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Northern Goshawk Optimization for Optimal Allocation of Multiple Types of Active and Reactive Power Distribution Generation in Radial Distribution Systems for Techno-Environmental Benefits

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Abstract: Radial distribution systems (RDSs) can work better from a technical, economic, and environmental point of view if they have the right mix of renewable energy-based distribution generation (DG) and reactive power sources like and distribution-static compensator (DSTATCOM). In this paper, the Northern Goshawk Optimization (NGO), a new meta-heuristic that mimics the hunting behaviour of the northern goshawk, is introduced as a way to figure out where and how big different types of active and reactive power DGs in RDSs should be. For the suggested multi-objective function, NGO is used to find the best places and sizes for photovoltaic systems (PVs), wind turbine systems (WTs), and DSTATCOMs. The main goals of the suggested method are to reduce distribution losses, improve the voltage profile, increase the voltage stability margin, and reduce greenhouse gas (GHG) emissions. Five different case studies are simulated to figure out how well the suggested method works with computers. Simulations use IEEE 33-bus feeder. When compared to the literature and other heuristic algorithms, the results show that NGO works. The computational efficiency of NGO is compared for four cases: (i) only PV ((ii) only WT (iii) only DSTATCOM and (vi) simultaneous PV, WT and DSTATCOM allocation. The results also show that the proposed NGO much efficient than other algorithms and also improves all techno-environmental factors and RDS performance in a big way.

Keywords: Capacitor bank, Distribution-static compensator, Multi-objective optimization, Northern goshawk optimization, Photovoltaic system, Radial distribution system, Wind turbine system.

1. Introduction

In recent years, the number of people who need electricity has grown by a factor of ten. This is because of the fast growth of the world's population, new technologies like electric cars, and industrialization. On the other hand, traditional energy sources can't meet all of the demand because their fuel sources are getting less and their prices are going up. Most traditional energy sources also release greenhouse gases (GHG), which contribute to global warming and air pollution. Adapting different types of renewable energy (RE) technologies has become an alternative way for people all over the world to work toward sustainability [1]. As distribution generation (DG) units, the RE sources can be added to the electrical distribution system (EDS) at different voltage levels. But the level of DG penetration is limited because of the radial configuration, which causes EDS to have problems like high distribution losses, a low voltage profile, less room for stability, and low reliability. To help with these problems, RE-DGs must be integrated in the right places and at the right sizes. On the other hand, RE is very intermittent, which leads to problems with power quality, operations, and managing energy [2]. So, many researchers are trying to find the best way to integrate RE-DGs into

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radial distribution systems (RDS) by using different meta-heuristic methods [3].

At first, this problem was solved with traditional numerical approaches, but later, heuristic approaches became more useful because they were simple, easy to adapt, and able to solve problems with multiple objectives, multiple constraints, and multiple types of variables [4]. In [5], different types of DGs are best integrated into RDSs using the whale optimization algorithm (WOA) to reduce losses (f1), improve voltage profiles (f2), make the system more stable (f3), and keep operational costs as low as possible (f4). In [6], the ant-lion optimization (ALO) and particle swarm optimization (PSO) algorithms are combined with the fuzzy logic controller (FLC) to find the best way to connect photovoltaic (PV) and wind turbine (WT)-based distributed generators (DGs) to meet multiple goals (i.e., f1, f2, f3, and f4). In [7], multi-objective PSO (MOPSO) is used to handle load changes with RE-DG allocation in the Portuguese distribution network while taking into account multiple goals (i.e., f1, f2, and f3). In [8], the modified sine cosine algorithm (MSCA) is introduced for handling techno-economic multi-objective functions (i.e., f1, f3, and f4) while solving optimal PV and WT type DGs integration. In [9], loss sensitivity factors (LSFs) and voltage stability indices (VSIs) are used to find locations, and improved-PSO (IPSO) is used to find the best sizes for PV-type DGs to reduce real and reactive power loss and improve the voltage profile.

