Contemporary Mathematics
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Research Article

Optimal Power Flow of Power System with Unified Power Flow Controller Using Moth Flame Optimization with Locational Marginal Price

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Received: 6 December 2023; **Revised:** 7 January 2024; **Accepted:** 11 January 2024

Abstract: Consideration of transmission line capacity and the optimal power flow (OPF) determines the locational marginal price (LMP), which in turn determines the performance and profitability of a producing unit. Reducing the total cost of the generators can lead to a drop in the market price of electricity. It is recommended to use numerical and repetition-based approaches for solving power flow equations due to their nonlinear nature. In order to achieve the ideal power flow at an affordable price, this paper employs a Moth Flame Optimization (MFO) to solve the equations. We then enhance the MFO's structure to make it more effective at performing the simultaneous calculations of power passing through transmission lines. Flexible AC transmission systems (FACTS) tool that has been utilized to overcome this problem is the Unified Power Flow Controller (UPFC). Lastly, the proposed MFO algorithm would include the following parameters in its output: bus voltages, line losses, generated power, total generating expenditures, and generator profits. In this work, the proposed method is tested on the IEEE 57-bus network also shows that it improves upon the OPF problem.

Keywords: optimal power flow, moth flame optimization, UPFC, locational marginal price

MSC: 76Z05, 92C10, 92C35

1. Introduction

Electric service engineering has entered a new era, marked by competition between service-owned and sovereign authorities and long-standing power dynamics [1, 2]. Some licenses are close to each other. From countryside to countryside, and by growth a brief market where numerous consumers buy least client pricing power. This improved use of market pressures, new dealer support and confidence growing contemporary power model and finance system power deal corporation union has increased electric load organize transmission. The goal is to promote financial competence in the use of electric power organizations. Transmission of financial data from connected electric power facilities. Networks provide a typical discussion starter. Well-organized power markets. Besides description, financial send out maximize low Plant usability affects pay rates. Transmission constraints of LMP is the little price of providing the next electric power surge at a bus considering generating marginal cost and physical transmission system aspects.

Competitiveness among market actors facilitates power trade. It will boost industrial production and lower electricity costs for all consumers [3]. Market players like power producers, deregulated energy markets benefit customers and system

DOI: https://doi.org/10.37256/cm.5220244060

operators. However, Energy market difficulties include generating loss, line outages, etc. [4, 5]. The Transmission systems are widely used due to electric market restructuring for electricity trading. To integrate in a deregulated system, needs suitable formulation between regulatory entities like pool operators' system managers. This study emphasizes the latter of these difficulties. We study pool, bilateral, and multilateral dispatch coordination and construct mathematical models. How forward and real-time dispatch works when all three modalities coexist is addressed [6]. Producing and distributing companies' agreements cause transmission congestion in deregulated electricity systems globally. Transmission line congestion may be handled in deregulated energy networks for safe and economical operation. In overloaded lines, series connected UPFC devices are installed to ease system congestion [7]. Energy power flows must be estimated and improved in an electrical generating system. Locating FACTS devices and improving the power transmission line Available Transfer Capability (ATC) is crucial. It reduces system congestion and boosts power [8].

Calculating the LMP is crucial for evaluating generation unit performance and profit. This relies on transmission line capacity and OPF to minimize generator costs, alleviate transmission line congestion, and lower market electricity prices [9]. The RLMP is a novel power market clearing method developed in this study. The risk-based security-constrained economic dispatch model generates the RLMP by modeling system security risk [10]. This study introduces two methods for placing series FACTS devices in deregulated energy markets to minimize congestion. Like the sensitivity factor-based strategy, the suggested strategies prioritize and narrow the solution space. The suggested methods use LMP differences and congestion rent, respectively [11]. Congestion in transmission lines might make it difficult to dispatch all planned power in a deregulated energy market. An interline power flow controller may enhance system stability and loadability by reducing system loss and power flow in severely laden lines. This study suggests using a Disparity Line Utilization Factor and Gravitational Search method to optimize placement and manage transmission line congestion [12]. We present single-objective and multi-objective optimization methods for optimal choice, location, and size of Static Var Compensators (SVC) and TCS in deregulated power systems to reduce branch loading (congestion), voltage stability, and line losses [13]. This research introduces an effective approach for optimizing FACTS device locations for congestion management by modifying device characteristics. Using FACTS devices for congestion control involves a two-step process.

To improve the network, first determine the ideal device placement and then optimize the control parameters [14]. After defining irrigation efficiency equations, hierarchical analysis developed goal function coefficients for all irrigation efficiencies in SWDC model. All irrigation efficiency formulae depend on input discharge [15]. Many recent research optimized furrow irrigation control settings. These experiments either optimized just complete irrigation status or not all infiltration parameters. This study uses MS visual basic (VB) programming to calculate the optimal soil water distribution curve equation [16]. Model training and forecasting utilize 42 and 5 years of monthly discharges from the 47-year period. The RMSE metric was used to compare static and dynamic artificial neural network models. Starting with data from October 1960 to September 2002, the finest static and dynamic neural network topologies are identified [17]. In addition, an impedance compensation approach is presented to address the numerical instability or numerical difficulties of Interline Power Flow Controller (IPFC) and a generalized unified power flow controller (GUPFC) models with low coupling transformer impedances or transformer-less controllers [18]. Multi transmission lines are controlled by an IPFC in this work. However, IPFC installation in the transmission line is difficult. The suggested technique uses tabu search (TS) algorithm and artificial neural network (ANN) to discover the optimal IPFC installation sites in a multi transmission line system [19]. Due to transmission corridor congestion, a deregulated energy market may not be able to dispatch all contractual power transactions. Environmental, right-of-way, and economic issues prevent power transmission network growth, thus power system reorganization must unleash transmission system potentials [20]. This work introduces a reliable and efficient meta-heuristic technique for congestion issue solving. This study proposes using the firefly algorithm (FFA) to reduce transmission network congestion in a pool-based energy market by rescheduling producers using active power [21]. Reference [22] proposes enhanced harmony search to tackle transmission expansion planning with adequacy-security issues in deregulated power systems. Zhuang and Galiana performed simulated annealing (SA) on unit commitment [23]. Jang et al. [24] proposed a computationally simple random search technique (RSM) for optimization issues.

