Distributed Generation Embedding to Enhancing the Iraqi Grids Based on Optimization Technique

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Abstract. This research aims to analyze the impact of Distributed Generation (DG) on congestion line mitigation, power loss reduction, and voltage profile enhancement for Iraq's 400kV national grid system. The suggested Particle Swarm Optimization (PSO) and Exchange Market Algorithm (EMA) are implemented to specify the optimum size and location based on an analytic approach depended on voltage, active losses, and congestion lines as fitness. Then it is added to the super 400kV Iraqi grid. The results demonstrate the efficiency of the proposed approach in determining the optimum size and location, decreasing the congestion line, reducing power losses, reducing line flow, and improving the bus voltage profile. The results are obtained with proposed algorithms implementation by using programming language within MATLAB /R2018a environment.

1.Introduction
Energy demand has increased rapidly and is expected to continue to rise. However, power generation extension has been limited due to resources and limitations, contributing to higher transmission line tension and increased threats for overloaded lines. Distributed Generators, which they symbolize (DGs), are now more commonly used in electrical networks to meet rising demand.

Distributed Generation (compared with central power system) is a small source of electric power generation (typically range from less than a kW to hundreds of MW), which is located close to the load. It is not a part of the central power system referred to as the grid applies to large-scale production of power at concentrated installations. These installations are typically placed away from the users and linked to high voltage transmission lines (range from MW to GW). This concept has evolved to include connecting distributed generators on transmission networks as large-scale generators (hundred megawatts), such as gas turbine and Compound Heat Power CHP that connect to the customer side meter [1, 2].

One way to reduce losses and costs, voltage improvement, and congestion lines are by connecting the generators on the distribution network side to cover the demand for electrical energy from the load side [2]. Large-scale integration of electric power networks has often expanded the process and control complexities of the grid. Power grids are often exposed to unexpected contingencies (disturbances) such as dramatic
alterations in load demand, short circuit faults, outages in one or more transmission lines, equipment outages, and generator failures [3-5].

The power grid’s security relates to the threat’s degree in its capability to manage unexpected disturbances (contingencies) without interruptions in customer service [6]. Any condition in the contingency set will contribute to the overloading of the transmission line or violates bus voltage limits during services. These contingencies must be quickly detected for a full evaluation. This critical approach to emergency detection is the emergency option that takes account of the generator or line interruption utilizing the maximum AC load flow software [7].

They were using the Genetic Algorithm (GA) to minimize losses and improve the voltage profile method. The DG unit’s optimal rating is also optimized by looking at the Real Values of Power Flow Performance Indices for the most extreme emergencies [8]. DG units in distribution networks have specific impacts, like voltage level enhancement, energy quality, and loss reduction. The enormous scale of study papers will currently be collected from the DG machine for optimum sizing and optimization [9].

An approach used depends on finding a factor depending on the ratio of line load flow changes between two buses to determine congestion lines and manage them through distributed generations [10]. Mitigation congestion of transmission lines is implemented by adding DG to an appropriate location and optimal size based on PSO [11]. Optimal DG allocation and sizing based on Ant Colony Algorithms and Genetic Algorithms are implemented. Active power losses are evaluated as a function of power supplied by generators as different levels of generation are penetrated from DG [12]. An Exchange Market Algorithm (EMA) methodology is used to solve the optimal reactive control dispatch problems of an extremely non-linear power structure. In analyzing the power system, optimization issues are most critical and typically devised as an optimal power flow (OPF) problem [13]. In [14], research provides a strategy for optimizing the position and size of Distributed generation in the distribution systems based on improved sunlight optimization (SFO) to mitigate system power loss. Based on the original sunflower optimization (SFO), a mutation technique is applied to update the best plant.

For configuring power distribution networks with the optimum allocation of several distributed generators, the paper suggests an improved equilibrium optimization algorithm (IEOA) combined with a proposed recycling technique. A multi-objective feature is created that considers total power loss and bus voltages enhancement concerning the device limits. Scan, refined genetic, and firefly [15].

