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Coordinated Optimal Placement of Energy Storage System and Capacitor Bank Considering Optimal Energy Storage Scheduling for Distribution System Using Mixed-Integer Particle Swarm Optimization

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Abstract: This paper proposes a mixed-integer particle swarm optimization (MIPSO) for coordinated optimal placement of energy storage system (ESS) and capacitor bank (CB). In the propose method, optimal ESS scheduling (OESSS) is solved by particle swarm optimization (PSO), as a subproblem, the optimal coordinated placement (COP) for ESS and CB, simultaneously. The distribution system annual loss minimization (DSALM) is used as the objectives of COP problem. The proposed method was tested with the IEEE 33-bus radial distribution test system. The results demonstrated that the proposed method is successful and robust in minimizing system losses, which loss saving of 35.12% when compare to the based case, which is the best solution among other existing methods.

Keywords: Optimal placement, Optimal scheduling, Minimize power loss, Energy storage system, Capacitor bank.

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1. Introduction

Nowadays, in distribution system, day-to-day fluctuations in power consumption. distributed high, resulting in significant power loss in the system. Therefore, a reduction in power loss and improved voltage are very important for the electrical distribution power systems (EDPs) to reduce energy consumption and operating costs. This problem can be solved by installing capacitor bank (CB) to compensate for reactive power and power consumption variations that can be managed with an energy storage system (ESS).

A number of methods have been presented with the purpose of reducing power loss and improving voltage in electrical power systems. such as, distribution system reconfiguration using modified particle swarm optimization (MPSO) [1], Soft Open Point (SOP) which is a type of power electrical component which can be used to replace traditional switches or normally open points (NOP) in network distribution was proposed in [2]. In [3], parameter improved particle swarm optimization (PIPSO) is solver for optimal sizing and placement of a distributed generation (DG), this paper integrating real power supporting of DG with IEEE 33 bus and 69 bus radial distribution network. CB has been used to solve optimal dispatch problem for reactive power in [4]. Particle swarm optimization (PSO) was utilized to test a power system to reduction in a power loss in [5]. In other system of this challenge, [6] calculated the operation of CB and tap-changing transformer using the Newton-Raphson load flow technique. When minimizing power loss is integrated with other aims, such as controlling voltage drop in the electrical system, fuzzy multi-objective optimization has been used genetic algorithms (GA) for control device in power system [7]. These methods, aimed at minimizing real power loss.

Optimal placement of CB is a method of locating the proper CB installation for the electrical system's best benefit. The capacitor placement challenge is a very well-known topic that has been discussed by a number of authors in the past, such as, genetic algorithm method [8, 9], the sperm whale algorithm (SWA) [10], moth-flame optimization algorithm [11] and complex calculation methods like fuzzy logic

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control (FLC) [12], these methods are used for reduce power loss, improve the voltage profile but not considering operation cost. In addition to other considerations, the cost of installing and operating capacitors will be considered, such as cuckoo search algorithm (CSA) [13], locust search method (LS) [14], particle swarm optimization (PSO) [15, 16], genetic algorithm (GA) [17], and hybrid approach of PSO-GA [18]. All the above methods can efficiently reduce the operating cost of the installed capacitor bank in the distribution system. [19] determining the size and location of reactive power compensation integrated with hydro power distributed generation into the power system. In the presence of distributed solar power generation (PV), [20] develop a model of a specific distribution system to select the appropriate capacity and location sets of newly installed CB, these prove that capacitors can be used in conjunction with EDPs for minimize power loss.

Similar to other resources, ESS can be solved in a multitude of situations, including optimizing capacity, increasing stability, balancing supply fluctuations, satisfying a load demand. However, under or over-voltage in the distribution system can be caused by inappropriate ESS allocation and sizing. Therefore, optimal placement of ESS (OPESS) is important for planning location and sizing of ESS, to maximize the benefits from ESS. Many research's used OPESS for integrating renewable energy sources (RER). For examples, [21] propose a wind generator with ESS to improve voltage profile and system loss using the PSO algorithm for optimal placement in the 34-bus unbalanced system. Some researches focus on integrating ESS with power PV station, such as, the optimal siting of battery energy storage system (BESS) in distribution network is solved by PSO to minimize the energy losses of the system [22, 23]. With similar objective function, [24-26] developed the GA optimization method to reduce daily loss and peak demand by PV stations while deploying ESS, but the cost of installing ESS is not considered. With the same concept, [27] developed a GA optimization approach for minimizing voltage fluctuations induced by PV penetration by distributing BESS across permitted nodes of a distribution system while considering for capital, land-of-use, and installation costs with a qualitative cost model. Therefore, OPESS can efficiently locate and install ESS to benefit the system.

In addition to finding the proper installation location for ESS, optimal scheduling of energy storage systems is also important for day-to-day operation. [28] presented a model based on LaGrange relaxation and tests with the IEEE 37 bus considering reshaping the load curve when using ESS. [29] used the exchange market algorithm (EMA), when ESS is installed with RER uncertainty. The 24-hour optimal scheduling for ESS using load forecasting and RER is developed in [30, 31] with prediction of the load forecast and operation time of PV in the short term. All of the above method confirms that ESS can manage energy allocation at various periods of the day to reduce power loss or peak demand load. However, the break-even point of today's ESS deployments isn't worth contemplating. Thereby, the high cost of ESS poses severe concerns, necessitating the development of cost-effective alternatives [32]. In addition, the optimal placement of ESS can be gain more benefit when incorporation the problem with CB placement.

Most of researches on optimal CB placement solve the total loss minimization using single loading condition. Meanwhile, the optimal scheduling of ESS is solved without optimal allocation. Therefore, this paper proposed the method for solving the optimal placement of CB and ESS, simultaneously, considering optimal scheduling of ESS.

