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Hybrid Approach for Managing Congestion Using Optimal Distributed Generator Positioning

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Abstract

Congestion management (CM) in a large power system network is a difficult task which can be solved by placing one or more distributed generators (DGs) on congested lines. The first concern is to determine the exact location of congested line for the placement of optimal size of DG so that cost can be minimized. In this work, hybridization of firefly technique and differential evolution optimization search has been proposed, which manages congestion effectively by rescheduling of generators satisfying the system constraints both technically and economically in the deregulated market scenario. Distributed generation (DG) is an important issue for distribution networks for power loss improvement. However, the location and size of generators remain a challenge for existing techniques. This work investigates the optimal placement of a distributed generator on a medium voltage radial feeder. Simulated annealing optimisation is used to find an optimal bus of connecting a distributed generator variable-spider. The optimisation technique is then applied to a power flow this is because connecting the distributed generator in maximum loss reduction on the feeder to find the optimal bus where a distributed generator can be connected to a medium voltage radial feeder, thereby improving power quality and fulfilling load demand with minimal size to make the system economical. To validate the proposed hybrid approach, results have been compared with firefly optimization technique results. It is observed that the hybrid approach is an efficient tool in handling CM resulting in a secure operation to reduce flows in the heavily loaded lines with low system loss and increasing power capability with improved stability of network by controlling power flows in the network. The power system congestion is treated as a vital issue in the restructured topology of the power system. The analysis of appropriate technique to control congestion is of preeminent interest.

Keywords: Cost minimization, Congestion management, Distribution generation, Optimization.

Introduction

Evaluation criteria for sizing a standalone PV system Selecting the evaluation criteria for designing standalone PV system for a required locality is one of the important works for obtaining optimum PV design. Beccali used ELECTRE to assess an action plan that can handle different renewable energy techniques at the regional level [1]. Goletsis applied approach of energy planning for ranking the energy projects [2]. Topcu and Ulengin construed possible energy scenarios based on environmental, economic, physical, political, and other not controllable aspects [3]. Ribeiro et al. developed a ranking tool for different scenarios that is called multi-criteria decision analysis. This ranking tool is based on criteria covering technical, economic, environmental, quality of life, and job market aspects. Thus, to address the evaluation criteria, various parameters are taken into consideration in designing standalone PV system as shown in Figure. 1. These performance parameters are used to evaluate and estimate the availability and feasibility of a standalone PV system.

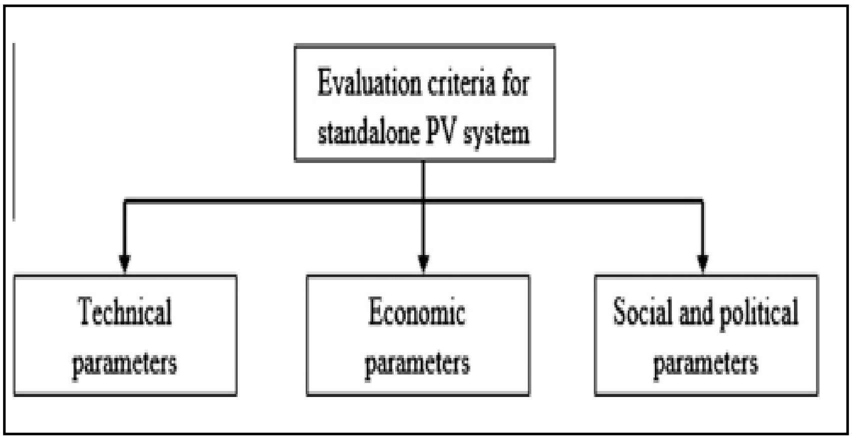

Figure. 1 Evaluation criteria for standalone PV system size optimization [1]

The persistence of the congestion problem indicates that new generation capacity or additional transmission facilities are needed to manage congestion. Decentralized production sources or renewable energies can be of great value in a highly congested area where LMPs are higher than elsewhere. In this study, we use LMP analysis and congestion rent to locate the optimal placement of the solar power plant to relieve congestion in transmission line. While the installation of solar power plant at an optimal location in the congested system could effectively improve the voltage profile, power quality and reliability of the grid, it also ensures the maximization of social welfare and congestion management. With regard to the sizing of solar power plant, a new challenge arises: the random and intermittent nature of solar power due to constant variation of irradiance and temperature. This means that the determined size of the solar power plant is actually the required output power from the point of view of the power system. However, the actual capacity of the solar power plant is not simply the same as the determined size. It is proposed here to calculate the actual capacity of the solar power plant based on probability density function methods (PDF). The proposed approach is evaluated in IEEE 30-bus test system.