2. Contingency screening

Maintaining security against possible threats is critical in the electric grid environment. The violation of its limitations of transmission lines represented part of the most specific threats. An index has been obtained to measure each line’s series analysis if it reaches or exceeds the line limiter (MVA) to detect and prevent this issue by the device operator. Evaluation of the process result of the line limit violations called (contingency screening). This research applied the (n-1) method, which n means a line or generator outage. This index is called the Real Power Flow Performance Index \((PI_{RPF})\), where equation (1) as its general formula [8].

\[
(PI_{RPF})^i = \sum_{\text{branches}} \left( \frac{w_i}{2n} \right) \left( \frac{p_i^{(1)} \text{flow}}{p_i^{(1)} \text{max}} \right)^{2n} + \sum_{\text{bus}} \left( \frac{w_i}{2n} \right) \left( \frac{\Delta V_j^{(0)}}{\Delta V_j^{(\text{limit})}} \right)^{2n}
\]  

(1)

\[
\Delta V_j^{(0)} = V_j^{(i)} - V_j^{(\text{limit})}
\]  

(2)

\[
V_j^{(\text{limit})} = V_j^{(\text{max})}, \quad \forall V_j^{(i)} \geq 1.0
\]  

(3)
\[ V_j \text{(limit)} = V_j \text{(min)}, \quad \forall V_j^{(i)} < 1.0 \]  
(4)

\[ V_j^{(i)} = V_j \text{(max)}, \quad \forall V_j^{(i)} > V_{\text{max}} \]  
(5)

\[ V_j^{(i)} = V_j \text{(min)}, \quad \forall V_j^{(i)} < V_{\text{min}} \]  
(6)

\[ \Delta V_j \text{(limit)} = \frac{V_j^{(\text{max})} - V_j^{(\text{min})}}{2} \]  
(7)

Where, \( i = 1 \ldots N_{\text{lines}}, \ [PI_{RPF}] \) denotes on the active power performance index for \( ith \) outage, \([ w_i] \) & \([ w_j] \) denote on weight factors for line \( l \) and for bus \( j \) respectively that chosen by the operator after taking into consideration the systems condition work, \( a[ P_{\text{flow}}] \) denotes on the line flow of the \( l \) th line for \( (i) \) th outage, \( a[ P_{l}^{(\text{max})}] \) denotes on the maximum rating of the \( l th \) line, \( N_{\text{bus}} \) denotes on total buses’ number, and the term \( (2n) \) denotes the order of active power performance index, which considered as 2.

3. Finding Line Losses

The power losses in any line between buses \( i \) and \( j \) can written as the sum of power flows from equation (8) [16].

\[ S_{Lij} = S_{ij} + S_{ji} \]  
(8)

The summation of all line losses lead to the total losses of the network can be calculated using equation (9)

\[ \text{Losses} = \sum_{K=1}^{N_{\text{line}}} S_L(K) \]  
(9)

Where \( S_L \) is a loss of one branch, \( N_{\text{line}} \) denotes on the total lines, \( K \) acts specified line.

4. The Objective function and optimization

The GA determines the optimum DG site and size. The aims are used in GA-based optimization technology to assign the optimum DG site and size for reducing voltage deviation, active power loss, and performance index. The objective function represents by equation (10) as follows:

\[ Min f = W_1 \sum_{l=1}^{N_{\text{bus}}} (V_{\text{ref}} - V_l)^2 + W_2 \sum_{j=1}^{N_{\text{line}}} P_{Lj} + W_3 \sum_{\text{all congested branches}} PI_{RPF} \]  
(10)

Where \( V_{\text{ref}} \) means a reference voltage, \( V_l \) means voltage at \( ith \) bus, \( P_{Lj} \) means the active power losses at \( j \) th line, \( N_{\text{bus}} \) means total busses’ number, \( N_{\text{line}} \) mean total lines’ number, and \( W_1 \), \( W_2 \), and \( W_3 \) are mean the objectives weights for voltage deviation, active power losses, and active power performance index respectively.

