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Electric Vehicle Charging Coordination on Distribution Network by Using Particle Swarm Optimization and Genetic Algorithm

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Abstract: The Electric Vehiclesbecoming very popular in the recent years. Typically, Electric Vehicles propulsion systems come from one or more electrical motors built inside the vehicles. This motor used electricity as energy combustion method. Due to the limited energy storage capacity, Electric Vehicles need to replenish by plugging into an electrical source. The problems appear during multiple Electric Vehicles perform charging process in an Electric Distribution Network. This process willbe causing line overload and efficiency degradation of Distribution Network. In performance to evaluate the potential of different of charging coordination, a classification has been made. The new coordinated process may consider minimum power losses and acceptable voltage limit. The process also needs to define the optimal uncoordinated and coordinated charging point. Therefore, a simulation-based framework will be performed, that use two algorithms which are Particle Swarm Optimization and Genetic Algorithm.

Index Terms: Electric Vehicle, Electric Distribution Network, Genetic Algorithm,Particle Swarm Optimization

I. INTRODUCTION

Nowadays,Plug-In Electric Vehicles (PEV) has become very popular. This phenomenonhas resultedlarge deployment across the Electrical Distribution Network (EDN). Sudden of excessive capacity loads will resultingline overload and efficiency degradation of the EDN. In order to solve thesematters, this project proposed a coordinated PEV charging strategyto prevent the line overload and minimizing the power losses due touncoordinated charging location of the PEVs.

Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) is used to solve the PEV charging coordination problem in EDN proposed in [1] .In this project, the proposed method responsible to solve the PEV charging coordination problem by determining an optimal charging coordinate on the EDN. The coordinate produced give the solution that enable the EDN to operate economically and satisfy the operational constraints.

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II. PEVS CHARGING COORDINATION

There are some issues during PEVs charging coordination caused due to lines and busses inside the EDN can be classified into two types which arevoltage limit [2], [3] and unacceptable power losses [2]. This sectionhighlights the method to improve these issues.

A. Voltage Limit

This project proposed the coordinate Electric Vehicles (EV) charging using optimization method in order to control the voltage on a residential electrical distribution feeder.The sensitivity matrix approach is proposed to maintain the voltage level for power EVs injection [3]. In order to validate the effectiveness of proposed scheme, the proposed method is compared with two cases (Case I and Case II):

Case I: Uncoordinated Case

Electric vehicle willchargeimmediately after connected to the grid, there are two uncoordinated situations where the voltage maybe adversely affected. The two normal situation is for arrival time which is mean 6:45PM, standard deviations 1 hours and departure time is 8:00AM, with standard deviation 0.75 hour.

Case II: Voltage droop charging control

EV will charges based on the profile at time t+1. (There are three given and compared but only LM1 is considered in this case.)

B. Power losses

The existing grid will exceed the load capacity when sudden addition of these intermittent. These will result the line overload and efficiency degradation of grid. In order to overcome line flow and power losses issues, a coordinated PEV charging strategy is proposed in [2]. Thus, it can prevent the line from overloaded and hence minimizing the power losses.

These sensitivity factors are derived from the Newton RaphsonJacobian to coordinate the charging activities of the PEVs. The factors also being used to identify the nodes and lines in the EPG that are prone to overload. Then, charging commands are sent to the identified nodes to assist in a coordinated charging as shown in Fig. 1.

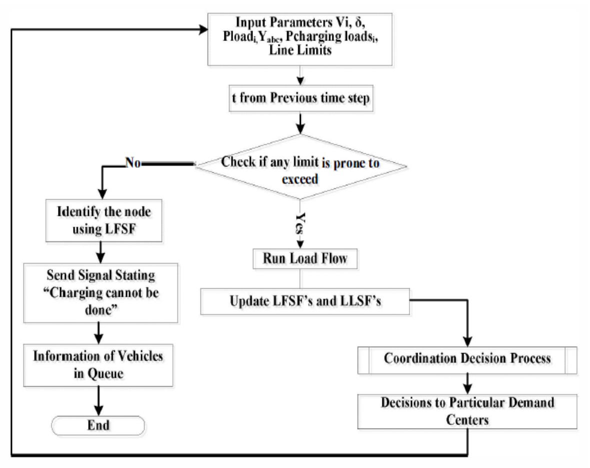

Fig. 1Flow Chart Coordinated Charging

Fig.2 shows a radial IEEE 6 bus distribution system used to implement the proposed method.