In this paper, coordinated optimal placement problem (COPP) of ESS and CB considering optimal ESS scheduling (OESSS) for distribution system annual loss minimization (DSALM) is proposed. The proposed method used the mixed-integer particle swarm optimization (MIPSO) to optimal placement of ESS and CBs, while OESSS is solved by PSO [33]. Thailand's power system load profile was used to verify the proposed method in the radial IEEE 33-bus distribution test system. The results shown that the proposed method can successfully provide optimal ESS and CB allocation.

In this paper, the COPP formulation is addressed in Section 2. Section 3 presents a MIPSO approach to the COPP. Section 4 shows the results of the radial distribution IEEE-33 bus test system. Lastly, Section 5 address the conclusion.

2. Problem formulation

The proposed method includes coordinated optimal placement problem (COPP) formulations considering daily ESS scheduling using MIPSO algorithm. The structure of a distribution grid typically includes active and reactive resources such as, bulk power systems, ESS, CB, and load demand, as shown in Fig. 1.

The objective function of COPP is formulated as follows:

Minimize

$$AAL = DP_{loss,total}(\boldsymbol{C_{ess}^{h}}, \boldsymbol{CBS}, \boldsymbol{B}), \qquad (1)$$

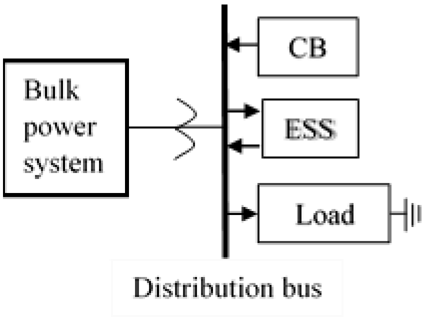

Figure. 1 A structure of distribution system with CB and ESS

for ESS and CB connected to bus **B** with state of charge $\mathbf{C^h_{ess}}$ and compensated from **CBS**.

The considered time interval is one day (24 hour),

$$P_{loss,total} = \sum_{h=1}^{24} P_{loss}^{h}, \tag{2}$$

where,

$$P_{loss}^{h} = \sum_{i=1}^{NB} \sum_{\substack{j=1 \\ j\neq i}}^{NB} G_{ij}\left[\left(V_i^h\right)^2 + \left(V_j^h\right)^2 - 2V_i^h V_j^h \cos(\delta_i^h - \delta_j^h)\right], \quad \text{for } i,j = 1,\ldots,NB, h = 1,\ldots,24, \tag{3}$$

Subject to the power balance constraints,

$$P_{Gi}^{h} - P_{Di}^{h} + \left(C_{ess,i}^{h} \times \left(\frac{\eta_c}{\eta_d}\right)\right) = \sum_{j=1}^{NB} |V_i^h||V_j^h||y_{ij}| \cos(\theta_{ij} - \delta_{ij}^h), \quad \text{for } i = 1,\ldots,NB, h = 1,\ldots,24, \tag{4}$$

$$Q_{Gi}^{h} - Q_{Di}^{h} - cbs_i = -\sum_{j=1}^{NB} |V_i^h||V_j^h||y_{ij}| \sin(\theta_{ij} - \delta_{ij}^h), \text{for } i = 1,\ldots,NB, h = 1,\ldots,24, \tag{5}$$

Line flow limit constraints,

$$|f_i^h| \le f_i^{max} \quad , \text{for } i = 1,\ldots,NL, h = 1,\ldots,24, \tag{6}$$

Power generation constraint,

$$P_{Gi}^{min} \le P_{Gi}^{h} \le P_{Gi}^{max} \quad , \quad \text{for } i = 1,\ldots,NG, h = 1,\ldots,24, \tag{7}$$

$$Q_{Gi}^{min} \le Q_{Gi}^{h} \le Q_{Gi}^{max} \quad , \quad \text{for } i = 1,\ldots,NG, h = 1,\ldots,24, \tag{8}$$

Bus voltage limit constraint,

$$\left|V_i^{min}\right| \le \left|V_i^h\right| \le \left|V_i^{max}\right|, \quad \text{for } i = 1,\ldots,NB, h = 1,\ldots,24. \tag{9}$$

The reactive power generation of CB can be represented as,

$$\boldsymbol{CBS} = [cbs_1, cbs_2, \ldots, cbs_i, \ldots, cbs_{NCB}], \quad \text{for } i = 1,\ldots,NCB. \tag{10}$$

The energy capacity, as well as the capacity for power charging and discharging, are all included in this paper's ESS model. [31] shows the efficiency of charging and discharging represented by [34],

$$\boldsymbol{ES} = [ES_i^1, \ldots, ES_i^h, \ldots . ES_i^{24}], \quad \text{for } i = 1,\ldots,NESS, h = 1,\ldots,24, \tag{11}$$

$$0 \le ES_i^h \le ES_i^{h,max} \quad \text{for } i = 1,\ldots,NESS, h = 1,\ldots,24, \tag{12}$$

$$\boldsymbol{C_{ess}} = \left[C_{ess,i}^1, \ldots, C_{ess,i}^h, \ldots C_{ess,i}^{24}\right] \quad \text{for } i = 1,\ldots,NESS, h = 1,\ldots,24, \tag{13}$$

$$C_{ess,i}^{h,min} \le C_{ess,i}^{h} \le C_{ess,i}^{h,max} \quad \text{for } i = 1,\ldots,NESS, h = 1,\ldots,24, \tag{14}$$

$$C_{ess,i}^{h} = \begin{cases} ES_i^1, h=1 \\ ES_i^h - ES_i^{h-1}, h=2,\ldots,24 \end{cases} \quad \text{for } i = 1,\ldots,NESS, h = 1,\ldots,24. \tag{15}$$

In this paper, if $C^h_{ess,i} < 0$, the ESS is in discharging condition, if $C^h_{ess,i} > 0$, the ESS is in charging condition.