The FFA, a meta-heuristic inspired by fireflies [25], is becoming more popular in practically all fields of science and technology for optimization. Reference [26] solved non-linear design issue using FFA. The FFA was used in reference

[27] to improve transmission system control variables for actual power loss and voltage stability limit. Reference [28] designs a Smith predictor controller for integration and unstable delay processes using the modified FFA. Current study proposes FFA for power network rescheduling to reduce congestion. Many optimization and congestion management [29, 30] approaches have been suggested to reduce congestion cost and loss in transmission networks, according to a literature review. However, the approach may be improved to reduce transaction curtailment, loss, and rescheduling expenses. This study introduces UPFC with MFO to manage transmission network congestion.

In this paper, generating scaling factor (GSF) was used to prevent congestion in minimum local points and calculate the power flow for each change in control variables. If the algorithm [31] violates line capacity, it exits this optimal point and continues to find the best response. It decreases convergence speed, makes power flow actual, and costs less than previous ways. A 24-hours of power flow on an IEEE 30 and 57-Node network was performed after MFO algorithm [32] introduction. The generator profit was computed by estimating the power price using UMP or LMP and comparing it to economic dispatching (ED) and quadratic programming using Lagrangian coefficients.

2. Problem formulation

The optimum power dispatch model in the deregulated energy market aims to minimize deviation from contract power transactions for market utilities. Simultaneously, operational equality and inequality requirements must be met for uninterrupted transactions.

2.1 *Objective function*

OPF aims to reduce active power generation expenses. The active power-based cost function of each producing unit is shown by this quadratic curve. Add each generator's cost function to get the system's goal function.

$$F_c = min(\sum_{i=1}^{ng} a_i P_{Gi}^2 + b_i P_{Gi} + c_i) \tag{1}$$

2.1.1 *Equality constraints*

Production should minimize cost while meeting power demand and transmission losses. So, power flow equations are equivalent limitations and which are given in (2) and (3).

$$\sum_{i=1}^{N} P_G = \sum_{i=1}^{N} P_{Di} + P_L \tag{2}$$

$$\sum_{i=1}^{N} Q_{Gi} = \sum_{i=1}^{N} Q_{Di} + Q_L \tag{3}$$

2.1.2 *Inequality constraints*

OPF limits vary according on power system equipment and dependability. Uneven constraints in buses connecting to power and producing units are usually high and low voltage. Generation restrictions include generator active power, transmission line capacity, TCUL tap adjustment, and phase shift. Limitations of unequal issue variables: Generator-powered buses have high and low active power. The voltage, Watt and wattles power and UPFC limits are given from equations (4) to (7) respectively.

$$V_{Gi}^{min} \leq V_{Gi} \leq V_{Gi}^{max} \tag{4}$$

$$P_{Gi}^{min} \leq P_{Gi} \leq P_{Gi}^{max} \tag{5}$$

$$Q_{Gi}^{min} \leq Q_{Gi} \leq Q_{Gi}^{max} \tag{6}$$

$$B_{upfc}^{min} \leq B_{upfc} \leq B_{upfc}^{max} \tag{7}$$

3. Electricity market price calculation

After calculating OPF and line power flow, we may compute electricity market price using two approaches. The first technique (UMP) uses power flow data without congestion, calculating electricity prices from the overall cost of functioning generators. Each node will have the equal power tariff. The nextprocess (LMP) is used when one or more transmission lines are at capacity and the power cost for each node will vary based on generator output.

3.1 *UMP price*

Consider the IEEE 30-BUS network's generation units to determine the generators' ultimate cost for the minimal producing power:

$$MC_i(P_i^{min}) = \frac{dF_i(P_i^{min})}{dP_i^{min}}\left(\frac{\$}{MWH}\right), \; i = 1,\, 2,\, 3,\, 6,\, 8 \tag{8}$$

Power price (π) will be determined by the cost of the more expensive generator, since employing the cheaper generator would result in losses and be unfeasible. Electricity costs are based on generators' lowest power to keep prices low.

$$\pi = max(MC_i(P_i^{min}))\left(\frac{\$}{MWh}\right) \tag{9}$$

3.2 *LMP price*

The power price at network locations will be different if transmission line capacity hits its limit, since producers cannot employ their full generation capacity. This is termed locational marginal pricing. LMP implies adding a 1-MW excess load using the cheapest generators that can generate without exceeding transmission line limits. Therefore, LMP may be calculated by considering generators that are not at their limitations. Final generators are ones with some capacity left. Thus, LMP in buses with final generators equals their ultimate cost. LMP of nodesdevoid of generators or whose generators have surpassed their maximum will also rely on buses with a final generator. Final-generator buses

$$\begin{aligned} &\pi_i = LMP_i = MC_i(P_i),\; P_i^{min} < P_i < P_i^{max},\; P_i \neq P_i^{min}, \\ &P_i \neq P_i^{max}, \quad i \in 1,\, 2,\, 3,\, 6,\, 8 \end{aligned} \tag{10}$$

Final generator buses are indicated by i. Finally, Figure 1 displays the flowchart of all stated steps with green blocks representing algorithm outputs.