Some researchers also focused on reactive power (VAr) compensation devices in EDSs, such as capacitor banks (CBs), short and series reactors, and custom power devices, such as automatic voltage regulators (AVR), tap-changing transformers, distribution static compensator (DSTATCOM), unified power quality controller (UPQC), and static synchronous series compensator (SSSC), etc. [10]. Most EDSs are radial and have a low voltage profile, so dynamic VAr compensation is needed to keep operations running smoothly. Compared to other VAr compensation devices, DSTATCOM is unique because it responds quickly to regulatory changes, produces fewer harmonics, costs less, and takes up less space. Like other active power DGs, the location and size of DSTATCOM need to be systematically optimised to get the techno-economic benefits that are wanted.

In [11], the goal is to minimise real power loss. The bat algorithm (BA) is used to optimise the location and size of DSTATCOMs in RDSs, and its effect on voltage stability and net savings is studied. In [12], the whale optimization algorithm is used to optimise multiple goals, such as reducing loss (f1), improving the voltage profile (f2), and making the system more stable (f3) (WOA). VSIs are used to set the locations ahead of time. In [13], a multi-optimization approach f1, f2, and net savings (f4) are shown by using the gravitational search algorithm to find the best way to distribute DSTATCOMs (GSA). Harmony search algorithm (HSA) [14], cuckoo search algorithm (CSA) [15], differential evolution (DE) [16], improved student psychology based algorithm (ISPBA) [17], improved bacterial search algorithm (IBSA) [18], and discrete-continuous PSO [19] are also recent works that focus on the techno-economic benefits of running and controlling EDS.

On the other hand, a lot of research is also done on how to use both DGs and DSTATCOMs at the same time to get the most out of both. Along with different multi-objectives like f1, f2, f3, and f4, these works also think about f5, which is the reduction of GHG emissions from conventional power sources. Recent works include the Improved Cat Swarm Optimization (ICSO) [20], the Bacterial Foraging Optimization Algorithm (BFOA) [21], the Cuckoo Search Algorithm (CSA) [22, 23], the Improved PSO [24], the Modified Bat Algorithm (MBA) [25], the Gray Wolf Optimization (GWO) [26], the Firefly Algorithm (FA) [27], and the Modified FA-PSO [28].

In recent years, many heuristic approaches that are inspired by nature and can be used to solve a wide range of complex optimization problems have been developed. But the no-free-lunch (NFL) theorem [32] says that a single algorithm might not be able to solve all kinds of optimization problems. This is why researchers are still trying to come up with new algorithms that are simple and work well. In the same way, Northern Goshawk Optimization (NGO) is a new meta-heuristic created by that mimics how the northern goshawk hunts [33].

The main goal of this work is to introduce a new optimization method based on NGO for improving the performance of RDS by integrating multiple PVs, WTs, and DSTATCOMs at the same time. NGO is used to figure out the best places and sizes for things. When making the multi-objective function, real power distribution loss, voltage profile, voltage stability, and GHG emissions are all taken into account. Four different scenarios are simulated to figure out how well the suggested method works with computers. For analysis, IEEE 33-bus RDS is used. When compared to the literature and other heuristic algorithms, the results show that NGO works. Also, the results show that the proposed

NGO improves all technological and environmental factors in RDS operation and control in a big way.

Here's how the rest of the paper is put together: In Section 2, the math models of PV-based DG, DSTATCOM, and their power injection modelling are shown. In Section 3, we talk about the proposed multi-objective function and the different operational and planning constraints. In Section 4, the idea of DA and how it can be modelled mathematically are talked about. In Section 5, the simulation results for IEEE 33-bus RDS in different situations are shown. In Section 6, the full and most important results of this research are given.

2. Modelling of distribution generation

This section explains how to model PV, WT, and DSTATCOM mathematically for backward/forward load flow study [34] by looking at their net-effective active and reactive power injections at its connected bus.