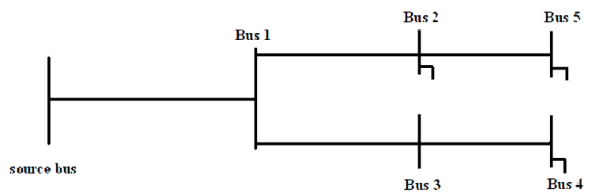

Fig. 2Modified IEEE 6 node bus system

III. PROPOSED ALGORITHMS

Fig. 3 shows the flow chart for PEV charging process. The proposed algorithms can be divided into 2 main parts which are power flow analysis and algorithms calculation:

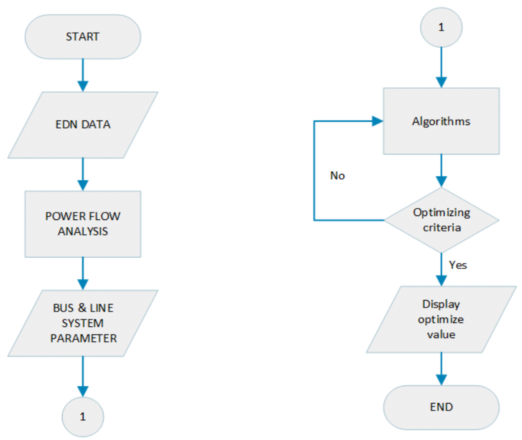

Fig.3PEV Charging process

A. Power flow analysis

In this stage, the data of bus and line are being initialize. The data being gather from the known source such as voltage-controlled busses, transformer data and injected Q due to the shunt capacitors.

The data then being class into matrix form for a better usage during execution of the analysis. The data are divided into two type which are bus data and line data. The line data being used to perform the Y admittance for the next stage of execution. Next, the bus data and Y bus being used in solving the power flow analysis through Newton Rapson method.

B. Algorithm calculation

In this stage, the output data combined with generated constrain which include minimum power losses and acceptable voltage limit. The voltage limit is generally set as approaching 1 which reflect the ideal voltage limit. Both PSO and GA perform their operation simultaneously.

During PSO optimizing the data, the operation of optimization is divided into several phase. 1st phase: Declaration of constant parameters. All related constant parameter must be declared. The number of populations, weight of inertia, maximum iteration and both coefficient (cognitive and social).Then identifying the initial position and velocity. The velocity is expected to be stationery and value of initial position are generated randomly with the help of particular contain.2nd phase:Calculate the fitness,Y and declare the used function. It's important that all the element inside the function are all being used. Then, assume all the initial position as Pbest. From the assumed Pbest list, find the value of Gbest. Proceed to calculate the new position and together with the new fitness. Construct back the matrix of Pbest and Gbest indoor to calculate the new position. Lastly, check for stopping criteria and do the next operation either stop or repeat until stopping criteria satisfied.

The same step implemented for GA optimization technique. 1st phase:Declaration of constant parameters. A solution on GA is coded by a string, called chromosome. The words string and chromosome are used interchangeably. Then, a string fitness is a measure of how good a solution it coded. Fitness is calculated by a fitness function. 2nd phase: Selection process. Implement the Roulette wheel selection is a way of picking out a string from among a group of string. Next, crossover.Procedure by which two parent mates to create a new offspring (children). Proceed with mutation. A certain probability flips a bi in the offspring.

C. Proposed Algorithms

The performance of the proposed algorithms is said to be optimized the power losses and within the acceptable voltage limit.

The objective function implemented is to minimize active power losses in the distribution network. Therefore, the following objective function is selected as follow [4].Where:

$$F_t = \min P_{loss} = \sum_{k=1}^{ntl} |I_k|^2 . R_k \tag{1}$$

F_l is the objective function to minimize power loss
P_{loss} is the active power loss
ntl is the number of lines in the distribution system

The voltage constraints of the distribution system will be considered by setting the upper and lower limits to correspond to voltage regulation limits typically set by utilities. In this paper, the voltage limits are set to +/- 10% (Vmin = 0.9pu and Vmax=1.1pu) which is typical of many distribution networks [5].Where:

$$V^{min} \leq V_k \leq V^{max} \, for \; k = 1 \ldots n \quad (2)$$

k is the bus number.

$$P_{cs}{}^{min} \leq P_{cs} \leq P_{cs}{}^{max} \quad (3)$$

The second constraint is the minimum allowable power demand of CS at bus k. The ceiling limit for the total maximum power demand of the distribution system is also set to prevent overload of the local distribution transformer. Where:

$$P_{cs}(h) + P_l \leq P_{Dmax} \quad (4)$$

Pcs and Pl is the total charging power demand of the charging station and the consumer base load demand at particular hours.

