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Impact of EV Fast DC Charging on Large Electric Power Distribution Systems

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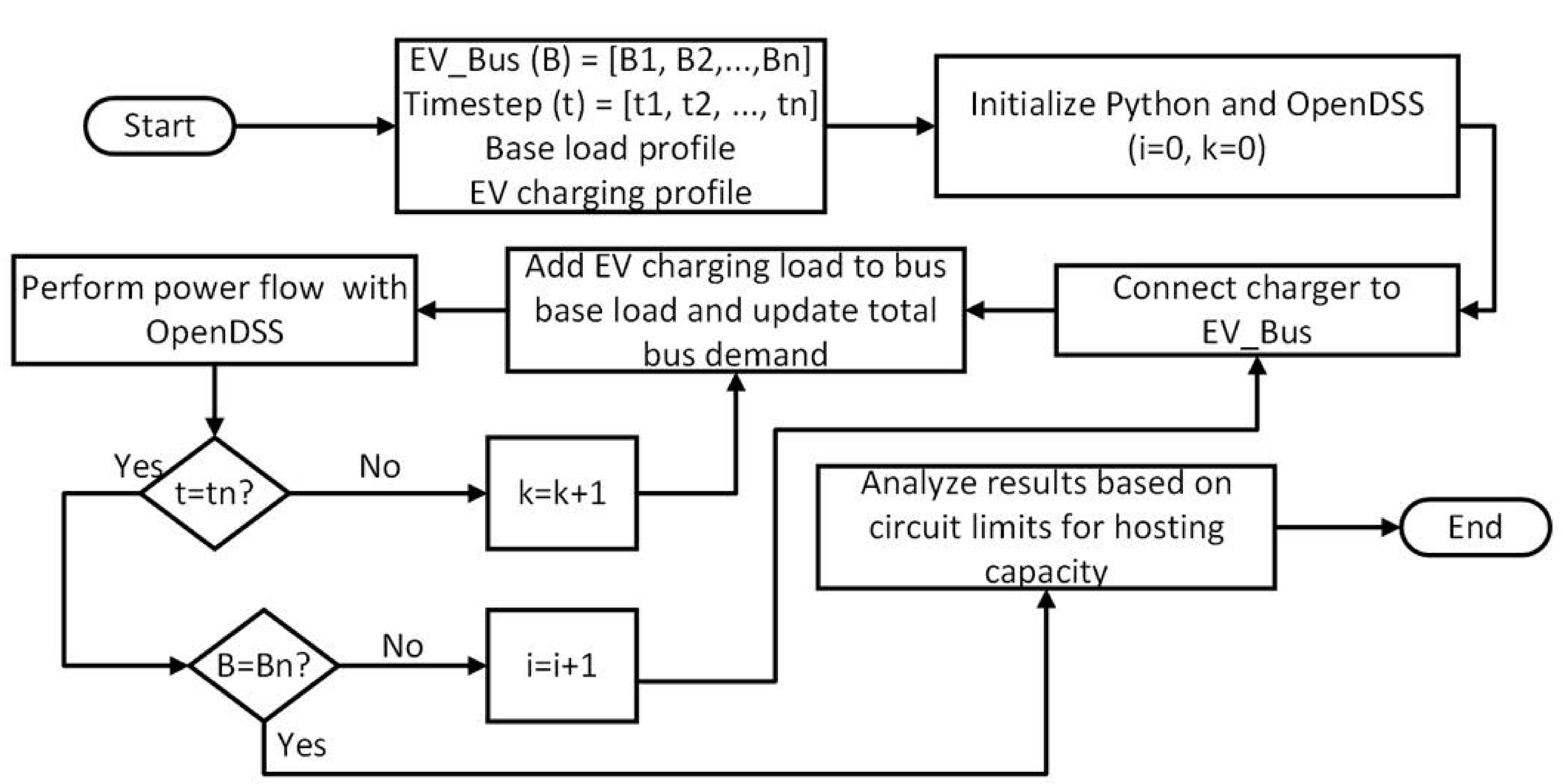
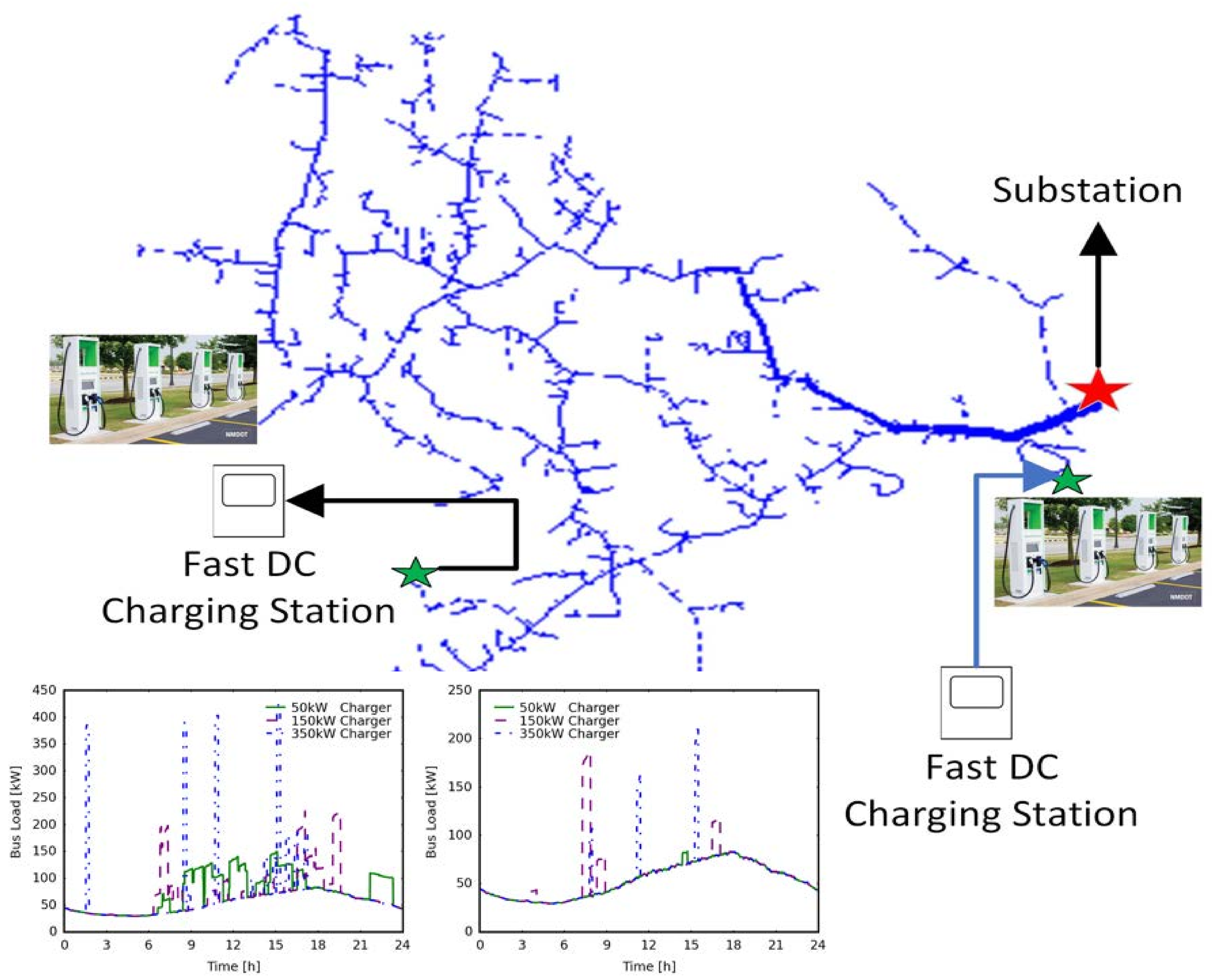
Introduction and Problem Statement

