

Performance Analysis of Optimal Sized Hybrid Renewable Energy Grid-Connected Systems

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Abstract

Hybrid solar energy-based power generation systems (PGS) are one of the exciting options for potential distributed networks. PV and wind grid linked PGSs are the most appropriate for its good output across various configurations. However, due to the system's complexity, special attention is required to achieve a successful engineering solution in the optimal balance between these two energy sources. This paper discusses optimum scale of PV and wind by following multiple optimization methods to various condition decision analysis (VCDA). The versatility of the VCDA algorithm was tested by taking into account several weighting parameter techniques for differing wind speeds and fluctuations in radiation levels, thus illustrating the advantages and limitations of the suggested optimum size approaches. The subsequent study can be called upon as a significant reference for decision makers, analysts and policymakers.

Key Words —Optimization of power plant design, various condition decision analysis, PV-WP systems.

Taxonomy

HRE	hybrid renewable energy	N_{PV}	PV modules number
PGSs	power generation systems	T_A	Ambient temperature.
VCDA	various condition decision analysis	$I_{SC.STC}$	Short-circuit current under nominal test criteria
K_I	Short-circuit current constant	T_{ref}	PV cell temperature at 28°C.
K_V	Open-circuit voltage constant	V	Speed of wind at the H_{WT}
WP	Wind Power	N_{PV}, N_{WP}, N_P	duration for PV, WT, and PGS systems.
P_{VP}	PV installed power	PV_{SV}	PV recover value.
PV_{OM}	PV maintenance and running costs.	W_{TP}	WP installed power
WP_{SV}	WP salvage value for each kW	β, γ, Ψ	Inflation rate, interest rate, growth rate.
w_j^s	Subjective criteria weight.	k	Criteria final score.
NOCT	Nominal operating cell temperature.	ξ	Coefficient of wind speed
$P_{WP.max}$	Maximum power of wind plant.	$P_{WT.out}$	Actual output WT power.
C_p	Efficiency of the wind turbine	α, β, γ	Coefficients similar to the generator emission feature.
$\eta_{PVinv.}$	PV system inverter efficiency	T_A	Ambient temperature
$\eta_{WPInv.}, \eta_{Mech}$	Inverter efficiency, mechanical components efficiency	I_{int}	Primary expenditure
v_{ci}, v_{ra}, v_{co}	inward, standard, outward wind speeds	FF	Fill factor
I_{int}	Initial investment		
v_r	Wind speed calculated at the reference height H_r		

Introduction

Hybrid renewable energy (HRE) is deemed most critical in the coming days for power generation systems (PGSs) in view of the complexities of increasing renewable energy (REE). Even as its research continues technologically and economically, HRE PGSs have shown internationally recognized environmental and social benefits. The non-consistent output power

for a standalone power generation systems contribution between several options is highly likely to be PV-WP generation systems. Net-connected hybrids have a large potential. The optimal design of these systems requires care, requiring trade-offs between decision-making criteria to improve sustained energy development. Technical literature is rich in proposals on methods for optimizing the size of hybrid PGS. Specific techniques have in the past been used on various methods. The new program will provide a unique technological performance [4]–[10]. PSO [1], genetic algorithms [2] and [3], non-linear, mixed integer programme [4], dual-simulation annealing-tabu search algorithms [5] and specific prospects for dual GMP price optimisation. A certain target feature is assumed in general to be reduced, which mainly is the overall cost of the system; certain technological and environmental criteria may be incorporated in the sizing phase in two schemes: firstly, considering the necessities as restrictions and, secondly, the transfer of the additional method. Therefore, the ultimate judgment on both methods is similarly relevant to all system requirements / variables. With the aid of a Multi-Objective PSO or genetics algorithm the Pareto system is considered to be a great solution collection in [11] and [12] at the same time to boost objective functions (environment, economic or technical). Thus these methods provide the best solution for different PV-WP configurations, thus leaving the decision maker's final choice, which may not be a simple task. In addition, all the parameters in this case are equally relevant. Essence, the right hybrid PV-WP method, a big balance of various parameters in design, contributes to a suboptimal solution cannot be derived from the solutions that are already proposed. The particle swarm optimization (PSO) algorithm was used for optimal location and tuning of a new custom power device (CPD) for minimization of the total CPD injected currents and the total harmonic distortion (THD) of current and voltage. Hence, the real-time control of reactive power with CPD was suggested. The PSO method was proposed to find out the optimal

size and location of the distributed active filter system for reducing total losses while satisfying harmonic voltages, THD limits on a typical 37-bus distribution system [13]. In [14] optimal location of UPQC for enhancing the power quality in distribution network under critical situations has been investigated. Cuckoo Optimization Algorithm is proposed to find the optimal placement and number of UPQCs for improving the power quality issues. Reconfiguration system and placement of UPQC were used for power loss reduction and maintaining voltage stability in a distribution network with different evolutionary algorithms [15]. Then, a steady-state model of UPQC was used for the forward/backward sweep load flow. Distributed power condition controller (DPCC) with the fuzzy based PI controller was proposed in [16] to enhance power quality in a multi-microgrid. The relative capacity credit of the renewable power plants is typically 25-50 percent. The intermittent renewable sources and loads in grid cause many negative problems in these networks.