The initial set of particles for bus that connected with ESS and CB as,

$$\boldsymbol{B} = [b_1, \ldots, b_i, \ldots, b_{NESS+NCB}]^T, \quad \text{for } 1 \le b_i \le NB, \tag{16}$$

$$b_i \in \{\text{integer}\}, \quad i = 1,\ldots,(NESS + NCB). \tag{17}$$

where,

AAL	is average annual loss (kWh),
D	is number of days,
$P_{loss,total}$	is the total daily loss,
P_{loss}^{h}	is the hourly loss in each hour,
G_{ij}	is the conductance of the lines between bus i and bus j for $j\neq i$,
V_{ij}^{h}	is the voltage of bus i,j in each hour,
δ_{ij}^{h}	is the voltage angle difference between bus i and j in each hour,
P_{Gi}^{h}	is active power of generator connected bus i in each hour,
P_{Gi}^{min}	is minimize active power generation,
P_{Gi}^{max}	is maximum active power generation,

Q_{Gi}^{h}	is reactive power of generator connected bus *i* in each hour,
Q_{Gi}^{min}	is minimize reactive power generation,
Q_{Gi}^{max}	is maximum reactive power generation,
f_i	is the MVA flow of line *i* in each hour is $f_i^{\,h}$,
f_i^{max}	is the limit of line flow (MVA),
$\lvert V_i\rvert^{h}$	is the voltage magnitude of bus *i*,
$\lvert V_i^{min}$	is minimum voltage magnitude for bus *i*,
$\lvert V_i\rvert^{max}$	is maximum voltage magnitude for bus *i*,
$\lvert y_{ij}\rvert$	is the magnitude of the y_{ij} element of Y_{bus}.,
θ_{ij}	is the angle of the y_{ij} element of Y_{bus},
NB	is the total number of buses,
NG	is the total number of generators,
NL	is the total number of lines,
CBS	is the matrix representing size of CB,
cbs_i	is the size of CB to be installed,
NCB	is the total number of CB in the system,
ES	is the matrix representing capacity of ESS,
ES_i^{h}	is the capacity of i^{th} ESS at hour *h*,
$\mathbf{C_{ess}}$	is the matrix of charge/discharge by ESS,
$C^{h}_{ess,i}$	is charge/discharge of i^{th} ESS at hour *h*,
η_c, η_d	are the charging and discharging efficiency,
NESS	is the total number of ESS in the system,
B	is the matrix representing bus number with ESS and CB,
b_i	is the bus number connected ESS and CB.

3. MIPSO based COPP algorithm

In this paper, the set of particles for bus number connected with ESS (**B**) in Eq. (16) was rounded to identify the location of ESS and CBs using Eq. (17). Subsequently, initial set of particles for schedule is obtained by Eqs. (11) to (15).

The schedule of $\mathbf{C^{h}_{ess}}$ in Eq. (15) is obtained by PSO. $\mathbf{C^{h}_{ess}}$ and **CBS** in Eq. (10) are used for obtain *AAL* in Eq. (1), the scheduling and placement were update position by PSO [33]. The annual loss is utilized as the objective function in Eq. (1), which is based on the load flow analysis. The minimum value of *AAL* among all particles is called *gbest*, and the minimum *AAL* of individual *ith* particle is called *pbest*. The COPP computational procedure as shown is Fig. 2.

4. Result and discussion

The proposed MIRPSO based COPP has been verified on the IEEE 33-bus radial distribution test system shown in Fig. 3. The system line data and bus data were obtained from [14].

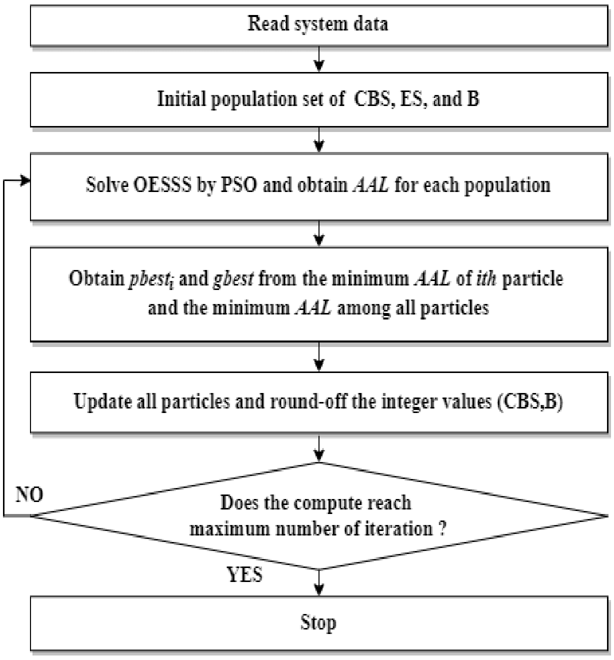

Figure. 2 The COPP computational procedure

The Thailand daily load curve on 14 April 2018, shown in Fig. 4. which is annual peak day, is used as the system load profile.

The simulation study includes,

Case 1: Reference case (without ESS and CBs),

Case 2: Optimal placement of ESS,

Case 3: Optimal placement of CBs,

Case 4: COPP of ESS and CBs.

4.1 Reference case (without ESS and CBs)

In this case, the IEEE 33-bus radial distribution test system without energy storage system and capacitor bank was solved by Newton-Raphson power flow for obtain *AAL*. The result illustrates the system average annual loss without capacitor bank and energy storage system is 129.78 kWh. The result *AAL* in this case used to compare with other cases.

