Modified African Buffalo for Optimal Accommodation of Distributed Energy Resources (DERs) for Annual Energy Loss Minimization in Active Distribution Systems

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Abstract

The paper is acquainted with a new optimization technique. Modified African Buffalo optimization (MABO), to solve optimal Distributed Energy Resources (DERs) accommodation problem formulated for annual energy loss minimization esteeming multiple distributed generations and shunt capacitors contemporaneously. To demonstrate the proposed MABO, primitively, the optimal endowment of DERs is obtained for power loss minimization of benchmark 33 – bus test active distribution system (ADN) and simulation resultants are compared with well - established optimization techniques. The optimal DER allocation is also predetermined for depreciation of annual energy loss in conjuration with node voltage deviation over three different load levels. The simulation results obtained are further compared with some of the existing optimization methods. The two-level comparability of optimization methods shows that the Modified African Buffalo method has better searching potency to determine optimal solutions for optimal DERs allocation problems of ADN.

Keywords: Year End Energy Loss, Distributed Generations, Active Distribution Systems, Modified African buffalo.

1 Introduction

The Distributed Generation (DGs) or DERs is the prominent concept of integration of small-sized power generating units close to load centre. This is a sustainable alternative to the traditional power generation. This do provide a techno-fiscal benefits to its stakeholders and distribution network operators (DNOs). As, they are helps DNO in achieving various objective with single mode of operation. The DERs has made an efficient impact on power distribution system (PDS) that has make the system more reliable and robust. Howbeit, the optimal and adequate accommodation of DERs in PDS is a challenging task as non-optimal accommodation may generate counterproductive results. Finding an optimal size and site of DGs\DERs is an ongoing topic of research bearing in mind numerous single and multi objectives. As, performance constraint of electrical power network such as power loss, stability, voltage profile, power quality, and system reliability etc, are generally measured and improved by optimal integration of various DERs.

The optimal integration of DERs in the network is found to be a mixed - integer, non

- linear, non - convex problem which involve various factors such as number, nodes, sizes and types of DERs, to be integrated in ADN. In prominent literature, numerous dominant optimization techniques are presented to solve the optimal DERs

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integration problem of ADN. These methods are trying to attain optimal solution out of vast possible solutions available for the problem, each having its advantages and challenges.

Tan et Ai, has bifurcated the DGs placement technique into three majors category, conventional; artificial intelligence and hybrid intelligent system techniques. Conventional techniques may include 2/3 rule, Analytical Methods, optimal power flow which are based on some set of conservative rules or mathematical models and are effective for single objective optimization problems for small systems. Furthermore, Artificial Intelligence (AI) techniques are found to be the better alternative, as these are nature inspire and adopt the natural behaviour of its influence substance. Some of the popular AI techniques found in literature can be Genetic Algorithm (GA), Particle Swarm Optimization (PSO). Teaching Learning Based Optimization (TLBO), Elephant Herding Optimization (EHO), Invasive Weed Optimization (IWO), Simulated Annealing (SA), Harmony Search Algorithm

(HSA), Fire -Work Algorithm (FWA) etc. The AI technique is found to be effective to determine global solution for complex real - life engineering Optimization problems. However, these techniques are having some limitations due to high computation time and generally work effectively for particular problem. NewDay's, improved and hybrid Optimization techniques are proposed to resolve some of limitations of their respective standard variants. Some of these Optimization methods may include Quasi - Oppositional TLBO(QOTLBO), Improved Elephant Herding Optimization (IEHO), improved PSO, improved TLBO etc.

2. Problem Formulation
3. DGs Integration using MABO
4. Simulation and Results

PROBLEM FORMULATION

PROBLEM FORMULATION This section presents the formulation of the optimal DG allocation problem. The objective function aims to minimize annual energy loss while also minimizing node voltage deviation. The function is expressed as shown in equation, where F1 and F2 represent different components of the objective function. F1 is calculated based on the annual energy loss, considering node voltage deviation as a penalty, as shown in equation. F2 represents the maximum voltage deviation across all nodes, as shown in equation. The constraints include voltage limits for all nodes, DER capacity limits, current flow limits and other parameters related to power injections, load demand, voltage angles, and magnitudes. The variables and parameters used in the formulation are defined accordingly. The weighing coefficients C1 and C2 are assumed to be equal. These are shown in equation 1.

$$\text{Min } F = C1.F1[1+C2.F2] \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

A Subsection Sample

Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follow a table, figure, equation etc. does not have an indent, either. Subsequent paragraphs, however, are indented. Sample Heading (Third Level). Only two levels of headings should be numbered. Lower-level headings remain unnumbered; they are formatted as run-in headings. Sample Heading (Forth Level). The contribution should contain no more than four levels of headings. The following Table 1 gives a summary of all heading levels.

Table 1. Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (cantered)	Lecture Notes	14 points, bold
1st-level heading	1 Introduction	12 points, bold
2nd-level heading	2 Printing Area	10 points, bold
3rd-level heading	Run-in Heading in Bold. Text follows	10 points, bold
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Displayed equations are cantered and set on a separate line.

$$x + y = z \quad (1)$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. 1).