In this article the VCDA approaches are used to solve some of the above limits so that the optimal size share can be defined among PV and WP plants. The suggested solution helps one to hit the optimal level by simultaneously implementing various criteria (technique, economic, environmental or social), without trying to transform it into a single entity. The responsiveness of the proposed algorithms has therefore also been evaluated in the light of the various weighting parameters and specific variance circumstances based on speed of wind and radiation emits from solar system. This can be used during either a new PGS hybrid design or the assessment of various unusual development for an accessible system. The following design models are described in Section II. Section III explains the VCDA and its suggested approach to optimization; Section IV provides the findings of a realistic argument for research and, ultimately, its implications are summarized in Section V.

Modeling and Concept systemic methods

This segment shows the numerical models taken for various PV-WP size configurations and theoretical design constraints. PGS aims primarily to meet cargo demand and enhance sustainability. If ample HRE sources are available then zero economic interest is used for the additional energy produced after meeting demand for price. The HRE plant is expected to respond best to the demand curve and therefore will not provide local power supplies with extra energy at a competitive rate. On the other side, if renewable energy reserves are small, the electricity shortfall is faced by the grid. Therefore, the load requirement factor is an essential input to the formulation criterion and is measured as recognised system data.

1. PV System Model

The developed power P_{PV} can be analyzed by the following expression:

$$P_{pv}(t) = N_{PV} V_{OC}(t) I_{SC}(t) \eta_{PVinv} FF(t) \quad (1)$$

Though open circuit voltage and short circuit current were depend on the required temperature T_C and the universal irradiance R_G . The numerical relationship was expressed by the following equations:

$$V_{OC}(t) = V_{OC.STC} + K_v(T_C(t) - T_{ref}(t)) \quad (2)$$

$$I_{SC}(t) = \{I_{SC.STC} + K_I[T_C(t) - T_{ref}(t)]\} \frac{R_G(t)}{1000} \quad (3)$$

$$T_C(t) = T_A(t) + \frac{NCOT - 20}{800} R_G(t) \quad (4)$$

2. Wind Power Generation Systems

The amount of wind power can be developed by its speed variation and can be expressed using [12].

$$v(t) = v_r(t) \cdot \left(\frac{H_{WT}}{H_r} \right)^\xi \quad (5)$$

The overall power generated by WP is computed by

$$P_{WT,max}(t) = \frac{1}{2} \rho A v(t)^3 C_{p\eta WTInv} \eta_{Mech}. \quad (6)$$

$$P_{WT,out} = \begin{cases} 0 & v(t) < v_{ci} \\ P_{WT,max} & v_{ci} \leq v(t) < v_{ra} \\ P_r & v_{ra} \leq v(t) \leq v_{co} \\ 0 & v_{co} < v(t) \end{cases} \quad (7)$$

The aforesaid numerical models of PV and WP were utilized to forecast and run the developed power linked to variable PV-WP generation system.

3. Design Criteria

This paper chooses to optimize the various design criteria, which reflect the ecological, cost-effective and social outline of the suggested ecological criteria — C_1 emission reduction. The reduction of atmospheric pollutants from SO_2 and NO_x emissions from HRE sources to accomplish the load is estimated in ton / h emissions rather than in fossil-fueled thermal units [11].

$$E_{ms}. = \alpha + \beta \sum_{t=1}^T P_{out}(t) + \gamma \left(\sum_{t=1}^T P_{out}(t) \right)^2 \quad (8)$$

Performance Criteria—Estimated Costs (C_2): This performance condition is measured as the amount of installation expenditure, operating and repair, and electricity from system costs minus the recovery benefit of photovoltaics or transmitting systems. The

following equations are used for the calculation of this performance criterion, labeled EC[11]:

$$I_{inv.} = PV_p PV_C + WT_p WT_C \quad (9)$$

$$SV_{PV_P} = PV_p PV_{SV} \left(\frac{1+\beta}{1+\gamma} \right)^{N_{pv}} \quad (10)$$

$$SV_{WT_P} = WT_p WT_{SV} \left(\frac{1+\beta}{1+\gamma} \right)^{N_{wt}} \quad (11)$$

$$SV_{PGS_P} = SV_{PV_P} + SV_{WT_P} \quad (12)$$

$$OM_{PV_P} = PV_p PV_{OM} \sum_{i=1}^{N_{pv}} \left(\frac{1+\psi}{1+\gamma} \right)^i \quad (13)$$

$$OM_{WT_P} = WT_p WT_{OM} \sum_{i=1}^{N_{wt}} \left(\frac{1+\psi}{1+\gamma} \right)^i \quad (14)$$

$$OM_{PGS_P} = OM_{PV_P} + OM_{WT_P} \quad (15)$$

$$C_{grid} = E_{grid} E_{cost} \quad (16)$$

$$EC = \frac{I_{inv.} - SV_{PGS_P} + OM_{PGS_P}}{N_p} + C_{grid}. \quad (17)$$

Social Criteria—Social Acceptance (C3): In this sense, the usage of the land and its visual effects have been taken into account, including, social impact evaluation phase, electromagnetic interference, acoustic disruption, flicker shades and habitat disturbance [15]. The use of the land involves social opposition to the deployment of the Hybrid PV-WP generation systems.