PDmax is the maximum allowable loading of the distribution transformer.

D. Case Studies

The proposed algorithms have been implemented in IEEE-33 bus radial distribution system. There are 10 buses allocated with Charging Stations (CS) by which the number of charging stations at each bus is determined by random allocation of EVs in the test system.

IV. RESULT AND DISCUSSION

In the uncontrolled charging scenario, all CS are assumed to charge EVs at the same time without considering its minimum power losses and acceptable voltage limit while for the controlled charging, the charging activities are proceeding by considering its required constraint. However, not all CS can operate at the same time in the respective charging scenario. The optimal coordination for the CS during a particular charging period is determined by means of PSO and GA technique. There are two cases of studies presented in the next sections which consist of the uncoordinated charging and optimally coordinated charging. Results obtained from the cases studies are analyzed and compared in term of active power losses and voltage limit.

A. Uncoordinated Charging

During this scenario, the CS can be operated from 10 different charging location. The CS is being select based on its demand. There are no algorithms implemented during this operation. The system shows that the operation to complete the power losses calculation are only take 7.2252 seconds. The number of iterations also only one. From basic concept of iteration, any analysis should not complete directly after its first iteration and it is call as in valid analysis. It proves that the data is not being optimize and the power losses also show a high value 17872.6068 kW. Since the CS allow to be activated in between 5 to 80, but the average is ranging from 9 to 56.

Fig. 4 shows the output only displays at for single dot of iteration this is due to the absent of algorithms. Plus, at the other point of iteration, its shows that the power losses are zero. Basically, it does not mean by zero, but the loop had already stop at 1st iteration and continuously terminate the remaining loop until the maximum number of iterations.

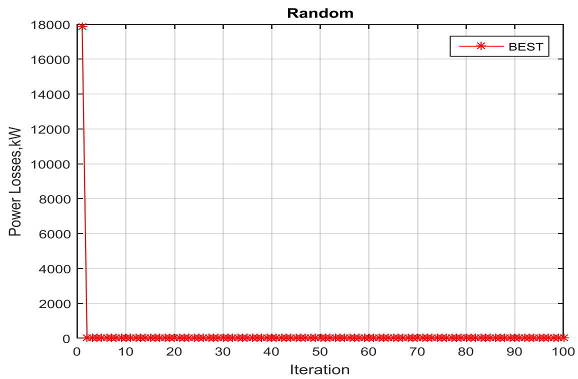

Fig. 4Output data for uncoordinated CS

B. Coordinated charging

During this session, the CS is set to be activated randomly at a time. But then, the CS only allow to be activated between 5 to 80 charging station only at a time. The data tested was taken from IEEE source, this to ensure the rigidity of the data.

The system tested are starting from 14 bus system, 30 bus system and 62 bus system. During all this system tested, the focus of researcher is to determine the best optimizer between PSO and GA in optimizing the PEV charging problems.

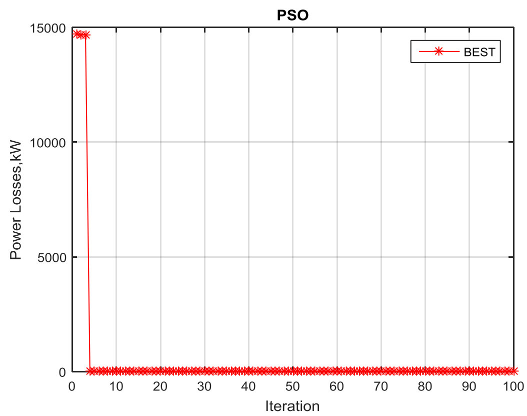

Fig. 5Output graph of PSO in 14 bus system

Fig. 5 shows the PSOoptimizationfor 3 looping iterations. The looping stop as the value of power losses from previous iteration is 0.001 difference from the present iteration.

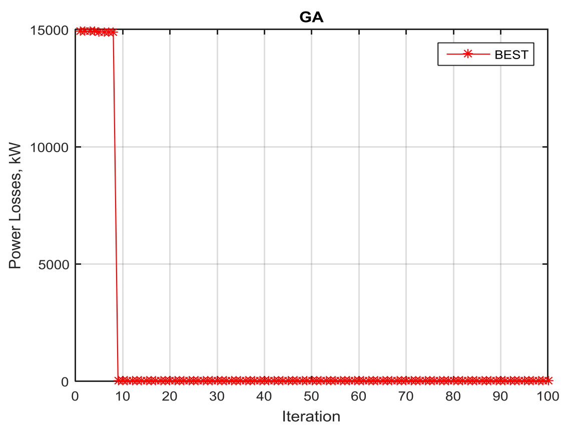

Fig. 6Output Graph of GA for 14 bus system

From Fig. 6, GA complete its optimizing looping in 8 iterations. From here its shows that GA consume greater time for completing its iteration ass compared to PSO.

