Optimal allocation of various types of DGs along with optimal allocation of EV load

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ABSTRACT

The need for energy has expanded along with the development of technology. Distributed generators (DGs) are integrated at the distribution level to overcome system demand. For various load requirements and system stability, multiple DG types are essential. In this paper battle royale optimization algorithm is utilized for the simultaneous placement of multiple types of DGs and EV load. Paper includes various case studies depending on optimal placement of type of DG along with EV load. Method includes multiple objective index while considering active power loss, reactive power loss and voltage deviation index. Along with DG sizing, the impact of each type of DG on the system performance is also analyzed. CIGRE 14-bus medium voltage distribution network is considered for this paper.

1. Introduction

Now a day, world is moving towards renewable energy due to its environment friendly and cost effective source of energy. Many researchers have obtained DG allocation with various types but they have limit to single type of DG [1]. Researchers have analyzed and calculated results after optimal allocation of each type of DG separately. In current paper, simultaneous optimal allocation of various types of DGs and EV load is obtained.

2. Methodology

In the current paper, optimal DG allocation and EV load allocation is obtained by minimizing active power loss, reactive power loss and voltage deviation using Battle Royale Optimization (BRO) algorithm presented by Taymaz in 2020[2]. The algorithm is expressed in [3] detail and also implemented for optimal DG allocation for 24 hours. Multi objective index (*MOI*) is considered which is the combination of all three objectives and presented in Eq. (1).

$$MOI = w1 * API + w2 * RPI + w3 * VDI \qquad (1)$$

Weight indices are *w1, w2* and *w3* for active power loss index (*API*), reactive power loss index (*RPI*) and voltage deviation index (*VDI*) respectively. While values for *w1, w2* and *w3* indices are 0.5, 0.25 and 0.25 respectively.
The mathematical equation for *API, RPI* and *VDI* is given in Eq. (2), Eq. (3) and Eq. (4) respectively.

$$API = [APL_{DG} / APL] \qquad (2)$$

$$RPI = [RPL_{DG} / RPL] \qquad (3)$$

$$VDI = max_{b=1}^{n}\left(\frac{|V_I| - |V_b|}{|V_I|}\right) \qquad (4)$$

The terms APL_{DG} and RPL_{DG} reflects active and reactive power loss of the system after DG integration while APL and RPL are referred as active and reactive power loss without DG respectively. V_I refers to nominal voltage which 1.0 pu while V_b is the voltage at bus 'b' after DG integration.

3. Results and discussions

CIGRE mv benchmark model is considered as test system which consists of 14 buses. The model consists of various types of pre-installed renewable and non-renewable DGs.
Along with it, 422 KW EV load is also considered which will be optimally placed in the system.
The model is implemented in mat lab software. Rated load and pre-installed DG data is utilized. The method includes optimal placement of four DGs in each case study while case studies are based on the type of DG integrated in the system. The following five cases are considered.
Case 1. DG with active and reactive power generation (P+Q) and EV
Case 2. DG with active power generation and reactive power consumption (P-Q) and EV
Case 3. DG with active power generation only (P) and EV
Case 4. DG with reactive power generation only(Q) and EV
Case 5. All above four types of DGs are installed (P+Q, P-Q, P, Q) and EV.
In all first four cases, optimal allocation of same four DGs of relevant type is obtained while in the fifth case optimal allocation of all four DGs are obtained. Both population and iteration for BRO algorithm is considered 300.
DG with active and reactive power have different values for each one. Results for all case studies are displayed in Table.1 while active power line losses, reactive power line losses and bus voltages are presented in Fig.2 (a), Fig.2 (b) and Fig.2 (c) respectively. The least active and reactive power losses lies in the case 5 that is 1.92 MW and 2.71 Mvar respectively. While minimum of maximum line loss also occurs in case while however minimum of maximum reactive losses occurs in 1.42 Mvar in case 2. Along with it minimum bus voltage occurs in case 4 while in all other cases minimum voltage lies above 0.95 pu. Least MOI value is also obtained in case 5 which is 0.854. The results shows that by integrating various types of DGs have better results than other single type of DG allocation.

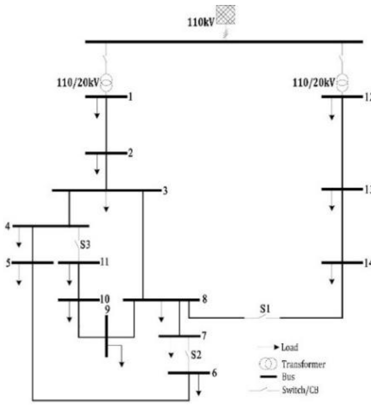
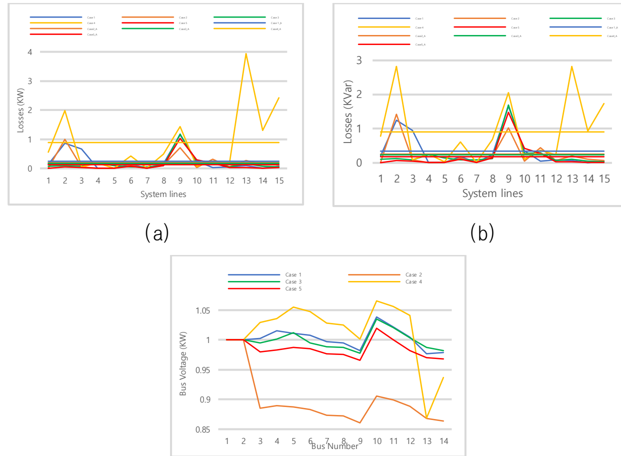


Fig.1 CIGRE system

Table.1: Overall Results

DG types	Before DG	Case 1	Case 2	Case 3	Case 4	Case 5
MOI	–	0.168181	0.149341	0.108623	0.529626	0.085442
DG location	–	3,12,2,8	12,2,11,1	5,8,12,1	13,12,9,2	1,8,12,4
EV location	–	4	4	5	1	5
DG sizes (k)	–	267,146,40,53,11,18,381,33	184,241,258,142,20,428,42,109	336,152,171,281	10,75,10,204	28,148,133,48,22,241
Active power loss (MW)	21.26	3.68	2.95	2.61	13.32	1.92
Reactive power loss (KVar)	21.36	5.15	3.85	3.55	13.60	2.71
Max act line losses	6.54	1.15	1.00	1.18	3.94	1.03
Max reactive line losses	4.70	1.66	1.42	1.69	2.82	1.48
Average bus voltage	0.93	1.00	0.90	1.00	1.01	0.99
Min bus voltage	0.70	0.98	0.86	0.98	0.87	0.97



(a) (b) (c)

Fig.2 (a)Active power losses, (b) Reactive power losses and (c) Voltage across each bus

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4. Conclusion

In this paper, optimal integration of various types of DGs along with EV load is considered. It can be seen from results that EV integration with the case 5 (integration of all four DG types) have better results than all other case studies in term of active and reactive power losses of the system and bus active power line losses while case 2 has better results in only line reactive power losses. Hence, integrating various types of DGs have better results for different of load connected in the system.

References

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