The social requirements methodology is carried out in this report using a fugitive logical algorithm, which reveals the input variables being the land area used in PGS and the amount of WP required, while the performance of this algorithm represents an indication

of social approval. The input and output quantity membership functions displayed in Fig. 1. Table I provides relevant fuzzy guidelines. In this article, the lesser number of WPs to fit the power demanded is provided greater priorities in installing PGS.

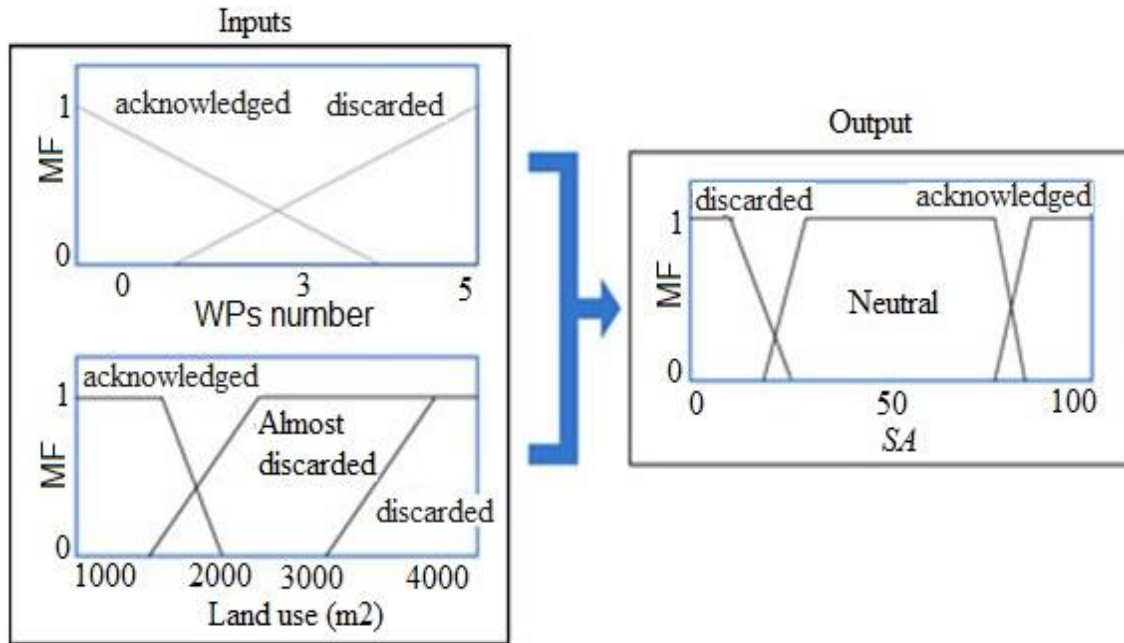


Fig.1. Social acceptance of designed membership functions.

TABLE I

Social acceptance for designed criterion

Rule	If (Area utilize)	WP number	Then (SA)
i	acknowledged	acknowledged	acknowledged
ii	almost discarded	acknowledged	acknowledged
iii	discarded	acknowledged	discarded
iv	acknowledged	discarded	neutral
v	almost discarded	discarded	discarded
vi	discarded	discarded	discarded

In the projected case study, the profiles shown in Fig.1 were used where the minimum installed PV capacity was set at a level up to 50 kW; wind power generation systems of 10, 30 and 50 kW have also been considered, and the arrangement of three wind generator turbine sizes consent for the maximum of possession as the least number of WPs is forced. With regard to calculations of land use, 1 kW installed photovoltaic power requires a maximum of 10m² [16], though essential land for the wind power generation system is measured in accordance with installation regulations and thumb rules. PGS includes the minimum land needed for PV and WP. Models for social analysis of requirements may vary from place to place since embracing or rejecting local populations relies heavily on their group.

4. *Design Constraint*

The overall energy intake from the HRE method is limited to a minimum by enforcing that certain quantities shall not be more than a certain threshold level for the pre-defined evaluated duration T, presumed to be 8450 H (per year). These are the following parameters:

$$TEL = \begin{cases} \sum_{t=1}^T (E_{PGS}(t) - LD(t)), \\ 0, \end{cases} \quad (18)$$

$$0 < TEL \leq THR$$

In conjunction with the energy efficiency policy implemented by the Network, the net energy generated from excess power is sold to the grid. The suggested optimization strategy also views excess electrical electricity as unjustified added expenses and, regardless of the added infrastructure built, societal acceptability fines, these must be

reduced. The importance of threshold depends very promptly on the output of PGS and is 0.5% of EPGS were considered.

