

## Introduction and Major Contributions

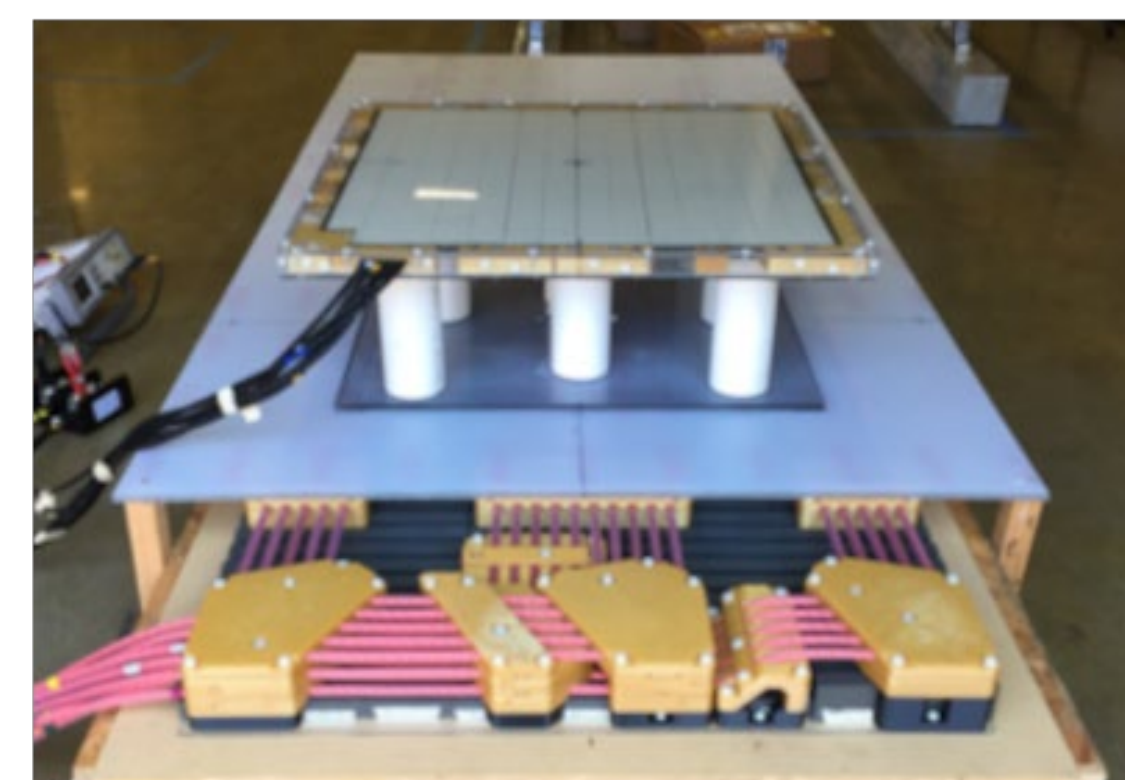
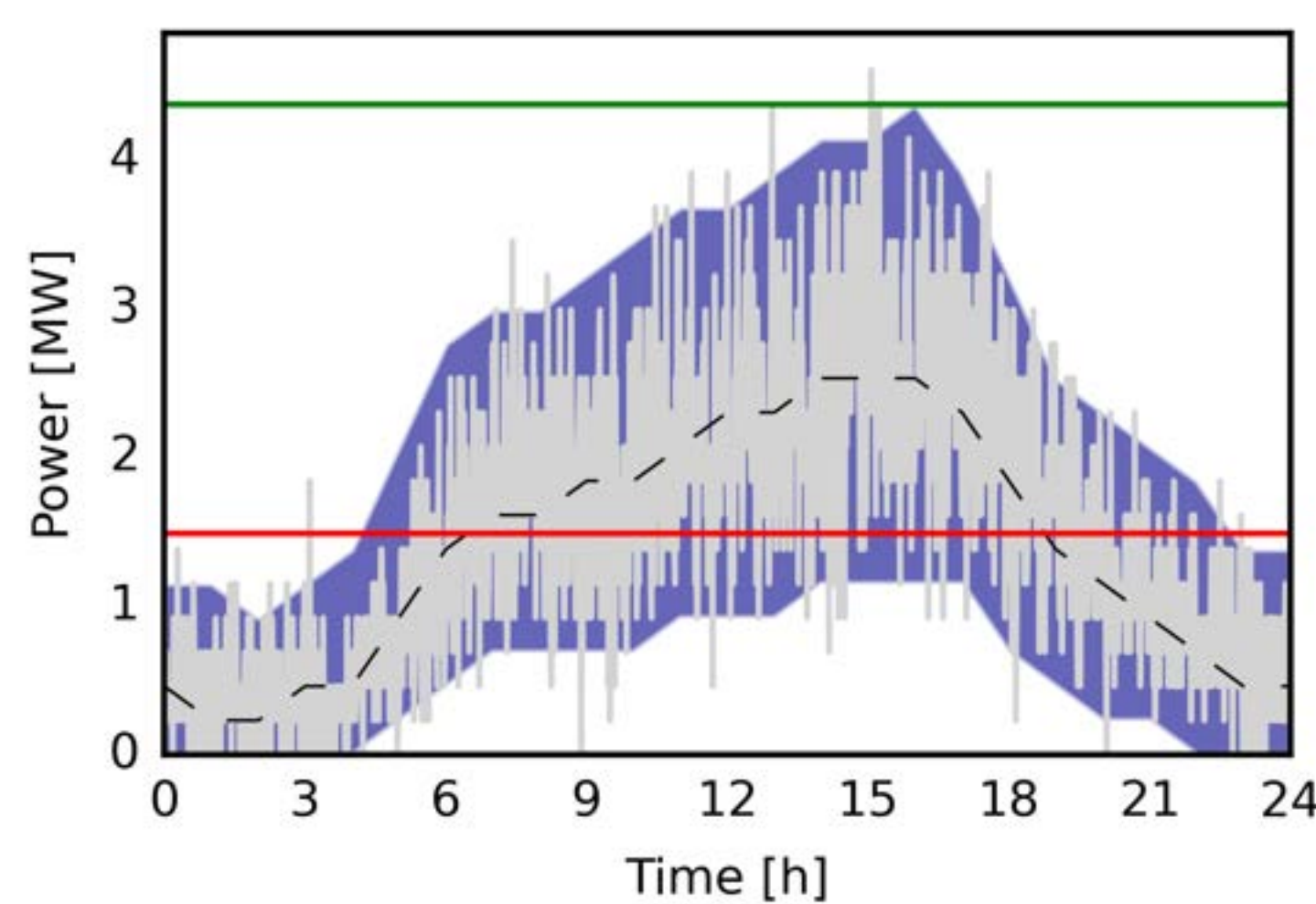
- Parametric studies for accurate load modeling considering location-specific traffic behavior for dynamic wireless charging (DWCS) of electric vehicles (EV) on a roadway
- Power electronic control compensation for highly variable demand, assuming 100% user uptake, independent on the number and speed of vehicles