Proposed Methodology

Particle Swarm Optimization

It was proposed by Kennedy and Eberhart in 1995. As mentioned in the original paper, sociobiologists believe a school of fish or a flock of birds that moves in a group "can profit from the experience of all other members". In other words, while a bird flying and searching randomly for food, for instance, all birds in the flock can share their discovery and help the entire flock get the best hunt

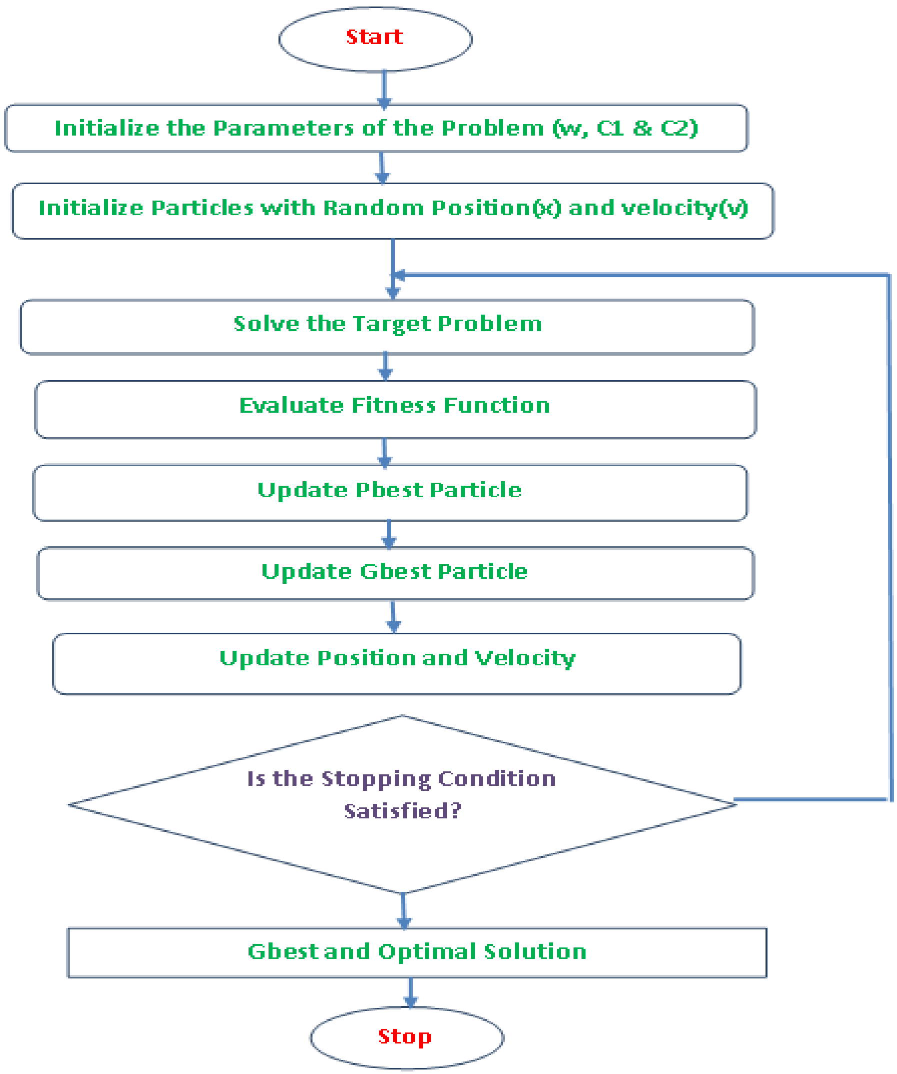

Figure 2: PSO Flow diagram

Grey Wolf Optimizer

The GWO algorithm mimics the leadership hierarchy and hunting mechanism of gray wolves in nature. Four types of grey wolves such as alpha, beta, delta, and omega are employed for simulating the leadership hierarchy. In addition, three main steps of hunting, searching for prey, encircling prey, and attacking prey, are implemented to perform optimization.

