and has a LF of 0.497. The consequences of this work NPC 162,987\$, COE 0.111 kWh. A.B.Kanase Patil [7] In this paper modeling, optimization and simulation of the proposed system were performed using LINGO and HOMER. Energy consumption of 561273 kWh/year. COE of hybrid energy system is 0.336 \$/kWh. Eduardo F. Silveira [8] The methodology used in the paper comprises three components: simulation, optimization and sensitive analysis of the hybrid systems. SPV with modules of 200 kWp without tracking and WT of 250 kW. The results of this work was NPC \$63,814,70, COE 0.37 \$/kWh. Kumaravel [9] played out the size enhancement of SPV-BGGS –micro hydel based HES utilizing HOMER apparatus for the rustic regions of Kerala, India.

They decided the COE as INR 7.274 for each kW h for the AAD of 56 kW h/d from the accessible assets of sun powered radiation of 3.89 kW h/m²/day, stream of 51.7 L/s and biomass of 0.692 ton/day. Balamurugan et al. [10] developed an optimization model for BGGs -WT-SPV-BB HES using HOMER tool in order to maximize the supply of energy to the loads with the minimization of dumped energy. They got the estimation of limit deficiency and dumped vitality as 10% and 1% of the aggregate vitality provided to the request separately at the base cost of vitality of INR 4.20 for each kW h. They found that the limit deficiency was diminished with the expansion of wind speed and sunlight based radiation. Anurag Chauhan [11] MHP-Biogas-BGGs-WT-SPV- BB based configuration is found to be the most suitable option for the study area as it offers the minimum NPC of \$ 825,408 COE at the estimated COE of \$ 0.092 per kW h along with the highest jobs generation of 0.1792 per year. The optimum configuration of this combination consists of 50 kW MHP system, 50 kW biogas system, 40 kW BGGs, 33 kW WT, 57 kW SPV, 427.20 kW h BB storage system and 47 kW converter. Farivar Fazelpour [12] The normal every day power utilization, arrived at the midpoint of over a yearly cycle, was 17 kWh/d, and the PPD was 1.5 kW, for the family considered. The electrical supply framework is required to fulfill these prerequisites. The examination comes about because of the contextual analysis demonstrate that, among five cross breed frameworks for providing electrical prerequisites, the most conservative was the wind-hydrogen-battery half breed framework, which has an aggregate NPC of US\$63,190 and a COE of US\$0.783/kWh (in view of 2015 US\$). Rohani and Nour [13] modelled and optimized a hybrid system consisting of SPV, WT, and DG to fulfil different energy demand using HOMER. The results showed that for 500 kW electrical powers, the optimal configuration has 30% and 15% proportion of WT and SPV respectively which leads to a total net present cost of \$14,504,952 over 25 years. Singh et al [14] A HFC and SPV based on HRES for stand-alone features is proposed. This rule association about a hydrogen tank, battery, then an electrolyzer are old as much kind of the electricity storage. The monetary viability over the use of HRES limit after furnish the electrical burden make a bid regarding educational lookup building MANIT Bhopal, India is examined. The fuzzy common sense program computes the highest quality value about headquarters or substitute cost of the components, as is below utilized in HOMER pro software program to calculate the most appropriate performance of HRES. The results suggests the HFC yet battery financial institution are the nearly giant modules over the HRES to meet assign assert at a night time or promptly morning hours. The AC primary lay consuming 20712.63 kWh/year outdoors regarding volume monitoring technology regarding HRES as was 24570.72 kWh/year. The excess of electricity evolved by way of HRES was 791.7709 kWh/year including the optimized price over energy, unmet electrical load then ability shortage concerning 0%. From the previous works, it has been found that many studies have been carried out for electrification of the small locality; a study on a cluster of villages is quite limited in the literature. Also, most of the researchers considered SPV/BB, WT/BB, SPV/DG/BB, WT/DG/BB, SPV/WT/BB, SPV/BGGs/BB, SPV/FC/BB and SPV/FC/WT/BB-based HES. Further, in most of the studies, the electrical energy demand of rural area is normally kept fixed for year round application during the design of HES. To the best knowledge of the authors, there is no comprehensive work on sensitivity analysis and fuzzy logic optimization based on different defuzzification methods of solar photovoltaic and wind turbine to supply electrical load demand of Energy Park RGPV, Bhopal. Based on the literature review carried out and research gaps identified as discussed above, the present paper deals with Optimization and sensitivity analysis of solar photovoltaic and Wind Turbine based on different defuzzification methods. [17].