2.1 Photovoltaic/wind turbine systems

As everyone knows, DC/AC or AC/AC power converters are used to connect RE-based DGs to the grid. The power factor of the converter can be used to control how much active and reactive power RE-DGs put into the grid [35].

$$P_{d(k)} = P_{d0(k)} - P_{dg(k)}, \forall k = 1{:}ndg \tag{1}$$

$$Q_{d(k)} = Q_{d0(k)} - P_{dg(k)} \times tan\left(cos^{-1}\left(pf_{dg(k)}\right)\right), \quad \forall k = 1{:}ndg \tag{2}$$

where $P_{d0(k)}$ and $Q_{d0(k)}$ are the real and reactive power loads of a bus-k at base case/ before RE-DG integration, respectively; $P_{d(k)}$ and $Q_{d(k)}$ are the real and reactive power loads of a bus-k after DG integration, respectively; $P_{dg(k)}$ is the real and reactive power injection by DGs, respectively; ndg are the number of RE-DGs, respectively. The power factor (pf_{dg}) of a PV-DG is usually treated as unity and thus, reactive power injection is zero. On the other hand, it is controllable in the range of 0.3 to 1 for WT-DGs [6].

2.2 DSTATCOM

The possible active and reactive power flows from DSTATCOM at a grid-connected point or point of common coupling (PCC) are given by [36],

$$P_{DS} = \frac{1}{X_{ip}}\left[|V_i|\left|V_p\right|sin\left(\alpha_{ip}\right)\right] \tag{3}$$

$$Q_{DS} = \frac{1}{X_{ip}}\left\{\left|V_p\right|\left(\left|V_p\right| - |V_i|cos\left(\alpha_{ip}\right)\right)\right\} \tag{4}$$

where P_{DS} and Q_{DS} are the active and reactive power exchanges between DSTATCOM unit and PCC/grid connecting point, respectively; $|V_i|$ and $\left|V_p\right|$ are the inverter/converter and PCC/grid point voltage magnitudes, respectively; $\alpha_{ip} = \left(\alpha_i - \alpha_p\right)$, where α_i and α_p are the load angle between inverter and PCC point, respectively. For small load angles, $\alpha_i \cong \alpha_p$, then $\alpha_{ip} \cong 0$. Thus, the active power by DSTATCOM becomes zero. The reactive power supplied by DSTATCOM is given by,

$$Q_{DS} = \frac{1}{X_{ip}}\left\{\left|V_p\right|\left(\left|V_p\right| - |V_i|\right)\right\} \tag{5}$$

By controlling inverters voltage magnitude $|V_i|$, w.r.t. PCC voltage magnitude$\left|V_p\right|$, DSTATCOM can be used for multi-purposes, as follows:

- Reactive power sink (Q^+): In this mode, DSTATCOM acts like reactive power sink and absorb the VAr form grid to reduce the voltage magnitudes by maintaining $\left|V_p\right|$ greater than $|V_i|$.
- Reactive power source (Q^-): For the condition $\left|V_p\right|$ less than $|V_i|$, DSTATCOM acts under capacitive mode and injects VAr into the grid for improving the voltage magnitudes.

On the other hand, the reactive power injections by DSTATCOM or their effect can be realized by offsetting the DSTATCOM size directly from the reactive load at a bus and it is expressed by,

$$Q_{d(k)} = Q_{d0(k)} \pm Q_{ds(k)}, \forall k = 1{:}nds \tag{6}$$

where Q_{ds} and nds are the reactive power support by DSTATCOM and number of DSTATCOM locations, respectively.

3. Problem formulation

The formulation of multi-objective function using real power loss (f_1), voltage profile (f_2), voltage stability (f_3), and GHG emission (f_4) is given here with different constraints.

3.1 Real power loss

The load flow technique [34] can be used to figure out the real power distribution losses. This can be written as,

$$P_{loss} = \sum_{k=1}^{nbr} I_k^2 r_k \tag{7}$$

where r_k and I_k are the resistance and current through branch-k, nbr is the number of branches in the network.