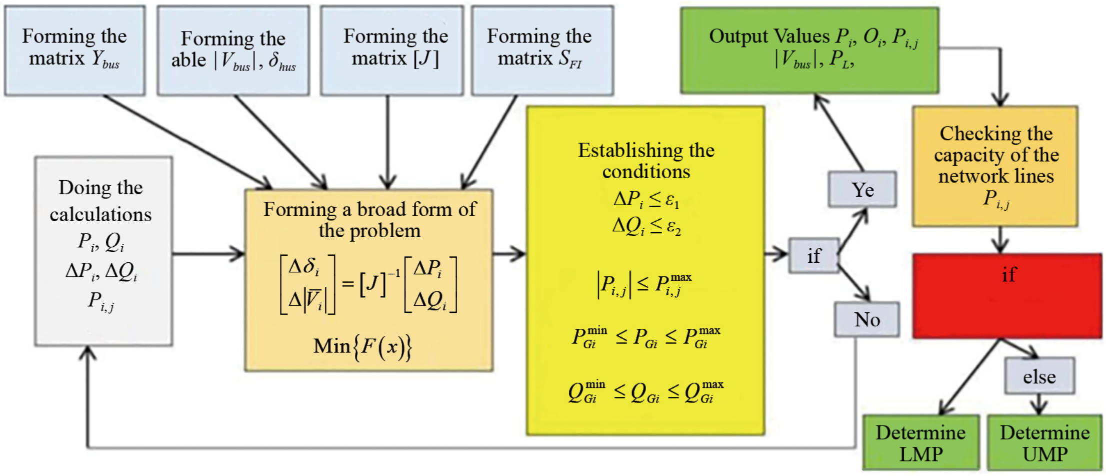

Figure 1. Block diagram of the stages

4. Moth flame optimization

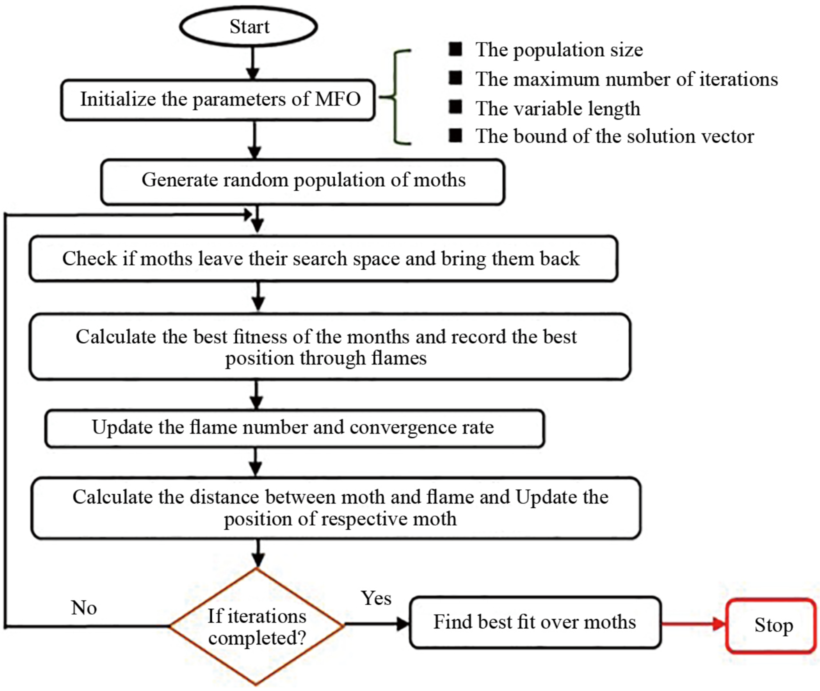

Figure 2. Flow chart of moth flame algorithm

This is a method of optimisation with roots in the natural world. The algorithm's design was inspired by the moths' method of navigating at night. The moths fly at a steady angle towards the moon. Moths often fly in spiral patterns around lights. The multi-objective function's solution is assumed to be represented by the moths. One of the parameters of the issue is the spatial distribution of the moths. The following is a summary of the mathematical models of moth behavior: In light of these constraints, we describe the logarithmic spiral used by the MFO method flow diagram shown in Figure 2, as where S is the spiral function, M_i is the i^{-th} moth, and F_j stands for the j^{-th} flame.

$$M_i = s(M_i,\ F_i) \tag{11}$$

$$S(M_i,\ F_i) = D_i \cdot e^{bt} \cdot \cos(2\pi t) + F_j \tag{12}$$

D_i is the distance between the i^{th} moth and the j^{th} flame, b is a constant used to define the shape of the logarithmic spiral, and t is a random number in the interval [-1, 1].

$$D_i = |F_i - M_i| \tag{13}$$

where M_i is the i^{th} moth for the j^{th} flame and D_i is the distance between them.

5. Results and discussions

5.1 *IEEE 30 bus system*

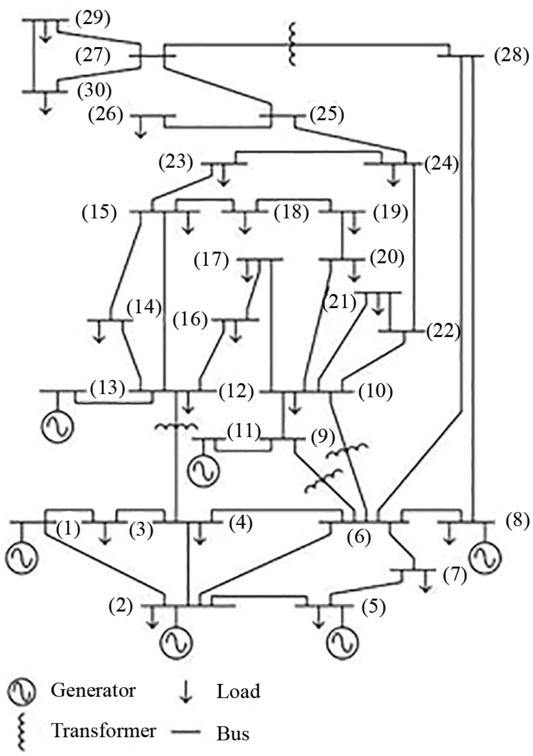

Figure 3. A IEEE 30-bus transmission systemm

Figure 3 depicts an IEEE 30 node network with 41 lines of transmission, 5 PV nodes, one slack bus, and the remaining load nodes. Currently, UPFCs are only being installed on load buses. Solar and wind power replace the final two remaining thermal generators at bus 23 and bus 27.

There is research being done on the generator reallocation for the IEEE-30 node network. The OPF is carried out for functions with a single goal, and then the multi-objective function optimization is carried out thereafter. The outcomes of both optimizations have been compared. The variable LMP stands for the locational marginal price, the variable UMP stands for the uniform marginal price, and the variable GSF stands for the generation scaling factor. MFO is an abbreviation for the algorithm for moth flame optimization. Table 1 indicates the OPF in 24 h using MFO. Table 2 shows the Calculations for profits of generators in MFO technique.

