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Optimal placement of D-STATCOM and PV solar in distribution system using probabilistic load models

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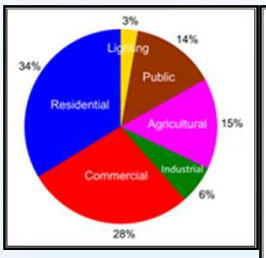
Abstract

This paper proposes a hybrid analytical and metaheuristic optimization technique to find the proper locations and sizes for the distributed generator (DG) and Distribution Static Synchronous Compensator (D-STATCOM) in distribution networks to minimize the total losses and improve the voltage profile. The D-STATCOM and DGs are arranged in order to reduce line losses and improve the voltage profile of the system. For this goal, the important parameters of a bus are optimized by Particle Swarm Optimization (PSO) algorithm. probabilistic load model also is calculated using Monte Carlo Simulation (MCS) method. Effectiveness of modified method is tested in a real distribution system of south Kerman (DSSK).

Metodology

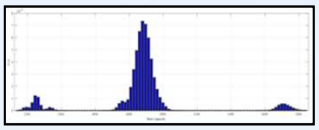
It is clear that the optimal placement and sizing of DG and D-STATCOM reduces the total power loss along with voltage profile improvement. In this paper, the optimal location and parameter setting (the reference set point) of the D-STATCOM is disigned as well as the location of the RESs with PSO algorithm. The objectives are expected active power losses reduction, expected voltage deviation index (VDI) improvement, and D-STATCOM expected installation cost minimizing considering probabilistic demand of the DSSK. In probabilistic voltage dependent load model, load is allowed to fluctuate at any instant of time and possible load demand is generated using Monte-Carlo Simulation (MCS). Load varies continually with a high degree of uncertainty and depends on customer behavior and temporal factors such as season of the year, day of the week or time of the day. In probability theory, load uncertainty can be adjusted by probabilistic density function (PDF), which fit its behavior. MCS is used to pick random values of input variable from their distribution functions, and for solving a deterministic radial load flow with these values. The probabilistic solution is reconstructed from deterministic data obtained for each simulation after a certain number of simulations. The number of simulations needed to achieve a precise result with the MCS is independent of system size and estimated as sufficient for this type of problem is 1500. Power load consumption is assumed as a normal distribution, characterized by mean value and standard deviation of active and reactive power consumed. The proposed test cases are depicted in first figure and this system is a part of distribution system from south of Kerman (DSSK), Iran. The second figure depicts the share of different load sectors, viz. residential, commercial, industrial, agricultural, public, and lighting, of total demand for the two systems

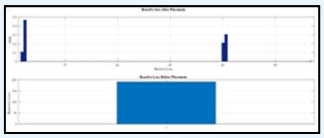


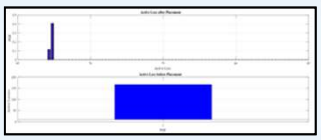
Results

The effectiveness of PSO algorithm is applied in DSSK to find the optimal place of DG and D-STATCOM and Load flow analysis is with deterministic and probabilistic MCS load model. Results obtained from the PSO algorithm are shown in table that shows the DG and D-STATCOM size obtained for different iterations during the program execution. First figure shows the best capacity of PV with the value of the PDF. Load flow analysis with D-STATCOM and PV placement with deterministic and probabilistic MCS load model and the results obtained are given in second figure and third figure that show active and reactive power before and after placement PV and D-STATCOM in DSSK.

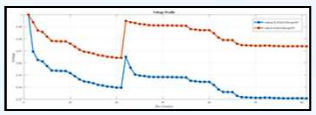
Parameter	Value
PV size	2.909 MW
PV location	Bus 24
D-STATCOM size	1.122 MVAR
D-STATCOM location	Bus 22

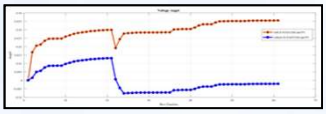






Voltage profile without D-STATCOM and PV with D-STATCOM and PV considering probabilistic load model is shown in fourth Figure. After D-STATCOM and PV placement, all 61 busses voltage DSSK are between 0.95p.u and 1.05p.u. fifth Figure shows the voltage angle base DSSK and with D-STATCOM and PV DSSK.





Optimal allocation of D-STATCOMs and PV solar has been taken into account in a probabilistic environment using the PSO algorithm and Monte Carlo simulation in the radial distribution networks. Simulations have been carried out on a real distribution system from south of Kerman (DSSK). The result shows the improvement in voltage profile and reduction in losses with D-STATCOM and PV placement. This paper can help the planning engineers to plan the distribution system with D-STATCOM for getting better voltage profile at reduced loss which in turns saves the energy as well as environment.