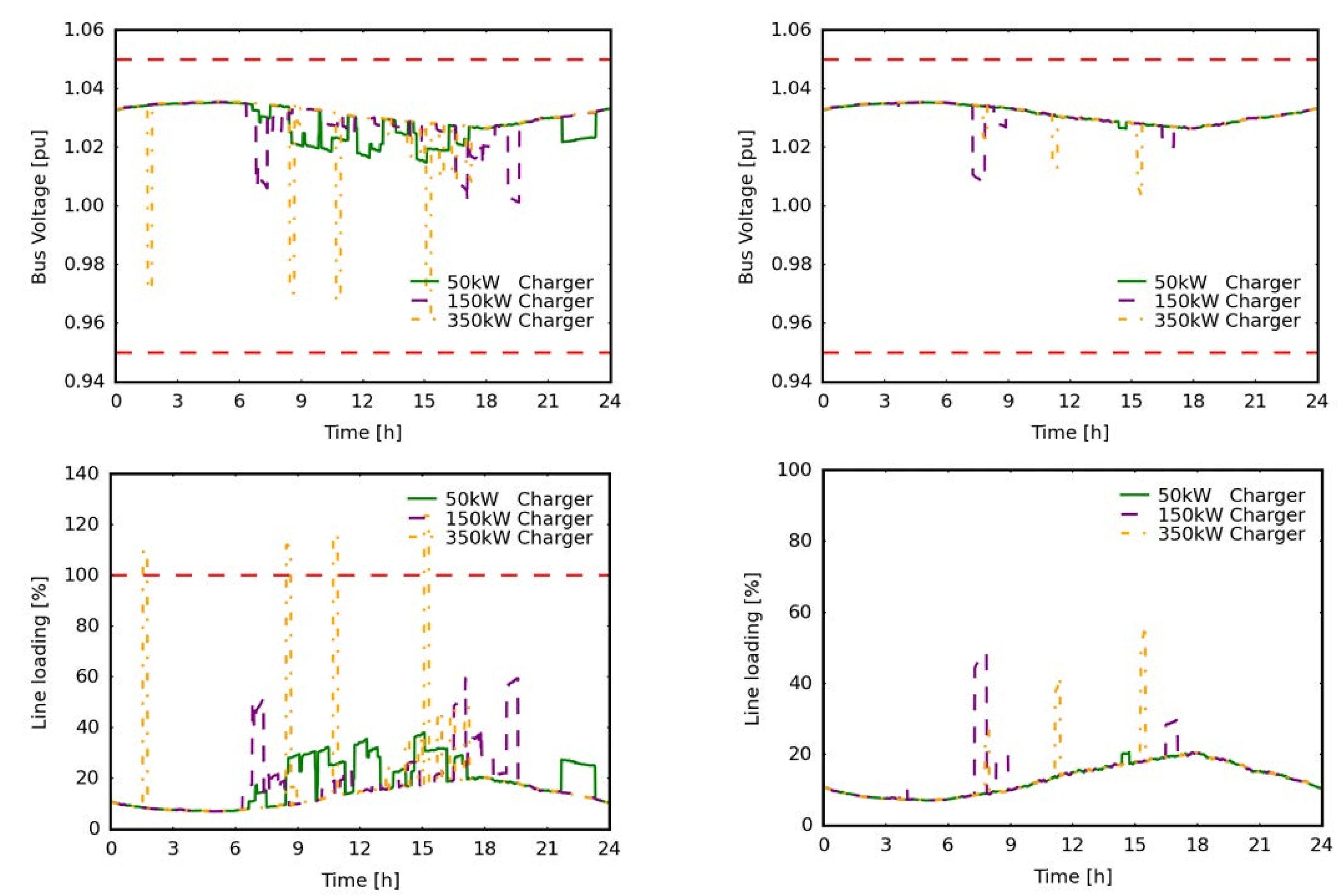
- EV fast DC charging, with power levels as high as 350kW, increases the burden on distribution grid components, which are designed for specific loading levels
- A framework is developed to estimate the maximum hosting capacity of these stations on a large electric power distribution system, which is based on:
  - Thermal limits of lines
  - Bus voltage limits
  - Distribution transformer loading
  - Point of interconnection of chargers
  - Rated capacity of DC charging stations.

