Multi-Objective Optimal Location and Sizing of Hybrid Photovoltaic System in Distribution Systems Using Crow Search Algorithm

Anand Kumar Pandey*‡, Sheeraz Kirmani*

*Department of Electrical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, New Delhi-110025, India

(anand.pandey.42@gmail.com, Sheerazkirmani@gmail.com)

‡ Corresponding Author; Anand Kumar Pandey, Jamia Millia Islamia, New Delhi-110025, India, Tel: +91 7838434833, anand.pandey.42@gmail.com

Received: 10.10.2019 Accepted:20.11.2019

Abstract- The optimal size and location of Distributed generation (DG) in a distribution system can minimize the power loss and improve the voltage profile of the distribution system. But the random placement of DG will not solve the problem of power loss and voltage profile. Therefore optimization algorithms are used to find the optimal size and location of DG to minimize the power loss and to improve the voltage profile. This research paper introduces a new metaheuristic algorithm which is the Crow search algorithm (CSA) to calculate the optimal size and location of multiple solar photovoltaic (PV) units for reducing the power loss and improving the voltage profile. This paper also discusses the complete mathematical modeling of probabilistic PV generation, time-varying load modeling, loss calculation, voltage stability, and optimal PV size calculation. The method proposed in this paper is tested on IEEE 30 and 57 bus test systems and compared with other existing methods like Genetic algorithm (GA), Particle swarm optimization (PSO) and Hybrid GA-PSO method. CSA has only 2 settings parameters while GA and PSO have 6 and 3 settings parameters. Because of this, computation time and complexity of the algorithm are less in comparison to other methods and it gives a better result. Therefore by using the CSA method, the optimal size and location of the DG can be found which gives less power loss and improved voltage profile, less computational time and easy to implement compared to other existing methods proposed here.

Keywords Solar PV, Distributed Generation, Crow search algorithm, Genetic Algorithm, Particle swarm optimization, hybrid GA-PSO method and optimal size.

1. Introduction

Power system performance in terms of the power losses and voltage profile can be improved by the use of renewable energy sources such as solar, wind, biogas, geothermal etc. As the data compiled by ministry of power around 22 percent of the total electricity produced in India got lost during distribution. There are many states in India which have as high as 40 percent transmission and distribution (T&D) losses. Odisha has 38.2 percent T&D loss in May 2018 which is worst among all the state second state is Madhya Pradesh which has 37.7 percent T&D loss which is followed by West Bengal having 31.44 percent T&D loss [1]. Table1 below gives the T & D losses in terms of total electricity generated in different states of India. From the table 1 it is obvious that the T&D losses plays a major role in Power system performance. One of the solutions to tackle this problem is to use distributed generators at load center. The definition of the Renewable energy resources or Distributed generations (DG) or embedded generation is that a source which is connected near to the load [2]. To minimize the power loss and improve the voltage profile placement of DG in distribution systems plays a major role. A random placement of DG will lead to more power losses and poor voltage profile. Therefore DGs are placed at optimal location of optimum size so that power loss can be reduced and voltage profile can be improved[3]. In literature different methods has been suggested to find the optimal size and location of DG in Distribution system. These methods can be classified as classical methods, artificial intelligent methods and hybrid intelligence methods. Comparison of each method is mentioned and given in [4]. From the paper it is clear that each method has some advantages and disadvantages both. In [3, 5] analytical methods are proposed to find the best size and location of DGs. In [6-8] Genetic algorithm (GA) approach and method is explained to find the optimal size and location of DG. Paper [9-12] discusses particle swarm optimization (PSO) method to find the

Table 1: State wise T&D losses

S.N.	State	T & D loss (in percent)	S.N.	State	T & D loss (in percent)
1	Himachal Pradesh	9.54	10	Chhattisgarh	20.84
2	Uttranchal	25.02	11	West Bengal	31.44
3	Haryana	23.7	12	Maharashtra	20.1
4	Rajasthan	25.1	13	Odisha	38.2
5	Uttar pradesh	29.6	14	Telangana	15.9
6	Bihar	31.8	15	Karnatka	15.4
7	Assam	22.1	16	Andhra Pradesh	21.8
8	Gujarat	15.4	17	Kerala	15.26
9	Madhya Pradesh	37.7	18	Tamil Nadu	14

optimal size and location of DG. An Artificial bee colony (ABC) method is explained in [13] to find the size and location of DG. In[14] ant lion optimization method is used to discuss the problem of DG location and sizing. In the literature different optimization methods has been discussed to find the optimal size and location of DG. In [15] GA and PSO combined method for the improvement of result has been proposed to find the location and size of DG. Mixed integer conic programming method is presented in [16] to find the type, location and sizing of battery and DG. In [17] author has included uncertainties of DG to find the optimal location and size of DG. In [25-30] different authors have used different methods and mathematical functions for planning of distribution systems. Methods which comes under classical approach has disadvantage of large computation time, slow convergence and can consider single objective while methods which comes under artificial intelligence category has advantage of efficient performance, needs fewer iterations and can handle complex problems but disadvantage of many setting parameters [4]. Parameter setting is one of the draw backs of optimization algorithms since it is time consuming work. Algorithms which have fewer parameters to adjust are easier to implement. In Crow search algorithm (CSA) only two parameters flight length and awareness probability need to be tuned while in GA six parameters like selection method, cross over method, cross over probability, mutation method, mutation probability and replacement method need to be tuned in PSO algorithm four parameters inertia weight, maximum value of velocity, individual learning factor and social learning factor need to be adjusted. This paper suggests a new metaheuristic method for optimal solar PV placement which has only 2 setting parameters. The remaining sections are as follows: Section 2 discusses about solar PV, load and energy storage modelling Section 3 explain problem formulation section 4 application of Crow search algorithm to find the optimal size of solar PV, Section 5 discusses about the result and discussion and in the last Section 6 we discuss about the conclusion.

2. Solar PV, Load and Energy storage modelling:

2.1 Solar PV modelling

Output of the PV module depends on the temperature and solar irradiation; from the panels the maximum amount of power can be extracted. The power value can vary with respect to time due to its normal and abnormal condition of weather pattern, changes of climate condition. The probabilistic nature of solar irradiance can be described using the beta probability distribution function as[15].

$$BDF = \begin{cases} \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)}(R^{a-1})(1-R^{b-1}) & 0 \le R \le 1, a, b \ge 0 \\ 0 & otherwise \end{cases} \quad (1)$$

Where BDF, is the beta distribution function; a,b are the parameters of beta distribution function; R denotes the random variable of solar irradiance.

$$b = (1-\mu)[\frac{\mu(1+\mu)}{\sigma^2} - 1] \quad (2)$$

$$a = \frac{\mu \times b}{1-\mu} \quad (3)$$

The standard deviation (σ) and the mean (μ) values are .given in table 4.