## Dynamic Wireless Charging Traffic Load Simulation

- DWCS provide electricity to EVs in motion at full roadway speed using electromagnetic coupling
- DWCS power demand is controlled by grid-side power electronics in response to vehicle traffic behavior on the roadway
- Due to the traffic dependency, system load is heavily dependent on vehicle speed, number, and the size of the system, varying greatly at the MW-level and can be modeled using:
  - Poisson Distribution interpolation of the number of vehicles arriving per defined time step
  - Normal Distribution sampling for an assumed constant speed for the duration of roadway travel
- Python scripts were developed to emulate vehicles entering the roadway with a duration related to their initial speed and the length of the DWCS roadway section (1 mile)
- Parametric control of the traffic load model enables studies for reduced variation with control modification.

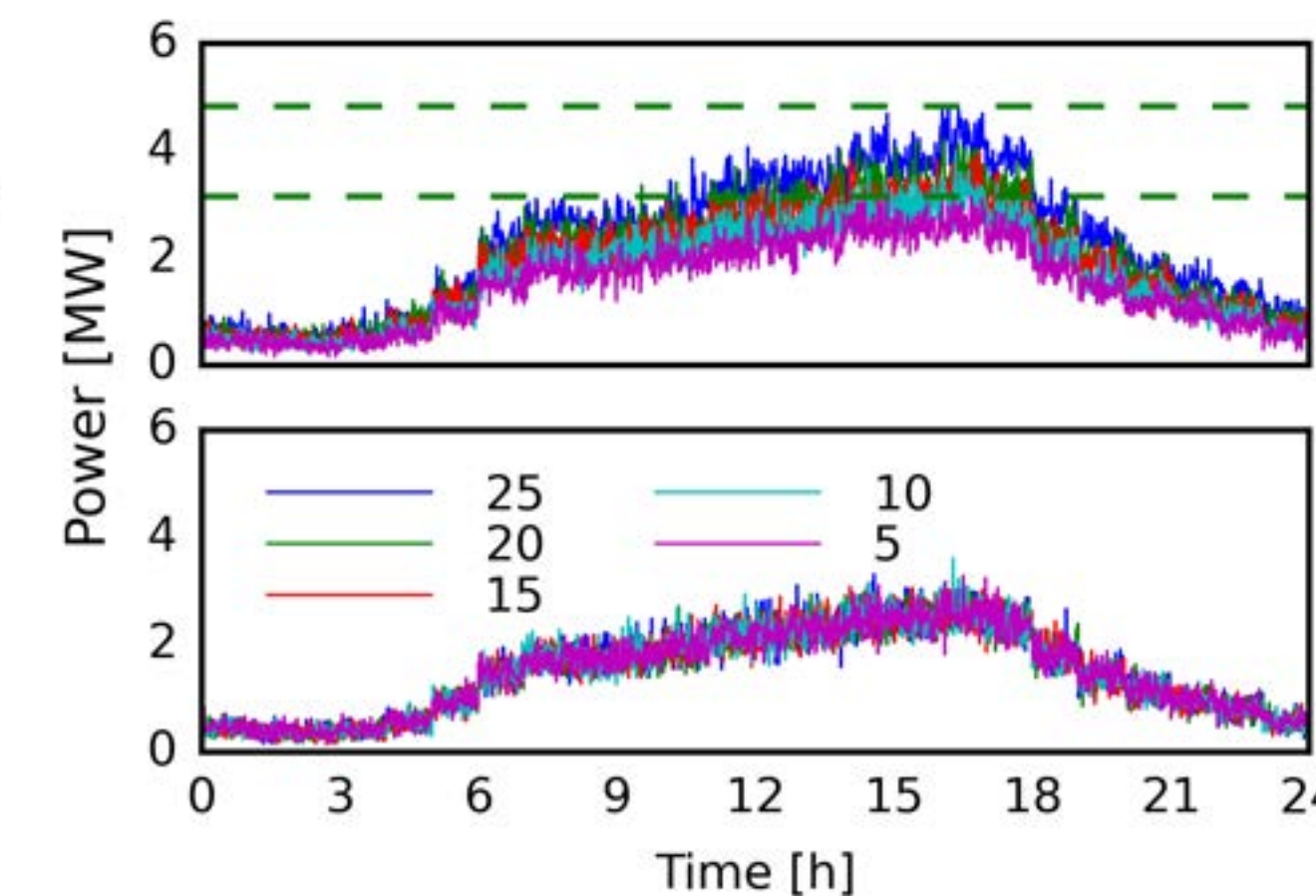
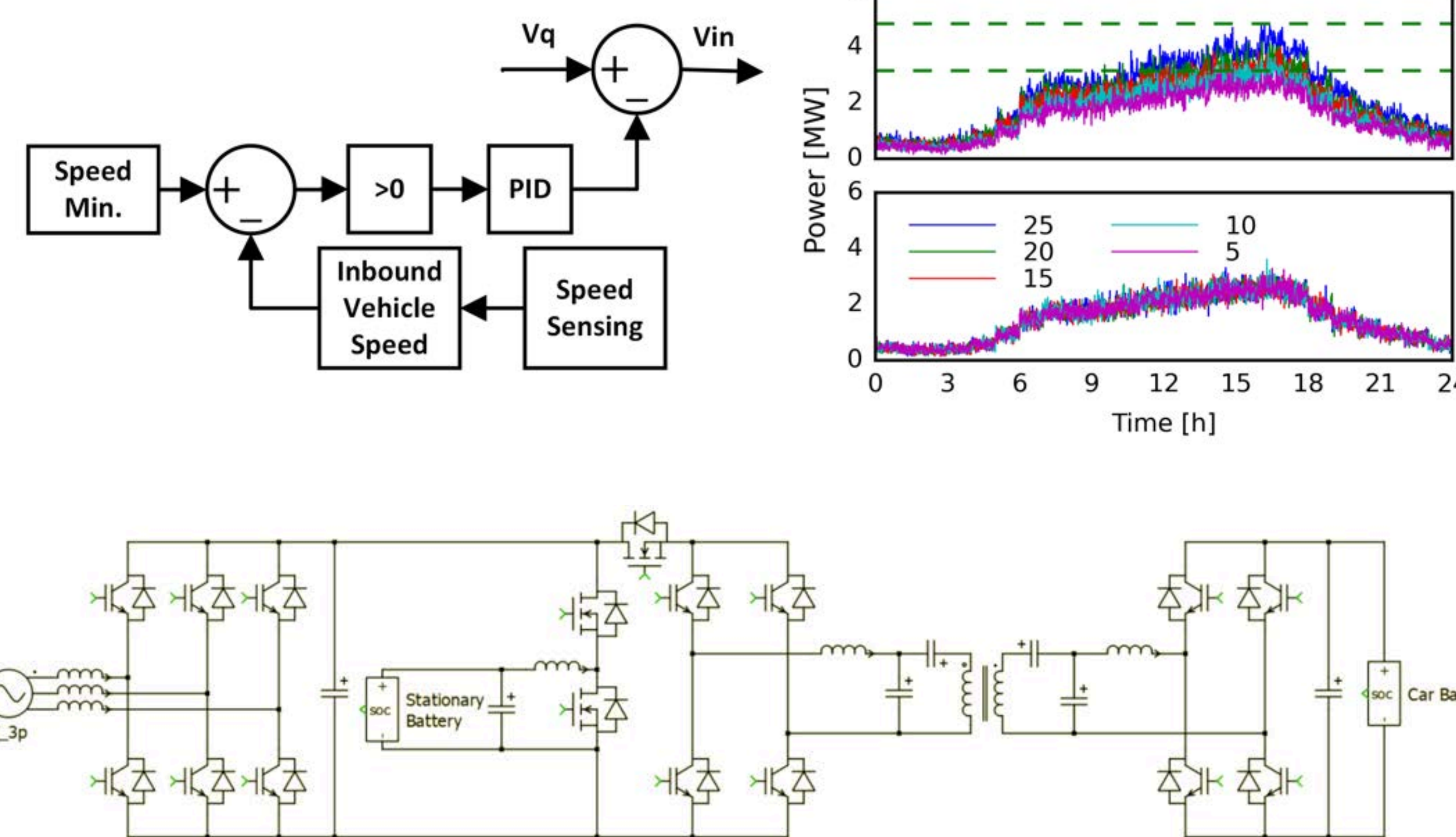
Left- Example DWCS load curve with 95% confidence interval