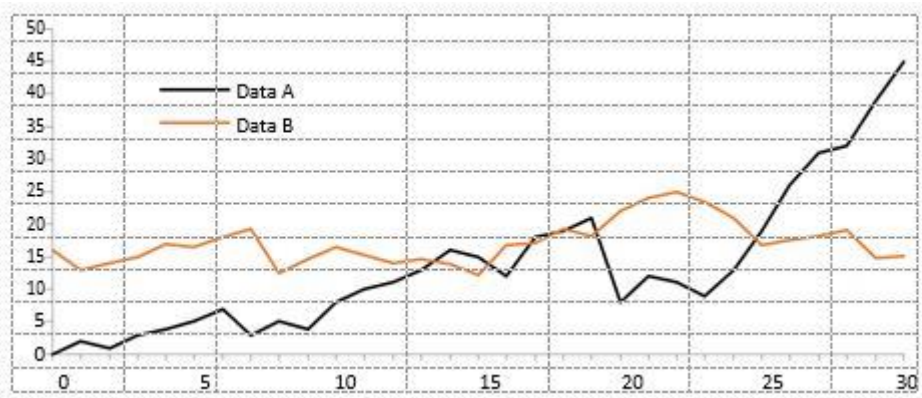

Figure 1: The caption for a figure is poitioned below the illustration. Short captions are cantered, while long captions are justified. The macro button automatically selects the appropriate format.

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In order to demonstrate the reflectiveness of the proposed MAB approach, the optimal DER allocation problem is articulated for the 33-bus test distribution system. This is a 12.66 kV radial distribution network with a total real demand of 3.715 MW and a reactive demand of 2.300 MWAr. The promoted work is checked up on in two sections. Initially, the effectiveness of the proposed approach is authenticated by the similar value available in the existing literature. Mostly, power loss minimization is intended while optimally allocating the DER in distribution systems. Consequently, the methodology is established for power loss minimization at the supposed loading, and simulation results are enacted in Table (1) for a normal load level. The resemblance shows that the proposed approach shows better solution-searching ability as compared to the other techniques. Techniques compared such as TLBO & QOTLBO, GA, PSO& GA/PSO, IA, ELF&LSF, analytical etc. The interpretation parameters of the supposed approach are shown in Table II for the tantamount case in 50 independent ordinals. The table shows the fitness values of the worst, best, and mean solutions with the standard deviation and CPU time. The consolidation characteristics of the approach are also presented in Fig. 3, which shows the best and mean fitness values of the function, i.e., power loss. After validating the proposed MSO, the approach is further adopted to solve the DER integration problem for minimization of annual energy loss and node voltage deviation in

distribution systems as presented in Section II. Without loss of simplicity, three load levels have been considered in this problem formulation. The load levels and load duration are presented in Table III.

TABLE 1 COMPARISON OF MAB WITH VARIOUS OPTIMIZATION TECHNIQUES IN LITERATURE

Method	**Optimal DG Nodes (Size in MW)**	**Loss (MW)**
TLBO [9]	30(1.186),28(1.181),12(1.196)	0.1346
GA [8]	30(1.091),29, (0.433),11(1.600)	0.1073
PSO [8]	32(0.930),13(0.992),08(1.87)	0.1054
GA/PSO [8]	32(1.300),16(0.873),11(0.935)	0.1037
QOTLBO [9]	30(1.189),26(1.189),13(1.084)	0.1035
LSF [25]	33(0.820),25(0.800),06(0.700)	0.0852
IA [25]	30(0.920),12(0.800),06(0.900)	0.0899
Analytical [26]	25(0.770),16(0.630),06(1.730)	0.0771
ELF [25]	30(0.800),24(0.900),13(0.800)	0.0746
MAB	30(1.047),25(0.791),13(0.985)	0.0738

TABLE 2 PERFORMANCE OF MS FOR 50 INDEPENDENT TRAILS

Method	Worst Fitness	Best Fitness	Mean Fitness	Stand Deviation	CPU time(s)
MAB	0.0907	0.0735	0.0825	0.00379	7.51

TABLE 3 DIFFERENT LOAD LEVEL WITH LOAD DURATION [11], [12], [19], [22]

Load Level	Multiplying Factor	Load Duration(H)
Peak(P)	1.6	1400
Normal(N)	1.0	5460
Light(L)	0.5	2000

A. In the first case, the optimal allocation of three DGs is considered for minimizing annual energy loss (AEL) in distribution systems. The allocation takes into account three different load levels: peak, normal, and light. Simultaneously, the node voltage deviation is minimized. The simulation results show that the proposed MSO method is highly effective in solving the DG integration problem, outperforming HSA and FWA in achieving the desired DG penetration. However, FWA performs slightly better than MSO and HSA in terms of minimum node voltage.

B. In the second case, the optimal allocation of three DGs and three SCs is considered for AEL minimization in distribution systems. The allocation aims to provide reactive power compensation in the system, with the added advantage of a lower per-unit cost for capacitors compared to DG units. The proposed MSO method is used to solve the problem, and the obtained optimal solution is compared with the solution obtained by ITLBO. The results show that the optimal DER allocation achieved through MSO provides both technological and economic benefits to the radial distribution system, resulting in a higher AEL reduction compared to ITLBO.

VI. CONCLUSIONS

This article presents a powerful optimization technique for solving the real-life DER integration problem in distribution systems. The technique demonstrates superior properties in exploring global optimal solutions for complex optimization problems. It is applied to solve the optimal DER integration problem in a benchmark 33-bus test distribution system, aiming to minimize AEL and node voltage deviation. The simulation results are compared with existing optimization methods such as HSA, FWA, and ITLBO, revealing that the proposed technique outperforms the compared methods in finding better optimal solutions. In the future, MSO can be utilized to tackle even more complex real-life engineering optimization problems.

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