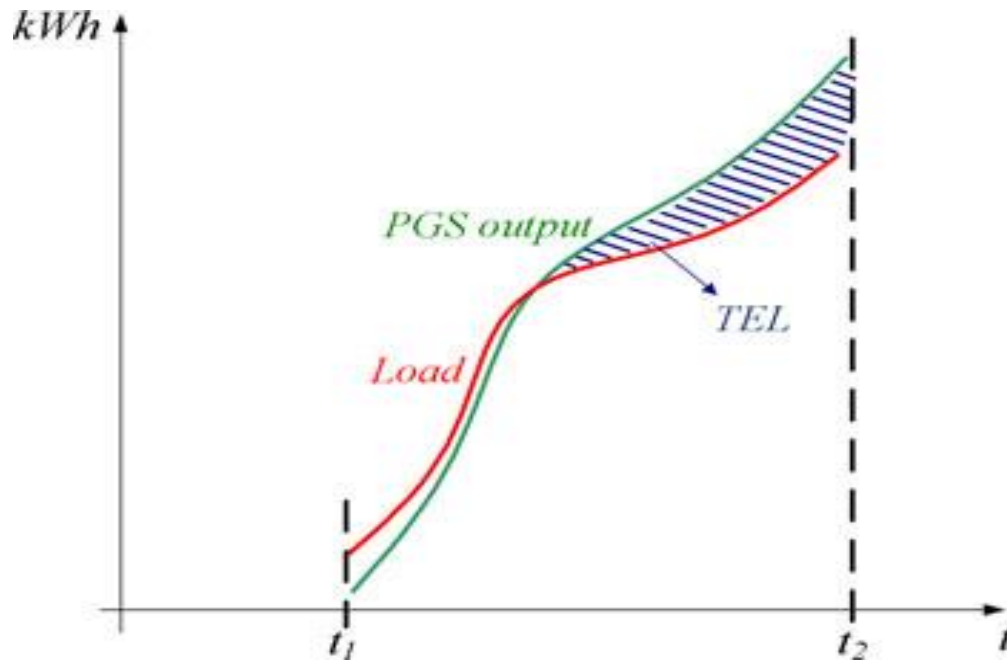


Fig.2 Illustration of Total energy lost (TEL).

SIZE OPTIMIZATION OF PV AND WP GENERATION SYSTEMS

The suggested technique uses various condition and decision analysis VCDA to achieve an optimum size of PV-WP systems in accordance to a variety of parameters, as stated in the introduction. VCDA approaches equate two or more choices with two or more parameters where each parameter has a given weight in its final judgment. In the following equation [17], the question could be formulated as:

$$\text{Condition} = [c_1 \quad c_2 \quad \dots \quad c_n] \quad (19)$$

$$\text{Weights} = [w_1 \quad w_2 \quad \dots \quad w_n] \quad (20)$$

$$X = \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_m \end{matrix} = \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1n} \\ X_{21} & X_{22} & \dots & X_{2n} \\ \dots & \dots & \dots & \dots \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{bmatrix}_{m \times n} \quad (21)$$

X_{ij} is the value of i^{th} parameter adjacent to the j^{th} condition and calculated by PV-WP simulations in this analysis. In order to solve multicriteria issues, as outlined in the previous section, the definition of criteria and alternatives is necessary and the weights of criteria and performance matrix will also be required.

1. Weighting Techniques

The suggested design method takes different weighting techniques to allow sensitivity study of the outcomes. These methods are briefly described below. Smarter is a discretionary option that tests model strategy, depending on its experience and interests. It relies on policy makers' judgment. The parameters considered (1 for the main criterion, 2 for the following criterion,) were graded by every participant decision-maker. The final conditions are then paired with all the results of the decision-makers for the same criterion. On this scale is based the weight of the parameters defined as j^{th} [18].

$$w_j^s = \frac{1}{n} \sum_{k=j}^n \frac{1}{k} \quad (22)$$

Entropy is a goal weighting method based on X which results in higher weight values if a larger discrepancy between the column of performance criteria (alternatives) has been achieved. For implementing Entropy, the following steps [19] are necessary.

i) P_{ij} can be estimated by using

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}} \quad (23)$$

ii) E_j can be estimated by using

$$E_j = -z \sum P_{ij} \ln P_{ij} \quad (24)$$

iii) d_j can be estimated by using

$$d_j = 1 - E_j \quad (25)$$

iv) w_j^b can be estimated by using

$$w_j^b = d_j / \sum_{j=1}^m d_j \quad \text{where } 0 \leq \omega_j^b \leq 1 \quad \text{and} \quad \sum_{j=1}^n w_j^b \quad (26)$$

Two different ways of combining the above-mentioned weighting methods are adequately followed:

$$ASCWM = (q \times w_j^s) + ((1-q) \times w_j^b) \quad (27)$$

$$MSCWM = \frac{w_j^s, w_j^b}{\sum_{j=1}^n w_j^s, w_j^b} \quad (28)$$

2. Sources sizing algorithm

The HPGS by an HG using PV and WP is modelled as given belows:

$$P_G^{(i,j)}(t) = N_{PV}^i P_{PV}(t) PV_{status}^i(t) + N_{WT}^j P_{WT}(t) WT_{status}^j(t) \quad (29)$$

