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Offer of secondary reserve with a pool of electric vehicles on the German market

Johannes Jargstorf[a,b,c,*], Manuel Wickert[b]

[a] KU Leuven, Electrical Engineering Department ESAT-ELECTA, Kasteelpark Arenberg 10, B-3001 Heverlee, Belgium
[b] Fraunhofer IWES, Energy Economy and Grid Operation, Koenigstor 59, 34119 Kassel, Germany
[c] Fernuniversitaet Hagen, Electrical Engineering Department, D-58084 Hagen, Germany

HIGHLIGHTS

- We analyze a business case of providing reserve power with electric vehicles.
- We include legal regulations for providing reserve power in the calculation.
- Reserve requirements lead to a significant drop in expected revenues.
- Results show that vehicles are not suitable to offer reserve power.

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ABSTRACT

This paper analyzes the business case of offering secondary downward reserve for frequency control on the German market by a pool of electrical vehicles. Former benchmark studies promised high revenues especially for this case. The benefits could provide an incentive to customers to buy an electric vehicle. The business case is analyzed for the German market as a case study. Specific regulations for this market, real driving patterns and real market data are taken into account when calculating revenues. Secondary reserve is strictly regulated, requiring a very high level of availability. As a result, simulated revenues are lower than assumed. Simulation shows average revenues of less than 5€ per month and vehicle. As a major bottleneck for an offer of secondary reserve, fully charged batteries are identified. Additionally an issue is made of costs for communication and customer compensation. Based on the simulation results, it is argued that the market for secondary reserve should not be accessed with these small units. For electric vehicles, easier accessible markets with lower related costs should be considered instead.

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1. Introduction

Electric Vehicles (EVs) are seen as a major contribution to sustainable mobility. They offer several advantages compared to Internal Combustion Engine (ICE) propelled vehicles like a higher well-to-wheel efficiency. In combination with renewable energy they have low CO_2 emissions that vanish entirely when charged with wind- and solar-power (Van Vliet et al., 2011). Also, they have no local emissions (Pasaoglu et al., 2012). This is one of the most important aspects as studies suggest a significant share of lung cancer and several thousand deaths per year to be directly related especially to particle emissions (Sovacool, 2010; Martuzzi and et al., 2006; World Health Organization, 2003). Besides this, electric vehicles can also act as storage for the intermittent generation of wind- and solar-power (Wang et al., 2011; Saber and Venayagamoorthy, 2011; Baier et al., 2010) and foster in this way integration of these sources of energy. Therefore, several countries set targets for the number of EVs to be reached. Germany, for instance, assumes 1 million EVs in 2020 (Bundesregierung, 2010).

A decisive disadvantage of EVs is currently costs (Wang, 2011; Van Vliet et al., 2011). Though running costs are assumed to be lower, high investment costs, especially for the battery, lead to much higher Total Costs of Ownership (TCO) compared to ICE propelled vehicles. This means that currently customers do not break-even with an EV (Wang, 2011). The key to lower TCO is high production volume. Costs for batteries will decrease significantly if produced in high volumes (Wang, 2011; Dinger et al., 2010). Still, it is very uncertain when lower TCO can be reached (Pasaoglu et al., 2012; Wang, 2011; Jargstorf and Job, 2011; Dinger et al., 2010). Currently, volumes remain small, mainly due to high costs which prevents costs from dropping sufficiently. So-called vehicle-to-grid (V2G) business models are proposed as a possible way to overcome this deadlock, by

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* Corresponding author. Present address: KU Leuven, Electrical Engineering Department ESAT-ELECTA, Kasteelpark Arenberg 10, B-3001 Heverlee, Belgium. Tel.: +32 16 321714; fax: +32 16 321985.
E-mail address: johannes.jargstorf@esat.kuleuven.be (J. Jargstorf).

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generating additional income for the vehicle owner that let them break-even (Kempton and Tomić, 2005b). In these models, the battery of the vehicle can act as a provider of ancillary services to the electricity grid while the car is not used. Several conceptual studies have calculated high revenues especially for frequency support in the US (Kempton and Tomić, 2005a,b; Tomic and Kempton, 2007; Turton and Moura, 2008; Quinn et al., 2010). For instance Kempton and Tomić (2005a) calculated annual profits of up to US$2500 per vehicle for such services.

For the European market Andersson et al. (2010), San Román et al. (2011) and Dallinger et al. (2011) analyzed such V2G models. In contrast to the studies from the US, Andersson et al. (2010) and Dallinger et al. (2011) outlined the preferability of downward reserve in Europe. Offering, secondary downward reserve on the German market showed to be the most promising offer in Europe. Andersson et al. (2010) calculated possible revenues of up to 80€ per car and month for this market, Dallinger et al. (2011) calculated profits of around 180€ per car and year.