The maximum power, fill factor of the panel, voltage, current, and temperature of the panels are derived by following equations[15]

Maximum power:

$$P(R) = N \times ff \times V_x \times I_x \quad (4)$$

The output power at different irradiance P(R) , number of modules are (N), fill factor is (ff), voltage and current obtained from the PV is V_x and I_x respectively.

Fill factor:

$$ff = \frac{V_{mp} \times I_{mp}}{V_{oc} \times I_{sc}} \quad (5)$$

V_{mp} and I_{mp} is the voltage and current at maximum power point; V_{oc} and I_{sc} is the Open circuit voltage and current.

Voltage:

$$V_x = V_{oc} - C_v \times T_{ycell} \quad (6)$$

Current:

$$I_x = R[I_{sc} + C_i \times T_{ycell}] \quad (7)$$

In (6 and 7) the open circuit voltage is (V_{oc}); Short circuit current (I_{sc}); voltage and current temperature coefficient (C_v, C_i).The cell temperature (T_{ycell}).

Cell temperature:

$$T_{ycell} = T_a + R(\frac{N_{ot}-20}{0.8}) \quad (8)$$

The normal operating temperature (T_{ycell}), the ambient temperature (T_a) is in (8).

Output power:

$$P(\tau) = \int_0^1 P(R) \times BDFdr \quad (9)$$

2.2 Load Modelling:

In this paper commercial load is assumed. The load under study is assumed to follow 24-h daily commercial load curve[16]. This is voltage dependant and represented by active and reactive power injection.

Active power injection:

$$P_k(\tau) = P_L(\tau) \times V_k^{np}(\tau) \quad (10)$$

Reactive power injection:

$$Q_k(\tau) = Q_L(\tau) \times V_k^{nq}(\tau) \quad (11)$$

In above equation (10, 11), the active and reactive loads are arranged as $P_L(\tau)$ and $Q_L(\tau)$; voltage at kth bus is $V_k^{np}(\tau), Q_L(\tau); P_k(\tau)$is the active power injections and $Q_k(\tau)$ is the reactive power injections at bus k. np=1.51 and nq=3.40 are respectively commercial load voltage exponents.

2.3 Energy storage modelling:

The battery energy storage (BES) is the battery and it is modelled to save energy, first calculate the demand power of 24 hrs, and it varies. Beyond the limit of load demand, energy is stored in the battery else, it supplies the power to the distribution system. The charging and discharging of battery at bus k in period t can be expressed as [17]

At Discharging:

$$\varepsilon_k(\tau) = \varepsilon(\tau-1) - \frac{P^{D_{ch}}(\tau)}{\eta_D}\Delta\tau, For\ P(\tau) > 0 \quad (12)$$

At charging:

$$\varepsilon_k(\tau) = \varepsilon(\tau-1) - \eta_c P^{ch}(\tau)\Delta\tau, For\ P(\tau) < 0 \quad (13)$$

The total energy stored in the battery ($\varepsilon_k(\tau)$); $P^{D_{ch}}(\tau)$ is Power at discharging; $P^{ch}(\tau)$ is at charging; η_d, η_c are the charging and discharging coefficients of battery; $\varepsilon_k(\tau)$ is total energy stored in the battery.

The upper and lower bounds of the BES unit is taken as follows[18]:

$$E_{BESK}^{min} \le E_{BESK}(t) \le E_{BESK}^{max}$$

Where $E_{BESK}^{min}$and E_{BESK}^{max} represent the minimum and maximum limit of the energy stored in BES unit. The minimum and maximum limit are assumed to be 20% and 90% of the total capacity of the BES unit [18].

3. Problem Formulation:

3.1 Conceptual design :

Proposed conceptual model of a stand-alone roof top PV-BES system is shown in fig. 1a and b. The idea is to minimize the active and reactive power losses for each load level at the minimum with a combination of PV-BES units. This modelling can be accomplished due to the PV and energy storage, and it can generate hybrid energy with variation of time and it is given by,

$$\epsilon(P_v + E_s)_k = \int_0^\tau P_k(\tau)d\tau$$
$$\Rightarrow \sum_{t=1}^{24} P_k(\tau)\Delta t \quad (14)$$

Here, in a 24-h day cycle when the PV output is zero or small battery supply energy to the load and for PV output more than load demand battery stores energy. The power factors of PV-BES unit are selected for each 1-h period. This approach can reduce energy loss, which is related to active and reactive power loss index. In this paper PV and battery units are placed at the same bus to avoid energy losses during charging of the battery.

3.2 *Active power loss index (APLI) and Reactive power loss index (RPLI)[15]*

3.2.1 Active Power loss index (APLI)

In a radial distribution system having n branches, the total active power loss (Ploss) can be given as:

$$P_{loss} = \sum_{j=1}^{k} \frac{P_j^2 + Q_j^2}{|V_j|^2} R_j \quad (15)$$

Total active power loss (P_{loss}(Pv+Es)) in the system because of the DG and BES both can be given as :

$$P_{loss}(P_v + E_s) = \sum_{j=1}^{k} \frac{P_k^2 - 2P_jP_k}{|V_j|^2} R_j + \sum_{j=1}^{k} \frac{a_k^2 P_k^2 - 2Q_j a_k P_k}{|V_j|^2} R_j + P_{loss} \quad (16)$$

$$APLI = \frac{P_{loss}(P_v+E_s)}{P_{loss}} \quad (17)$$

$$Q_K = a_K P_K \quad (18)$$

Where, $a_K = \pm\tan(\cos^{-1}(pf_k))$

Active power loss index is APLI ; the resistance and the voltage magnitude of the node is R_j and $|V_j|$ it is represented in (15-17).