$\forall i \in [1, i_{max}], j \in [1, j_{max}], t > 0$

where

$$PV_{status}^i(t) = \begin{cases} 0 & G_{PV}^i(t) < FOR_{PV} \quad \forall t > 0 \\ 1 & otherwise \end{cases} \quad (30)$$

where

$$G_{PV}^i(t) = rand()$$

and

$$WT_{status}^j(t) = \begin{cases} 0 & G_{WT}^j(t) < FOR_{WT} \quad \forall t > 0 \\ 1 & otherwise \end{cases} \quad (31)$$

where

$$G_{WT}^i(t) = rand()$$

subjected to following capacities constraints:

$$N_{PV}^{\min} \leq N_{PV}^i \leq N_{PV}^{\max}$$

$$N_{WT}^{\min} \leq N_{WT}^i \leq N_{WT}^{\max}$$

PVs and WPs, P_{PV} and P_{WP} are the power produced by the PV – WP networks, PV status and the state of WPs is a PV and WP level, which decides whether it should be power or not. PV and WP are the PV's and WP's. If the value of the PV status of a solar PV is 0, it means that because of some fault or other reason the Solar PV cannot produce power. The PV status and WP status values are determined with the forced ratings for PV and WP as defined in (10) and (11). The random numbers G_{PV} and G_{WP} are the numbers generated with the MATLAB command rand). A minimum and maximum number of PVs and WPs were determined using the following expression:

N_{PV}^{\min} , N_{WP}^{\min} , N_{PV}^{\max} and N_{WP}^{\max} · N_{PV}^{\min} .

$$N_{PV}^{\min} = \frac{\sum_{t=1}^n \alpha P_L(t)}{\sum_{t=1}^n P_{PV}(t)} \quad (32)$$

$$N_{WP}^{\min} = \frac{\sum_{t=1}^n \beta P_L(t)}{\sum_{t=1}^n P_{WP}(t)} \quad (33)$$

$$N_{PV}^{\max} = \frac{\sum_{t=1}^n \gamma P_L(t)}{\sum_{t=1}^n P_{PV}(t)} \quad (34)$$

$$N_{WP}^{\max} = \frac{\sum_{t=1}^n \rho P_L(t)}{\sum_{t=1}^n P_{WP}(t)} \quad (35)$$

where α , β , γ and ρ are constant factors and n is required interval. The instant error among generation and load can be computed by:

$$\square p^{(i,j)}(t) = P_L(t) - P_G^{(i,j)}(t) \quad \forall t > 0 \quad (36)$$

where Δp shows the instant error. The overall instant error were represented by ΔP and computed as

$$\square P^{(i,j)}(t) = \sum_{t=1}^n (\square p^{(i,j)}(t)) \quad \forall t > 0 \quad (37)$$

A smaller cumulated failure value indicates that an unreliable generation efficiently meets the need for the load whereas a larger combined failure value implies that the difference between the blended generation of renewable energy and the need for load is large. The accumulated error is estimated and processed in a matrix as follows for any conceivable PV / WP combination:

$$\Delta P = \begin{bmatrix} \Delta P^{(1,1)} & \dots & \Delta P^{(1,j_{\max})} \\ \vdots & \ddots & \vdots \\ \Delta P^{(i_{\max},1)} & \dots & \Delta P^{(i_{\max},j_{\max})} \end{bmatrix}_{(i_{\max} \times j_{\max})} \quad (38)$$

where ΔP is the error matrix representing all total error potential values. In the NPV and NWP variables, values which are equal to increasing total error are preserved as :

$$N_{PV} = \left[N_{PV}^{\min} \quad \dots \quad N_{PV}^{\max} \right]_{(i_{\max} \times 1)}^T \quad (39)$$

$$N_{WT} = \left[N_{WT}^{\min} \quad \dots \quad N_{WT}^{\max} \right]_{(1 \times j_{\max})} \quad (40)$$

A search area is developed by taking ΔP , N_{PV} and N_{WT}

$$S_{area} = \begin{bmatrix} 0 & N_{WT} \\ N_{PV} & \Delta P \end{bmatrix}_{(i_{\max}+1) \times (j_{\max}+1)} \quad (41)$$

The S_{area} includes all possible PV and WP compounds and cumulative errors corresponding to each compound. The minimum value of ΔP is reduced by selecting from each column of the minimum value.

$$\Delta P_{\min} = [\Delta P_{\min}^1 \cdots \Delta P_{\min}^{j_{\max}}]_{(1 \times j_{\max})} \quad (42)$$

where

$$\begin{aligned} \Delta P_{\min}^j &= \min(S_{space}(z, j)) \forall j \\ z &= 2, \dots, i_{\max} + 1 \end{aligned} \quad (43)$$

The values of N_{PV} and N_{WP} that match to each ΔP_{\min} are expressed as

$$N_{PV_{\min}} = [N_{PV_{\min}}^1 \cdots N_{PV_{\min}}^{j_{\max}}]^T_{(j_{\max} \times 1)} \quad (44)$$

$$N_{WT_{\min}} = [N_{WT_{\min}}^1 \cdots N_{WT_{\min}}^{j_{\max}}]_{(1 \times j_{\max})} \quad (45)$$

The logic of SSA is presented in Fig.4.