II. SITE DESCRIPTION AND LOAD PROFILE

Bhopal is a big city or the capital city of Madhya Pradesh state, India, with the wide variety of residents close to four million people. It is a center of small and moderate businesses, education institute, focused generally on producing shoppers goods, scientific equipment, pharmaceuticals, textiles, and so on. Bhopal, Madhya Pradesh, India liberality is 496 meters height so is even according to 1,627 feet. Bhopal is located in canter's over India solar strength additionally reachable because of over 6-8 hours [18]. The selected proposed area of the educational institute, University Institute of Technology RGPV, popularly known as UIT RGPV or UIT RGTU, is a public institution located in Bhopal, India. The institution was established by the government of Madhya Pradesh with the name Government Engineering College (GEC). It is an autonomous institution as of 2010. UIT RGPV located at 23° 31' N latitude and 77°36'E longitude. Figure 1.Shows the photograph of University Institute of Technology RGPV, Bhopal India. Bhopal is located in the central part of India. Solar radiation in this area is available for 6-8 hours in a day. The campus of Rajiv Gandhi Technological University is around 241.14 acres in area situated on four lanes Risen - Narsingarh by pass main highway. The electrical AC loads are usually the most significant single influence on the optimum sizing and costing of hybrid energy system components. So, deciding on the load profile is one of the essential steps in the design of the HES. Energy Park , UIT RGPV the primary layer is required in conformity with use electric equipment like tube light, roof fan, computer, or street light. Load profile varies according to weather condition. Weather in India is alienated into three different seasons - winter, summer, and the rainy [19].



Figure 1: University Institute of Technology RGPV, Bhopal

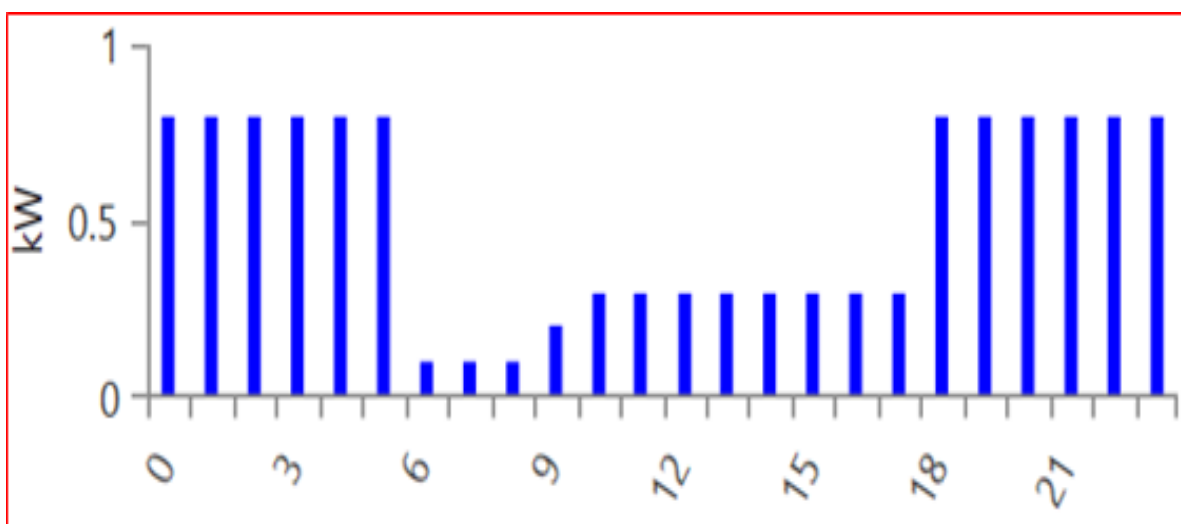


Figure 2: One day load profile of proposed area

III. FUZZY LOGIC SYSTEM BASED COST OPTIMIZATION

Fuzzy logic helps in conceptualizing the fuzziness in the order into a crisp quantifiable parameter. Thus fuzzy logic primarily based models can be adapted for advantageous energy planning to arrive at pragmatic solutions [20,21]. Fuzzy logic deals with reality and it is a shape of many-valued logic. It offers a reasoning that is approximate having additionally exact values alternatively than crisp values [22]. Fuzzy common sense handles the idea of fact value that stages between entirely true and completely false (0–1). A membership function worth over zero implies so much the analogous element is sincerely not an element over the fuzzy set, while a price on cohesion means up to expectation the factor entirely belongs after the set. A grade of membership in between corresponds to the fuzzy group to set. Fuzzy logic has been utilized in many disciplines [23].

There are specific ways to express ambiguous logic and probability uncertainty. The ambiguous set concept used the idea of fuzzy set membership, while the concept uses the idea of subjective prospects. Generally, the variety of membership functions used in fuzzy logic is 'A' triangular and 'T' is trapezoidal. Figure 3. Shows the block diagram of the fuzzy logic system.