3.2 Average voltage deviation index

In EDS, the connected loads are sensitive to voltage, so the magnitude of the voltage on each load bus needs to stay close to the nominal value. But the radiality configuration can't keep the voltage profile the same. So, the voltage deviation index tells us something about the overall voltage profile of the network,

$$AVDI = \frac{1}{nbus}\sum_{i=1}^{nbus}\left||V_n| - |V_i|\right| \tag{8}$$

The higher values of $AVDI$ indicates lower voltage profile in the network and lower $AVDI$ indicates good voltage profile.

3.3 Voltage stability index

The voltage stability index (VSI) is a way to figure out how stable a bus's voltage is. Higher VSI values mean that something is stable. So, the minimum VSI of all the buses in a network should be thought of as the minimum voltage stability of the whole network [36]. After doing load flow and looking at the voltage profile, VSI j for a bus-j is written as,

$$VSI_j = |V_i|^4 - 4\left(P_{d(j)}x_{ij} - Q_{d(j)}r_{ij}\right)^2 - 4\left(P_{d(j)}r_{ij} + Q_{d(j)}x_{ij}\right)|V_i|^2, \forall j = 2{:}\,nbus \tag{9}$$

where $|V_i|$ is the voltage magnitude of bus-*i*, r_{ij} and x_{ij} are the resistance and reactance of branch-*k*, connected between buses *i* and *j*, respectively.

3.4 Greenhouse gas emission

GHG emissions from conventional power plants that are connected to the grid is one of the biggest concerns for sustainability. Before DGs are added to the network, the grid needs to meet the total network demand (load plus losses). With PV-DGs, the amount of power brought in from the grid can be cut down, and so can GHG emissions, which can be measured by,

$$GHG_{em} = (CO_2 + NO_x + SO_2) \times P_{ss} \tag{10}$$

where GHG_{em} is the total GHG emission by the grid-associated conventional power sources, CO_2, NO_x and SO_2 are the most accounted emissions [37]; P_{ss} is the total active power demand (includes load and losses) on the substation/grid.

3.5 Constraints

The following are the major constraints considered while optimizing the aforementioned objective functions.

Real and reactive power imports at sub-station bus are equal to summation of distribution losses, total load minus total DGs/CBs power.

$$P_{ss} = P_{loss(c)} + \sum_{i=1}^{nbus} P_{d(i)} - \sum_{k=1}^{ndg} P_{dg(k)} \tag{11}$$

$$Q_{ss} = Q_{loss} + \sum_{i=1}^{nbus} Q_{d(i)} - \sum_{k=1}^{ndg} Q_{dg(k)} - \sum_{i=1}^{ncb}\sum_{k}^{nc} Q_{c(k)} \tag{12}$$

where Q_{ss} is the total reactive power demand (includes load and losses) on the main grid or power imported by the sub-station bus.

Real and reactive power compensation limits, bus voltage magnitude limits, branch current limits, as expressed in Eqs. (13) to (16), respectively.

$$P_{dg}^{min} \le P_{dg} \le P_{dg}^{max} \tag{13}$$

$$Q_{ds}^{min} \le Q_{ds} \le P_{ds}^{max} \tag{14}$$

$$|V_i|^{min} \le |V_i| \le |V_i|^{max} \tag{15}$$

$$I_k \le {I_k}^{max} \tag{16}$$

where P_{dg}^{min} and P_{dg}^{max} are the minimum and maximum limits for RE-DG's real power, respectively; Q_{ds}^{min} and Q_{ds}^{max} are the minimum and maximum limits for DSTATCOM's reactive power, respectively; $|V_i|^{min}$ and $|V_i|^{max}$ are the minimum and maximum limits for bus voltage magnitudes, respectively; I_k and ${I_k}^{max}$ are current flow and its limit of the branch-*k*, respectively.