Initialization: $i \leftarrow 1, j \leftarrow 1, t \leftarrow 1$

• **Data Generation**

Read: $c, \sigma, I, Load$

Calculate: $P_{PV}, P_{WT}, P_L, N_{PV}^{min}, N_{WT}^{min}, N_{PV}^{max}, N_{WT}^{max}, P_G$

Save: $P_{PV}, P_{WT}, P_L, N_{PV}^{min}, N_{WT}^{min}, N_{PV}^{max}, N_{WT}^{max}, P_G$

• **Search Space Formation**

While $i \leq i_{max}$ **Do**

While $j \leq j_{max}$ **Do**

Calculate: $\Delta P^{(i,j)}, \Delta P$

Save: $\Delta P, N_{PV}, N_{WT}$

Calculate: S_{space}

$j \leftarrow j + 1$

End While

$i \leftarrow i + 1$

End While

• **Reduced Search Space Formation**

While $j \leq j_{max} + 1$ **Do**

While $i \leq i_{max} + 1$ **Do**

Calculate: $\Delta P_{min}^j, N_{PV_{min}}^j, N_{WT_{min}}^j$

$i \leftarrow i + 1$

End While

Calculate: $\Delta P_{min}, N_{PV_{min}}, N_{WT_{min}}$

$j \leftarrow j + 1$

End While

Calculate: RS_{space}

Fig. 4 Algorithm 1: SSA

Results and discussions

The variations of solar PV and WP power are shown in the Fig.6. As previously stated, efficiency and costs are the key criteria for the evaluation of microgrid output. It should be remembered that a mixture of WP and PV is given for increasing solution vector array, and total installed ability of RE sources is improved by an improvement in the array. The optimum combination is the index with an optimal decision variable value. Due to the higher value of the optimum decision variable, the reliability at reasonably low cost is comparatively higher while the lowest value of the optimal decision variable shows a high reliability at high costs or low reliability at lowness. The combination PV and WP, which correlates to the SV index number 187, is the optimal answer from Fig.5. The PV and WP power is respectively 57 MW and 187 MW. The limit and then the patterns for the optimum judgment variable value were found at the outset. Lower ODV values at the onset are attributed to a smaller volume of energy supplied in PV and WP power. Similarly, ODV values are also small for higher indices, because costs are very high with largely installed capacity, making the solution un-economic. Although its impact on ODV is higher (service of energy) compared to costs, as the expense of RE sources and storage is high and overall cost becomes even higher for very large capacities, which makes a solution very expensive. In addition to this, the Figs.6. It may also be noticed that the exactly minimum and maximum PV and WP capacity limitations must be chosen though the optimum size of each method is determined. The limitations can cause the algorithms to operate in a region that has low ODV values and leads to a solution that is uneconomic. As stated previously, the RE sources' production is erratic, hence it may happen, during service of the HG, that the Reg performance is inadequate to satisfy the demand needed, in these situations the HG purchases energy from the utilities grid to transfer the load. The Fig.5 shows the overall energy

transferred by the HG and the utilities grid to reach the necessary load. It is seen that the change in indexes raises the energy given by the HG while the energy generated by the power grid declines. At first, HG-supported electricity decreases and the grid capacity declines both saturated and heavy. The increase in demand and generation is seen over the span of one year in Fig.6. The supply can be shown to still be the same as demand. As the analysis network is linked to the grid and the power grid acts as a buffer. Therefore when the production capacity of HG is not appropriate for supplying the necessary load demand, HG acquires power from the grid, which renders the overall device extremely stable.