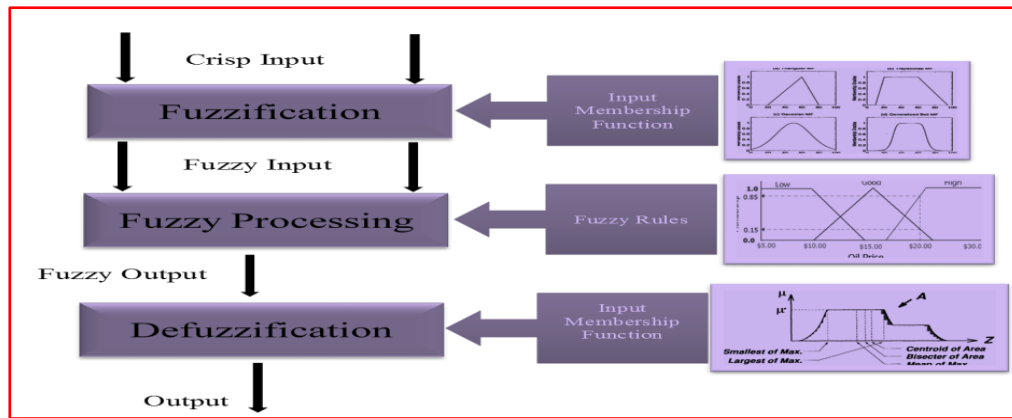


Figure 3: Block diagram of fuzzy logic system [14]

A 1 kW solar PV energy system's capital cost ranges from 50000 to 80000 Rs. and replacement cost varies from 40000 to 64000 by using fuzzy logic programming most precise answer for the provided cost tiers can be obtained [35,36]. Figure 4. Shows trapezoidal membership feature of solar PV system cost. The trapezoidal curve is a function of a vector, $CostPV_{min-max}$ and depends on four scalar parameters $CostPV_1, CostPV_2, CostPV_3$, and $CostPV_4$ as given by, Eq. (1).

In this work expected energy unit capital cost from 60000 to 90000 Rs./kW, replacement cost from 48000 to 72000 Rs./kW [27-30]. By using fuzzy logic programming, most correct solution for the given cost ranges can be obtained. Figure 5. shows the trapezoidal membership function of wind turbine generating system cost analysis. The trapezoidal curve is a function of a vector, $CostWT_{min-max}$ and depends on four scalar parameters $CostWT_1, CostWT_2, CostWT_3$, and $CostWT_4$ as given by, Eq. (2).

The capital cost used from 6000 to 8000 per battery. Battery capacity used 2V, 742Ah. The replacement cost was 4800 to 6400 Rs. [41]. By using fuzzy logic programming, most correct solution for the give cost ranges can be obtained. Figure 6. shows the trapezoidal membership function of battery cost. The trapezoidal curve is a function of a vector, $CostBT_{min-max}$ and depends on four scalar parameters $CostBT_1, CostBT_2, CostBT_3$, and $CostBT_4$ as given by, Eq.(3)

For HES 2kW converter have been considered. The capital cost of converter ranges from 10000 to 15000 Rs., replacement cost 8000 to 12000 Rs. [31,32]. By using fuzzy logic programming, most correct solution for the give cost ranges can be obtained. Figure 7. shows the trapezoidal membership function of converter cost. The trapezoidal curve is a function of a vector, $CostCN_{min-max}$ and depends on four scalar parameters $CostCN_1, CostCN_2, CostCN_3$, and $CostCN_4$ as given by, Eq.(4).

$$f(CostPV_{min-max}; CostPV_1, CostPV_2, CostPV_3, CostPV_4) = \left\{ \begin{array}{ll} 0, & CostPV_{min-max} \leq CostPV_1 \\ \frac{CostPV_{min-max} - CostPV_1}{CostPV_2 - CostPV_1}, & CostPV_1 \leq CostPV_{min-max} \leq CostPV_2 \\ 1, & CostPV_2 \leq CostPV_{min-max} \leq CostPV_3 \\ \frac{CostPV_4 - CostPV_{min-max}}{CostPV_4 - CostPV_3}, & CostPV_3 \leq CostPV_{min-max} \leq CostPV_4 \\ 0, & CostPV_4 \leq CostPV_{min-max} \end{array} \right\} \quad (1)$$