Figure 4 indicates the network's power demand, generation production and transmission losses and cost convergence in MFO approach shown in Figures 5 and 6. Generation cost profit between with and without UPFC describes in Figure7. Figure 8 indicates the generation loss cost between with and without UPFC. Generation losses between with and without UPFC shown in Figure 9. Voltage convergence with and without UPFC indicates in Figure 10.

Table 1. MFO outcome from OPF in one day

Hour	P1	P2	P5	P8	P11	P13	PD	Loss	Cost of production	Market price (UMP or LMP)
1	54.0083	20	15	10	35	30	162	2.008	223.34	UMP
2	71.2756	23.4808	15	10	35	30	182.18	2.5765	274.73	UMP
3	81.3129	25.881	15	10	35	30	194.12	3.074	306.828	UMP
4	88.343	27.571	15	10	35	30	202.4	3.49	329.89	UMP
5	98.344	29.98	15.4215	10	35	30	214.5	4.192	364.78	UMP
6	104.763	31.542	15.99	10	35	30	222.6	4.7	388.6	UMP
7	113.89	33.73	16.697	10	35	30	234.1	5.18	422.8	UMP
8	118.959	35.4569	17.2147	10	35	30	243	5.744	451.0153	UMP
9	127.3858	36.9671	17.66	10	35	30	251	6.0156	474.72	UMP
10	137.64	39.304	18.36	10	35	30	263.1	6.6326	513.25	UMP
11	146.832	41.6951	19.149	10	35	30	275.3	7.3776	553.304	UMP
12	153.0477	43.3018	19.6	10	35	30	283.4	7.55	579.4931	LMP
13	137.1144	39.0586	17.6044	10	35	30	263.13	5.6474	510.08	UMP
14	127.3858	36.9671	17.66	10	35	30	251	6.0156	474.72	UMP
15	118.959	35.4569	17.2147	10	35	30	243	5.744	451.0153	UMP
16	104.763	31.542	15.99	10	35	30	222.6	4.7	388.6	UMP
17	88.343	27.571	15	10	35	30	202.4	3.49	329.8	UMP
18	104.763	31.542	15.99	10	35	30	222.6	4.7	388.6	UMP
19	118.959	35.4569	17.2147	10	35	30	243	5.744	451.0153	UMP
20	137.1144	39.0586	17.6044	10	35	30	263.13	5.6474	510.08	UMP
21	118.959	35.4569	17.2147	10	35	30	243	5.744	451.0153	UMP
22	104.763	31.542	15.99	10	35	30	222.6	4.7	388.6	UMP
23	88.343	27.571	15	10	35	30	202.4	3.49	329.89	UMP
24	70.8558	23.4768	15.38	10	35	30	182.16	2.56	274.78	UMP