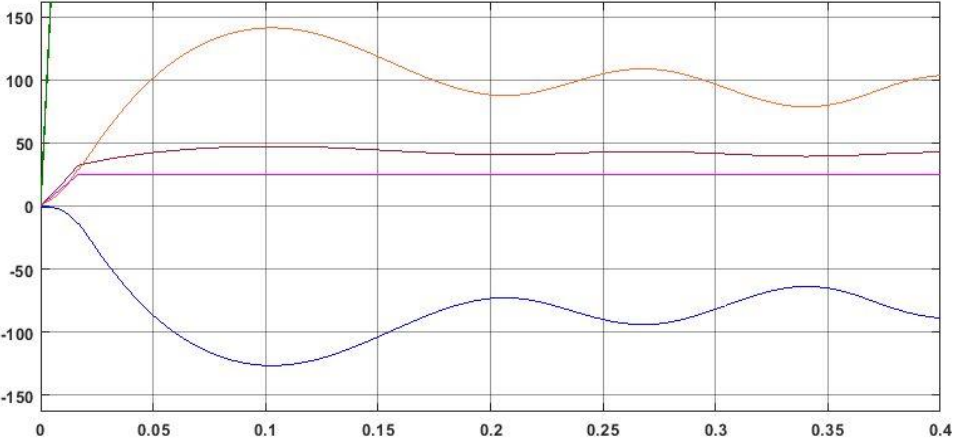


Fig. 5 Energy relationship among grid and HG

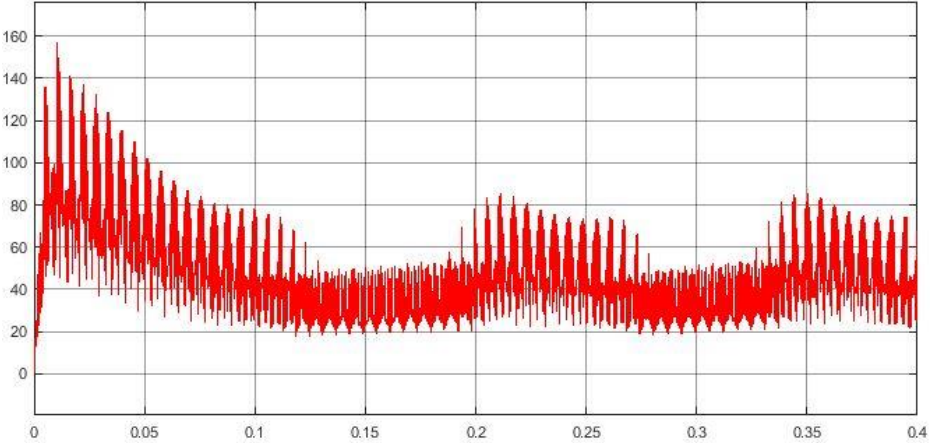


Fig. 6 deviation in generation and demand across the year.

Through the use of PSO algorithms, the issues of sizing are designed to prove the global equilibrium is feasible. The PV and WP algorithm gives an effective power of 57.3 MW and 187 MW. Therefore, both algorithms found a small variation in PV size because of the rendering factor. The two algorithms produce less time and guarantee maximum global results while the calculation time for the proposed algorithm is the same. In addition, the proposed technique can not view how the solution is established and how the algorithm can be contacted in order to find the solution that is needed in a straightforward and comprehensible way.

In Fig.7 presented that the hybrid fluctuations of the WG and PV power generation were effectively controlled below the 10 percent limit for the 10 minutes using method 2. The results above show that using the control method 2 the rate of power fluctuations in the specific ranges can more efficiently be regulated. It should also be noted that the filter time constant needs to be modified and updated timely because of the inertia feature of the first order filter, otherwise sometimes the power fluctuation limit is difficult to ensure. It is important that this method (Method 1) is a function of the variable time constant checks strategy. Method 2 is however not only more easy to apply, but also can ensure the efficient control of the power fluctuation rate within a limited range once power fluctuation limit value is provided. Moreover, the power fluctuation rate limit value will be regularly updated on the basis of operating conditions of the specific location. It is also suggested.

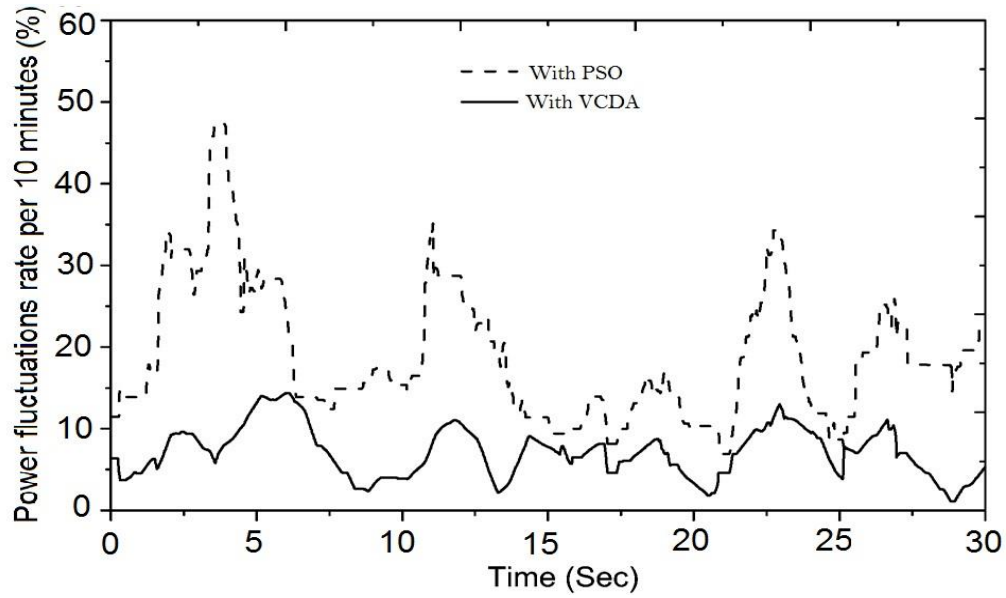


Fig. 7 Comparison with existing the Schemes

A comparative statement with different schemes was presented in Fig.8. The proposed technique exhibits better performance.