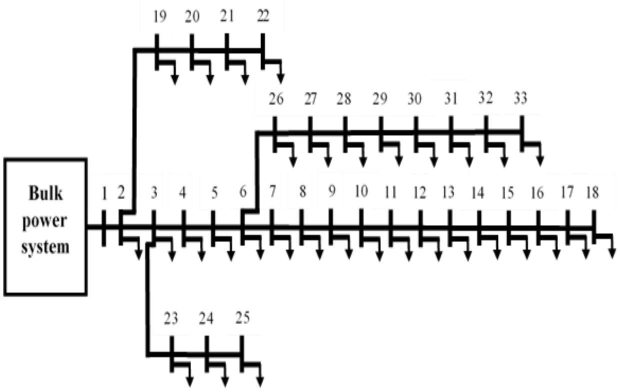

Figure. 3 IEEE 33-bus radial distribution test system

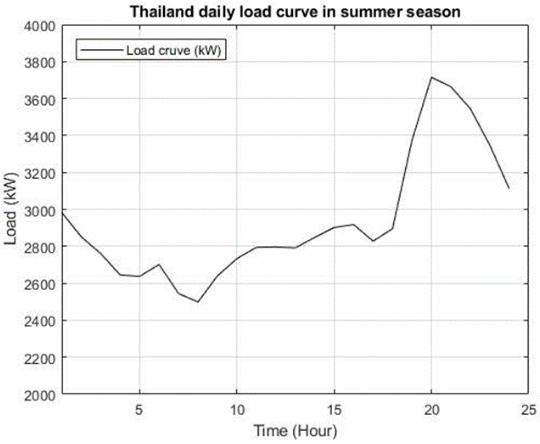

Figure. 4 Thailand daily load curve for test system

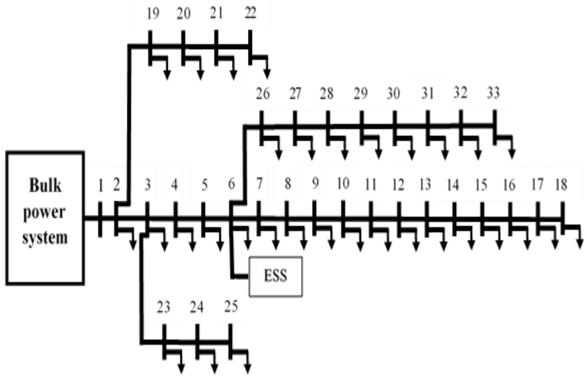

Figure. 5 The modified IEEE 33-bus radial distribution test system with ESS

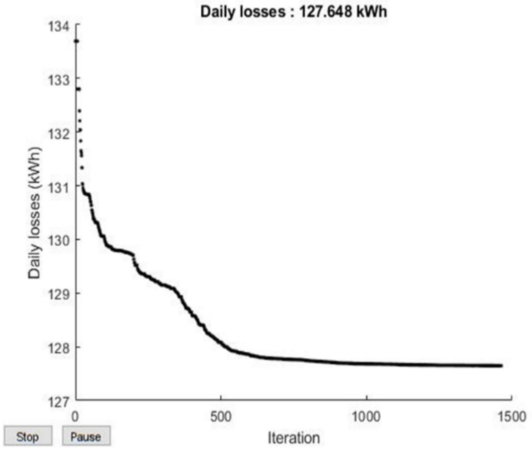

Figure. 6 Daily loss in each iteration

4.2 Optimal placement of ESS

In this case, the size 1.5 MW/10 MWh ESS is used to test the propose algorithm. The optimal ESS was investigated by the proposed MIPSO considering OESSS. As shown in Fig. 5, bus number 6 was chosen for install the ESS. In this case, the *AAL* with OPESS is 127.65 kWh, Fig. 6 shows the convergence plot of solution.

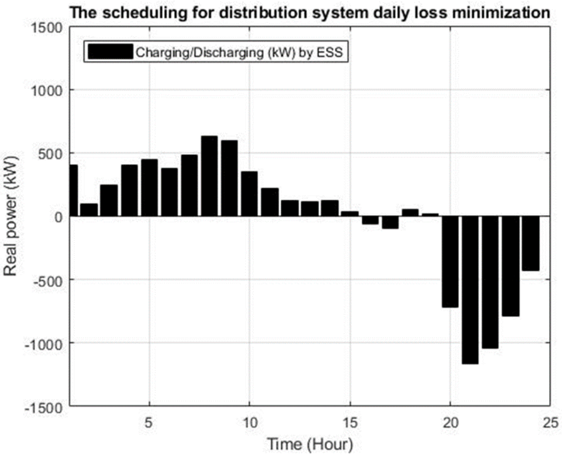

Figure. 7 The scheduling for distribution system daily loss minimization

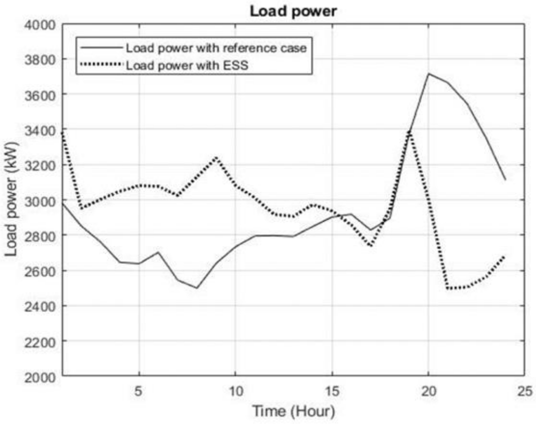

Figure. 8 The comparison of power load with and without ESS

The scheduling of ESS is shown in Fig. 7. Due to ESS is charging when off-peak and discharging when peak load, so peak power load with ESS was decease at 21.00 o'clock, as shown in Fig. 8. ESS is possible to handle high peak demand loads. However, it is still significantly unable to compensate for the system loss and voltage decrease. As a result, CB can assist in the solution of this problem.