4. Northern goshawk optimization

Northern Goshawks are Accipiter. It eats small and large birds, raptors, mice, rabbits, squirrels, foxes, and raccoons. Northern goshawks hunt twice. Once it spots something, it chases it with its tail. The northern goshawk moves fast in the first stage. The second stage is tail-chase. [33].

The northern goshawk searches for the population-based NGO. Each NGO member symbolises a prospective problem solution, giving them varying values. Randomization determines who searches first.

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$$g_{ij} = g_{j,up} + rand \times (g_{j,up} - g_{j,lb}),\\ i = 1,2, \dots, nd, j = 1,2, \dots, np \quad (17)$$

where g_{ij} is the jth variable of ith solution, nd is the dimension of search space, np is the number of search variables, $rand$ is a random number between 0 and 1, $g_{j,lb}$ and $g_{j,up}$ are the lower and upper limit of jth search variable, respectively.

For this initial population, NGO determines the best fitness function value and correspondingly its population and stores as pre-iterative solution.

4.1 Exploration phase

A Northern Goshawk will assault an undetermined target during the preliminary phase of the hunt. It is simpler for the NGO to search if the prey are chosen at random in this phase. Following this, the entire search region is carefully examined to determine the optimal area.

$$P_{pi} = G_k, i = 1,2, \dots, np,\\ k = 1,2, \dots, i-1, i, i+1, \dots, np \quad (18)$$

$$g_{ij}^{n,P1} = \begin{cases} g_{ij} + r_1(p_{ij} - N.g_{ij}), & OF_{pi} < OF_i \\ g_{ij} + r_1(g_{ij} - p_{ij}), & OF_{pi} \geq OF_i \end{cases} \quad (19)$$

$$G_i = \begin{cases} G_i^{n,P1}, & OF_{pi}^{n,P1} < OF_i \\ G_i, & OF_{pi}^{n,P1} \geq OF_i \end{cases} \quad (20)$$

where P_{pi} is the ith northern goshawk's prey position, OF_{pi} is the fitness function value, k is a random value between [1, np], $G_i^{n,P1}$ is the current new location of ith solution, $g_{ij}^{n,P1}$ is its jth dimension, $OF_{pi}^{n,P1}$ is new fitness function value at the exploration phase, r_1 is uniformly distributed random number, N is randomly generated as 1 or 2.

4.2 Exploitation phase

After being attacked, northern goshawk prey flees. Northern goshawks tail their prey. Northern goshawks are fast and can hunt anywhere. This behaviour simulation improves local search. NGO assumes hunting within R of an attack point.

First and second NGO iterations change all population members. The best solution, new population statistics, and objective function are then chosen. The program updates population members using Eqs. (18) to (23) until the last iteration.

$$g_{ij}^{n,P2} = g_{ij} + R(2r_2 - 1)g_{ij} \quad (21)$$

$$R = 0.02\left(1 - \frac{it}{it_{max}}\right) \quad (22)$$

$$G_i = \begin{cases} G_i^{n,P2}, & OF_{pi}^{n,P2} < OF_i \\ G_i, & OF_{pi}^{n,P2} \geq OF_i \end{cases} \quad (23)$$

where it and it_{max} is the current iteration and maximum number of iterations, respectively; $G_i^{n,P2}$ is the current new location of ith solution, $g_{ij}^{n,P1}$ is its jth dimension, $OF_{pi}^{n,P2}$ is new fitness function value at the exploitation phase, r_2 is uniformly distributed random number.

5. Results and discussion

For each scenario, IEEE 33-bus RDSs are simulated [37]. Case 1 optimises PV-position DGs and size. Case 1 optimises WT-DG placement and dimensions. Case 3 optimises DSTATCOM placement and size. In the fourth case, one PV, WT, and DSTATCOM are given. NGO's efficiency is compared to other heuristic algorithms and the literature.

