Electric cars: Policy

Lecture notes: Lecture 3.4

With a high number of electric cars in the future, *aggregators,* who are representing large numbers of individual fuel cell vehicles in a Car a Power Plant system, could operate in the electricity markets and provide system services to electricity system operators. If the aggregator trades power from the vehicle in several markets, *vehicle-to-grid contracts* are needed.

To cope with the different needs from the aggregator and car owner perspective, we develop *three contract types* for Vehicle to Grid:

1. Price-based
2. Volume-based
3. And control-based contracts

These contract types can be used to attract heterogeneous *prosumers* with varying needs within systems with distinct characteristics and goals. By *"prosumer" we understand a person who consumes and produces electricity;* the term is a mixture of the word "producer" and "consumer". Although the aggregator can offer aggregated energy from cars in the markets, it also has to make decisions about the operation of individual vehicles, taking into account the different needs and preferences of the drivers and the technical characteristics of the vehicles. These aspects which define the availability and activation criteria of each car delineate how it can be operated by the aggregator and have to be explicitly defined in a contract.

Price-based contracts

Price-based vehicle-to-grid contracts involve a price signal for the activation of V2G. The driver defines a *minimum price* he wants to receive for V2G. Therefore, the aggregator will use the vehicle only when he can provide this remuneration (for example when market price is higher) and as long as there is enough energy in the vehicle. This type of contract could be used for drivers to participate in the wholesale energy market, where average prices may not be high enough, but peak prices can make V2G profitable.

Contract parameter	Description
Min. V2G price	Minimum price for activation, defined by driver
Guaranteed fuel level	Minimum level of hydrogen in the tank guaranteed after operation
V2G remuneration	Remuneration for energy supply, for example, min. V2G price

Table: Contract parameters for price-based contracts

Volume-based contracts

Volume-based contracts involve commitment of a predefined volume of energy within a certain time interval. It means that the *drivers can limit the amount of energy they are willing to provide* (maximum volume). Volume-based contracts can be attractive for *drivers who have a very predictable driving schedule* and can be plugged in regularly, for example at the workplace parking facilities or at home.

Contract parameter	Description
Time interval	Time interval (start + duration) for availability
Max. volume	Maximum volume usable for V2G
V2G remuneration	Energy and capacity remuneration
Guaranteed fuel level	Minimum level of fuel guaranteed after operation
Min. fuel required at plug-in	Calculated level of fuel required in the vehicle before plug-in

Table: Contract parameters for volume-based contracts

Control-based contracts

With *control-based contracts* the driver cedes control to the aggregator as soon as the car is plugged in. The *availability is defined by the time interval*, which could be pre-committed or informed by *indicating the expected departure time*. This may be the contract form with lowest complexity and in the absence of a time interval commitment it gives freedom to the driver to plug in anytime. However, when plugged in, *the driver cannot limit how much energy may be used by the aggregator*. Control-based contracts could be attractive in cases when vehicle availability is high without commitment, for example, large fleet of FCEVs that are usually plugged in at regular times, and/or when volume commitment beforehand is not necessary because it is not scheduled ahead.

Contract parameter	Description
Time interval	Plug-in time (voluntary of precommitted)
V2G remuneration	Energy and capacity remuneration
Guaranteed fuel level	Minimum level of energy guaranteed after operation, requested by driver

Table: Contract parameters for control-based contracts

These three contract types *show different ways for drivers and aggregators to make agreements* on the availability and activation criteria of their flexible V2G resources. The *main differences are the level of commitment of the plug-in time and the activation criterion*: either the energy available (volume) or a minimum price preference. In each case, the aspect over which the driver has control is different. In practice, hybrid forms of contracts could be used by aggregators to ensure a certain level of participation of drivers.

In terms of implementation of V2G, the contract types we just discussed can be used by aggregators to choose a market for V2G and then attract drivers with the characteristics that can be suitable for that market, and vice versa. Moreover, aggregators can use the structure of contracts to design incentives for the participation of drivers, for example, by rewarding availability, energy, or the commitment of time or volume.