$$(CostWT_{min-max}; CostWT_1, CostWT_2, CostWT_3, CostWT_4) = \left\{ \begin{array}{ll} 0, & CostWT_{min-max} \leq CostWT_1 \\ \frac{CostWT_{min-max} - CostWT_1}{CostWT_2 - CostWT_1}, & CostWT_1 \leq CostWT_{min-max} \leq CostWT_2 \\ 1, & CostWT_2 \leq CostWT_{min-max} \leq CostWT_3 \\ \frac{CostWT_4 - CostWT_{min-max}}{CostWT_4 - CostWT_3}, & CostWT_3 \leq CostWT_{min-max} \leq CostWT_4 \\ 0, & CostWT_4 \leq CostWT_{min-max} \end{array} \right\} \quad (2)$$

$$f(\text{CostBT}_{\min-\max}; \text{CostBT}_1, \text{CostBT}_2, \text{CostBT}_3, \text{CostBT}_4) = \left\{ \begin{array}{ll} 0, & \text{CostBT}_{\min-\max} \leq \text{CostBT}_1 \\ \frac{\text{CostBT}_{\min-\max} - \text{CostBT}_1}{\text{CostBT}_2 - \text{CostBT}_1}, & \text{CostBT}_1 \leq \text{CostBT}_{\min-\max} \leq \text{CostBT}_2 \\ 1, & \text{CostBT}_2 \leq \text{CostBT}_{\min-\max} \leq \text{CostBT}_3 \\ \frac{\text{CostBT}_4 - \text{CostBT}_{\min-\max}}{\text{CostBT}_4 - \text{CostBT}_3}, & \text{CostBT}_3 \leq \text{CostBT}_{\min-\max} \leq \text{CostBT}_4 \\ 0, & \text{CostBT}_4 \leq \text{CostBT}_{\min-\max} \end{array} \right\} \quad (3)$$

$$f(\text{CostCN}_{\min-\max}; \text{CostCN}_1, \text{CostCN}_2, \text{CostCN}_3, \text{CostCN}_4) = \left\{ \begin{array}{ll} 0, & \text{CostCN}_{\min-\max} \leq \text{CostCN}_1 \\ \frac{\text{CostCN}_{\min-\max} - \text{CostCN}_1}{\text{CostCN}_2 - \text{CostCN}_1}, & \text{CostCN}_1 \leq \text{CostCN}_{\min-\max} \leq \text{CostCN}_2 \\ 1, & \text{CostCN}_2 \leq \text{CostCN}_{\min-\max} \leq \text{CostCN}_3 \\ \frac{\text{CostCN}_4 - \text{CostCN}_{\min-\max}}{\text{CostCN}_4 - \text{CostCN}_3}, & \text{CostCN}_3 \leq \text{CostCN}_{\min-\max} \leq \text{CostCN}_4 \\ 0, & \text{CostCN}_4 \leq \text{CostCN}_{\min-\max} \end{array} \right\} \quad (4)$$



Figure 4: Trapezoidal membership function of solar PV system cost analysis

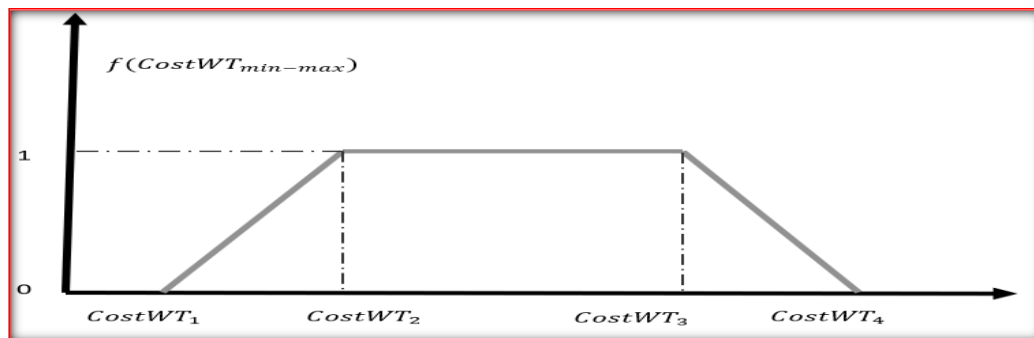


Figure 5: Trapezoidal membership function of wind turbine generating system cost analysis