5.1 IEEE 33-bus RDS

Real power loads for the base IEEE 33-bus RDS are 3715 kW, and reactive power loads are 2300 kVAr. It operates at a voltage of 12.66 kV. By performing load flow, it can see that the system loses 210.9976 kW of actual power and 143.0325 kVAr of reactive power when there is no compensation. The lowest voltage is found at bus 18, where it is 0.9038 p.u. The system is believed to have low voltage stability with a VSI estimated in accordance with [36] of 0.6685. The rate of GHG emission for this mode of operation is 8.0391e+6 lb/h.

5.2 PV-DG allocation

The greatest power a PV system can produce is 3715 kW. The suggested NGO chooses the ideal site between buses 2 and 33. The ideal location is bus 6, and the ideal PV system size is 2590.2409 kW. The system performance is altered by having this PV system in the following ways: it losses 111.0298 kW of actual power and 81.684 kVAr of reactive power. The lowest voltage is found at bus 18, where it is 0.9424 p.u. The VSI in this instance is predicted to be 0.7901 and the GHG emission to be 2.5305e+6 lb/h. 2589.6. In comparison to the results of WOA [5], BFOA [21], HPO [38] and MOA [39], the proposed NGO is resulted for global optima.

Table 1. System performance for different cases

Parameters	Base Case	Case 1	Case 2	Case 3	Case 4
PV (kW/Bus#)	–	2590.24/ 6	–	–	817.72/ 13
WT (kW/p.f./Bus#)	–	–	2558.18/ 0.824/ 6	–	1116.48/ 0.733/ 30
DSTATCOM (kVAr/Bus#)	–	–	–	1258/ 30	443.07/ 11
$\mathbf{P_{loss}}$ (kW)	210.998	111.030	67.868	151.378	28.613
$\mathbf{Q_{loss}}$ (kVAr)	143.032	81.684	54.832	103.820	20.375
$\mathbf{V_{min}}$ (p.u.)	0.9038	0.9424	0.9583	0.9165	0.9802
Vmin_Bus #	18	18	18	18	25
VSI	0.6685	0.7901	0.8450	0.7069	0.9345
GHG emission $\times 10^6$ (lb/h)	8.039108	2.530476	2.507746	7.917028	3.705076

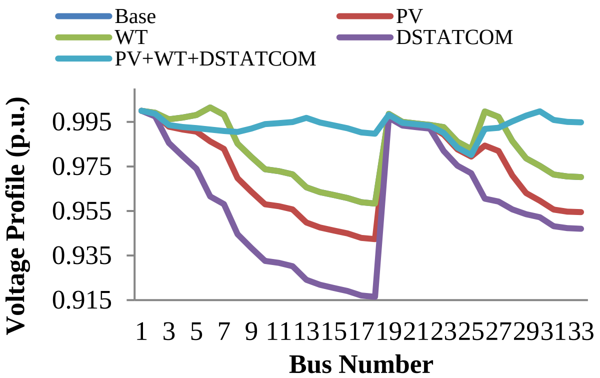

Figure. 1 Voltage profile for different cases

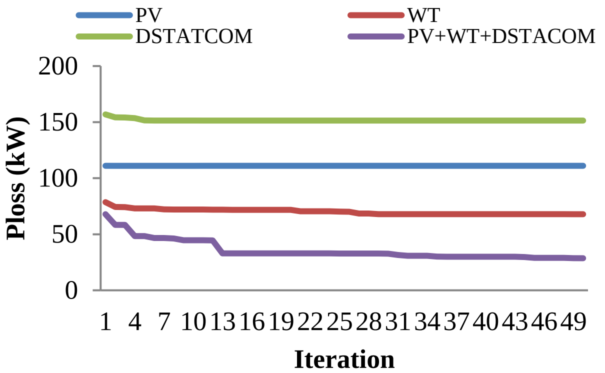

Figure. 2 Convergence characteristics of NGO for different cases

5.3 WT-DG allocation

The WT-DG allocation results are as follows: Bus-6 and 2558.18 kW are the best options for location and size. Power factor 0.824 is the most optimal setting for this application. The system losses are 67.868 kW of actual power and 54.832 kVAr of reactive power as a result of the addition of this WT system. The lowest voltage is found on bus 18, at 0.9583 p.u. The VSI is 0.845, and the GHG emissions are 2.5077e+6 lb/h under these conditions. The simulation results given by BFOA [21] are compared with the proposed NGO and it is observed that the NGO is attained better results in terms of global optima.

