Master Project

Optimal bidirectional electric vehicle charging to minimize carbon footprint in a realistic simulation environment

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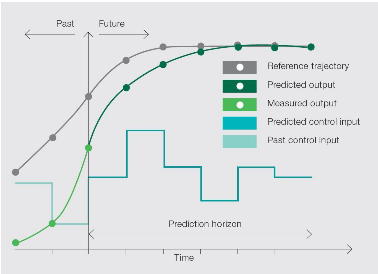
Context

Due to increasing market penetration of battery electric vehicles as well as the electrification of buildings (heat pumps, electric stoves etc), electricity demand peaks are becoming higher. At the same time, the base load of the grid is deteriorating because the supply side contains increasing amounts of renewable sources (which are usually less predictable and more volatile). To make sure that large-scale EV adoption is possible from grid capacity point of view, it is of crucial importance that electric vehicle charging is regulated to alleviate grid pressure and demand peaks, and to make best use of the supply peaks. This is done by making use of the *flexibility* that is provided by electric vehicles. Electric vehicles impose a so called flexible load on the grid. It is flexible, since there is often a certain amount of temporal freedom when it comes to charging electric vehicles. For example, while a vehicle is typically connected to a charge point for about 12 consecutive hours, it only needs about 4 hours to obtain the required state of charge. This leaves room to choose when to charge the vehicle making it a flexible load. Today, smart charging happens in a unidirectional manner, meaning that the vehicle receives the amount of energy needed at times when there is little demand and lots of supply, while ensuring the lowest possible charging costs. A lot more flexibility however, can be created by using bidirectional charging, meaning that the vehicle can discharge its battery to provide electricity to the grid or household. This way, sustainable energy can be stored in a vehicle battery for later use, for example to heat homes, cook or to supply to the grid during high demand hours.



The focus of this project is to develop an algorithm that optimally uses this *Vehicle-to-Grid* technology to ensure the lowest carbon footprint related to a households electricity consumption, while also satisfying the users state-of-charge demand for driving. Since the data from the vehicle is relatively unreliable, a Kalman filter must be made to improve accuracy of the state of charge data. Next, a Model Predictive Controller must be constructed to effectively steer the state of charge to follow a desired trajectory. Lastly, this trajectory must be determined by a smart charging algorithm determining the best times to charge and discharge.

Project tasks

This master thesis project is aimed at developing a bidirectional smart charging strategy and implementing it in a real world application. To to so, the following tasks are proposed:

1. Implement Kalman filter to increase reliability of SOC data
2. Implement MPC to accurately control charging
3. Develop algorithm that can solve for minimal carbon emissions while satisfying driver needs

This master thesis project is done in coorporation with Jedlix. The algorithm will be designed and validated experimentally.