Reference

[1] P. Bapaiah, "Power quality improvement by using DSTATCOM," International Journal of Emerging Trends in Electrical and Electronics, vol. 2, no. 4, pp. 1-12, 2013.
[2] H. R. Esmaeilian and R. Fadaeinedjad, "Energy loss minimization in distribution systems utilizing an enhanced reconfiguration method integrating distributed generation," IEEE Systems Journal, vol. 9, no. 4, pp. 1430-1439, 2014.
[3] A. R. Gupta and A. Kumar, "Optimal placement of D-STATCOM in distribution network using new sensitivity index with probabilistic load models," in 2015 2nd International Conference on Recent Advances in Engineering & Computational Sciences (RAECS), 2015: IEEE, pp. 1-6.
[4] T. Ahmed et al., "Energy management of a battery storage and D-STATCOM integrated power system using the fractional order sliding mode control," CSEE Journal of Power and Energy Systems, vol. 7, no. 5, pp. 996-1010, 2020.
[5] B. Singh and J. Solanki, "A comparison of control algorithms for DSTATCOM," IEEE transactions on Industrial Electronics, vol. 56, no. 7, pp. 2738-2745, 2009.
[6] S. R. Salkuti, "Optimal allocation of DG and D-STATCOM in a distribution system using evolutionary based Bat algorithm," International Journal of Advanced Computer Science and Applications, vol. 12, no. 4, 2021.
[7] R. T. Bhimarasetti and A. Kumar, "Distributed generation placement in unbalanced distribution system with seasonal load variation," in 2014 Eighteenth National Power Systems Conference (NPSC), 2014: IEEE, pp. 1-5.
[8] A. Uniyal and A. Kumar, "Comparison of optimal DG placement using CSA, GSA, PSO and GA for minimum real power loss in radial distribution system," in 2016 IEEE 6th International Conference on Power Systems (ICPS), 2016: IEEE, pp. 1-6.
[9] G. Vulasala, S. Sirigiri, and R. Thiruveedula, "Feeder reconfiguration for loss reduction in unbalanced distribution system using genetic algorithm," International Journal of Computer and Information Engineering, vol. 3, no. 4, pp. 1050-1058, 2009.
[10] G. Isha and P. Jagatheeswari, "Optimal allocation of DSTATCOM and PV array in distribution system employing fuzzy-lightning search algorithm," Automatika, vol. 62, no. 3-4, pp. 339-352, 2021.
[11] A. R. Gupta and A. Kumar, "Impact of DG and D-STATCOM placement on improving the reactive loading capability of mesh distribution system," Procedia Technology, vol. 25, pp. 676-683, 2016.
[12] G. Tahiliani and A. R. Gupta, "Electrical Distribution System Analysis with Atom Search Optimization based DG and DSTATCOM Allocation," in 2022 IEEE Delhi Section Conference (DELCON), 2022: IEEE, pp. 1-6.
[13] X. Zhou, W. Zhong, Y. Ma, K. Guo, J. Yin, and C. Wei, "Control strategy research of D-STATCOM using active disturbance rejection control based on total disturbance error compensation," IEEE Access, vol. 9, pp. 50138-50150, 2021.
[14] R. Khorram-Nia, A. Baziar, and A. Kavousi-Fard, "A novel stochastic framework for the optimal placement and sizing of distribution static compensator," 2013.
[15] R. Khorram-Nia, A. Baziar, and A. Kavousi-Fard, "A novel stochastic framework for the optimal placement and sizing of distribution static compensator," 2013.
[16] S. Rezaeian-Marjani, S. Galvani, V. Talavat, and M. Farhadi-Kangarlu, "Optimal allocation of D-STATCOM in distribution networks including correlated renewable energy sources," International Journal of Electrical Power & Energy Systems, vol. 122, p. 106178, 2020.
[17] S. Ayazi and A. Askarzadeh, "Finding optimal path of feeder routing problem in power distribution network by an efficient and new methodology," International Transactions on Electrical Energy Systems, vol. 31, no. 12, p. e13196, 2021.
[18] H. Esmaeilian, M. Mahmoodabadi, and A. Mahdavinia, "COMPREHENSIVE LARGE-SCALE DISTRIBUTION TEST NETWORKS," 2021.

[19] M. Manohara, K. Deepika, and T. DEVARAJU, "Optimal placement of DSTATCOM and load flow analysis of radial distribution network," International Journal of Engineering Science and Technology (IJEST), vol. 4, no. 6, pp. 2967-2980, 2012.
[20] M. Jayamohan, E. Bindumol, and C. Babu, "Voltage stability enhancement of radial distribution system by optimal placement of DG and D-STATCOM," 2016.