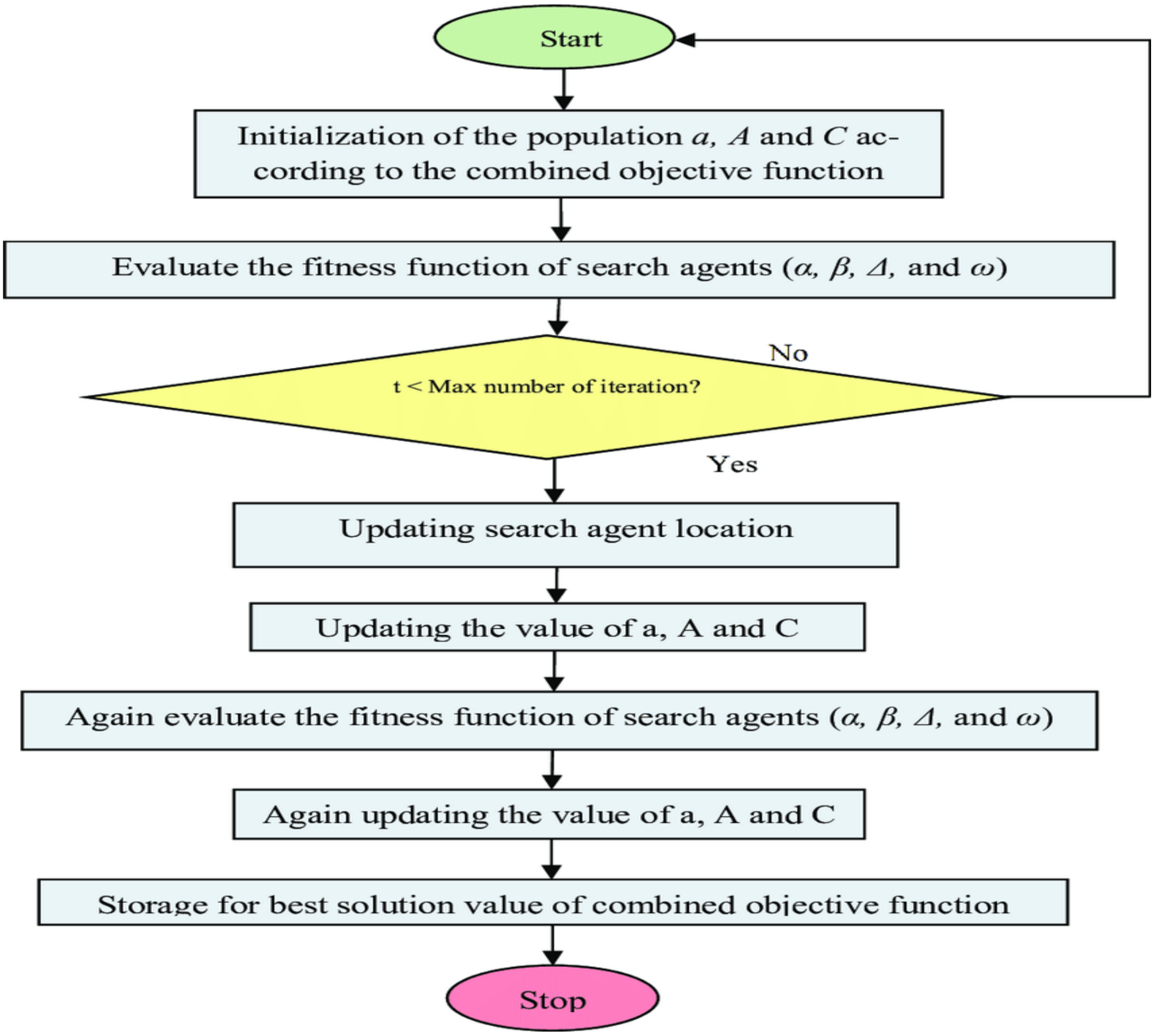

Figure 3: Greywolf Flow Diagram

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Sparrow Search Algorithm

The sparrow search algorithm (SSA) is an effective optimization technique, which simulates the group wisdom foraging and anti-predation behaviors of sparrows. Searching is the process which is to look into or over carefully or thoroughly in an effort to find or discover something [1]. In sparrow search is the simple act of gathering food, either for immediate consumption or future storage. The sparrows are generally gregarious birds and have various species.