Right- Experimental Prototype for a wireless charging coil



## Traffic Speed Compensation

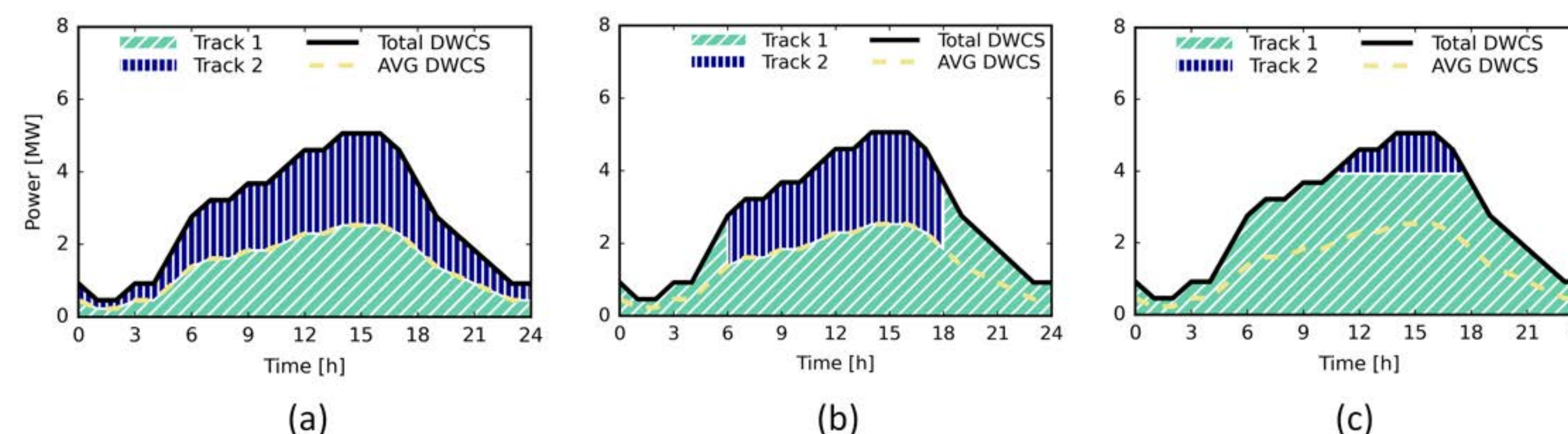
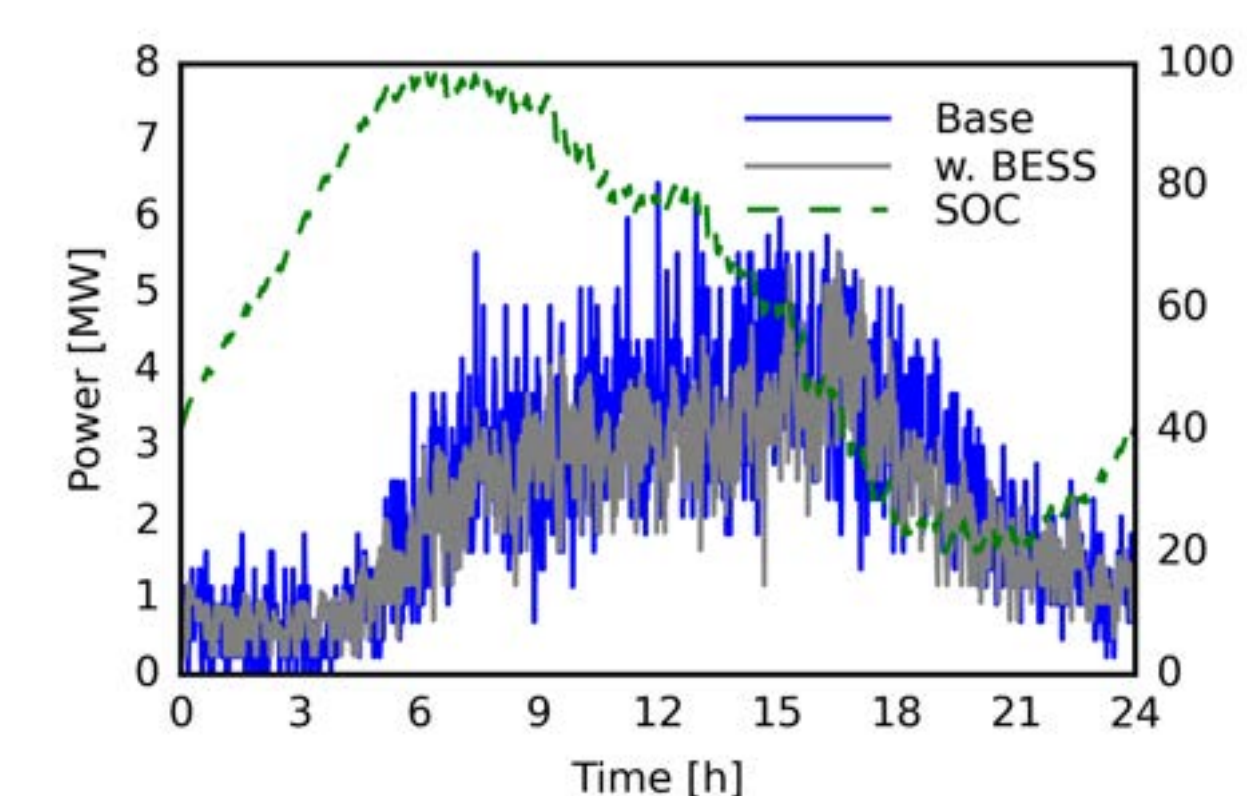
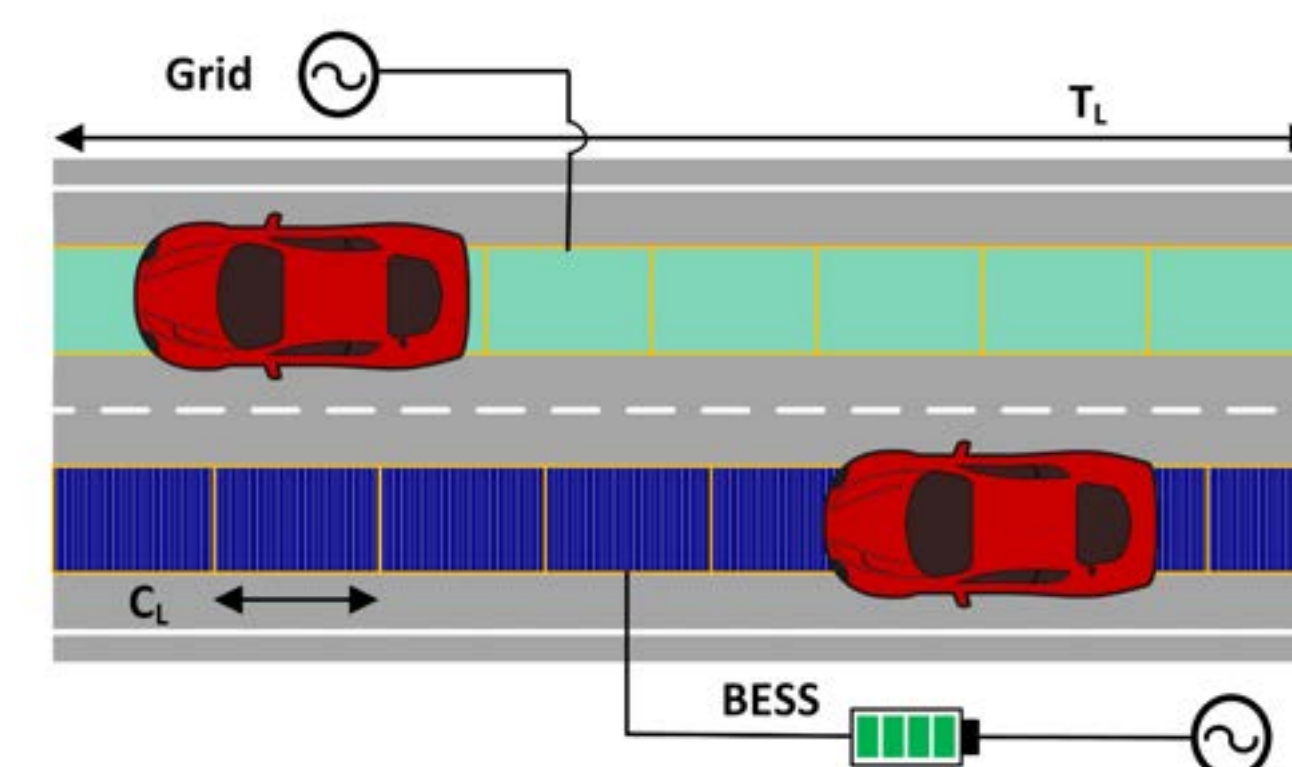
- Variability in the speed of traffic can greatly alter expected electric load due to the limited timing for energy transfer
- Slow drivers receive more energy and account for a higher load
- Increased speed variation can increase average and maximum power by 40% from the base speeds
- To compensate for driver choice, a control scheme is proposed to limit the energy transfer below a defined limit
- Variation in speed reduces by as much as 20-30% with speed control in a similar fashion to the proposed PID approach.