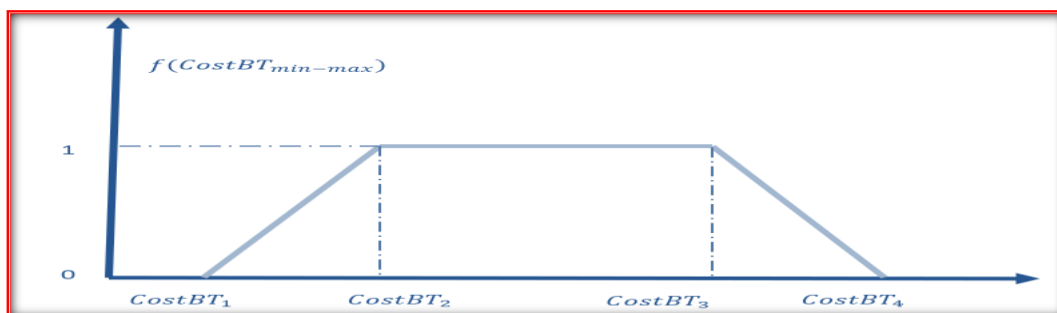


Figure 6: Trapezoidal membership function of battery cost analysis

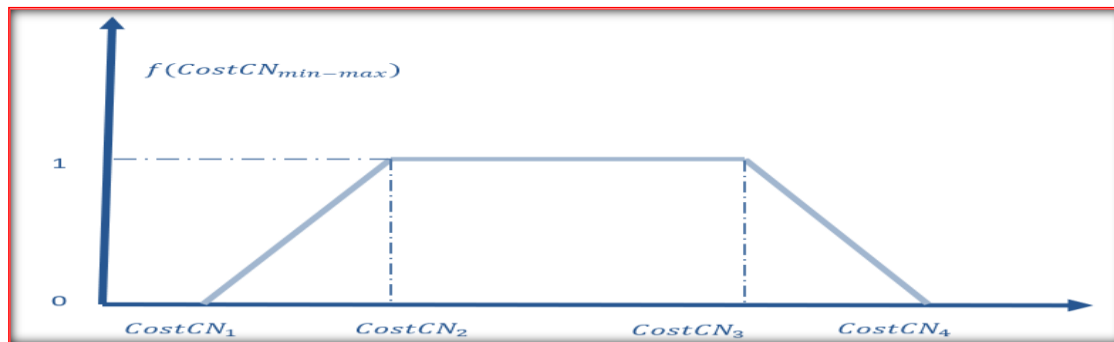


Figure 7: Trapezoidal membership function of converter cost analysis

IV. HOMER SIMULATION MODEL

The optimal sizing and costing of the components of the proposed hybrid energy system have been done using HOMER pro software (version 3.11.6). The name HOMER is an abbreviation of a Hybrid Optimization Model for Electrical Renewable, and it is developed by U.S. National Renewable Energy Laboratory (NREL) [33,34]. HOMER Pro is connected to grid and allows simulation of off-grid systems, which include various combinations of solar PV modules, wind turbines, biomass-based power generators, micro-turbines, fuel cells, batteries, hydrogen storage and many fuel auxiliary generators. Generating electricity from Options and different types of loads the proposed simulation model is designed using HOMER Pro software. Figure 8. Shows a proposed system architecture of HES based on three renewable energy sources. In this HES uses a combination of a solar photovoltaic, wind turbine and battery . The battery is an energy storage device; it acts as a source of energy when the load demands additional energy which cannot be satisfied by the power generating sources [36,37].

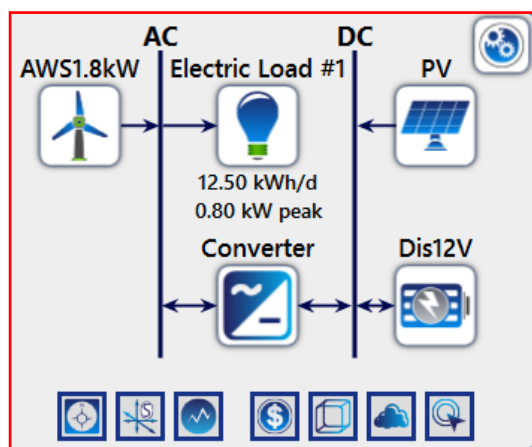


Figure 8: The proposed system architecture of hybrid energy system

The calculation criteria for analysing the current work is based on Net Current Cost (NPC), Cost of Energy (COE) and Salvage Cost (SC). The costs include cost of capital cost, replacement costs, O & M costs, fuel costs, emissions penalties, and the cost of buying power from the grid. [34] Revenue includes rescue costs and grid sales revenue. HOMER pro analyses the total net present cost consuming the following, Eq. (5).

$$C_{NPC} = \frac{C_{AT}}{CRF(i_r, N_{proj})} \quad (5)$$

Where C_{NPC} is the total NPC (\$), C_{AT} is the total annualized cost (\$/year). CRF is the capital recovery factor, i_r is the interest rate of (6.18%), N_{proj} is the project lifetime in years (20 years).

$$CRF(i_r, N_{proj}) = \frac{i_r (1+i_r)^{N_{proj}}}{(1+i_r)^{N_{proj}} - 1} \quad (6)$$

The yearly actual interest rate is the bargain rate old after a change in one-time costs then annualized costs. The longevity yearly real interest rate is to be considered from the nominal interest rate and expressed as Eq. (7).

$$i_r = \frac{i' - f}{1 + f} \quad (7)$$

Where i' is the nominal interest rate, f is the annual inflation rate.

