BEng Project Mission Statement

REMOTELY ACTIVATED CONTROL AND DEMAND RESPONSE OF AGGREGATED ELECTRIC VEHICLES

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Supervisor: Dr Sasa Djokic
Subject Area: Electric Vehicles, Smart Grid

Description and Objectives of the Project :

The aim of the project is to analyse the feasibility of implementing a remote on-off switching control scheme of charging a fleet of "high-end" electric vehicles (HE-EVs, which are generally defined as EVs with battery capacity of around 100 kWh, or higher). The work on the project will have several stages:

- Initial analysis will provide a detailed review of existing grid-to-vehicle (G2V) and vehicle-to-grid (V2G) demand response methods.
- Afterwards, a machine learning analysis of a representative set of HE-EV user profiles will be performed, in order to predict the time-varying (i.e. time of the day, day of the week) charge status and potential of individual vehicles in the HE-EV fleet to contribute to the target control objectives.
- Next stage will be dedicated to a design of a flexible and computationally efficient algorithm to calculate the predicted demand-response capabilities of a sample HE-EV fleet.
- The final stage will be related to the techno-economic analysis of developed control schemes and algorithms, using sample data provided by the industrial supervising company (Jaguar Land Rover, JLR).

Motivation and Relevance

This project will examine the techno-economic feasibility and initial design of a control scheme that would allow JLR to aggregate demand response across a fleet of their HE-EVs. By aggregating the demand response of a fleet of HE-EVs charging on the same grid JLR will be able to bid on the energy market by offering grid balancing/support services and receive the corresponding compensation for the service.

Through the incentivising of customers to opt in to the scheme and remuneration for provided demand response functionalities (e.g. by offering remuneration to be used towards vehicle servicing for HE-EV owners), this demand-response control scheme could generate an additional income for the company on a product that has already been sold.

An important constraint is that the implementation of the scheme should result in the minimum, or no discomfort for the HE-EV users, as the on-off switching of the chargers will not impact user-required state of charge of HE-EV battery and time at which it should be delivered.

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Project Scope

This project will focus on controlling only HE-EVs charged at a home charging station, with simple on-off remote control switching and without any further "smart control functionalities" (e.g. control of charging power level, or electricity tariff-based charging control). The demand response capabilities of the modelled HE-EVs will be analysed in both the English and Scottish low voltage grids (220V). Any data and information not provided by the JLR will be based on available public specifications of similar HE-EVs, e.g. a Tesla Model S 100D.

Preparatory Tasks:

- Review existing demand response methods.
- Familiarise with suitable methods for remote control of EV charging (both in G2V and V2G applications).
- Identify typical fleet size and related demand capabilities of HE-EVs based on both current EV uptake statistics and predicted growth rates.
- Research and familiarise with potential algorithms for implementation of adaptive/machine learning techniques.

Main Tasks:

- Predict demand-response capability of a HE-EV fleet and whether the grid demand response capabilities are met.
- Analyse available historical data to design an initial block diagram of the proposed control algorithm and scheme.
- Formulate basic elements of the control algorithm and design interfaces for data structures in Python code implementation.
- Evaluate the economical advantage to JLR that this scheme could provide and the start-up cost associated with implementing such a system
- Test Python implementation.

Scope for Extension:

- Investigate use of developed algorithms in different LV networks (urban, sub-urban, rural).
- Extend control scheme functionality to the other types of EVs (low-end, hybrid, etc.) and multiple EV manufacturers, which should be all aggregated by a single algorithm, or through a single on-board diagnostic (OBD) port.

Background Knowledge:

- Python Programming
- Charging methods and protocols of electric vehicles.
- Demand response and grid stabilisation methods.

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Required Resources:

- Representative data on HE-EV typical driving parameters (driving distances, journey start/end times, etc.), which should be supplied by JLR:
  - Sample Data from a range of users within same time period including
  - Location of HE-EV
  - Charge level of HE-EV
  - Charge status of HE-EV
  - Departure Time of HE-EV
  - Max available charge rate
  - Other relevant data
- Algorithm computational time, depending on the amount of data that should be processed

Location:

- Research to be established at the University of Edinburgh
- Industrial supervision will be provided from the Innovation Acceleration Team of Jaguar Land Rover based at Warwick University.

The academic supervisor and student are satisfied that this project is suitable for performance and assessment in accordance with the guidelines of the course documentation.

Signed

Student: ..... Michael McDonald.....

Academic Supervisor:..... Dr Sasa Djokic .....

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