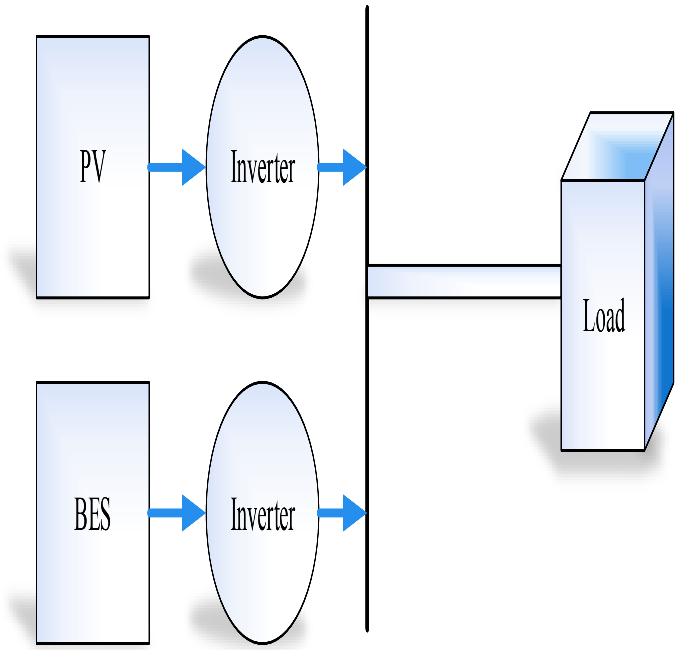

Fig. 1(a). Model of a PV-BES system connected to a load

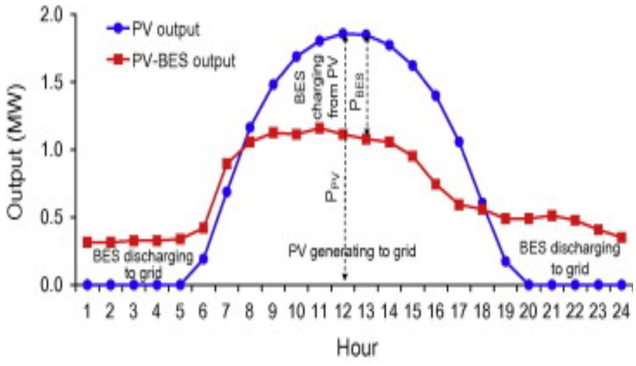

Fig. 1(b). Charging and discharging characteristics of BES and PV output.

3.2.2 Reactive power loss index

In a radial distribution system having n branches, the total reactive power loss (Q_{loss}) can be given as :

$$Q_{loss} = \sum_{j=1}^{k} \frac{P_j^2+Q_j^2}{|V_j|^2} X_j \tag{19}$$

Total reactive power loss (Q_{loss}(Pv+Es)) in the system because of the DG and BES both can be given as :

$$Q_{loss}(P_v + E_s) = \sum_{j=1}^{k} \frac{P_k^2 - 2P_jP_k}{|V_j|^2} X_j + \sum_{j=1}^{k} \frac{a_k^2P_k^2 - 2Q_ja_kP_k}{|V_j|^2} X_j + Q_{loss} \tag{20}$$

$$RPLI = \frac{Q_{loss}(P_v+E_s)}{Q_{loss}} \tag{21}$$

The reactive power loss index is RPLI; Q_{loss} is the reactive power loss

3.3 Multi-objective index (MOI)

Multi-objective index is given as:

$$MOI = \sigma_1 APLI + \sigma_2 RPLI \tag{22}$$

Where $\sum_{i-1}^{2} \sigma_i = 1$

The (MOI) is the multi-objective index. It is the addition of active power loss index (APLI) and reactive power loss index (RPLI). σ_1 and σ_2 are impact indices which values lies between 0 to 1. In this paper the value of σ_1 and σ_2 are taken as 0.7 and 0.3 respectively[19]. Finding the suitable values of the weight depends on the experience and concerns of the engineers. Now the average multiobjective index (AMOI) over the total time (T=24 h) can be calculated as:

$$AMOI = \frac{1}{\tau}\int_0^{\tau} MOI(\tau)d\tau \tag{23}$$

$\Rightarrow$

$$\Rightarrow \frac{1}{24}\sum_{t=1}^{24} MOI(\tau)d\tau \tag{24}$$

Minimum value of the AMOI over the total time indicated gives the best PV and BES allocation for energy loss reduction and voltage stability improvement.

3.4 Objective Function:

The objective function is to minimize the active and reactive power loss of the system using mutiobjective index (MOI) i.e. Objective function

$$\min(MOI) = \min\left(\frac{\sigma_1}{P_L} P_{LPV} + \frac{\sigma_2}{Q_L} Q_{LPV}\right) \tag{25}$$

Where P_L and P_{LPV} indicate the active power loss of the system without and with DG system. Q_L and Q_{LPV} indicate the reactive power loss of the system without and with DG system.

Under the constraints of:

$$V^{min} \le V_k(\tau) \le V^{max} \tag{26}$$

$$DG^{min} \le DG \le DG^{max} \tag{27}$$

V^{min} and V^{max} are minimum and maximum voltage limit of the bus. DG^{min} and DG^{max} are the minimum and maximum size of the DG.

3.5 Energy loss and Voltage stability

Energy loss:

Total energy loss in a year over the time period of 24 h can be obtained as:

$$E_{loss} = 365 \sum_{t=1}^{24} P_{loss}(\tau)\,\Delta\tau \tag{28}$$

Where $P_{loss}(t)$ is active power loss at any time t.

Voltage stability:

Active power demand

$$P_{demand} = \lambda P_0 \tag{29}$$

Reactive power demand

$$Q_{demand} = \lambda Q_0 \tag{30}$$

P_o and Q_o are initial active and reactive power demand respectively.

4. Proposed Methodology:

The output of the solar system depends on the solar irradiance and the temperature. The battery is required to store the energy, and it can supply the energy when the PV system is in abnormal condition. The major problem in the distribution systems are charging, discharging, PV size, and DG location. The capacity of the PV panels are varies in accordance with the voltage, and power. We can estimate how much amount of power can be generated from the single panel, and it will be equal in all kind of panels. First, discuss the optimization algorithms to reduce the optimal size, and the battery is designed to save the power as well as discharge the power, for these reasons the algorithms are established. The system is analysed in IEEE 30, and IEEE 57 bus system.

Crow Search Algorithm (CSA) [20]

One of the meta-heuristic algorithms is a crow search algorithm, which can be used to find the optimal sizing and location of DG system. The inspiration of the algorithm is based on the intelligence of the crows. The lifestyle of the crows depend on the following behaviors,

- Self-awareness
- Recognition faces
- Using tools
- Warn and flock
- Sophisticated communication ways
- Recalling the food's hidden place

The brain bodies ratios of the crows are slightly differ from the humans, while comparing with other birds; the crows are the most intelligent birds in nature. The evolutionary process among the crows are defined as hiding of food and recovering the extra food. The position of the crow and the number of iteration is considered in equation (31).

$$Z(l.m) = \langle z^1(l,m), z^2(l,m), \dots\dots, z^n(l,m)\rangle; for \begin{cases} i = 1,2,..,N \\ k = 1,2,\dots.,max \end{cases} \quad (31)$$

The crow has the best remembering capability, which can easily get the best visited location and it is represented by,

$$R(l,m) = \langle r^1(l,m), r^2(l,m), \dots\dots, r^n(l,m)\rangle \quad (32)$$

The behaviour of the crows are pursuit, and evasion which is defined by,

Pursuit:

The crows are moving like one by one to knows about the hidden place, moving of first crow never seen the following crow, unfortunately the follower can take food

Evasion:

When the crow knows about the follower, it just take the decision to move randomly, for that calculate the probability (ap) of random generation. The uniformly distributed values () are taken as 0 and 1. The major calculations are awareness probability, and taking a random value.

$$if\ d_l \geq ap = 1\ and\ d_l \leq ap = 0$$

The probability of the random value is greater than awareness probability, then the condition is given by,

$$Z(l, m+1) = [z(l,m) + d_l \times f_g(l,m) \times (R(l,m) - Z(l,m))] \quad (33)$$

The position can be evaluated by,

$$\begin{cases} F(z(l,m+1))\ if\ F(z(l,m+1) < F(z(l,m)) \\ (l,m) \qquad\qquad\qquad otherwise \end{cases} \quad (34)$$

In above representation, $F(z(l,m+1))$ term denotes the objective function, in which calculate the sizing of PV.