The total annualized cost of HES is expressed as following, Eq. (8).

$$C_{AT} = C_{A,Ca} + C_{A,Re} + C_{A,OM} + C_{A,Fu} \quad (8)$$

Where $C_{A,Ca}$ is the annualized capital cost (\$), $C_{A,Re}$ is the annualized replacement cost, $C_{A,OM}$ is the annualized maintenance cost, $C_{A,Fu}$ is the annualized fuel cost of HES component. The annualized capital cost of a component can be calculated by using the following, Eq. (9). [35,40].

$$C_{A,Ca} = C_{I,Ca} \times CRF(i_r, N_{proj}) \quad (9)$$

Where $C_{I,Ca}$ is the initial capital cost of the component

The annualized replacement cost of a component can be calculated by using the following, Eq. (10).

$$C_{A,Re} = C_{Re} \times F_{Re} \times SFF(i_r, N_{comp}) - S \times SFF(i_r, N_{proj}) \quad (10)$$

Where C_{Re} is the replacement cost of the component (\$), F_{Re} is the replacement factor, SFF is the sinking fund factor, S is the salvage value of the component.

To evaluate the financial viability of the project, the Levelized cost of energy (CoE) of generation has been calculated as, Eq. (11).

$$CoE = \frac{C_{AT}}{E_{PL} + E_{DL} + E_G} \quad (11)$$

Where E_{PL} is the primary load served (AC and DC) in kWh/year, E_{DL} is the deferrable load served in kWh/year, E_G is the total grid sales.

Optimization techniques require some data contributes such as hour load demand, availability of energy resources, system technical and financial data HES components, positive end value of the user's end capacity and other obstacles mandatory by the modeler. Battery bank storage limits At any hour (t), battery bank storage capacity is subjected to the following constraint as:

$$E_{Battmin} \leq E_{Batt}(t) \leq E_{Battmax} \quad (12)$$

where, $E_{Battmin}$ and $E_{Battmax}$ respectively represent minimum and maximum value of battery bank storage capacity.

In the considered HES, excess electricity is generated under the condition when total generation exceeds demand and simultaneously, battery reaches to its maximum storage capacity. Mathematically, excess electricity (kWh/yr) in the considered HES has been estimated as:

$$P_{EE}(t) = \begin{cases} P_{Gen}(t) - P_{Load}(t); & \text{When } P_{Gen}(t) > P_{Load}(t) \text{ and } E_{Batt}(t) = E_{Battmax} \\ 0; & \text{Otherwise} \end{cases} \quad (13)$$

$$E_{EE} = \sum_{t=1}^{8760} P_{EE}(t) \quad (14)$$

where, $P_{EE}(t)$ is hourly excess power (kW), $P_{Gen}(t)$ is sum of hourly generation from all the considered resources (kW), $P_{Load}(t)$ is hourly electrical energy demand (kW) and E_{EE} is annualized excess electricity in kWh/year.

V. RESULTS AND DISCUSSION

In this section present, the overall capital and replacement cost analysis of different components of HES are presented. Fuzzy trapezoidal membership function for capital and replacement cost of HES components are discussed in section 3. Using different defuzzification methods optimum value of capital and replacement cost is computed.

Table 1: Overall optimum capital cost (CC) and replacement cost (RC) of different defuzzification methods Solar PV.

	Solar PV capital cost (CC)	Solar PV replacement cost (RC)
Centroid Method (CM)	65012 (Rs.)	53008 (Rs.)
Bisector Method (BM)	64985 (Rs.)	53102 (Rs.)
MOM	64250 (Rs.)	54000 (Rs.)
SOM	54000 (Rs.)	47000 (Rs.)
LOM	74500 (Rs.)	61000 (Rs.)

Table 2: Overall optimum capital cost (CC) and replacement cost (RC) of different defuzzification methods wind turbine.

	wind turbine capital cost (CC)	wind turbine replacement cost (RC)
Centroid Method (CM)	76034 (Rs.)	60256 (Rs.)
Bisector Method (BM)	76033 (Rs.)	60303 (Rs.)
MOM	76520 (Rs.)	60500 (Rs.)
SOM	70180 (Rs.)	56000 (Rs.)
LOM	82860 (Rs.)	60500 (Rs.)