5. The elements of (PSO)

The basic PSO elements can clarified as following: [17]

5.1. Particle \( s_{id}^k \)

It is The candidate’s current location of the control variables where \( i=1, 2, 3, \ldots n, \quad d=1,2,3,\ldots m, \quad n \) represents control variables number, \( m \) is represent candidate particles number for each one of control variable. To illustrate that, let the vector of the control variables are \([ S1, S2, S3, \ldots Sn] \), then, the set of
particles of nth control variables $S_n$ are $(s_{n1}, s_{n2}, s_{n3}, \ldots, s_{nD})$. Each particle represents a position in the search space solution.

5.2. **Particle velocity** $v_{id}^k$

Particle velocity is the current velocity of particles’ motion in the swarm population at iteration $k$.

5.3. **Individual best position (pbest$_{id}$)**

The best position that points to best fitness value for each particle is called the individual best position or (local best position) or (personal best position).

5.4. **Global best position (gbest$_i$)**

Global best represents best position among all the individual better positions ever achieved, where $gbest_i^k$ represent the best position overall the individual best position (i.e., global position) for $i$th control variable at iteration $k$.

5.5. **Updating**

5.5.1. **Velocity** $v_{id}^{k+1}$

Updating the particle velocity can be according the following equation:

$$v_{id}^{k+1} = w \cdot v_{id}^k + c_1 \times \text{rand}_1 \times (pbest_{id}^k - s_{id}^k) + c_2 \times \text{rand}_2 \times (gbest_i^k - s_{id}^k)$$

(11)

where $v_{id}^k$ is the current velocity of the particle at iteration $k$; $v_{id}^{k+1}$ is the updating velocity of the particle at iteration $k+1$; $s_{id}^k$ is the particle position at iteration $k$; $w$ is the inertia weight; $c_1$ & $c_2$ are a randomly chosen number; $\text{rand}_1$ & $\text{rand}_2$ are a uniformly distributed random number between $[0,1]$; $k$ is the iteration number.

If the velocity limits are violated by a particle, the algorithm sets its velocity equal to the violated limit.

5.5.2. **Position**

The current position can be updated as following equation:

$$s_{id}^{k+1} = v_{id}^k + v_{id}^{k+1}$$

(12)

If the position limits are violated by a particle, the algorithm sets its position to the violated limit.

5.6. **Inertia weight**

Selection of the weight factor must be in a way that making a balance between local and global searching as well as to make a faster convergence. The implementation of this shall be by choose a large value of the weight factor for the initial iterations and gradually decrease the weight factor in sequential iterations as in equation (13)

$$w = w_{\text{max}} - k \times \frac{(w_{\text{max}} - w_{\text{min}})}{K_{\text{max}}}$$

(13)

where $w_{\text{max}} = 0.9$; $w_{\text{min}} = 0.4$; $k$ represents currently iteration number; $K_{\text{max}}$ represents maximum iteration number [17].

6. **Principle of EMA**

The capital market inspires EMA in which, depending on principles and their own experience and strategies, stockholders will take various decisions [18]. These choices can either stabilize or generate
volatility in the market. By splitting stocks and undertaking fewer risks, stockholders tend to maximize their benefits. Unlike the fluctuating style, citizens may achieve the maximum potential benefit in the prevailing balanced market situation by forecasting the current situation without considering the danger in their transactions. The possibility of swinging grades in the stock market can be either very advantageous or very dangerous to stockholders [19]. The EMA formulation implements the principles and fundamental requirements of the stock market are worked up for two states, namely states of equilibrium and fluctuations, as follows:

6.1. Balanced State
Stock market participants are grouped into three divisions according to their fitness functions:
- Superior stockholders are put in the first group (10 percent to 30 percent of total members). The participants of this community do not modify their stocks to retain their position in the market.
- Intermediate stockholders fall in the second group (20 percent to 50 percent of total members). By matching their stocks with stocks in the first type, these stockholders aim to attain a worldwide optimum.
- The remaining participants of the business are categorized into the third group with the lowest fitness feature value.