Fast DC Charging Hosting Capacity Framework

- In the proposed framework, the grid's maximum DC charging hosting capacity without significant infrastructural upgrades is assessed
- Buses, at both near and distant locations from the substation, are selected for installing the fast DC charger. Different ratings of the charging station are studied
- The proposed approach considers the variability of baseload at the point of interconnection and combines it with the charging profile of the charger to obtain the total bus load
- Various utilization levels of the charging stations are tested to evaluate their impact on the grid
- The Python API of OpenDSS, an open-source distribution system modeling software, is utilized to conduct Newton-Raphson power flow calculations
- Simulation results are analyzed to assess the impact of fast DC charging on the grid based on circuit limits.

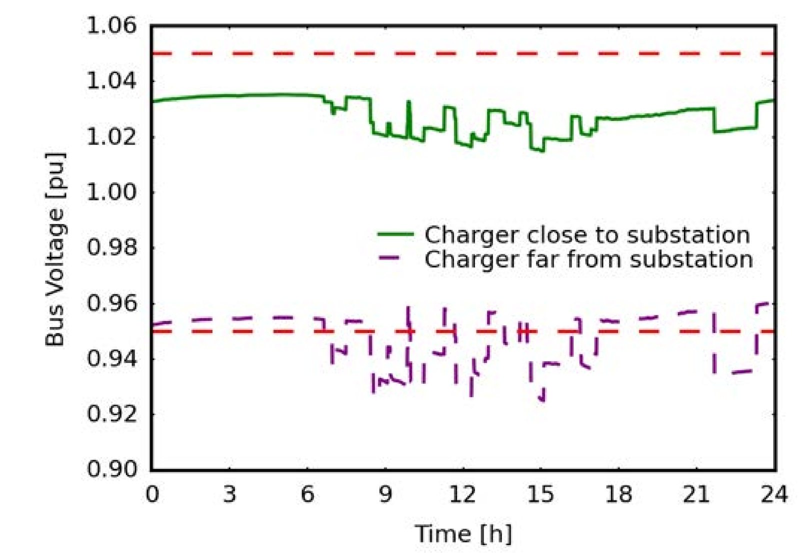




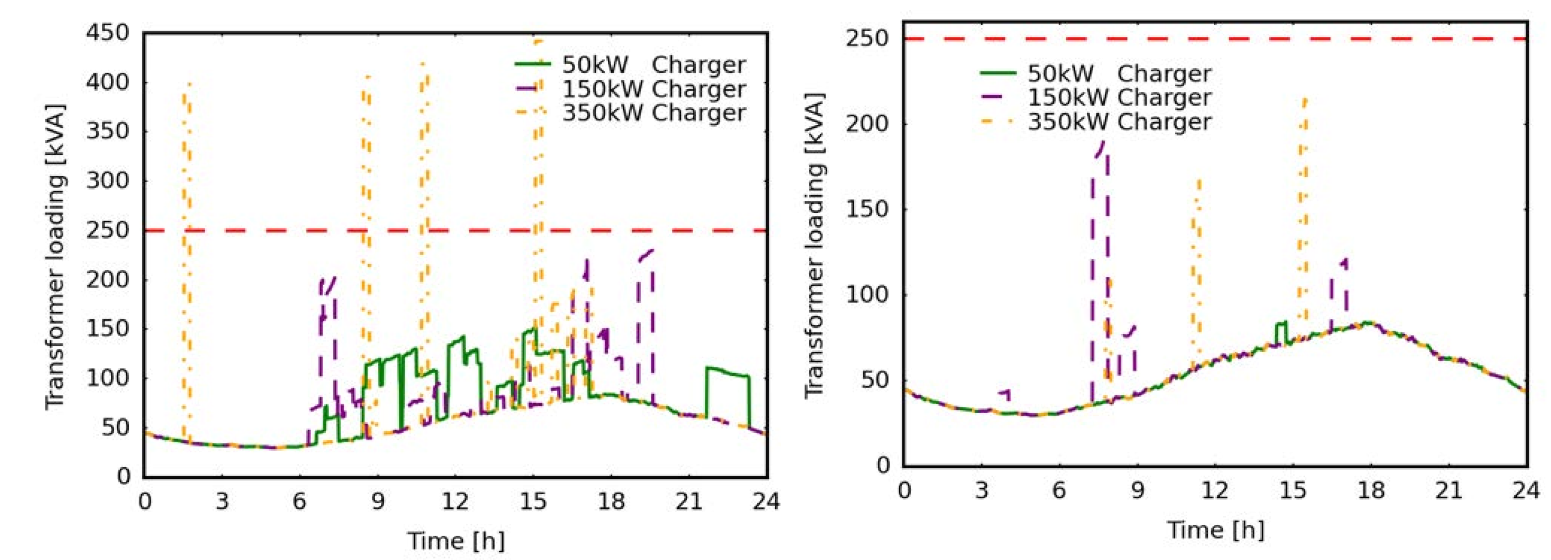


Case Study – Modified IEEE 8500 Test Bus System

- The IEEE 8500 bus test feeder, a 7.2kV system with a 27.5MVA substation transformer, is modified to include EV fast DC chargers
- Two buses, one near the substation with a 250kVA transformer and another further away with a 100kVA transformer, were selected for installing the charging stations. Two port chargers, rated 50kW, 150kW, and 350kW were considered in the analysis
- Publicly available high-resolution minute-based EV charging profiles from NREL were utilized for each charger. Both high and low utilization profiles representative of EV market penetration levels were studied
- Co-simulation of Python and OpenDSS is employed to solve the power flow problem for each timestep.



Point of interconnection further away from the substation shows violation of voltage lower limit for high utilization of 50kW charger, which is the lowest assessed



Impact Assessment

- Bus voltage at the point of interconnection fluctuated with varying charging load
- The voltage limits of the bus near the substation, set at 0.95pu and 1.05pu, were not violated across all assessed charger capacities and levels of utilization
- Transformer loading limit was not exceeded for all charger options at low utilization but was violated for the 350kW station during high utilization
- Line loading remained below 100% except during high utilization of the 350kW charger, reaching around 120%.

Conclusions

- The rated capacity of EV fast DC charging stations significantly affects the hosting capacity of a large electric power distribution system
- High utilization of charging stations, which corresponds to high EV market penetration impacted the parameters assessed
- Locating charging stations near the substation kept bus voltage within set limits
- Future work is to integrate energy storage systems to mitigate overloading of lines and transformers.

Acknowledgement

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