Step1: Input the line data, bus data, bus voltage limit and adjustable parameters of the algorithm like flock size (N), maximum number of iterations ($iter_{max}$), flight length (fl) and awareness probability (AP).

Step2: Calculate the active power loss and reactive power loss using eqn. (15, 19) and initialize the position and memory of crows.

Step3: Find the value of objective function for each crow using eqn. (25) and determine the position.

Step4: Now generate the new position for each crow using eq. (34)

Step5: Check the feasibility of each position, if the new position of the crow is feasible the crow updates its position otherwise stays in the same position.

Step6: Evaluate the fitness function of new positions.

Step7: Update memory .If the fitness function value of the new position of the crow is better than the fitness function value of the memorized position, the crow updates its memory by the new position.

Step8: Check termination criterion. Steps 4-7 are repeated until $iter_{max}$is reached. When the termination criterion is met, the best position of the memory in terms of the objective function value is reported as the solution of the optimization problem.

Table 2: Nomenclature used in Proposed Methodolog

$Z(l,m)$	Position of the crow
N	Number of individual crows
k	Maximum number of iteration
$R(l,m)$	Visited location
$g(l,m)$	Flight length
$R(l,m)$	Best position
f	Random variable

The algorithm related with the works are given in the pseudo code and it is by,

Table 3: Algorithm of CSO

Step 1: Initialize Decision variables (load flow)
Step 2: Population size (24hrs)
Step 3: Initialize current and voltage temperature coefficients (equation6&7)
Step 4: Initialize the size of PV
Step 5: Set upper and lower bounds
Step 6:Evaluate the objective function (Min (PV Size))
Step 7: Find fitness function of all position between the upper and lower bounds
Step 8: Initialize maximum number of iteration
Step 9:For
t=1:maximum number of iteration
Choose random variables based on population size
For
i=1:N(24hrs)
If rand position>step 3
Generate new position for first state
Else
For
j=1:step 1
Generate new position
End
End
End

Step 10: Evaluate fitness of new generated coefficients
Step 11: Repeat step 9, until reach the better results
End

The analysis and expressions are mathematically derived and the results are taken which is given in next section.

5. Result and Discussion

The definition wise the optimal size is the size, which can maximize the internal rate of the return investment of the PV system. Fist initializing the load flow, and finding the losses of the system. The values of generated active and reactive power, as well as the active and reactive load power are taken for the calculation. Here the IEEE 30 and 57 bus test system is carried out for the analysis of the proposed system. The details about the test systems are given in []. The output of the solar PV panel, voltage, losses and the size of the panel are analyzed for the IEEE 30 and 57 bus test system, which is discussed in this section. For the study purpose 4 units of solar PV system has been taken at different power factor explained in Fig.2. From the solar PV modelling discussed in problem formulation section, Output power of the unit 1 Solar PV panel is calculated using eqn. (1) to (9) and Table.1-2 and represented in Fig.3. For unit 2, 3 and 4 similar calculation and graph can be plotted. All these units are placed at pre-defined locations unit 1and unit 3 are assumed to be placed at bus number 22, 25, and 29. Unit 2 and unit 4 are placed at 20, 29. By considering these locations optimal size of four units has been calculated.

Table 4: Mean & Standard deviation of solar irradiance

Hour	μ(kw/m^2)	σ (kw/m^2)	Hour	μ(kw/m^2)	σ (kw/m^2)
1	0	0	13	0.657	0.164
2	0	0	14	0.612	0.147
3	0	0	15	0.497	0.143
4	0	0	16	0.349	0.116
5	0	0	17	0.203	0.081
6	0.007	0.021	18	0.068	0.063
7	0.081	0.036	19	0.003	0.012
8	0.237	0.056	20	0	0
9	0.400	0.087	21	0	0
10	0.523	0.127	22	0	0
11	0.632	0.156	23	0	0
12	0.663	0.162	24	0	0

Table 5: PV module characteristics

PV module characteristics	Value
Nominal Cell operating temperature, N_{OT} (^{0}C)	43
Current at maximum power point, I_{MPP} (A)	7.76
Voltage at maximum power point, V_{MPP} (V)	28.36
Short circuit current, I_{sc} (A)	8.38
Open circuit voltage, V_{oc} (V)	36.96
Current temperature coefficients, K_i (A/^{o}C)	0.00545
Voltage temperature coefficients, K_v (V/^{o}C)	0.1278

The output power obtained from the unit-1 in each interval of time is plotted on semi-log graph in Fig.1

Now, by using the crow search optimization algorithm which is proposed in this article and explained in proposed methodology section we can find the optimal size of Solar PV panel. This is given in Table 6.

Result of IEEE- 30 bus test system:

Now if we compare the size of solar PV before and after the optimization obtained from the proposed method and plotted in Fig. 3. We comment that size of the solar PV is reduced after the optimization. In this study four different solar units have been taken for study on the basis of different power factor. Figure 4 represent power loss of the system. The method proposed here is compared with other intelligent algorithm like Genetic algorithm (GA), Particle swarm optimization (PSO) method and Hybrid PSO-GA method and same is plotted in Figure 5. From the figure it is clear that Crow search optimization gives better result compare to other methods. The optimal size of each method like HPSO-GA, PSO, GA, and CSA are 2.9e05

Table 6: Optimal Size obtained from CSA

Hour(hr)	Size(MW)	Hour(hr)	Size(MW)
1	0	13	3.9559
2	0	14	3.0040
3	0	15	2.4303
4	0	16	2.2826
5	0	17	2.0616
6	1.5844	18	1.7363
7	1.8474	19	1.6667
8	2.2219	20	0
9	2.3757	21	0
10	2.4679	22	0
11	2.9078	23	0
12	4.4290	24	0