4.3 Optimal placement of CBs

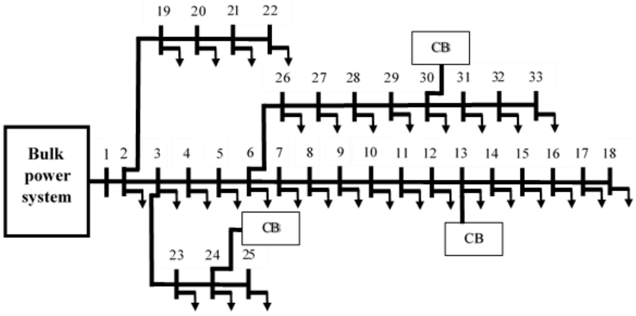

Figure. 9 The modified IEEE 33-bus radial distribution test system with optimal placement CBs

Table 1. Comparison method to minimize total loss in optimal CB placement

Solver	-	LS [14]	MIPSO	
Case	Ref.	Without DLP	Without DLP	With DLP
Total Loss(kWh)	210.98	139.23	139.23	86.01
MaximumV(p.u.)	1.0000	1.0000	1.0000	1.0000
MinimumV(p.u.)	0.9038	0.9291	0.9291	0.9423
Loss Saving(%)	**0.00**	**34.01**	**34.01**	**59.23**

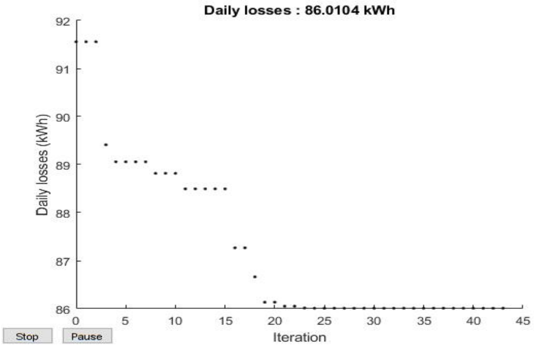

Figure. 10 Daily loss in each iteration

The optimal CB placement in the IEEE 33-bus radial distribution test system by the proposed method was compared to other previous published research, with the aim of minimizing total loss and operation cost [14]. Table 1 shows that the proposed method resulted in the same solution with [14] for conventional problem formulation. However, the daily load profile (DLP) was not considered in [14].

Therefore, in this paper, the DLP was considered to solve for the *AAL*. The 350, 600, and 1050 kVar CBs are used for optimal placement. From the propose method, CB was installed at bus 13,24 and 30, as shown in Fig. 9. The *AAL* of this case is 86.0104 kWh, which loss saving of 59.23% (saving more than without DLP case). Fig. 10 shows that the algorithm convergence to minimum loss in 43 iterations. The voltage profile in each bus was compensated condition by MIPSO. The voltage drop in this case is lower than in the reference case and ESS case, as shown in Fig. 16.

4.4 COPP of ESS and CBs

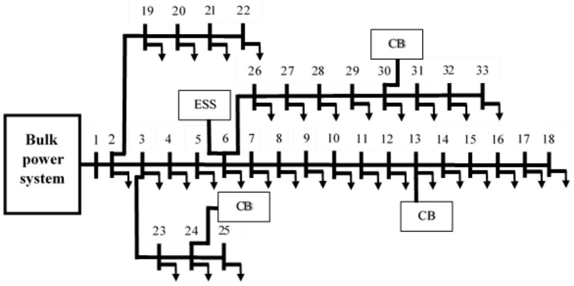

Figure. 11 The modified IEEE 33-bus radial distribution test system with optimal placement ESS and CBs