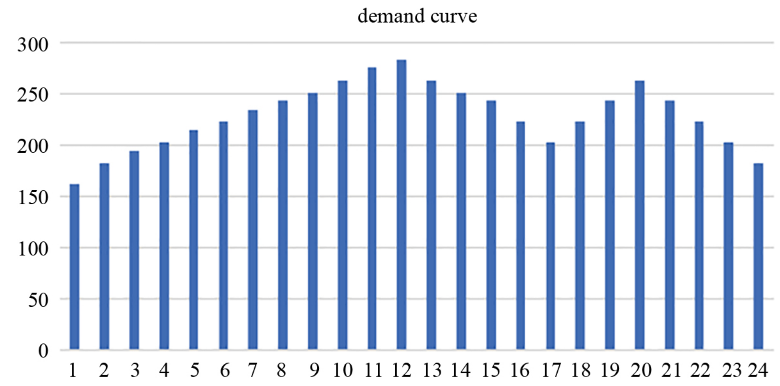

Figure 4. Network's power demand

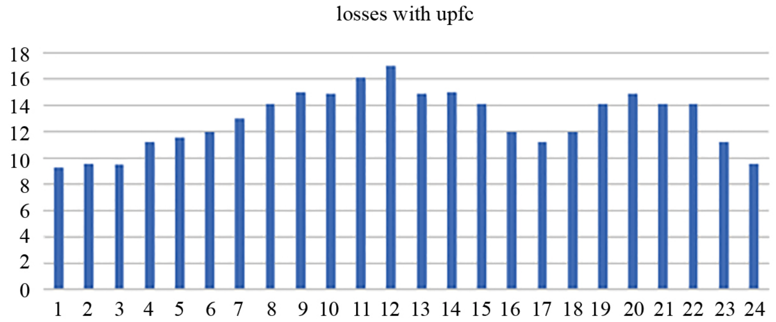

Figure 5. Generation production and transmission losses in the MFO approach

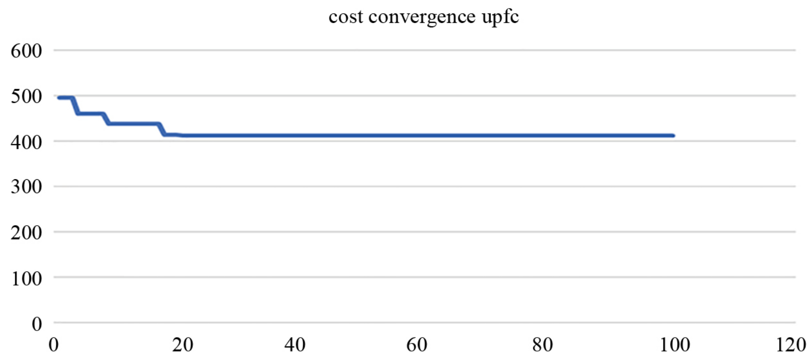

Figure 6. MFO approach cost convergence

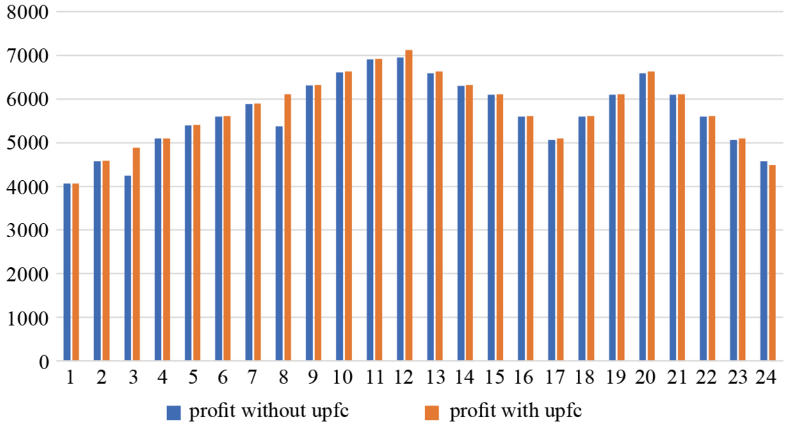

Figure 7. Generation cost profit between with and without UPFC

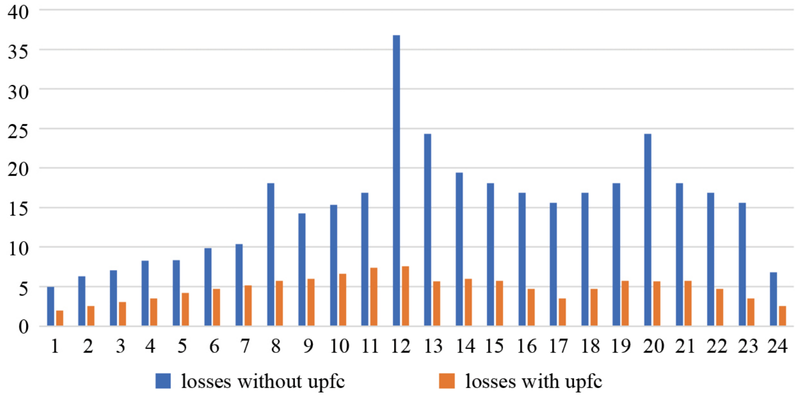

Figure 8. Generation loss cost between with and without UPFC

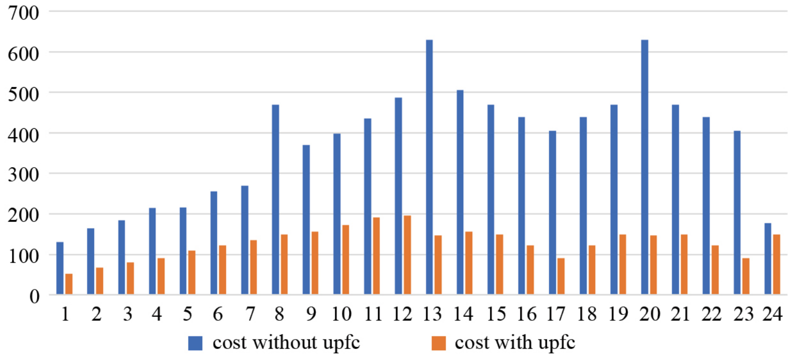

Figure 9. Voltage convergence with and without UPFC

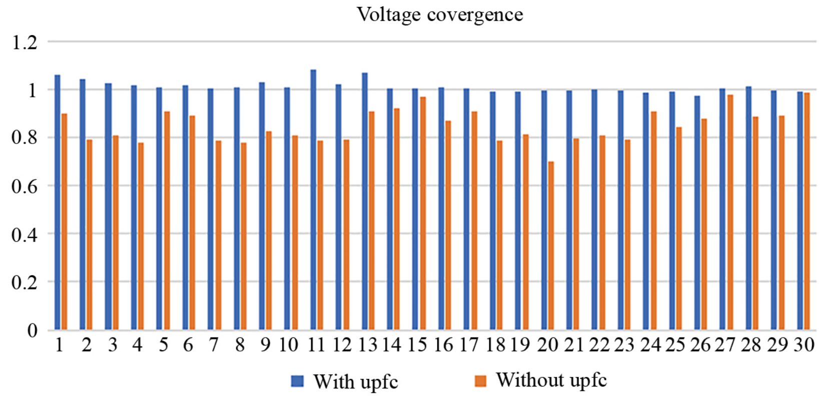

Figure 10. Voltage convergence with and without UPFC

Table 2. Estimates of generator earnings using the MFO technique

Hour	P1	P2	P5	P8	P11	P13	Loss cost	Total profit of generators	pi
1	1,393.27	518	390.93	246.66	844.375	727.5	52.1929	4,068.54	28
2	1,834.114	606.703	390.93	246.66	844.375	727.5	66.96	4,583.322	28
3	2,089.34	667.6	390.93	246.66	844.375	727.5	79.88	4,886.525	28
4	2,267.652	710.463	390.93	246.66	844.375	727.5	90.6944	5,096.88	28
5	2,520.675	771.246	401.51	246.66	844.375	727.5	108.927	5,403.039	28
6	2,682.681	810.567	415.75	246.66	844.375	727.5	122.117	5,605.416	28
7	2,912.5	865.503	433.39	246.66	844.375	727.5	134.58	5,895.348	28
8	3,039.866	908.754	446.18	296.1338	844.375	727.5	149.22	6,113.58	28
9	3,251.191	946.48	457.32	246.66	844.375	727.5	156.26	6,317.266	28
10	3,507.59	1,004.83	474.65	246.66	844.375	727.5	172.28	6,633.325	28
11	3,736.78	1,064.07	494.122	246.66	844.375	727.5	191.61	6,921.897	28
12	3,891.4	1,103.85	505.19	246.66	844.375	727.5	196.08	7,122.895	LMP
13	3,494.46	998.59	455.94	257.766	844.375	727.5	146.7	6,631.9	28
14	3,251.191	946.48	457.32	246.66	844.375	727.5	156.26	6,317.266	28
15	3,039.866	908.754	446.18	296.1338	844.375	727.5	149.22	6,113.58	28
16	2,682.681	810.567	415.75	246.66	844.375	727.5	122.117	5,605.416	28
17	2,267.652	710.463	390.93	246.66	844.375	727.5	90.6944	5,096.88	28
18	2,682.681	810.567	415.75	246.66	844.375	727.5	122.117	5,605.416	28
19	3,039.866	908.754	446.18	296.1338	844.375	727.5	149.22	6,113.58	28
20	3,494.46	998.59	455.94	257.766	844.375	727.5	146.7	6,631.9	28
21	3,039.866	908.754	446.18	296.1338	844.375	727.5	149.22	6,113.58	28
22	2,682.681	810.567	415.75	246.66	844.375	727.5	122.117	5,605.416	28
23	2,267.652	710.463	390.93	246.66	844.375	727.5	90.6944	5,096.88	28
24	1,823.424	606.62	390.93	246.66	844.375	727.5	149.22	4,490.28	28

