Voltage Regulation of Microgrids Containing Electric Vehicles

Xiyao Jiu[1], Meiqin Mao[1], Liuchen Chang[1,2], Yangyang Wang[1]

1.Hefei University of Technology, China 2. University of New Brunswick, Canada

Abstract

Abstract—Voltage in microgrids always have significant fluctuation because output power of wind turbines (WT) and photovoltaic (PV) generators vary at random. This paper investigates microgrids containing electric vehicles (EVs), considering the EVs' dual role of both "source" and "load". Bidirectional flow of EVs' energy is made use of to keep voltage of the microgrid in stability. For this purpose, a decentralized method based on gossip is proposed and compared with the centralized method. The simulation results show although that the integration of Evs can regulate the voltage effectively by both methods, the decentralize method cost lower time than the centralized one.

I. Centralized method

Objective Function:

$$\min F = \min(\mu_1 \frac{F_1(x)}{F_{1\max}} + \mu_2 \frac{F_2(x)}{F_{2\max}})$$

Minimization of the cost(F_1):

$$F_1 = \sum_{t=1}^{T}(\sum_{i=1}^{N_{DG}} C_i(t) + C_{grid}(t) + C_{ev}(t))$$

Minimization of voltage deviation(F_2):

$$F_2 = \sum_{i\in N} | V_i - V_{ref} |$$

Optimization variables : $P_{ev}(i)$

Constraints:

$$P_{Gi} - P_{Di} - V_i \sum_{j=1}^{n} V_j (G_{ij}\cos\theta_{ij} + B_{ij}\sin\theta_{ij}) = 0 \qquad Q_{Gi} - Q_{Di} + V_i \sum_{j=1}^{n} V_j (G_{ij}\sin\theta_{ij} - B_{ij}\cos\theta_{ij}) = 0$$

$$V_{i\min} < V_i < V_{i\max} \qquad C_{total}^{dis} < C(t) < C_{total}^{ch}$$

Particle Swarm Optimization (PSO) is used to solve the optimization problem above.

II. Decentralized method

Decentralized method is based on Gossip Algorithm. It is shown in Fig.1.

Gossip Algorithm is a kind of distributed algorithm. During each round of a gossip algorithm, every node selects and contacts one or more of its neighboring nodes and exchanges information with them. Before the beginning of the next round, the information is processed locally and enhanced with local measurements to create the information to be exchanged.

Two kinds of Gossip Algorithm is used here. Algorithm 1 is the summation algorithm. It is used to calculate the total power of all electric vehicles. Algorithm 2 is the maximize algorithm. It is used to calculate the maximum value of the schedulable capacity.

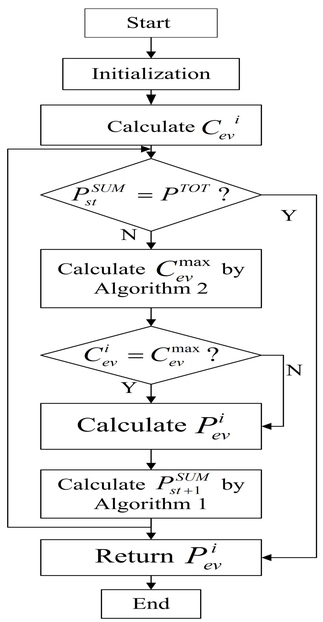

Fig.1. Gossip algorithm for voltage regulation

III. Case Study

For the microgrid shown in Fig. 4. , 4 scenarios are simulated.

Scenario 1: No EVs connected to the microgrid.

Scenario 2: EVs connected to the microgrid and charged or discharged uncoordinately.

Scenario 3: EVs connected to the microgrid and charged or discharged coordinately by Centralized method.

Scenario 4 EVs connected to the microgrid and charged or discharged coordinately by decentralized method.

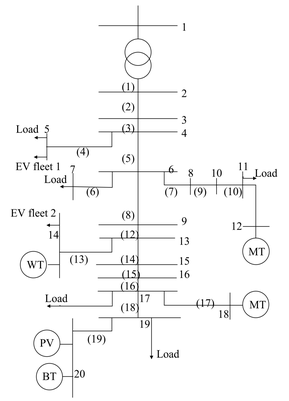

Fig.2. Diagram of Test microgrid

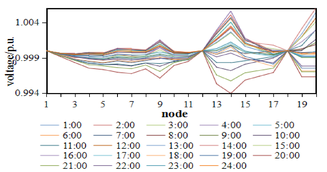

Fig.3. Node Voltage in Scenario 1

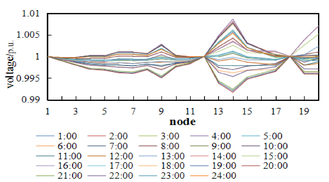

Fig.4. Node Voltage in Scenario 2

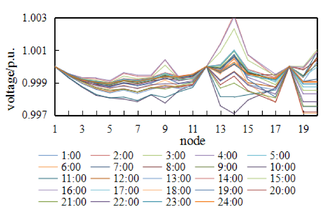

Fig.5. Node Voltage in Scenario 3

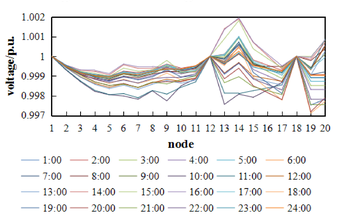

Fig.6. Node Voltage in Scenario 4

The computational time is 3.52s by centralized method, while it is 1.61s by the decentralized one.

IV. Conclusion

This paper investigates voltage regulation ability in the microgrid with EVs. And both centralized and decentralized methods are used and compared. The simulation results show that by the proposed decentralized method, the quality of voltage can be improved significantly. And this method computes faster than the centralized one.