Table 3: Overall optimum capital cost (CC) and replacement cost (RC) of different defuzzification methods battery.

	Battery capital cost (CC)	Battery replacement cost (RC)
Centroid Method (CM)	7052 (Rs.)	5681 (Rs.)
Bisector Method (BM)	7053 (Rs.)	5685 (Rs.)
MOM	7075 (Rs.)	5760 (Rs.)
SOM	6450 (Rs.)	5250 (Rs.)
LOM	7700 (Rs.)	6270 (Rs.)

Table 4 Overall optimum capital cost (CC) and replacement cost (RC) of different defuzzification methods Converter

	Converter capital cost (CC)	Converter replacement cost (RC)
Centroid Method (CM)	12602 (Rs.)	10086 (Rs.)
Bisector Method (BM)	12602 (Rs.)	10087 (Rs.)
MOM	12602 (Rs.)	10103 (Rs.)
SOM	10618 (Rs.)	8720 (Rs.)
LOM	14585 (Rs.)	11485 (Rs.)

Fuzzy logic algorithms are used in the HOMER Pro software as input parameters to calculate the optimal cost analysis of the proposed hybrid energy system. The maximum optimum cost, as shown in the figure given below, is obtained by SOM method, this cost of hybrid energy system for different parameters is felt on the basis of performance. HES component with size, cost and power generation is given in this figure. The most feasible HES consists of a 2 kW solar PV and 2 kW wind turbine to obtain the minimum total net present cost and cost of energy with minimum percent capacity shortage. The NPC is 274981 (Rs) and COE is 5.14 (Rs). Table 5. has shown the 20 years net present cost of HES components. Table 6. has shown the annualized cost of HES components.

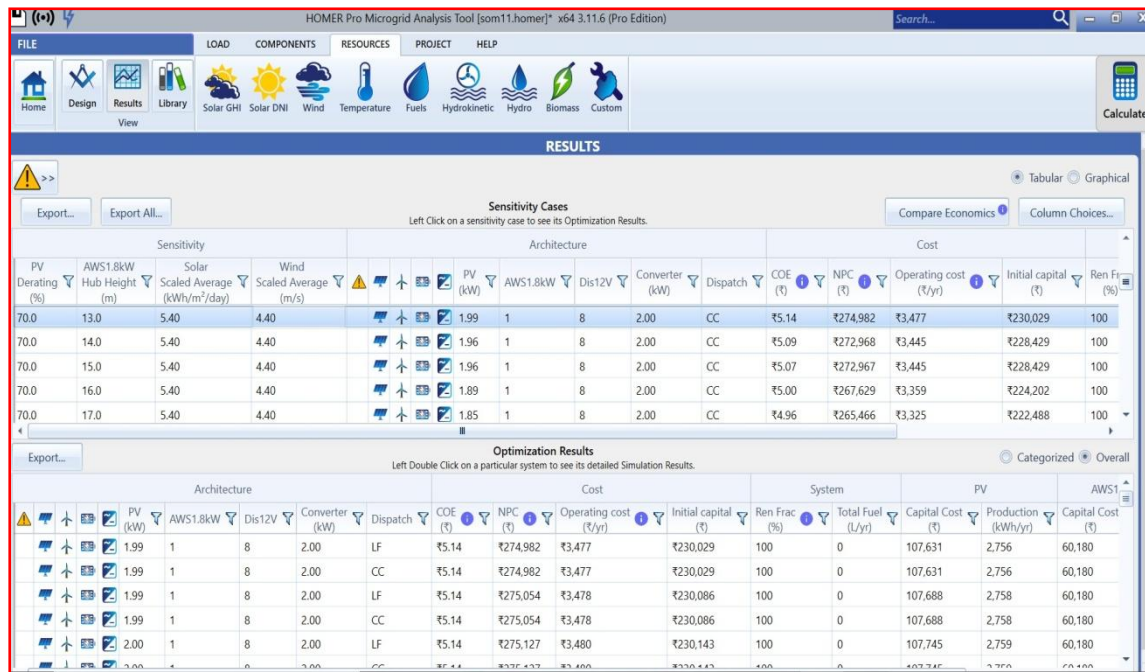


Figure 9: HOMER Simulation Results with Sizing and Cost Analysis based on SOM Method