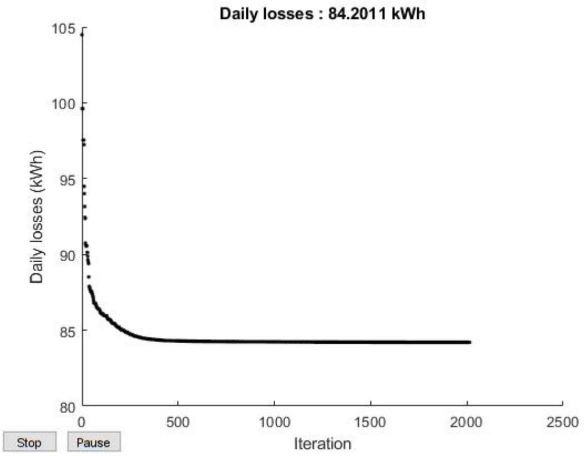

Figure. 12 Daily loss in each iteration

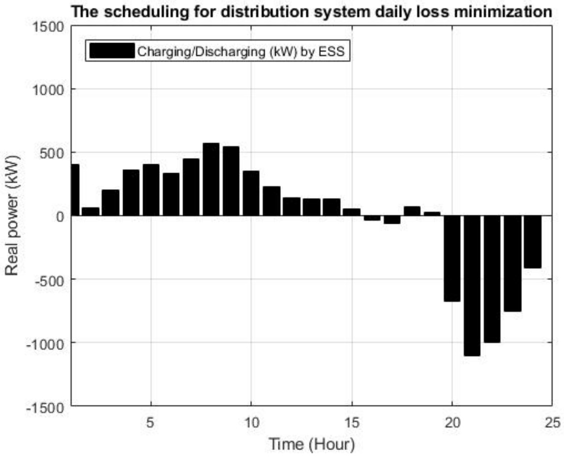

Figure. 13 The scheduling for distribution system daily loss minimization

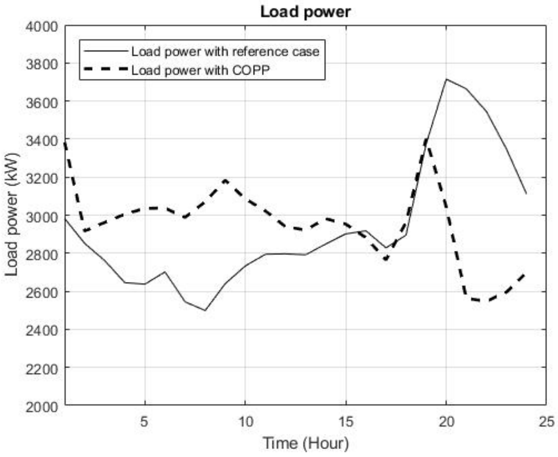

Figure. 14 The comparison of power load with and without optimal placement ESS and CBs

With the proposed MIPSO based. Fig. 11. shows that bus number 6 was chosen to install 1.5 MW/10 MWh of ESS and buses numbers 13, 24, and 30 were placed by CBs, with the sizes of 350, 600, and 1050 KVar, respectively.

Table 2. Hourly loss of IEEE 33-bus radial distribution test system for cases 1-4

Time	Case 1	Case 2	Case 3	Case 4
	Hourly losses (kW)	Hourly losses (kW)	Hourly losses (kW)	Hourly losses (kW)
1	131.7409	156.1866	87.3708	110.6394
2	119.7343	126.0988	79.5606	83.7840
3	111.8022	125.7058	74.3875	85.4428
4	102.1437	125.5076	68.0735	87.8815
5	101.4991	125.5794	67.6515	88.1850
6	106.8218	124.8462	71.1337	86.4586
7	94.1166	126.1528	62.8132	90.7851
8	90.5947	127.0256	60.5014	91.7468
9	101.7402	124.4514	67.8094	87.4914
10	109.4596	121.0148	72.8576	84.8111
11	114.7226	121.4062	76.2933	83.6642
12	114.8860	121.1142	76.4000	83.5383
13	114.4751	120.9067	76.1319	83.0816
14	119.4523	121.2097	79.3769	81.8394
15	124.2406	121.5404	82.4947	81.0080
16	125.7144	121.1590	83.4536	80.3963
17	117.6576	120.1695	78.2073	81.7191
18	123.6554	120.8485	82.1139	80.4152
19	171.3835	131.7973	112.9943	77.5112
20	210.9875	144.9729	138.3603	79.3673
21	204.7166	142.5138	134.3585	78.8940
22	190.6568	137.9043	125.3664	77.6928
23	168.5288	130.8732	111.1571	77.0083
24	144.0933	124.5576	95.3812	77.4656
AAL	**129.78**	**127.65**	**86.01**	**84.20**

Table 2 illustrated *AAL* of the modified IEEE 33-bus radial distribution test system with ESS and CBs is reduced to 84.20 kWh, lower than those case 1-3. In addition, the proposed method has been solved by GA for comparison with the PSO method. The results shown that the PSO based COPP was able to provide more efficient findings than GA when considering minimizing total loss, as shown in Table 3.

From Fig. 12, the convergence of *AAL* is 2000 iterations. The scheduling of ESS in Fig. 13, shows that state of charge of this case is similar to case 2. Similarly, the peak power load with ESS and CBs was decease at 21.00 o'clock shown as Fig. 14.

In this case, the curve of hourly loss was leveled smoother than ESS in case 2, as shown in Fig. 15. Meanwhile, Fig. 16. shows the voltage profiles for case 1-4. The results show that when ESS and CBs are placed optimally, significant improvements in bus voltage can be achieved when compared to other cases. Finally, the proposed method is efficiency minimize the *AAL* by the optimal placement ESS and CBs, considering the optimal scheduling ESS.

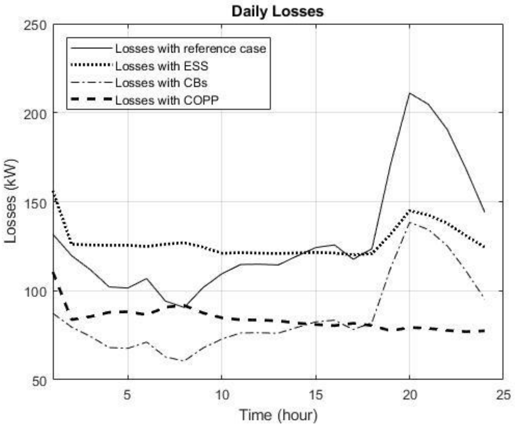

Figure. 15 The comparison of daily losses

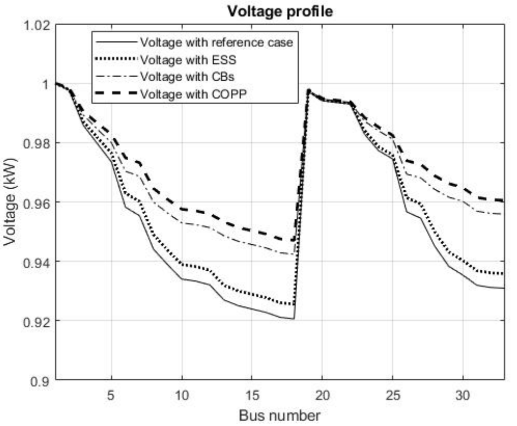

Figure. 16 The comparison of voltage profile (average from 24 hour)

