CHAPTER V
CONCLUSION

The presentation of this thesis comprises of 5 chapter which comprises of introduction, literature review, methodology, simulation result and conclusion.

Introduction chapter presents background, problem statement, objective and structure of thesis to overview a detail and problem of bipolar DC distribution grid with EV charging demand integration.

Literature review presents overview of DC distribution grid such as structure (unipolar and bipolar structure), voltage level in view of end's user or grid operator, impact of EV and concept of V2G technology.

Methodology presents a calculation method of bipolar DC power flow, load balancing method and EV load demand evaluation to evaluate effect on unbalance load and EV charging demand on bipolar DC distribution grid via voltage profile, system power loss and VUF

Simulation result can be separated into 4 parts as follow:

First part is a base case simulation which validate a source code with other article and simulate a 48-hours base case of bipolar DC distribution system to evaluate voltage profile, daily energy loss and VUF of unbalance condition. After that in second part, a load balancing method is used to reduce daily energy loss and VUF of base case system.

A conclusion of first part presents a validation which uses balanced 4-bus DC bipolar distribution grid and unbalanced 21-bus DC bipolar distribution grid. The referred simulation result of the system is solved by using PSCAD program which this thesis uses MATLAB source code based on GMM technique to simulate a power flow of the system. The simulation presents two categories based on a type of distribution system which a result presents a percentage error of source result and PSCAD simulation result from referenced article. In case of balanced 4-bus DC bipolar distribution grid, the result presents a percentage error of validation that equals 0.31%.

in the other case, the percentage error is less than 0.01% with total power loss 95.42 kW and -2.7 % of VUF which the program has satisfactory performance and will be used in the other case study.

The base case simulation (Case I) presents a 48-hours of unbalanced 21-bus DC bipolar distribution system with various dynamic load for using as base case which a simulation result presents a voltage profile, total energy loss, VUF. The simulation can be concluded as follow:

In case of voltage magnitude presents a weak bus location of positive and negative power which a weak bus of positive pole locates at bus 17 is 0.983 p.u. and -0.95 p.u. for negative pole in 15.30 p.m. or timeslot 61 due to unbalance load demand capacity between positive pole and negative pole that the load comprises of unipolar load and bipolar load. In case of highest VUF, the highest VUF locates at bus 18 which have 3.34 % of VUF at 15.30 p.m. due to differential capacity of load demand between positive pole and negative pole at bus 18.

To reduce an unbalance problem of the system, A load balancing method based on PSO is used to solve the problem that was present in Case II or load balancing case simulation. The load balancing method is used to balance a unipolar load demand between positive pole and negative pole by searching an optimal connection type. Which the system with optimal connection type of load can be reduce VUF from 3.34 % to 0.37 % at bus 18 at 15.30 p.m. in case of voltage improvement at bus 17, a load balancing method reduce voltage at positive pole from 0.983 p.u. to 0.967 and increase voltage at negative pole from -0.95 p.u. to -0.968 p.u. with 0.34% of VUF at 15.30 p.m. the case have total energy loss is 471.175 kWh which is 1.73 % of total energy demand of the system or 50.821% of total energy loss of case I.

Third part presents EV charging load demand evaluation by using MCS based on mean and standard deviation of plug-in time and daily travel distance to estimate EV’s user behavior which the output of MCS proposed a 48-hrs. EV charging load profile based on 50 of EV quantity distributed on the system with 44.5 kWh of EV battery capacity.

After that, the result of third part is used to integrate with balance system from second subsection that presents an impact of EV charging demand on distribution grid.

Lastly in fourth part, the impact of EV charging demand was solved by load balancing method with EV charging load.

The fourth part comprises of case III and case IV. the case III presents load balancing case with unbalancing probabilistic EV load demand which uses a balanced 21-bus bipolar distribution system as a simulation system integrated with 448-hrs. EV charging demand to simulate impact of uncontrolled EV charging demand on distribution grid. A simulation result of case III presents an impact of EV load demand in form of voltage profile, VUF and energy loss of the system. Firstly, a lowest positive voltage located at 09:15 a.m. of bus 17 which have 0.952 p.u. as a voltage at the moment. Which a reason of the problem at bus 17 is load demand at this moment and 4.5 kW of EV charging load demand during 08:00 p.m. to 10:45 a.m. in the other hand, the lowest negative voltage locates at 08.45 a.m. of bus 17 which have 16 kW of EV charging demand and bipolar load. The voltage decreases from -0.975 p.u. to -0.952 p.u. In case of highest VUF, a highest VUF locates at bus 17 which have 1.326%. a total energy loss is 1,132.83 kWh that increases from case II 661.705 kWh or as 2.44 % of total energy load demand. As a result of higher current flow at each bus and the resulting imbalance state, the EV load demand can have an impact on the overall power loss of the system.

The case IV integrates load balancing method to EV load demand at each bus to reduce impact of uncontrolled EV charging load demand which a simulation result can reduce total energy loss from 1,132.83 kWh to 655.06 kWh or 17.61 % of total energy loss. A highest VUF locates at 17.00 p.m. of bus 17 increase from 1.326 % to 1.523 %.

5.1 Future work

The future work is battery integration to load balancing method which can be a huge capacity of battery system or fleet of EV to support load balancing method. An advantage of battery system is high capacity so the battery can act as load to increase load demand or act as source to support load in the network. In the other hand, EV batteries are a movable battery which can be moved to serve power to optimal bus based on optimization technique for search an optimal position of EV to give a maximize benefit on distribution grid.