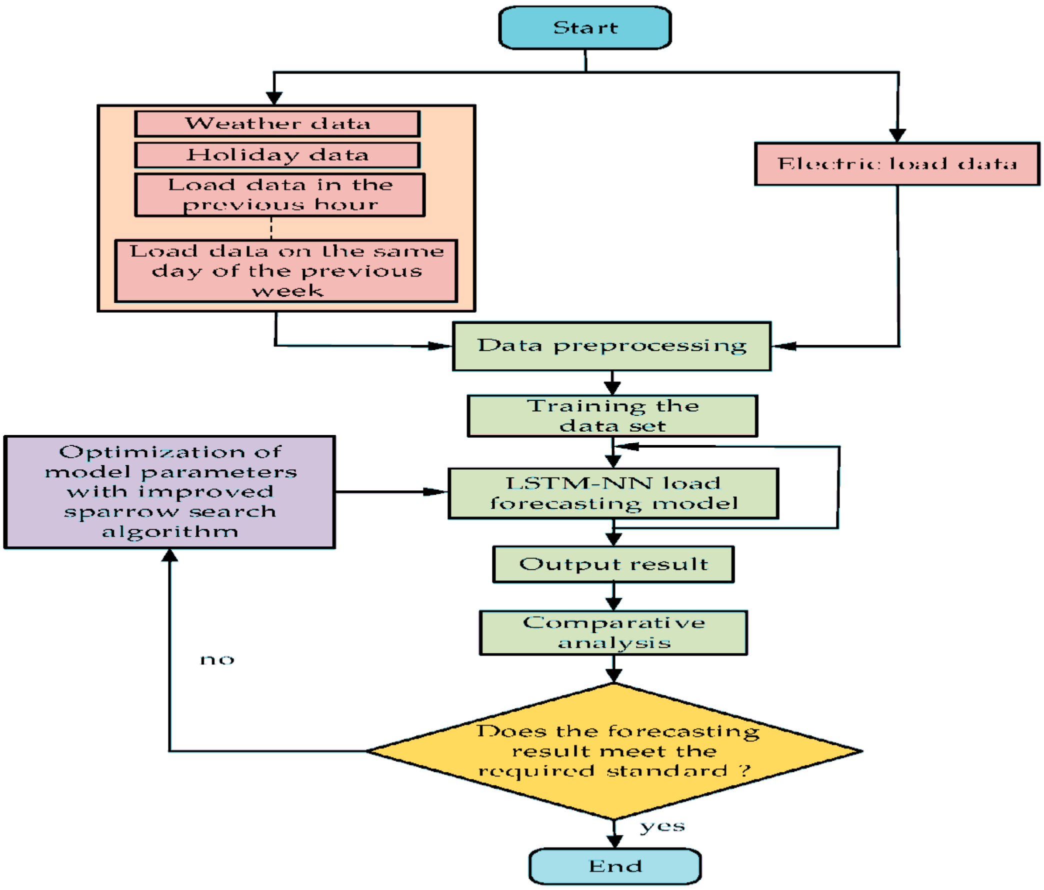

Figure 4: Sparrow Flow Diagram

Results

PSO is a stochastic optimization technique based on the movement and intelligence of swarms. In PSO, the concept of social interaction is used for solving a problem. It uses a number of particles (agents) that constitute a swarm moving around in the search space, looking for the best solution

Table 1:PSO Optimization Load Flow

Bus No.	Voltage (pu)	Angle Degree	MW	|MVAR|
1	1.118	0.085	0	
2	1.062	-5.26	40	48.673
3	1.042	-7.452	0	
4	1.102	-9.21	0	
5	1.048	-14.138	0	36.216
6	1.034	-11.066	0	
7	1.016	-12.845	0	
8	1.03	-11.745	0	31.476
9	1.122	-14.053	0	
10	1.144	-15.733	0	
11	1.179	-14.105	0	16.463
12	1.083	-14.925	0	
13	1.166	-14.914	0	10.912
14	1.14	-15.791	0	
15	1.06	-15.867	0	
16	1.14	-15.549	0	
17	1.056	-15.874	0	
18	1.096	-16.452	0	
19	1.086	-16.682	0	
20	1.104	-16.469	0	
21	1.126	-16.217	0	
22	1.037	-16.06	0	
23	1.062	-16.153	0	
24	1.068	-16.362	0	
25	1.069	-15.98	0	
26	1.055	-16.424	0	
27	1.029	-15.539	0	
28	1.086	-11.705	0	
29	1.02	-16.691	0	
30	1.079	-17.608	0	