6.2. Fluctuating State
It divided to three categories as:
- Members try to maintain their place with the other owners and do not modify their stocks.
- Members in this group are seeking to boost their rank by altering their rank stocks.
- By adjusting the valuation of their stocks and a larger quest domain, members of this group continue to increase higher scores [20].

The Flowchart of procedures applying PSO and EMA to find the optimal DG size and location is shown in figure 1.

![Figure 1. Flowchart of procedure applying PSO and EMA to find the optimal DG size and location.](image-url)
7. The results and discussion

The proposed approach is applied to the Iraqi super grid 400kV where all data [21]. Iraqi Super Gird system 400 kV comprises (36) bus bars, (21) generator buses, (15) load buses, and (52) transmission lines. figure 7 represented the single line diagram of the 400 kV Iraqi Grid. The population size is 50, and iteration is 50, \( w_{\text{max}} \) equal 0.9, \( w_{\text{min}} \) equal 0.4, \( c_2 \) and \( c_1 \) equal 2. There are three emergencies in the network when the \((n-1)\) method is applied. According to the arrangement in table 1, lines 30(15-20)( AMN4- KUTP) and line 31 (15-20)( AMN4- KUTP) represented the most dangerous lines. Lines number 30 and 31 are two lines connected between buses [15 (AMN4)] and [20 (KUTP)].

Table 1. Results of Grid with and without DG by PSO.

| Ser. No. | Branch or unit No. | From bus | To Bus | PI power | PI voltage | PI \( RPF \) total | Sum Congestion Line | Congestion line |
|---------|-------------------|----------|--------|----------|------------|-------------------|-------------------|-----------------|
| 1       | 30                | 15 (AMN4) | 20 (KUTP) | 1.2344    | 1.8025     | 3.0369           | 1                 | (31)(15-20) (AMN4-KUTP) |
| 2       | 31                | 15 (AMN4) | 20 (KUTP) | 1.2344    | 1.8025     | 3.0369           | 1                 | (30)(15-20) (AMN4-KUTP) |
| 3       | 20                | 11 (BGS4) | 16 (BGC4)| 1.1403    | 1.3025     | 2.4428           | 1                 | (25)(12-15) (BGE4-AMN4) |

According to the research methodology with the proposed PSO and EMA, it is possible to mitigate the congestion lines, reduce the losses, improve voltage profile, and minimize load flow by connecting certain numbers of DG units in the network that leads to these goals. The initial generator size will be within a range (0-1000) MW as a group. Each group represents 1DG and has many generators. Table 2 and figures 2 and 3 are shown many things as the alleviation of congestion line from 3 lines to without line and the losses reduction, when applied PSO, from(46.22+j149.34) at the base case to (17.63+j153.73) (MVA), (14.54+j125.7) (MVA), (14.21+j132.6) (MVA) and (17.18+j149.34) (MVA). The losses percentage reduction are 61.85%, 68.54%, 69.26%, and 62.83%. The voltage profile is also improved where the voltage deviation changed from 0.01361 to 0.01335, 0.01322, 0.01316, and 0.01331 when connected 1DG, 2DGs, 3DGs and 4DGs, respectively. Table 3 and figure 2 shown the results by applying EMA. The losses are reduced to (21.86+j192.3) MVA at a percentage reduction of 52.7%. The voltage deviation reduced to 0.012944 when connected 4DGs, which illustrate the voltage improvement.

Table 2. Results of Grid with and without DG by PSO.

| Cases | P Loss (MW) | Q Loss (Mvar) | Congestion Lines | DG site bus | DG size (MW) | Loss Reduction (MW) | Loss Reduction % | Voltage Deviation (VD) |
|-------|-------------|---------------|-----------------|-------------|--------------|--------------------|-------------------|-----------------------|
| Without DG | 46.22        | 149.34        | 0               | 0           | 1000         | 28.59              | 61.85             | 0.01361               |
| With 1DG | 17.63        | 153.73        | 0               | 10          | 1000         | 28.59              | 61.85             | 0.01335               |
| With 2DG | 14.54        | 125.70        | 0               | 10          | 1000         | 31.68              | 68.54             | 0.01322               |
| With 3DG | 14.21        | 122.60        | 0               | 10          | 195.1        | 32.01              | 69.26             | 0.01316               |
| With 4DG | 17.18        | 149.34        | 0               | 10          | 1000         | 29.04              | 62.83             | 0.01331               |
Table 3. Results of Grid with and without DG by EMA.