## Traffic Density Compensation with Accurate Sensing

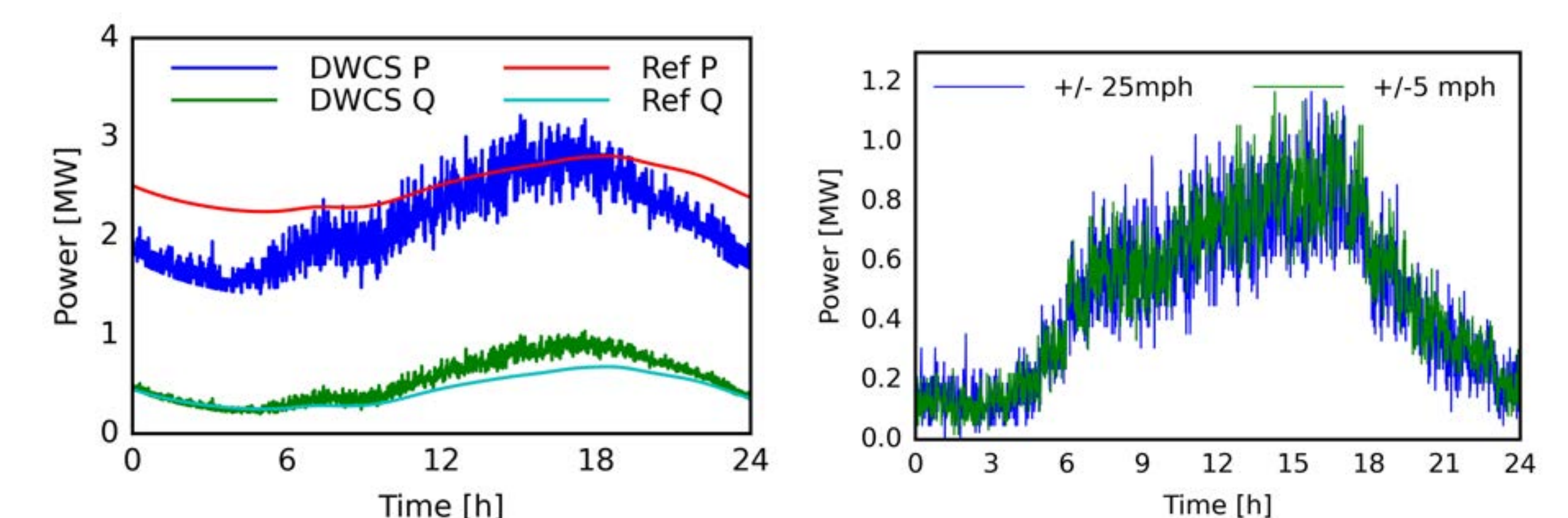
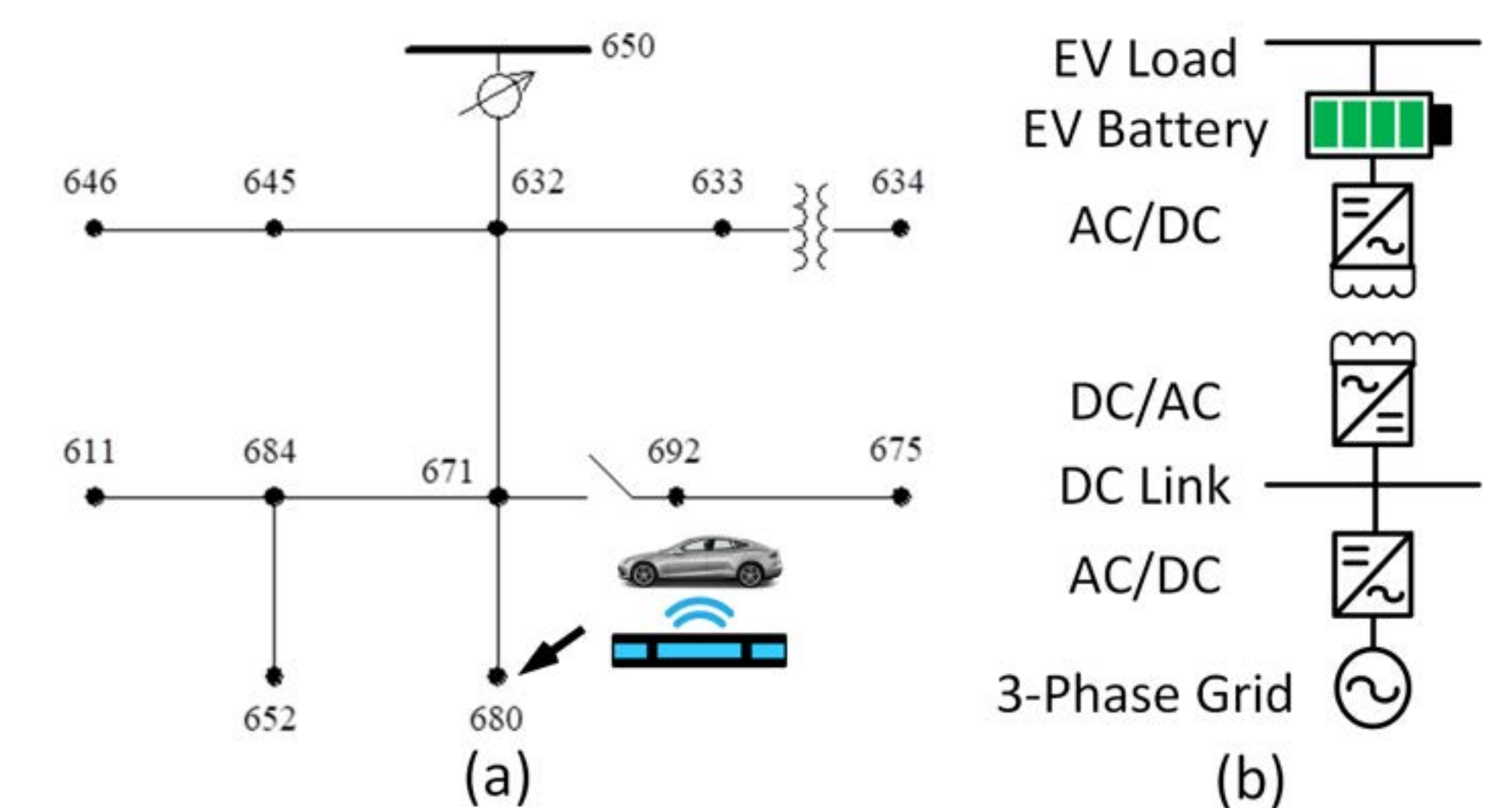
- The density of vehicles on the roadway can greatly increase load during peak hours and is affected by speed-related traffic jams
- The Annual Average Daily Travel (AADT) used in this study is provided by the Kentucky Transportation Cabinet with sensing along I-70 between Bowling Green, KY, and Nashville, TN
- High sensing resolution for traffic data is necessary to effectively capture variation of vehicles currently on the roadway
- High traffic density can be accounted for using integrated battery energy storage systems and shifting between lanes of a roadway as shown below in two potential methods:

- Shifting based on peak demand time within the system
- Allocating a defined capacity for peak shaving.
- Ripple and variability can be reduced by 60 and 40% respectively



## Case Study – Aggregate Load on IEEE Distribution

- OpenDSS by EPRI is employed as an electric power distribution system simulator to study DER grid integration
- A modified IEEE 13 bus distribution system was modeled with an added aggregated DWCS load scaled to and replacing the largest system load alongside residential load variation.
- Power flow solution with added DWCS showcases increased variability in voltage and power. Speed and traffic volume compensation reduces overall power system impact.



## Conclusions

- Speed compensation can reduce maximum and average power variability by 20-30% with different speed mean and deviation
- Shifting or shaving of peak load demand may reduce power system impact of DWCS load without compensation and increase converter utilization by up to 50%.

## Future and Ongoing Work

- Further developments concerning segmentation and feasible scalability of transmitting coils when connected to the larger power system
- Full implementation, simulation, and testing for the control of the switchable dynamic wireless charging coil with an integrated battery system.

## Acknowledgement

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