Table 3. Simulation results with IEEE 33-bus radial distribution test system for cases 1-4

Case	1	2	3	4	
Solver	-	MIPSO	MIPSO	GA	MIPSO
OPESS(NO.)	-	6	-	6	6
OPCB(NO.)	-	-	13,24,30	13,24,30	13,24,30
AAL (kWh)	129.78	127.64	86.01	84.82	84.20
MaximumV(p.u.)	1.0000	1.0000	1.0000	1.0000	1.0000
MinimumV(p.u.)	0.9206	0.9256	0.9423	0.9511	0.9470
AAL Saving (%)	**0.00**	**1.65**	**33.73**	**34.64**	**35.12**

5. Conclusion

In this paper, the COPP with DSALM sub problem is proposed, using MIPSO. The proposed method was evaluated using a modified IEEE 33-bus radial distribution test system with the load profile of the Thai power system during the summer season. When properly allocated by MIPSO, CBs can better compensate for reactive power. Meanwhile, the bus with the ESS installed can effectively determine the power consumption schedule with the PSO. The results show that, the proposed method is efficient and dependable for coordinated allocation ESS and CB in minimizing system losses, which *AAL* saving of 35.12 % when compare to the based case.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, K. Kaiyawong and K. Chayakulkheeree; methodology, K. Kaiyawong and K. Chayakulkheeree; software, K. Kaiyawong; validation, K. Kaiyawong and K. Chayakulkheeree; formal analysis, K. Kaiyawong and K. Chayakulkheeree; investigation, K. Kaiyawong and K. Chayakulkheeree; resources, K. Kaiyawong; data curation, K. Kaiyawong; writing—original draft preparation, K. Kaiyawong; writing—review and editing, K. Chayakulkheeree; visualization, K. Kaiyawong; supervision, K. Chayakulkheeree;.

Reference

[1] F. M. F. Flaih, L. Xiangning, S. M. Dawood, and M. A. Mohammed, “Distribution System Reconfiguration for Power Loss Minimization and Voltage Profile Improvement Using Modified Particle Swarm Optimization”, In: *Proc. of IEEE PES Asia-Pacific Power and Energy Conference*, pp. 120-124, 2016.

[2] M. Ismail, E. Hassane, E. M. Hassan, and L. Tijani, “Power Losses Minimization in Distribution System Using Soft Open Point”, In: *Proc. of IEEE 1st International Conference on Innovation Research in Applied Science, Engineering and Technology*, 2020.

[3] S. Angalaeswari and K. Jamuna, “Optimal Placement and Sizing of Real Power Supporting DG in Radial Distribution Networks”, In: *Proc. of IEEE 2015 International WIE Conference on Electrical and Computer Engineering*, pp. 342-345, 2019.

[4] B. Gaur, R. Ucheniya, and A. Saraswat, “Real Power Transmission Loss Minimization and Bus Voltage Improvement Using STATCOM”, In: *Proc. of IEEE 2019 3rd International Conference on Recent Developments in Control*, pp. 236-241, 2019.

[5] F. R. C. Soldevilla and F. A. C. Huerta, “Minimization of Losses in Power Systems by Reactive Power Dispatch using Particle Swarm Optimization”, In: *Proc. of IEEE International Universities Power Engineering Conference*, 2019.

[6] D. Lukman, “Loss Minimization in Load Flow Simulation in Power System”, In: *Proc. of 4th IEEE International Conference on Power Electronics and Drive Systems. IEEE PEDS-Indonesia. Proceedings*, pp. 84-88, 2001.

[7] F. G. Bagriyanik and M. Bagriyanik, “Power Loss Minimization Using Fuzzy Multi-objective Formulation and Genetic Algorithm”, In: *Proc. of IEEE Bologna Power Tech Conference Proceedings*, 2003.

[8] M. Azis, Hartono, and Y. Muharni, “Optimal Capacitor Placement For IEEE 118 Bus System By Using Genetic Algorithm”, In: *Proc. of 2nd International Conference on High Voltage Engineering and Power Systems*, 2019.

[9] M. Mahdavian, M. H. Kafi, A. Movahedi, and M. Janghorbani, “Improve Performance in Electrical Power Distribution System by Optimal Capacitor Placement Using Genetic Algorithm”, In: *Proc. of 14th International Conference on Electrical Engineering/Electronics/Computer/ Telecomunications and Information Technology*, pp. 749-752, 2017.

[10] O. Ivanov, “Capacitor Banks Placement Optimization Improvement Using the Sperm Whale Algorithm”, In: *Proc. of ECAI 2019-International Conference–11th Edition Electronics, Computers and Artificial Intelligence*, 2019.

[11] O. Ceylar and S. Paudyal, “Optimal Capacitor Placement and Sizing Considering Load Profile Variations Using Moth-Flame Optimization Algorithm”, In: *Proc. of International Conference on Modern Power Systems*, 2017.

[12] S. JoyalIsac, K. S. Kumar, and P. V. Kumar, “Optimal Capacitor Placement in Radial Distribution System to minimize the loss using Fuzzy Logic Control”, In: *Proc. of International Conference on Smart Structure and System*, pp. 33-40, 2013.

[13] V. Cholapandian, T. Yuvaraj, and K. Devabalaji, “Optimal Allocation of Capacitor Banks in Distribution Networks using Cuckoo Search Algorithm”, In: *Proc. of 7th International Conference on Electrical Energy Systems*, pp. 475-478, 2021.