5.4 DSTATCOM allocation

The following are the DSTATCOM allocation results: The greatest possibilities in terms of size and location are Bus-30 and 1258 kVAr. Due to the addition of this WT system, the system losses are 151.378 kW of actual power and 103.82 kVAr of reactive power. Bus 18 has the lowest voltage at 0.9165 p.u. Under these circumstances, the VSI is 0.7079 and the GHG emissions are 7.9171 + 6 lb/h. The simulation results given by GSA [13] and BFOA [21] are compared with the proposed NGO and it is observed that the NGO is attained better results in terms of global optima.

5.5 PV, WT and DSTATCOMs allocation

In this instance, PV, WT, and DSTATCOM's size and placement are all optimised simultaneously. The best NGO results are as follows: The size of the PV system, which is located on Bus-13, is 817.72 kW. The WT system, which is situated at bus-30 and has a power factor of 0.733, is 1116.48 kW in size. DSTATCOM is located on bus 11 and has a power output of 443.07 kVAr. The system lost 20.375 kVAr of reactive power and 28.613 kW of real power as a result of the addition of this WT system. Bus 25 has the lowest voltage, with 0.9802 p.u. The VSI is 0.9345 and the GHG emissions are 3.7051e+6 lb/h under these circumstances.

The optimal DG sizes and the effectiveness of the RDS in each of these four scenarios are shown in Table 1. The voltage profile and convergence of NGO are depicted in Fig. 1 and 2, respectively.

This can be solved using the NFL principle. No algorithm can solve all optimization problems, according to the NFL theorem. This theorem states that an optimization algorithm's ability to solve some problems does not guarantee success with others. In this connection, researchers are still inspiring to develop new algorithms such as Stochastic Komodo Algorithm (SKA) [40] and Fixed Step Average and Subtraction Based Optimizer (ASBO) [41] etc. Thus, evaluation of proposed NGO efficiency with respect to newly introduced algorithms is still an interesting issue and can be considered as future scope of this research.

6. Conclusion

The RDSs can perform better technically, economically, and environmentally by integrating DG and reactive power sources (DSTATCOM). The Northern Goshawk Optimization (NGO) is a new meta-heuristic that replicates the northern goshawk's hunting behaviour for locating and sizing active and reactive power DGs in RDSs. NGO determines PV, WT, and DSTATCOM locations and sizes for the multi-objective function. The suggested solution reduces distribution losses, improves voltage profile, and boosts voltage stability margin. The proposed method's computational efficiency is tested using five case studies. IEEE 33-bus RDS simulates. Integrating stand-alone PV, WT, DSTATCOM, and their combinations reduces losses to 111.03 kW, 67.868 kW, 151.378 kW, and 28.613 kW from 210.988 kW. By integrating PV, WT, DSTATCOM, and their combinations, the VSI is improved to 0.7901, 0.8445, 0.7069, and 0.9345 from 0.6685. Optimally integrating PV, WT, DSTATCOM, and their combinations reduces GHG emissions (in106 lb/h) to 2.530476, 2.507746, 7.917028, and 3.705076 from 8.039108. NGO's results compare favourably to literature and heuristics. The proposed NGO enhances techno-environmental and RDS factors.

Conflicts of Interest

Authors declare that no conflicts of interest.

Author Contributions

Manohara M: Conceptualization, software, investigation, simulation, writing—original draft preparation, Veera Reddy V.C and Vijaya Kumar M: validation, formal analysis, and supervision.

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