Yet, these references provide a benchmark analysis. Except for Dallinger et al. (2011), no real driving patterns are considered. Andersson et al. (2010), for instance, assumed that the storage capacity is always sufficient. The authors stated that their calculation was a maximum case.

Also, current German regulations for secondary control reserve are not taken into account. This includes requirements for availability and communication but also dealing with imbalances. Though regulations can be subjected to change, they need to be considered as specific national rules can have significant impact on calculated profits. Also, today's payments, which are usually used to calculate possible profits, are linked to today's rules. Payments might differ significantly under different rules. When arguing for a change of regulations, it also has to be considered, whether this affects core rules of a market. Such rules might not be changeable without changing the nature of the market.

In this paper, the business case of an offer of secondary downward reserve on the German market with a pool of electric vehicles is analyzed. This market was chosen because benchmark analysis promised high revenues especially for this case. Revenues from this business case shall give an incentive to customers to buy electric vehicles they otherwise would not buy. The economic feasibility of the business case is analyzed, using actual driving patterns as well as regulatory aspects of the respective control market. Thus, a major question is, whether the analyzed business case generates enough profit so that it can be used as an incentive scheme for the purchase of an EV. If this is not the case, it needs to be considered, whether potential changes to regulation would make this case profitable. To calculate revenues, an agent based driving simulation is used. This work can be seen as a case study for other European countries applying the ENTSO-E framework of frequency-load-control (ENTSO-E, 2011).

In Section 2 specific regulations for a bid on the German market are discussed. In Section 3 general assumptions for the proposed business model is provided. In Section 4 the simulation model is presented and in Section 5 the simulation results. These results are discussed in Section 6. Section 7 provides a conclusion.

2. Regulatory framework

2.1. General aspects

According to the ENTSO-E (2011) framework for former UCTE countries three types of frequency control[1] are used to balance unanticipated mismatches between generation and consumption: primary, secondary and tertiary control. Reserves are needed to be always able to activate this control. Depending on the mismatch, control power is further divided into upward control (lack of generation/too much consumption) and downward control (too much generation/lack of consumption).

The rather high level ENTSO-E framework is in Germany further specified in the respective grid code (TransmissionCode) (German transmission system operators, 2009a), its appendices (German transmission system operators, 2009b,c) and in decisions made by the Bundesnetzagentur (Federal Grid Agency), a national regulation body (German federal grid agency, 2007, 2011).[2] These regulations include no specific regulations for EVs yet. In this paper, these regulations as of today are used. In Germany, the three different types of control reserve are further divided into positive (upward) and negative (downward) control reserve. In this study, secondary downward control reserve is taken into account, based on the considerations in Section 1.

Secondary control reserve is provided by designated plants to relieve primary control reserve. It is activated automatically to restore nominal frequency. It shall also restore power exchange between regulation zones to nominal value and it is used in case of deviations <10 mHz. The transmission system operators (TSOs) are responsible for holding reserves available and activating them. In Germany, the TSOs tender secondary control reserve publicly using a common Internet platform.[3] It was contracted during time of writing for one month in two time periods (peak time and off-peak time) separated in upward and downward reserves. Peak time is working days Monday to Friday 8 am until 8 pm. Off-peak time is the remaining time period. At the time of writing minimum offer was 10 MW which can be provided by a pool. Secondary control reserve is usually activated continuously with the power stochastically altering (German transmission system operators, 2009b).

Remuneration for secondary downward reserve consists of a price for providing the reserve (capacity price or reservation price) and a price for the actual energy (energy price or activation price). The activation price can be positive or negative.[4] Both prices depend on the offer of the supplier. Suppliers of reserve are selected based on the merit order of the capacity price. Activation happens automatically according to the merit order of the separate activation price. Though the activation price can be negative, the TSO has to activate the provider first that offers the most favorable activation price (German federal grid agency, 2011). In the case of downward reserve, this is the one who pays the most for the energy.

2.2. Specific aspects

To be accepted, a potential provider of control reserve has to fulfill so-called pre-qualification requirements of the grid code. A fundamental aspect is the required 100% availability of secondary reserve due to the notable importance of secondary reserve for system security (German federal grid agency, 2011). As a consequence, secondary control reserve has to be provided independently from actual activation (German transmission system operators, 2009b). This means that the fleet of vehicles must be

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[1] Respectively frequency control reserve.

[2] German federal grid agency (2007) was replaced by German federal grid agency (2011). Mayor changes involved a reduced minimum bid of 5 MW and a contract period of 1 week. Most other regulations remained the same as in German federal grid agency (2007). As shown later, these changes do not affect the business case.

[3] www.regelleistung.net

[4] This is the TSO perspective. A positive price means that the TSO gets money in case of activation. For the supplier, the perspective is vice versa.

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