5.2 *IEEE-57 bus system*

Figure 11 depicts an IEEE-57 node network with 80 lines of transmission, six PV nodes, one slack bus, and the remaining load nodes. Currently, UPFCs are only being installed on load buses. Solar and wind power replace the final two remaining thermal generators at bus 9 and bus 12. There is research being done on the generator reallocation for the IEEE-57 node network. The OPF is carried out for functions with a single goal, and then the multi-objective function optimization is carried out thereafter. The outcomes of both optimizations have been compared. The variable LMP stands for the locational marginal price, the variable UMP stands for the uniform marginal price, and the variable GSF stands for the generation scaling factor. MFO is an abbreviation for the algorithm for moth flame optimization. Table 3 indicates the OPF in 24 h using MFO. Table 4 shows the Calculations for profits of generators in MFO technique.

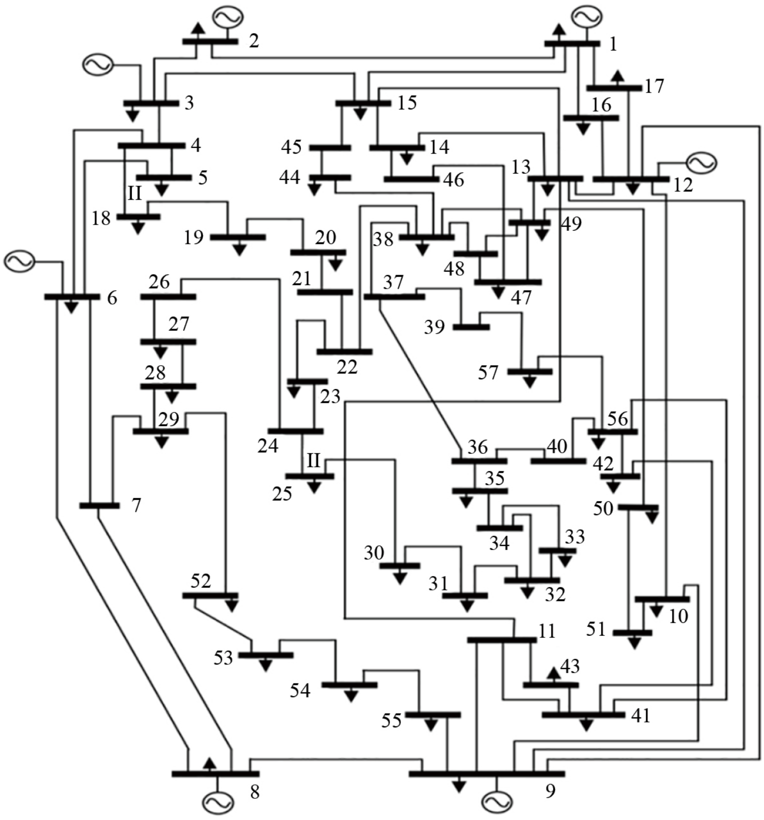

Figure 11. IEEE 57 bus transmission system

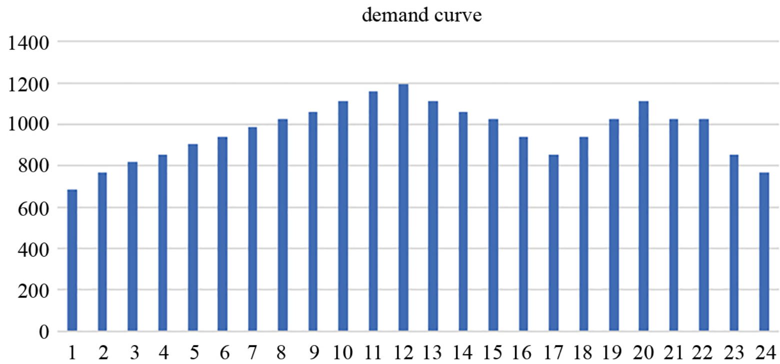

Figure 12. Network's power demand

For 57 bus system, Figure 12 indicates the network's power demand, generation production and transmission losses and cost convergence in MFO approach shown in Figures 13 and 14. Generation cost profit between with and without UPFC describes in Figure15. Figure 16 indicates the generation loss cost between with and without UPFC. Generation losses between with and without UPFC shown in Figure 17. Voltage convergence with and without UPFC indicates in Figure 18.