Table. 1 Comparison of all optimizing scenario.

Parameter	Uncoordinated					PSO					GA				
Stopping criteria	0.001					0.001					0.001				
Literation	Nil					3					4				
Time taken, s	7					23.7674					33.9882				
CS	68	52	17	11	23	26	8	5	5	5	64	34	16	17	27
	11	18	18	27	52	5	5	5	14	5	26	15	31	22	29
Power losses, kW	17884.8677					17673.7885					17869.6923				

From Table 1, its clearly show that there is a huge difference between all situation. As compared to uncoordinated, PSO and GA, PSO become the most efficient optimizer with less time consumption and lowest power losses.

The CS is said to be random for the uncoordinated charging cycle. The coordinated charging result of GA and PSO optimization are separately run then compare. This make the system less time effective. The Algorithms also being tested to 14, 30 and 62 bus system. All the data are being summarize in Table 2.

Table. 2 Complete data comparison for all system bus.

Parameter	PSO			GA		
Bus system	14	30	62	14	30	62
Stopping criteria	0.001	0.001	0.001	0.001	0.001	0.001
Literation	3	3	3	8	4	3
Time taken, s	11.0172	23.7674	116.8739	23.2611	33.9882	116.2218
Power losses, kW	14686.8172	17673.7885	55066.9229	14897.7168	17869.6923	55086.9081

V. CONCLUSION

Based on data collected in this research, PSO algorithm method was successfully solved EDN problem better than GA algorithm. From the case studies, it has been observed that there is a reduction in total power losses from PSO method compared to Genetic Algorithm (GA) and uncoordinated cycle. Here PSO shows better solution quality, better convergence characteristic and better computation efficiency than GA in solving PEV charging coordination.

REFERENCES

1. Y. Yeh, "Development of a Genetic Algorithm based Electric Vehicle Charging Coordination on Distribution Networks," vol. 00, no. c, 2015.
2. P. Alluri, S. Member, J. Solanki, I. Member, S. K. Solanki, and I. S. Member, "Charging Coordination of Plug-In Electric Vehicles Based on the Line flow Limits and Power Losses p / Q / V / I . i," pp. 233–238, 2015.
3. O. Beaude, S. Member, Y. He, S. Member, M. Hennebel, and A. Ev, "Introducing Decentralized EV Charging Coordination for the Voltage Regulation," pp. 1–5, 2013.
4. D. Pandey and J. S. Bhadoriya, "Optimal Placement & Sizing Of Distributed Generation (DG) To Minimize Active Power Loss Using Particle Swarm Optimization (PSO)," vol. 3, no. 7, pp. 246–254, 2014.
5. S. Deilami *et al.*, "Paper Presentation—Real-Time Coordination of Plug-In Electric Vehicle Charging in Smart Grids to Minimize Power Losses and Improve Voltage Profile," *IEEE Trans. Smart Grid*, vol. 2, no. 3, pp. 456–467, 2011.
6. Y. Shen, H. Han, Z. Yuan, and H. Xu, "Coordinated Charging of Plug-In ElectricVehicles In the Charging Station," pp. 2–5, 2014.
7. N. B. A, J. F. Franco, M. Lavorato, M. J. Rider, R. Romero, and S. Member, "Plug-In Electric Vehicle Charging Coordination in Electrical Distribution Systems Using a Tabu Search Algorithm," 2015.
8. S. Member, M. F. Shaaban, S. Member, S. Member, F. Karray, and S. Member, "Priority-based Charging Coordination of Plug-in Electric Vehicles in Smart Parking Lots," pp. 1–5, 2014.
9. A. S. Masoum *et al.*, "Online Coordination of Plug-In Electric Vehicle Charging in Smart Grid with Distributed Wind Power Generation Systems," pp. 4–8, 2014.
10. I. Solteira, "GRASP Algorithm for Charging Coordination of Plug-In Electric Vehicles in Electrical Distribution Systems," 2016.
11. J. F. Franco, M. J. Rider, R. Romero, and S. Member, "An MILP Model for the Plug-In Electric Vehicle Charging Coordination Problem in Electrical Distribution Systems," pp. 1–5, 2014.

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