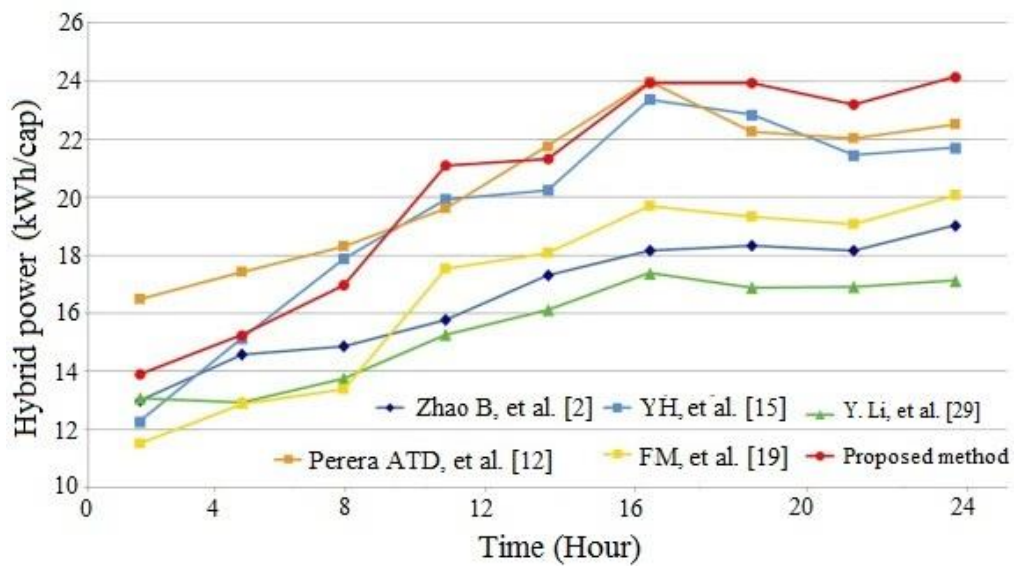


Fig. 8 Comparison with existing the Schemes

The algorithm proposed also does not require parameter tuning, like traditional optimization approaches focused on impact and testing methods. Table 2 identifies the different potential approaches to demonstrate the efficiency, based on unit cost, the energy provided by renewable energies (energies provided by HG) and CO₂ emissions, of the suggested methodology.

Table II Input Data

Load Type	Maximum Load	Average Load	Factors of Load
	300 kW	48kW	46%
Climate Conditions	Maximum Value		Base Value
Speed of Wind	24m/s		4.9 m/s
Radiation produced by Sun	845 W/m ²		149.4W/m ²

Case I shows that the technology of modern generation generates both electricity. The lowest cost per unit is, while in this situation the highest emissions. The remaining cases show that electricity comes from both HG and station. The general costs of Case II are practical, and there are also sensible emissions occurred in this condition. The renewable energy used in case III is understandable in comparison to case II. Table 3 indicates that the rise in the renewable energy percentage given by switching from Cases II to III equals the decreased expense percentage.

**TABLE III
WP AND PV CELL PARAMETERS**

Wind Turbines	
Particulars	Values
Power	250 MW
Impedance	0.765Ω
Inductance	3.52 mH
Magnetizing Flux	0.25 wb
No. of Poles (DFIG)	4
Torque (Max)	2.32 Nm/A
Wind speed (Avg)	14 m/s
PV modules	
Number of cells	36
Highest power	150 W
OC voltage (V_{oc})	35.24 V

SC current (I_{sc})	8.33 A
Max. Volt	57.14 V
Max. Current	8.35 A

The percentage reduction in CO₂ emissions is also rising, counter to the investment increase. Case III levels are approximately 70% lower than those for Case I, i.e. modern decades. Cases III CO₂ levels are also less than Case III. Case V has the lowest CO₂ emissions, but in this case, the power of RE and BESS sources for most is very high per units of expenditure. The cost for each product in Case I V remains higher and CO₂ pollution decreased. The above discussion clearly shows Case III to be an excellent solution because it offers considerable clean energy and reduces CO₂ emissions significantly per unit charge, namely 14.27 c / kWh at a reasonable cost. It should be remembered that cost is the aspect / function of several other factors , for example where solar irradiation, wind velocity or load curve is more accurately associated, contributes to a more cost reduction, which renders our optimized approach stronger and more rational. MATLAB is utilized to model and simulate. Simulation is conducted on the core i7 6th generation RAM platform, 2.6 GHz, 16 GB.

Conclusion

A technique to optimize the capacity of RE sources e.g. was proposed in this paper. The optimal capacity is measured on the basis of the energy supplied per unit cost ratio. The ideal method has been shown to be inexpensive and to contain less emissions of CO₂. A cost- and pollution analysis is often made under some chosen situations, and the best alternative is proven to be preferable to the other alternatives. The value of the approach suggested resides in ensuring that it will not over- and under-size as all feasible alternatives are found. Moreover, forced outages of

WP are considered to make the methodology more practical. The suggested approach is very general and can be extended to different types of generation and storage technologies and to other geographical locations.

Compliance with Ethical Standards

1. Disclosure of potential conflicts of interest: The authors declare that they have no conflict of interest.

2. Research involving human participants and/or animals: This paper does not contain any studies with human participants or animals performed by any of the authors.

3. Informed consent: Informed consent was obtained from all individual participants included in the study.

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