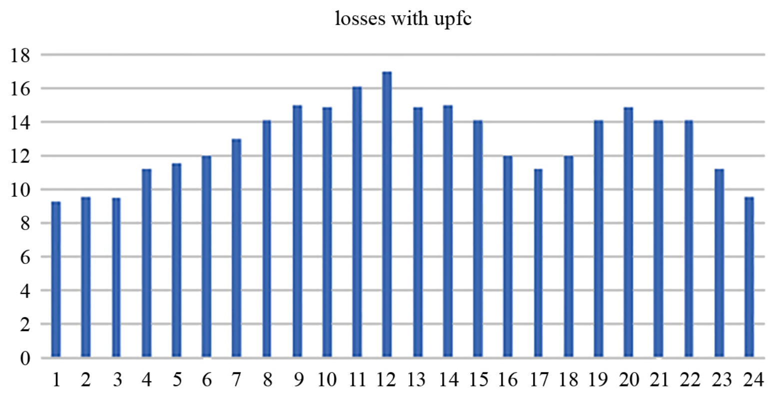

Figure 13. Generation production and transmission losses in the MFO approach

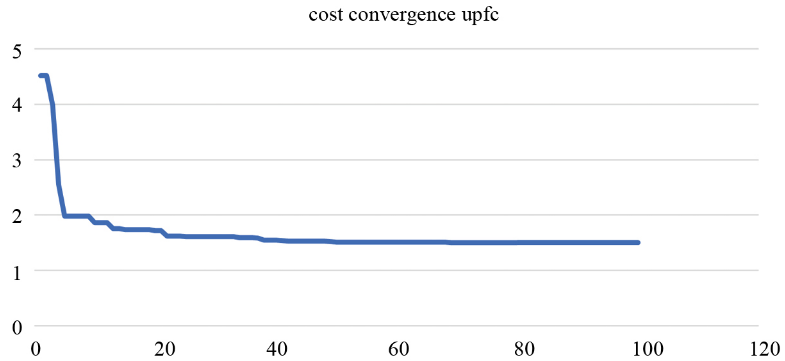

Figure 14. MFO approach cost convergence

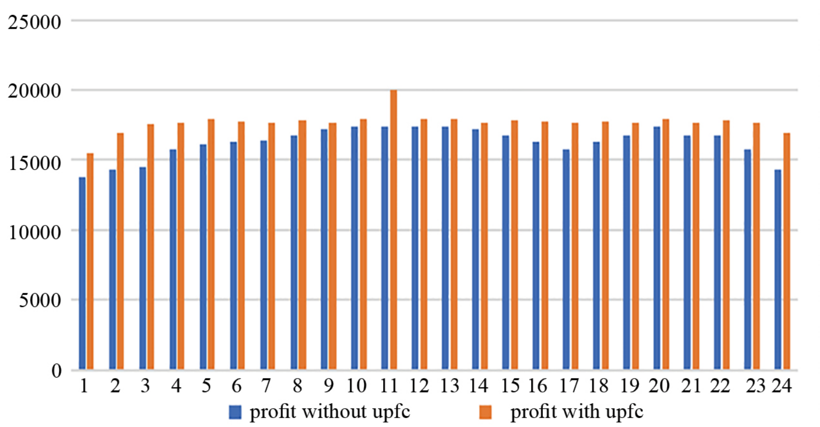

Figure 15. Generation cost profit between with and without UPFC

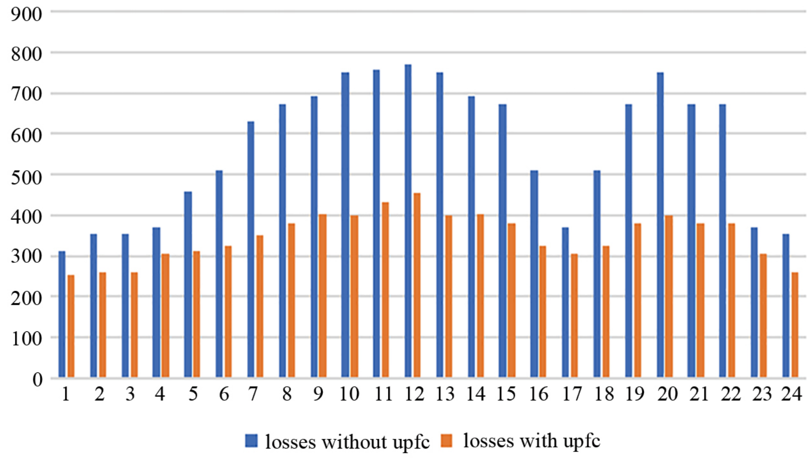

Figure 16. Generation loss cost between with and without UPFC

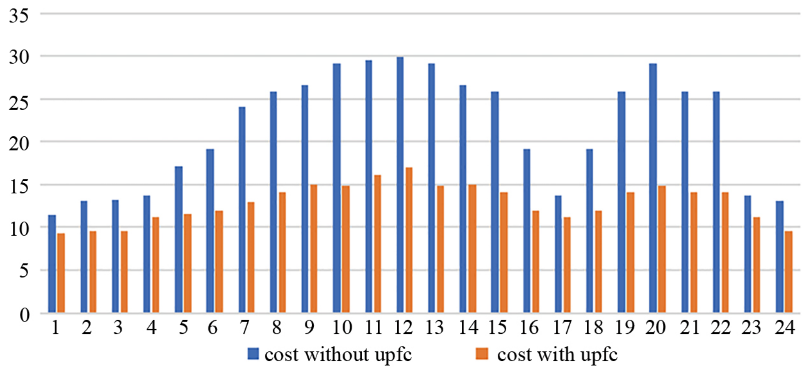

Figure 17. Generation losses between with and without UPFC

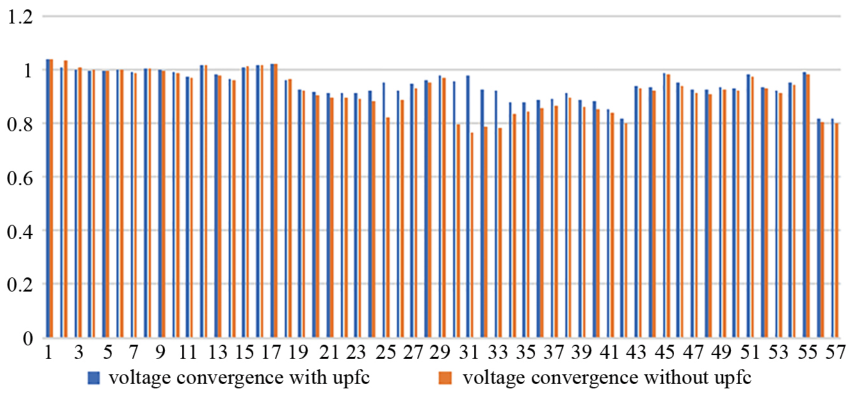

Figure 18. Voltage convergence with and without UPFC

Table 3. MFO outcome from OPF in one day

Hour	P1	P2	P3	P6	P8	P9	P12	PD	Cost of production	Loss	Market price (UMP or LMP)
1	88.63	1.1013	6.0979	1.3959	19.2367	200	376.1	683.28	3,061	9.288	UMP
2	35.145	0.0678	9.6745	0.0143	123.1302	200	410	768.66	3,820.1	9.5321	UMP
3	49.634	0.0018	15.219	0.0261	153.97	200	410	819.123	5,191.2	9.523	UMP
4	19.8119	100	7.378	0	128.78	200	410	854.04	7,604.2	11.2	UMP
5	73.81	0.182	20.9373	2.1	210.12	200	410	905.34	7,675.2	11.53	UMP
6	46.38	100	16.05	1	180.01	200	410	939.54	1,000	12.01	UMP
7	96.2	0.056	33.59	0.0057	262.47	200	410	987.96	10,021	13	UMP
8	104.3	0.016	31.6	0.005	292.39	200	410	1,024.92	10,010	14.1	UMP
9	113.11	8.9	31.01	0.078	310.12	200	410	1,059.13	11,500	15.001	UMP
10	137.5	31.6	46.12	1.116	296.01	200	410	1,110.3	14,001	14.9	UMP
11	133.5	13.01	44.01	9.6521	367.31	200	410	1,161.624	15,101	16.12	UMP
12	122.011	47.012	45.521	7.9213	378.41	200	410	1,195.8	17,510	17.01	LMP
13	137.5	31.6	46.12	1.116	296.01	200	410	1,110.3	14,001	14.9	UMP
14	113.11	8.9	31.01	0.078	310.12	200	410	1,059.13	11,500	15.001	UMP
15	104.3	0.016	31.6	0.005	292.39	200	410	1,024.92	10,010	14.1	UMP
16	46.38	100	16.05	1	180.01	200	410	939.54	1,000	12.01	UMP
17	19.8119	100	7.378	0	128.78	200	410	854.04	7,604.2	11.2	UMP
18	46.38	100	16.05	1	180.01	200	410	939.54	1,000	12.01	UMP
19	104.3	0.016	31.6	0.005	292.39	200	410	1,024.92	10,010	14.1	UMP
20	137.5	31.6	46.12	1.116	296.01	200	410	1,110.3	14,001	14.9	UMP
21	104.3	0.016	31.6	0.005	292.39	200	410	1,024.92	10,010	14.1	UMP
22	104.3	0.016	31.6	0.005	292.39	200	410	1,024.92	10,010	14.1	UMP
23	19.8119	100	7.378	0	128.78	200	410	854.04	7,604.2	11.2	UMP
24	35.145	0.0678	9.6745	0.0143	123.1302	200	410	768.66	3,820.1	9.5321	UMP

Table 4. Estimates of generator earnings using the MFO technique

Hour	P1	P2	P3	P6	P8	P9	P12	Loss cost	Total profit of generators	pi
1	1,872.099	8.7982	161.45	11.1478	530.412	1,200	1,594.287	253.372	5,124.8171	48
2	888.22	0.5423	247.49	0.1144	3,111.07	1,200	6,057.43	259.848	11,245.0167	48
3	1,198.58	0.0144	368.24	1.1484	3,784.9	1,200	6,057.43	259.6	12,350.71	48
4	524.274	700	192.97	0	3,237.71	1,200	6,057.43	303.86	11,608.524	48