Greywolf Optimization Results

Grey wolf optimization algorithm (GWO) is a new meta-heuristic optimization technology. Its principle is to imitate the behaviour of grey wolves in nature to hunt in a cooperative way.

Table 2: Greywolf Optimization Load Flow

Bus No.|	Voltage| pu |	Angle Degree	MW	MVAR|
1	1.062	0.051	0	
2	1.053	-5.269	40	48.518
3	1.034	-7.537	0	
4	1.09	-9.28	0	
5	1.018	-14.138	0	36.593
6	1.023	-11.061	0	
7	1.036	-12.865	0	
8	1.074	-11.781	0	30.958
9	1.13	-14.083	0	
10	1.104	-15.71	0	
11	1.1	-14.095	0	16.492
12	1.082	-14.846	0	
13	1.073	-14.877	0	10.971
14	1.093	-15.73	0	
15	1.122	-15.864	0	
16	1.132	-15.482	0	
17	1.101	-15.827	0	
18	1.038	-16.444	0	
19	1.074	-16.711	0	
20	1.118	-16.481	0	
21	1.08	-16.165	0	
22	1.121	-16.022	0	
23	1.049	-16.157	0	
24	1.116	-16.407	0	
25	1.04	-16.014	0	
26	1.087	-16.414	0	
27	1.1	-15.493	0	
28	1.035	-11.66	0	
29	1.024	-16.688	0	
30	1.025	-17.647	0	

Sparrow Search Optimization Results

Sparrow search optimization intelligent algorithms, this algorithm has better effect, but still has the problems of slow convergence speed, insufficient solution accuracy and easy to fall into local optimum.

Table 3: Sparrow Search Optimization Load Flow

Bus No	Voltage (pu)	Angle Degree	MW	MVAR
1	1.121	0.046	0	
2	1.068	-5.27	40	48.46
3	1.094	-7.454	0	
4	1.02	-9.2	0	
5	1.083	-14.135	0	36.756
6	1.105	-11.044	0	
7	1.061	-12.854	0	
8	1.084	-11.744	0	31.65
9	1.144	-14.128	0	
10	1.079	-15.702	0	
11	1.151	-14.04	0	16.594
12	1.093	-14.895	0	
13	1.107	-14.925	0	10.352
14	1.115	-15.807	0	
15	1.13	-15.862	0	
16	1.062	-15.486	0	
17	1.125	-15.808	0	
18	1.049	-16.457	0	
19	1.07	-16.678	0	
20	1.085	-16.463	0	
21	1.038	-16.222	0	
22	1.125	-16.068	0	
23	1.092	-16.157	0	
24	1.074	-16.401	0	
25	1.066	-16.017	0	
26	1.004	-16.397	0	
27	1.051	-15.509	0	
28	1.071	-11.652	0	
29	1.009	-16.765	0	
30	1.01	-17.567	0	