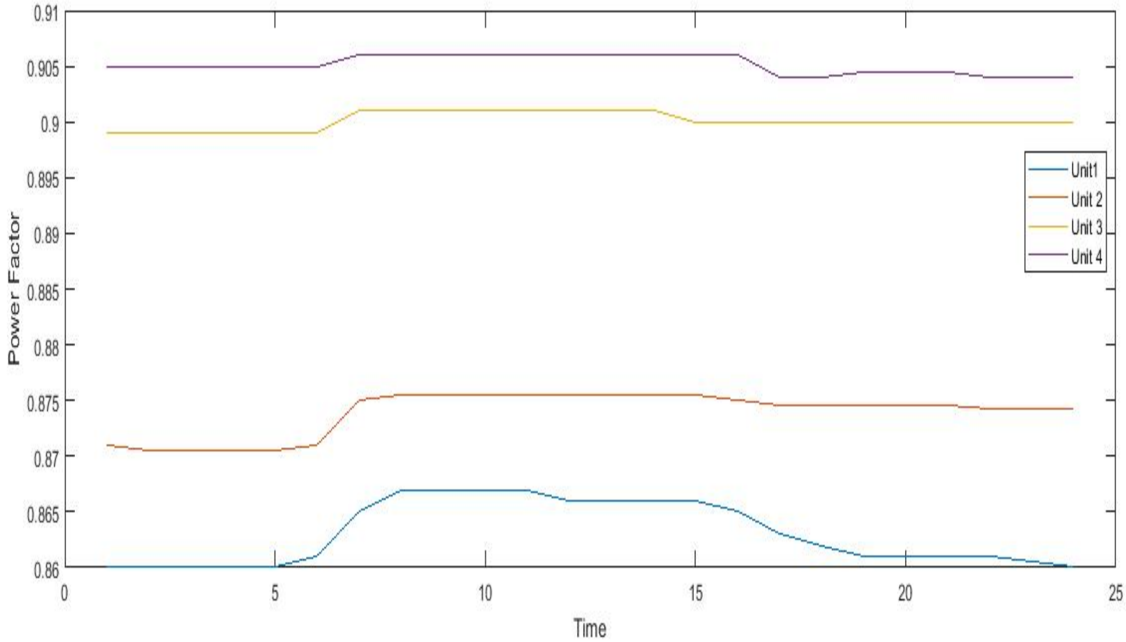

Figure 2: Power Factor of Different Units

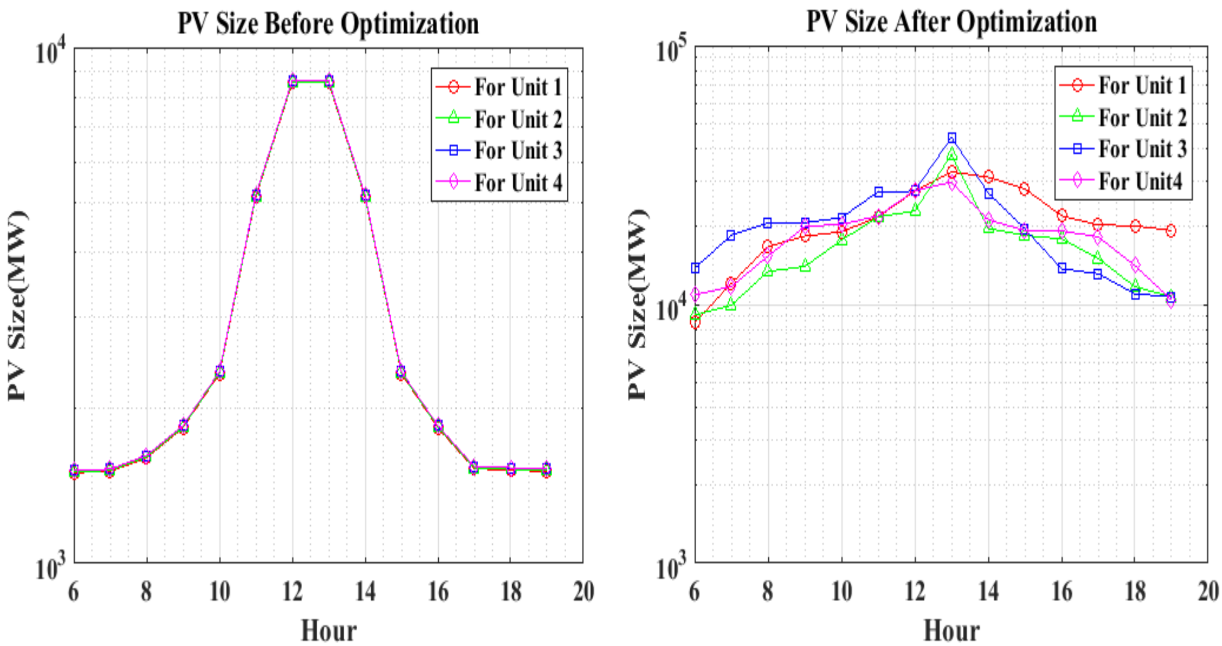

Figure 3: PV size before and after optimization of IEEE 30 bus system

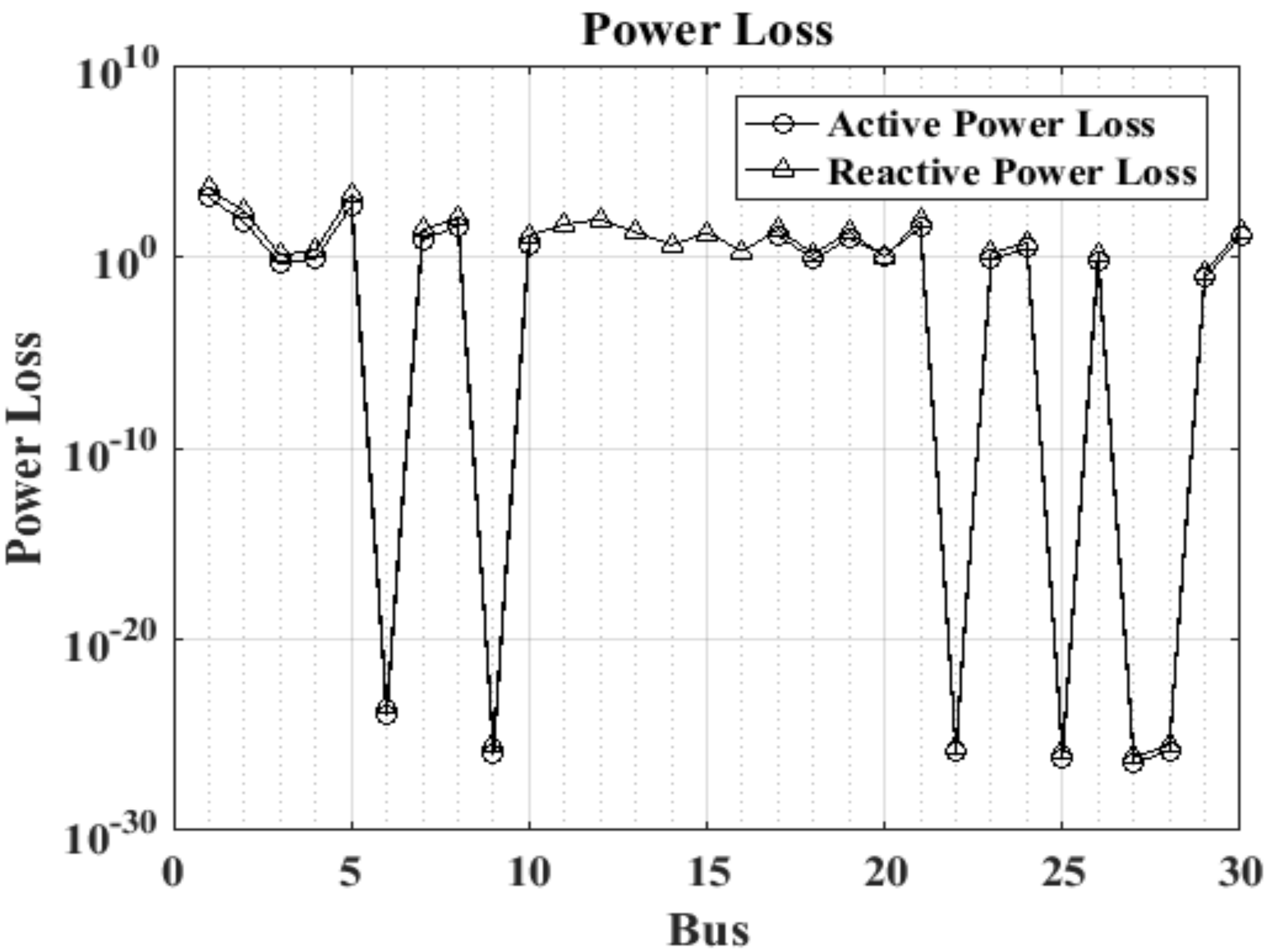

Figure 4: Power loss of IEEE 30 bus

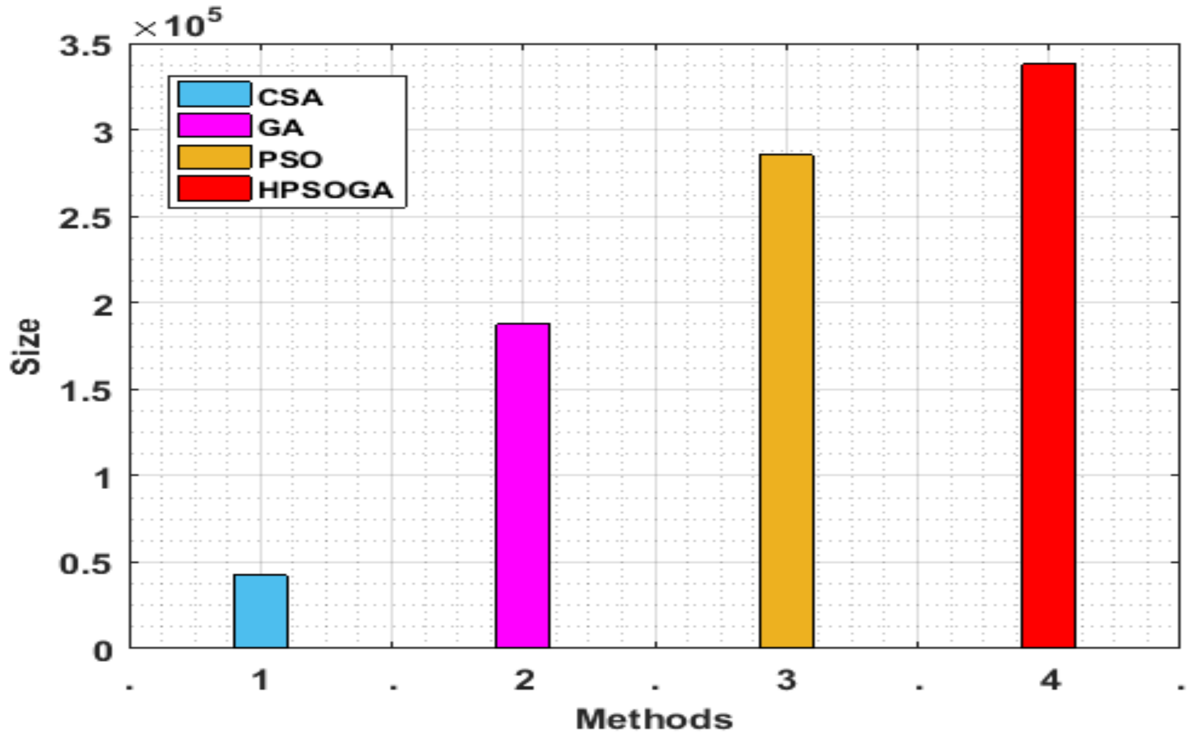

Figure 5: Comparison of PV size with existing algorithms for IEEE 30 bus

Result of IEEE- 57 bus test system:

2.0e05 W, 1.87e05 W and 4.57e04 W respectively. Now if we compare the size of solar PV before and after the optimization obtained from the proposed method and plotted in Fig. 6. We comment that size of the solar PV is reduced after the optimization. In this study four different solar units have been taken for study on the basis of different power factor. Figure 4 represent power loss of the system. The method proposed here is compared with other intelligent algorithm like Genetic algorithm (GA), Particle swarm optimization (PSO) method and Hybrid PSO-GA method and same is plotted in Figure 5. From the figure it is clear that Crow search optimization gives better result in compare to other methods. The optimal size of each method like HPSO-GA, PSO, GA, and CSA are 2.9e05 W, 2.87e05 W, 5.61e04 W and 4.80e04 W respectively

Table 7: Optimal Size obtained from CSA

Hour(hr)	Size(mw)	Hour(hr)	Size(mw)
1	0	13	3.9559
2	0	14	3.0040.7
3	0	15	2.4303.5
4	0	16	2.2826
5	0	17	2.0616.5
6	1.5844.9	18	1.7363.2
7	1.8474.5	19	1.6667.3
8	2.2219.8	20	0
9	2.3757.8	21	0
10	2.4679.9	22	0
11	2.9078.7	23	0