5	1,644.08	0.14559	476.65	16.7559	4,903.23	1,200	6,057.43	312.5343	13,985.7595	48
6	1,131.714	700	385.2	8	4,322.72	1,200	6,057.43	325.087	13,479.974	48
7	1,975.456	0.44796	646.99	0.0456	5,819.79	1,200	6,057.43	350.8856	15,349.27	48
8	2,076.23	0.128	635.16	0.04	6,289	1,200	6,057.43	379.373	15,878.615	48
9	2,174.276	70.4079	627.87	0.62394	6,548.29	1,200	6,057.43	402.5657	16,276.334	48
10	2,382.875	242.814	759.6	8.9155	6,343.07	1,200	6,057.43	399.97	16,594.734	48
11	2,354.99	102.387	748.06	76.2851	7,289.53	1,200	6,057.43	431.1953	17,397.485	48
12	2,261.101	353.99	756.55	62.743	7,416.57	1,200	6,057.43	453.8551	17,654.53	LMP
13	2,382.875	242.814	759.6	8.9155	6,343.07	1,200	6,057.43	399.97	16,594.734	48
14	2,174.276	70.4079	627.87	0.62394	6,548.29	1,200	6,057.43	402.5657	16,276.334	48
15	2,076.23	0.128	635.16	0.04	6,289	1,200	6,057.43	379.373	15,878.615	48
16	1,131.714	700	385.2	8	4,322.72	1,200	6,057.43	325.087	13,479.974	48
17	524.274	700	192.97	0	3,237.71	1,200	6,057.43	303.86	11,608.524	48
18	1,131.714	700	385.2	8	4,322.72	1,200	6,057.43	325.087	13,479.974	48
19	2,076.23	0.128	635.16	0.04	6,289	1,200	6,057.43	379.373	15,878.615	48
20	2,382.875	242.814	759.6	8.9155	6,343.07	1,200	6,057.43	399.97	16,594.734	48
21	2,076.23	0.128	635.16	0.04	6,289	1,200	6,057.43	379.373	15,878.615	48
22	2,076.23	0.128	635.16	0.04	6,289	1,200	6,057.43	379.373	15,878.615	48
23	524.274	700	192.97	0	3,237.71	1,200	6,057.43	303.86	11,608.524	48
24	888.22	0.5423	247.49	0.1144	3,111.07	1,200	6,057.43	259.848	11,245.0167	48

6. Conclusion

Through the use of the metaheuristic algorithm MFO, the OPF problem as well as the locational marginal price (LMP) are resolved and calculated in this paper. In the event that the minimum point that is attained does not satisfy the prerequisites for the generation of flow power in the network, the process will be repeated until the prescribed circumstances are satisfied. The power of generating units, network losses, bus voltage, generation cost, and power moving via lines are the outputs of the recommended method. We could also calculate the market price of electricity and the profit of generators by studying the capacity of lines. In addition, we could compute the profit of generators. The results of the simulation illustrate the effectiveness of the MFO algorithm, which has resulted in reduced losses, reduced processing time, reduced producing costs, and an OPF that is better in accordance with the actual situation. In Future, the proposed optimization can be studied for generating systems with different renewable energy sources and the cost and loss estimation for different load and source systems can be studied.

Conflict of interest

The authors declare no competing financial interest.

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