| Cases     | P Loss MW | Q Loss Mvar | Congestion Lines | DG site bus | DG size MW | Loss Reduction MW | Loss Reduction % | Voltage Deviation (VD) |
|-----------|-----------|-------------|------------------|-------------|-------------|-------------------|-------------------|------------------------|
| Without DG | 46.22     | 413.06      | 3                | /           | /           | /                 | /                 | 0.01361                |
| Add 1DG   | 32.81     | 297.4       | 1                | 12          | 955         | 13.41             | 29.01             | 0.01341                |
| Add 2DG   | 25.42     | 234.6       | 0                | 10          | 1000        | 20.8              | 45.002            | 0.01324                |
| Add 3DG   | 20.82     | 201.3       | 0                | 17          | 1000        | 25.4              | 54.95             | 0.013012               |
| Add 4DG   | 21.86     | 192.3       | 0                | 12          | 522         | 24.36             | 52.7              | 0.012944               |

Figure 2. Illustrate the results of active power losses for Iraqi Grid 400kV with PSO and EMA.
Figure 3. Bus voltage without and with DG by applying PSO.

Figure 4 shows the reduction of power flow when connected DGs to the network. The power flow percentage reduction is increased from 14.25% to 20.53% and from 27.86% to 36.54% by applying EMA and PSO, respectively. The main reason for reducing the power flow is the inevitable result of the generating units’ rescheduling and losses reduction result in reduction of the loads’ drawn current. It leads to significant results, such as reducing the operation fuel cost and reducing harmful emissions.

Figure 4. Percentage Power Flow Reduction for Iraqi Grid 400kV with DGs by PSO and EMA.

8. Loading 5% and 10%

For studying the grid’s possibility for loading increasing with applying PSO and EMA, the loads were increased to 5% from the normal case (8803.9+j3135.8) MVA to (9244.1+j3292.59) MVA. Also, increase the loads to 10%, which all become (9684.29+j3449.38) MVA. That led to an increase in the congestion lines to 4 and 11 lines. The losses are increased and the voltage is dropped, as shown in table 4 and figures 5 and 6. After connecting the DG with ascending numbers to insert active power with applied PSO, we notice bus voltage improvement observed in buses 10, 11, 12, 13, 15, 16, 17, 18, and 19. The losses are reduced from (63.37+j569.04) MVA to (16.44+j143.18) MVA at 5% and from (84.95+j764.84) MVA to (15.85+j136.88) MVA at 10%. The congestion lines are reduced from 4 and 11 lines to without line at 5% and 10%, respectively. Also, applied EMA led to reduced losses to (25.54+j201.2) MVA and (27.85+j235.98) MVA at 5% and 10%, respectively, for four DGs.

Table 4. Results of loading the network with and without DG by PSO.

| Cases       | Loading (MW) | Loading (Mvar) | Total Losses (MW) | Total Losses (Mvar) | Congestion line No. without outage | Congestion line No. with outage |
|-------------|--------------|----------------|-------------------|---------------------|----------------------------------|---------------------------------|
| Base case   | 8803.9       | 3135.8         | 46.19             | 413.08              | Nil                              | 3                               |
| Load increase 5% with PSO | 9244.1       | 3292.59        | 63.37             | 569.04              | Nil                              | 4                               |
| Without DG  | 8244.1       | 3292.59        | 25.32             | 223.28              | Nil                              | 0                               |
| With 1DG    | 7510.4       | 3292.59        | 19.69             | 172.12              | Nil                              | 0                               |
| With 2DG    | 6873.5       | 3292.59        | 15.61             | 135.1               | Nil                              | 0                               |
| With 3DG    | 7348.03      | 3292.59        | 16.44             | 143.18              | Nil                              | 1                               |
| Load increase 10% with PSO | 9684.29      | 3449.38        | 84.95             | 764.84              | 3                                | 11                              |
| Without DG  | 8684.29      | 3449.38        | 37.05             | 329.84              | Nil                              | 0                               |
| With 1DG    | 7684.3       | 3449.38        | 23.32             | 204.65              | Nil                              | 0                               |
| With 2DG    | 7375.9       | 3449.38        | 17.23             | 149.3               | Nil                              | 0                               |
| With 3DG    | 7383.8       | 3449.38        | 15.85             | 136.88              | Nil                              | 0                               |