12	4.4290.4	24	0

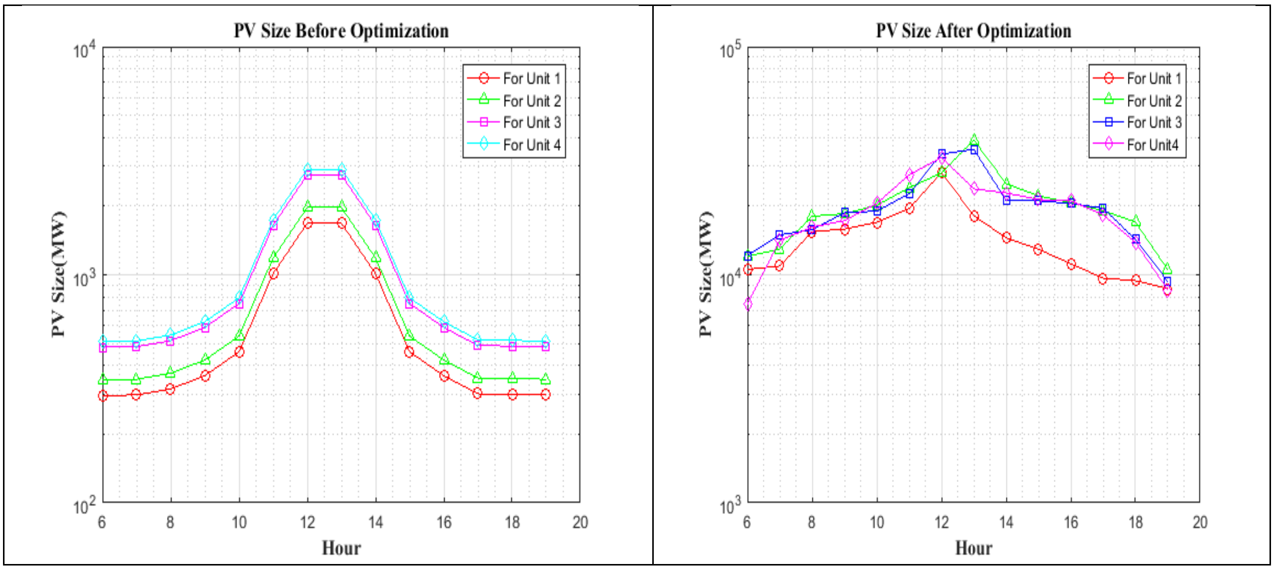

Figure 6: PV size before and after optimization of IEEE 30 bus system

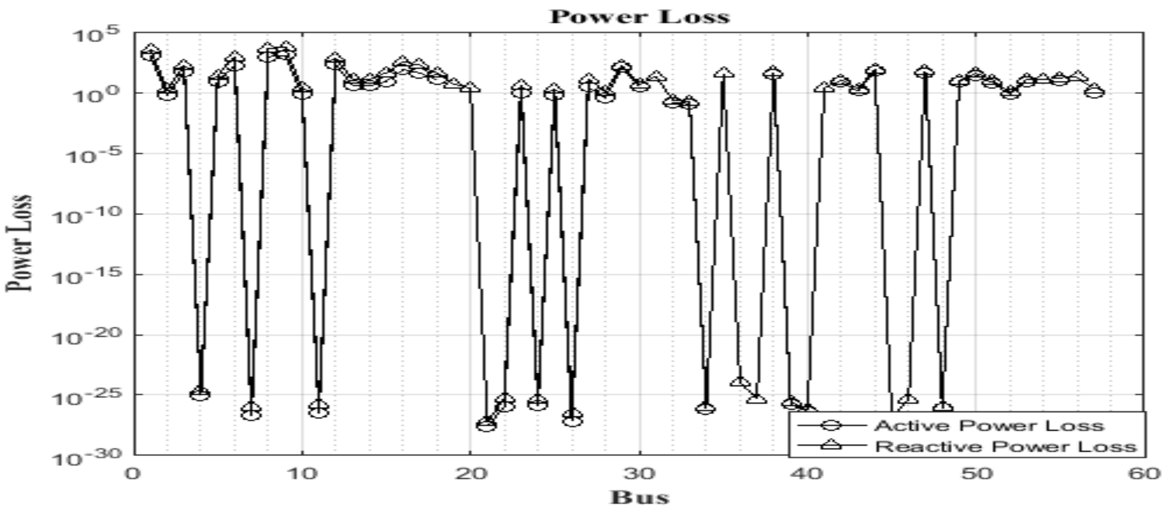

Figure 7: Power loss of IEEE- 67bus

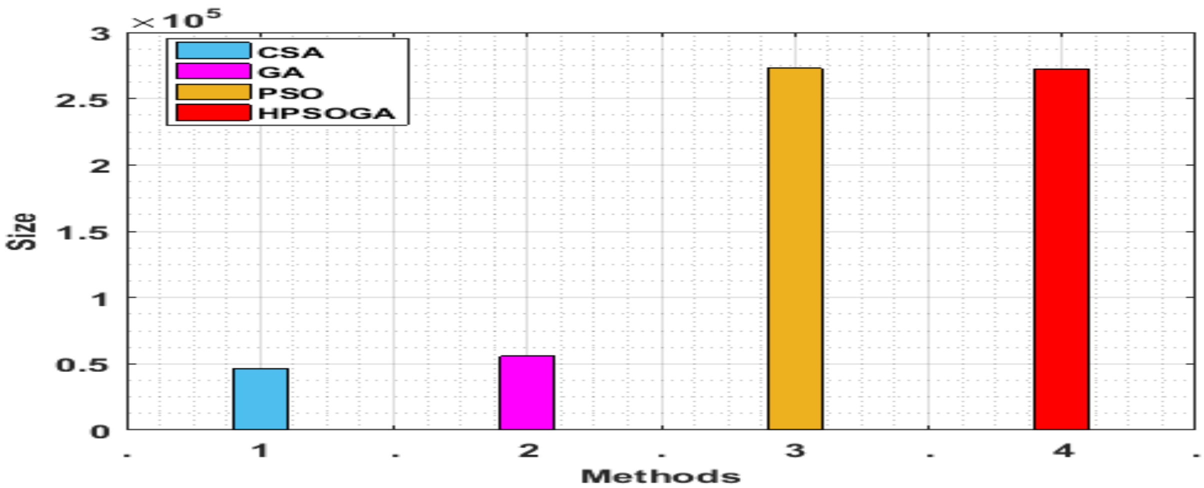

Figure 8: Comparison of PV size with existing algorithms for IEEE 30 bus

Table 8: Optimal Size of DG

S.No	Test system	Algorithms	Optimal size (Mw)				Total size (Mw)
			Unit 1	Unit2	Unit 3	Unit 4	
1	IEEE 30	HPSO-GA	7.39e04	8.33e04	7.38e4	7.39e	2.9e05
		PSO	7.17e04	7.18e04	7.23e04	7.24e04	2.0e05
		GA	4.66e04	4.69e04	4.70e04	4.71e04	1.87e05
		CS	1.27e04	0.99e4	1.11e04	1.19e04	4.57e04
2	IEEE57	HPSO-GA	7.41e04	7.38e04	7.38e04	7.37e04	2.95e05
		PSO	7.17e04	7.22e04	7.13e04	7.24e04	2.87e04
		GA	1.07e04	1.21e04	1.62e04	1.70e04	5.61e04
		CS	1.20e04	1.11e04	0.977e03	1.51e04	4.80e04

6. Conclusion

Thus the proposed system has successfully implemented in MATLAB environment**,** under this, the mathematical modelling is derived and the constraints of voltage and energy are being satisfied. The power losses of active and reactive are gown through the Newton Raphson load flow analysis. The crow search optimization algorithm has been developed to overcome the issue of optimal sizing. The energy storage modelling is done to save the power; all these calculations are based on the time interval, which is to be 24 hrs. The results are made among the particle swarm optimization algorithm (PSO), and genetic algorithm (GA), and hybrid particle swarm genetic algorithm (HPSOGA) in which the voltage, loss, loading parameter, and the size are estimated. The optimal size of the HPSOGA, PSO, GA, and CS for IEEE 30 bus and 67 bus test system is given in table 8. From the obtained values, the proposed system can enable the efficient results rather than the existing methods.