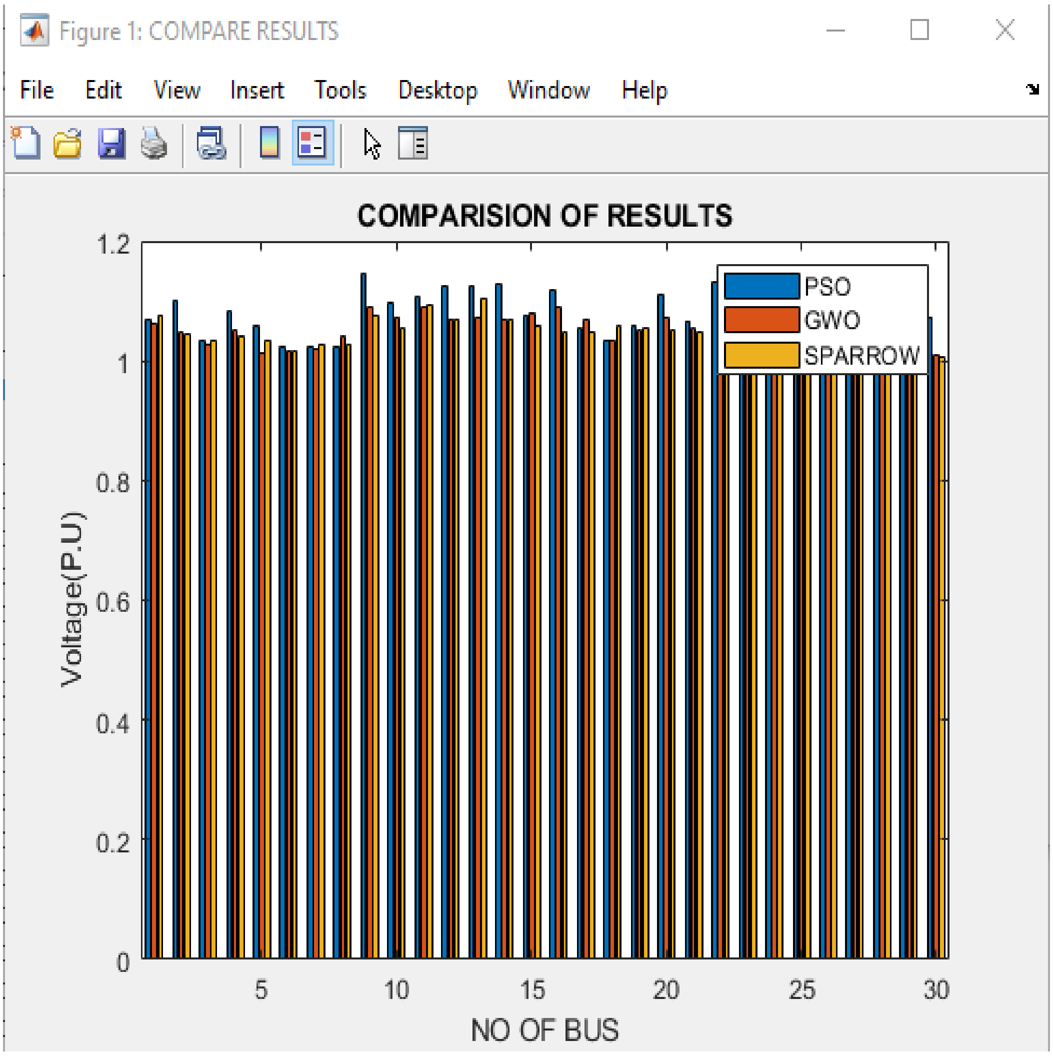

Figure 5: Voltage at IEEE 30 Bus System

Table 4: LMP Result Comparison

Optimization	LMP	TIME(S)
PSO Optimization	11.0305	0.007201
Greywolf Optimization	11.0611	0.084772
Sparrow Optimization	10.8751	0.059403

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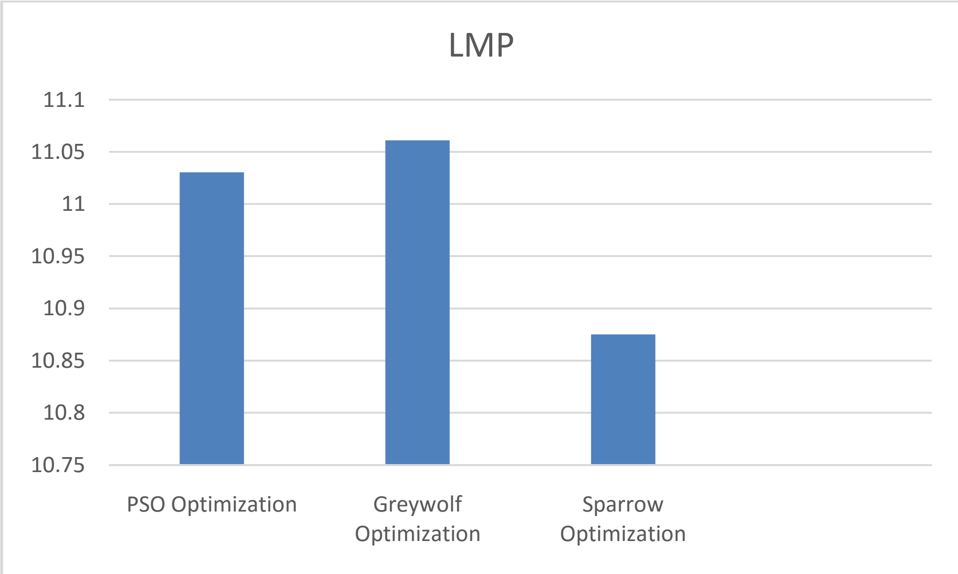