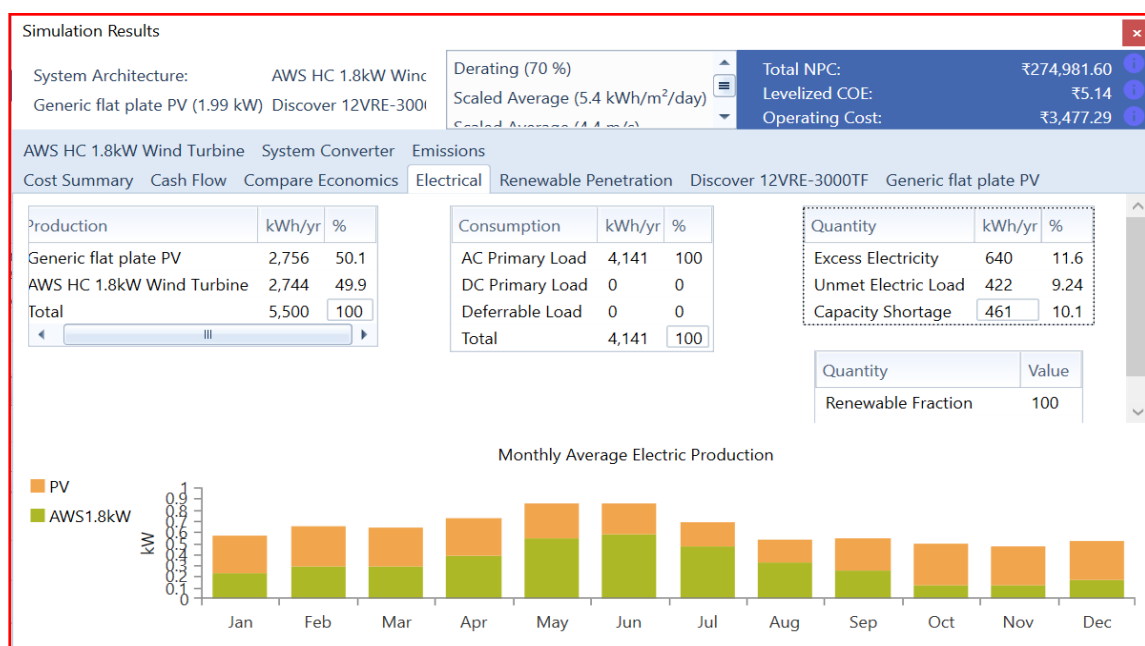


Figure.10: Optimum sizing and costing results based on SOM method.

Table 5. 20 year Net Present Costs of HES components

Component	Capital(Rs)	Replacement(Rs)	O&M(Rs)	Salvage(Rs)	Total(Rs)
Wind Turbine	₹60,180.00	₹15,328.26	₹1,292.75	(₹8,638.46)	₹68,162.55
Battery	₹51,600.00	₹33,659.76	₹5,171.01	(₹7,845.84)	₹82,584.92
Solar PV	₹107,630.86	₹0.00	₹2,576.67	₹0.00	₹110,207.53
System Converter	₹10,618.00	₹3,402.68	₹646.38	(₹640.42)	₹14,026.63
System	₹230,028.86	₹52,390.69	₹9,686.80	(₹17,124.72)	₹274,981.63

Table 6: yearly Net Present Costs of HES components

Component	Capital(Rs)	Replacement(Rs)	O&M(Rs)	Salvage(Rs)	Total(Rs)
Wind Turbine	₹4,655.19	₹1,185.71	₹100.00	(₹668.22)	₹5,272.67
Battery	₹3,991.49	₹2,603.73	₹400.00	(₹606.91)	₹6,388.31
Solar PV	₹8,325.72	₹0.00	₹199.32	₹0.00	₹8,525.03
System Converter	₹821.35	₹263.21	₹50.00	(₹49.54)	₹1,085.02
System	₹17,793.74	₹4,052.65	₹749.32	(₹1,324.67)	₹21,271.03

VI. CONCLUSIONS

HESs are developing as the most prevalent and operative solutions for energy supply problems in many parts of the world. Stand-alone HES, which uses renewable energy sources, acts as a reliable and clean source of energy. This paper has examined the possibility of supply of electrical power for the supply of power located in the Energy Park, RGPV Bhopal to 23 degree 31 'N latitude and 77 degrees 36' longitude, India. Fuzzy logic cost optimization with HOMER pro software involves 2 kilowatt solar PV and 2 kilowatt wind turbine to achieve the most cost-effective energy costs with at least total capacity costs. NPC is 274981 (Rupees) and COE is 5.14 (Rupees). It can be seen that the power generation of solar PV is 2756 kWh / year and wind turbine power generation is 2744 kWh / year. Total electricity generation for supply demand of 4141 kWh / year is 5500 kWh / year. From the analysis, it is concluded that solar PV, wind turbine and battery runs at different times of day so that the demand for load is easily fulfilled without any interruption.

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