References

[1] Power, M.o., Ministry of Power, India, Annual Report. April 2018.
[2] Pepermans, G., et al., Distributed generation: definition, benefits and issues. Energy policy, 2005. **33**(6): p. 787-798.
[3] Acharya, N., P. Mahat, and N. Mithulananthan, An analytical approach for DG allocation in primary distribution network. International Journal of Electrical Power Energy Systems, 2006. **28**(10): p. 669-678.
[4] HA, M.P., P.D. Huy, and V.K. Ramachandaramurthy, A review of the optimal allocation of distributed generation: Objectives, constraints, methods, and algorithms. Renewable Sustainable Energy Reviews 2017. **75**: p. 293-312.
[5] Gözel, T. and M.H. Hocaoglu, An analytical method for the sizing and siting of distributed generators in radial systems. Electric Power Systems Research 2009. **79**(6): p. 912-918.
[6] El-Ela, A.A., S.M. Allam, and M. Shatla, Maximal optimal benefits of distributed generation using genetic algorithms. Electric Power Systems Research, 2010. **80**(7): p. 869-877.
[7] Evangelopoulos, V.A., P.S. Georgilakis, and Distribution, Optimal distributed generation placement under uncertainties based on point estimate method embedded genetic algorithm. IET Generation, Transmission, 2014. **8**(3): p. 389-400.
[8] Pandey, A.K. and S. Kirmani. Implementation of genetic algorithm to find the optimal timing of overcurrent relays. in Power Electronics and Motion Control Conference (PEMC), 2016 IEEE International. 2016. Verna, Bulgaria: IEEE.
[9] Aman, M., et al., Optimal placement and sizing of a DG based on a new power stability index and line losses. International Journal of Electrical Power, 2012. **43**(1): p. 1296-1304.
[10] Kansal, S., et al., Optimal placement of different type of DG sources in distribution networks. International Journal of Electrical Power, 2013. **53**: p. 752-760.
[11] Devi, S., M. Geethanjali, and E. Systems, Optimal location and sizing determination of Distributed Generation and DSTATCOM using Particle Swarm Optimization algorithm. International Journal of Electrical Power, 2014. **62**: p. 562-570.
[12] Kansal, S., V. Kumar, and B. Tyagi, Hybrid approach for optimal placement of multiple DGs of multiple types in distribution networks. International Journal of Electrical Power Energy Systems, 2016. **75**: p. 226-235.
[13] Abu-Mouti, F.S. and M. El-Hawary, Optimal distributed generation allocation and sizing in distribution systems via artificial bee colony

algorithm. IEEE transactions on power delivery, 2011. **26**(4): p. 2090-2101.

[14] Ali, E., S.A. Elazim, and A. Abdelaziz, Optimal allocation and sizing of renewable distributed generation using ant lion optimization algorithm. Electrical Engineering, 2018. **100**(1): p. 99-109.

[15] Moradi, Mohammad Hasan, and M. Abedini. "A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systems." *International Journal of Electrical Power & Energy Systems* 34.1 (2012): 66-74.

[16] Home-Ortiz, Juan M., et al. "Optimal location-allocation of storage devices and renewable-based DG in distribution systems." *Electric Power Systems Research* 172 (2019): 11-21.

[17] HassanzadehFard, Hamid, and Alireza Jalilian. "Optimal sizing and location of renewable energy based DG units in distribution systems considering load growth." *International Journal of Electrical Power & Energy Systems* 101 (2018): 356-370

[18] Hung, D.Q., N. Mithulananthan, and R. Bansal, Integration of PV and BES units in commercial distribution systems considering energy loss and voltage stability. Applied Energy, 2014. **113**: p. 1162-1170.

[19] Lopez, E., et al., Online reconfiguration considering variability demand: Applications to real networks. IEEE Transactions on Power systems, 2004. **19**(1): p. 549-553.

[20] Chen, S., H.B. Gooi, and M. Wang, Sizing of energy storage for microgrids. IEEE Transactions on Smart Grid, 2012. **3**(1): p. 142-151.

[21] Gabash, A. and P. Li, Active-reactive optimal power flow in distribution networks with embedded generation and battery storage. IEEE Transactions on Power Systems, 2012. **27**(4): p. 2026-2035.

[22] Ochoa, L.F., A. Padilha-Feltrin, and G.P. Harrison, Evaluating distributed generation impacts with a multiobjective index. IEEE Transactions on Power Delivery, 2006. **21**(3): p. 1452-1458.

[23] Askarzadeh, A., A novel metaheuristic method for solving constrained engineering optimization problems: crow search algorithm. Computers Structures, 2016. **169**: p. 1-12.

[24] Kothari, I.J. and Nagrath, D.P. (2007) Modern Power System Analysis. 3rd Edition, New York.

[25] A. K. Pandey and S. Kirmani, "Efficient Approach for DG Placement and Size in Medium Voltage Distribution Systems," *2018 2nd IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES)*, Delhi, India, 2018, pp. 127-131

[26] Essallah, Sirine, Adel Bouallegue, and A. K. Khedher. "Optimal sizing and placement of DG units in radial distribution system." *International Journal of Renewable Energy Research (IJRER)* 8.1 (2018): 166-177.

[27] D. Motyka, M. Kajanová and P. Braciník, "The Impact of Embedded Generation on Distribution Grid Operation," *2018 7th International Conference on Renewable Energy Research and Applications (ICRERA)*, Paris, 2018, pp. 360-364.

[28] T. Sakagami, Y. Shimizu and H. Kitano, "Exchangeable batteries for micro EVs and renewable energy," *2017 IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA)*, San Diego, CA, 2017, pp. 701-705.

[29] P. Mazidi, G. N. Baltas, M. Eliassi and P. Rodríguez, "A Model for Flexibility Analysis of RESS with Electric Energy Storage and Reserve," *2018 7th International Conference on Renewable Energy Research and Applications (ICRERA)*, Paris, 2018, pp. 1004-1009.

[30] M. Saleh, Y. Esa, N. Onuorah and A. A. Mohamed, "Optimal microgrids placement in electric distribution systems using complex network framework," *2017 IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA)*, San Diego, CA, 2017, pp. 1036-1040.

[31] Y. Tominaga, M. Tanaka, H. Eto, Y. Mizuno, N. Matsui and F. Kurokawa, "Design Optimization of Renewable Energy System Using EMO," *2018 International Conference on Smart Grid (icSmartGrid)*, Nagasaki, Japan, 2018, pp. 258-263.