Figure 6: LMP Result Comparison for Different Optimization

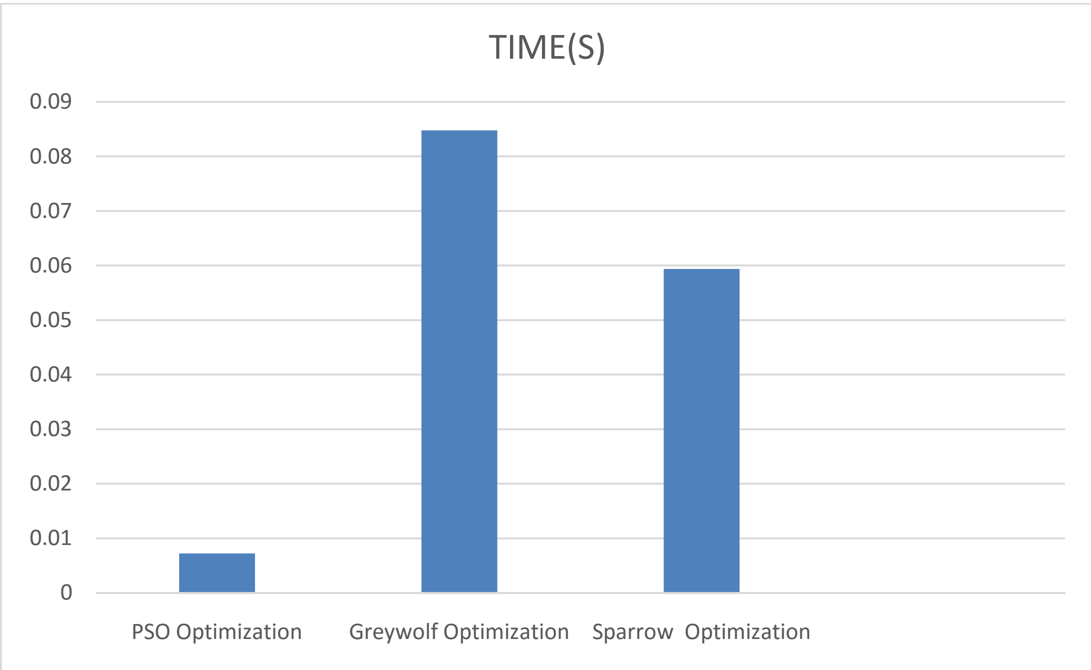

Figure 7: Iteration Time to Perform Algorithm

Conclusion

The purpose of the research was to assess the impact of renewable energy resources mainly solar power on transmission congestion management in the deregulated power system and the maximization of social welfare using LMP analysis. LMP, which consists of a congestion component, as well as a fixed component and a loss component, plays an important role in the deregulated power market. It is used in a practical way for optimal placement of solar power plant in this study and congestion rent is used to confirm the effectiveness of the Highest LMP Method. Therefore, the measures necessary to maintain the lowest possible LMP values are a priority. The MATLAB software's Optimal Power Flow (OPF) method is used and the LMP at each bus is determined. The optimal sizing and location of solar power plant is formulated from the perspective of maximizing social welfare. System locations are examined to study the impact of renewable energy resources penetration on LMPs, so it is concluded that: Locally, solar energy has the effect of eliminating the marginal congestion component of the LMP, so making the LMP equal to each node of the system. The optimal dispatch from solar power is thus found to reduce the congestion rent and shadow prices associated with the line flow. Moreover, solar power with free cost is found to have better performance in terms of alleviating congestion in the network and maximizing.

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