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Table 5. Results of loading the network with and without DG by EMA.

| Cases                  | Loading (MW) | Loading (Mvar) | Total Losses (MW) | Total Losses (Mvar) | Conges. line No. without outage | Conges. line No. with outage |
|------------------------|--------------|----------------|-------------------|---------------------|-------------------------------|-------------------------------|
| Base case without loading | 8803.9       | 3135.8         | 46.22             | 413.06              | Nil                           | 3                             |
| Without DG             | 9244.1       | 3292.59        | 63.37             | 569.04              | Nil                           | 4                             |
| With 1DG               | 8443.2       | 3292.59        | 29.62             | 312.5               | Nil                           | 1                             |
| With 2DG               | 7919.6       | 3292.59        | 27.73             | 298.22              | Nil                           | 0                             |
| With 3DG               | 702.9        | 3292.59        | 25.66             | 245.2               | Nil                           | 0                             |
| With 4DG               | 7356.3       | 3292.59        | 25.45             | 201.2               | Nil                           | 0                             |
| Load increase 5% with EMA |             |                |                   |                     |                               |                               |
| Without DG             | 9684.3       | 3449.38        | 84.95             | 764.84              | 1                             | 11                            |
| With 1DG               | 8992.5       | 3449.38        | 41.1              | 397.2               | Nil                           | 3                             |
| With 2DG               | 7823.6       | 3449.38        | 32.8              | 357.56              | Nil                           | 0                             |
| With 3DG               | 7532.1       | 3449.38        | 29.33             | 243.3               | Nil                           | 0                             |
| With 4DG               | 7462.6       | 3449.38        | 27.85             | 235.98              | Nil                           | 0                             |

Figure 5. Bus voltage without and with DG Under Loading 5%.

Figure 6. Bus voltage without and with DG Under Loading 10%.
Figure 6. Bus voltage without and with DG under loading 10%.

Figure 7. Single line diagram of the 400 kV Iraqi SHV Gird System.

9. Conclusion
In this paper, the proposed approach, which applies the contingency (n-1) line and generator outage for Iraqi high grid 400 kV (i.e., is carried out under single line outage and generator outage contingencies. Newton Raphson load flow within MATLAB programming language was applied. An optimization techniques PSO and EMA, have proven their effectiveness in obtaining important results, especially when connecting 1DG, 2DGs, 3DGs, and 4DGs to the network. This approach is applied to the Iraqi Super Grid 400kV to provide important solutions by connecting specific numbers of generating units in the optimal location and size to enhance its performance characteristic. Several important results were obtained that enhance the reliability of the network. The congestion lines are reduced from three lines to without line. The losses are reduced from(46.22+j413.06) at the base case to (17.63+j153.73) (MVA), (14.54+j125.7) (MVA), (14.21+j122.6) (MVA) and (17.18+j149.34) (MVA) with percentage reduction are 61.85%, 68.54%, 69.26%, and 62.83%. The percentage reduction of load flow increases from 27.86% to 32.95%, 36.49%, and 36.54%. In the same manner, when applying EMA. Also, the voltage profile is improved, as shown in the result of voltage deviation (VD) in table 2, table 3 and figure 3. These results have led to the enhancement and improvement of the network's performance, which is reflected in the improvement of other elements, such as reducing operation fuel costs and reducing environmental pollution emissions with the possibility of increasing its loading with additional loads. In comparison, these two algorithms found that relative preference to PSO.