[14] P. Diaz, M. P. Cisneros, E. Cuevas, O. Camarena, F. Fausto, and A. Gonzalez, “A Swarm Approach for Improving Voltage Profiles and Reduce Power on Electrical Distribution Network”, *IEEE Access*, pp. 49498-49512, 2018.

[15] D. Sattianadan, M. Sudhkaran, K. Vijayakumar, and S. Vidyasagar, “Optimal Placement of Capacitor in Radial Distribution System Using PSO”, In: *Proc. of Chennai and Dr.MGR University Second International Conference on Sustainable Energy and Intelligent System*, pp. 326-331, 2011.

[16] R. N. D. C. Filho, "Optimal capacitor placement in radial distribution system using QPSO", *Simposio Brasileiro de Sistemas Eletricos*, 2018.

[17] A. Mujezinović, N. Turković, N. Dautbašić, M. M. Dedović, and I. Turković, "Use of Integer Genetic Algorithm for Optimal Allocation and Sizing of the Shunt Capacitor Banks in the Radial Distribution Networks", *18th International Symposium INFOTEH-JAHORINA*, 2019.

[18] G. Upadhyay, R. Saxena, and G. Joshi, "Optimal Capacitor Placement and Sizing in Distribution System Using Hybrid Approach of PSO-GA", In: *Proc. of IEEE International Conference on Advance in Electrical Technology for Green Energy*, 2017.

[19] M. B. Nappu, A. Arief, and M. I. Bachtiar, "Strategic Placement of Capacitor and DG for Voltage Improvement after Large Penetration of Renewable Energy Power Plant: An Indonesian Study", In: *Proc. of 7th International Conference on Renewable Energy Research and Applications*, pp. 627-631, 2018.

[20] G. J. Cho, Y. S. Oh, M. S. Kim, B. Mather, and B. M. Hodge, "Optimal Capacitor Bank Capacity and Placement in Distribution Systems with High Distributed Solar Power Penetration", *IEEE Power & Energy Society General Meeting*, 2017.

[21] S. B. Karanki, D. Xu, B. Venkatesh, and B. N. Singh, "Optimal Location of Battery Energy Storage Systems in Power Distribution Network for Integrating Renewable Energy Sources", *IEEE Energy Conversion Congress and Exposition*, pp. 4553-4558, 2013.

[22] B. C. Neagu, M. Gavrilas, R. D. Pentiuc, and E. Hopulele, "Optimal Placement of Energy Storage Systems in Microgrids Using a PSO based Approach", *IEEE PES Innovative Smart Grid Technologies Europe*, 2019.

[23] D. A. Rapris, P. S. Periandros, P. A. Gkaidatzis, A. S. Bouhouras, and D. P. Labridis, "Optimal Siting of BESS in Distribution Networks under High PV Penetration", In: *Proc. of 53rd International Universities Power Engineering Conference*, 2018.

[24] A. Alzahrani, H. Alharthi, and M. Khalid, "Minimization of Power Losses through Optimal Battery Placement in a Distributed Network with High Penetration of Photovoltaics", *Energies Journal*, 13, 140, 2020.

[25] A. Alzahrani, H. Alharthi, and M. Khalid, "Optimal Battery Energy Storage Placement in Highly PV-Penetreated Distribution Networks", In: *Proc. of IEEE Power & Energy Society Innovative Smart Grid Technologies Conference*, 2020.

[26] M. Nick and M. Hohmann, "Optimal Location and Sizing of Distributed Storage Systems in Active Distribution Networks", In: *Proc. of IEEE Grenoble Conference*, 2013.

[27] O. Babacan, W. Torre, and J. Kleissl, "Siting and sizing of distributed energy storage to mitigate voltage impact by solar PV in distribution systems", *Solar Energy*, 146, pp. 199-208, 2017.

[28] A. Garces, C. A. Correa, and R. Bolarios, "Optimal Operation of Distributed Energy Storage Units for Minimizing Energy Losses", In: *Proc. of IEEE PES Transmission & Distribution Conference and Exposition - Latin America*, 2014.

[29] T. Khalili, A. Jafari, and E. Babaei, "Scheduling and Siting of Storages Considering Power Peak Shaving and Loss Reduction by Exchange Market Algorithm", In: *Proc. of Smart Grid Conference*, 2017.

[30] Y. Y. Hong, M. Y. Wu, and S. H. Lee, "Optimal Day-ahead Energy Scheduling of Battery in Distribution Systems Considering Uncertainty", In: *Proc. of 5th International Conference on Green Technology and Sustainable Development*, 2020.

[31] W. Lee, J. Jung, and M. Lee, "Development of 24-hour Optimal Scheduling Algorithm for Energy Storage System using Load Forecasting and Renewable Energy Forecasting", *IEEE Power & Energy Society General Meeting*, 2017.

[32] Y. Oka and A. Yokoyama, "Optimal Operation Scheduling and Economical Evaluation Method of Battery Energy Storage System in Power System with a Large Penetration of Photovoltaic Generation", *IEEE Grenoble Conference*, 2013.

[33] J. Kennedy and R. Eberhart, "Particle Swarm Optimization", In: *Proc. of IEEE Proceedings of ICNN'95 - International Conference on Neural Networks*, pp. 1942-1948, 1995.

[34] K. Kaiyawong and K. Chayakulkheeree, "Optimal Energy Storage System Scheduling for Distribution System Daily Loss Minimization Using Particle Swarm Optimization", In: *Proc. of the 43rd Electrical Engineering Conference*, 2020.

[35] P. Lohray, S. Gali, S. Rangisetti, and T. Nikoubin, "Rounding Technique Analysis for Power-Area & Energy Efficient Approximate Multiplier Design", In: *Proc. of IEEE 9th Annual Computing and Communication Workshop and Conference*, pp. 420-425, 2019.