10. References
[1] Dasan, S. B., Ramalakshmi, S. S., & Devi, R. K. (2009, December). “Optimal Siting and Sizing of Hybrid Distributed Generation Using EP”. In 2009 International Conference on Power Systems (pp. 1-6). IEEE.
[2] El-Khattam, W., & Salama, M. M. (2004). "Distributed Generation Technologies, Definitions and Benefits ". Electric power systems research, 71(2), 119-128.
[3] P. S. R. Murty, 2017, " Power System Analysis ", Second Edition, Elsevier Ltd., USA.
[4] Leonard L. Grigsby, 2012, " Power Systems", Third Edition, CRC Press Tylor & Francis Group, London.
[5] P. Kundur, 1994, " Power System Stability and Control", Mc Graw-Hill Professional Publishing, New York.
[6] Ian Dobson and David E. Newman, 2017, "Cascading Blackout Overall Structure and Some Implications for Sampling and Mitigation", International Journal of Electrical Power & Energy Systems, Vol. 86, March, PP. 29-32.

[7] J.A refae and H.Maghrabi,(1999). "Radial Basis function Network for Contingency Analysis of Bulk Power System", IEEE Transaction on power system Vol.4 No.2.

[8] Singh, A. K., & Parida, S. K. (2013). "Congestion Management with Distributed Generation and Its Impact on Electricity Market. International Journal of Electrical Power & Energy Systems, 48, 39-47.

[9] El-Khattam W, Hegazy YG, Salama MMA,(2005). "An Integrated Distributed Generation Optimization Model for Distribution " system planning. IEEE T Power Syst 20: 1158-1165.

[10] Dehnavi, E., Aminifar, F., & Afsharnia, S. (2019). "Congestion Management Through Distributed Generations and Energy Storage Systems". International Transactions on Electrical Energy Systems, 29(6), e12018.

[11] Muthulakshmi, K., Sasiraja, R. M., & Kumar, V. S. (2016). The Phenomenal Alleviation of Transmission Congestion by Optimally Placed Multiple Distributed Generators Using PSO. Circuits and Systems, 7(8), 1677-1688.

[12] Zakaria, Y. Y., Swief, R. A., El-Amery, N. H., & Ibrahim, A. M. (2020, January). "Optimal Distributed Generation Allocation and Sizing Using Genetic and Ant Colony Algorithms". In Journal of Physics: Conference Series (Vol. 1447, No. 1, p. 012023). IOP Publishing.

[13] Rajan, A., & Malakar, T. (2016). Exchange Market Algorithm Based Optimum Reactive Power Dispatch. Applied Soft Computing, 43, 320-336.

[14] Nguyen, T. T. (2021). “Enhanced Sunflower Optimization for Placement Distributed Generation in Distribution System”. International Journal of Electrical and Computer Engineering, 11(1), 107.

[15] Shaheen, A. M., Elsayed, A. M., El-Sehiemy, R. A., & Abdelaziz, A. Y. (2020). Equilibrium Optimization Algorithm for Network Reconfiguration and Distributed Generation Allocation in Power Systems. Applied Soft Computing, 98, 106867.

[16] Saadat, H. (1999). Power System Analysis (Vol. 2). McGraw-Hill.

[17] Al-Bahrai, L., & Dumbrava, V. (2016). Optimal Power Flow Based on Particle Swarm Optimization. University Politehnica of Bucharest Scientific Bulletin Series C-Electrical Engineering and Computer Science, 78(3), 253-264.

[18] Statman, M. (1999). “Foreign Stocks in Behavioral Portfolios”. Financial Analysts Journal, 55(2), 12-16.

[19] Birnbaum, M. H. (2008). “New paradoxes of risky decision making”. Psychological review, 115(2), 463.

[20] Jafari, A., Khalili, T., Babaie, E., & Bidram, A. (2019). “A Hybrid Optimization Technique Using Exchange Market and Genetic Algorithms”. IEEE Access, 8, 2417-2427.

[21] Abdulsada, M. A., & Tuaimah, F. M. (2017). “Power System Static Security Assessment for Iraqi Super High Voltage Grid”. International Journal of Applied Engineering Research, 12(19), 8354-8365.