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Profitability evaluation of introduction of Vehicle-to-grid – enabled Frequency Containment Reserve services into the business model of electric vehicle Charge Point Operator.

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Summary

The current paper defines a quantification framework for the introduction of frequency containment reserve (FCR) services, enabled by the vehicle-to-grid (V2G) technology, into the business model of an archetypical electric vehicle (EV) charge point operator (CPO), implying additional revenues and costs. This study investigates these additional financial factors and integrates them into the currently existing CPO business model, eventually evaluating the financial profitability of this introduction under the given circumstances and comparing it with the profitability of the traditional CPO business model.

Keywords: EV (electric vehicle), business model, charging infrastructure, smart grid, V2G (vehicle to grid)

1 Introduction

The modern world experiences a massive electrification trend, and the increasing popularity of electric vehicles (EVs) is a major part of it. However, the electrification of transport can eventually put a significant pressure on electricity grids, increasing peak loads [1]. Fortunately, the rising popularity of EVs can also be an enabler to mitigate this issue through the use of the vehicle-to-grid (V2G) technology. The V2G technology is a new resource, allowing EVs to discharge the energy back to the grid and opening the door to grid balancing (flexibility) services, such as frequency regulation and peak shaving [2]. These services can become new core value propositions of EV charging business ecosystem and generate new significant revenue streams for its participants in general and EV charge point operators (CPO) in particular [3][4].

However, the existing literature offers limited knowledge on the effect of introduction of V2G-enabled grid balancing services into the business models of the participants of EV charging infrastructure [3] [4], fully lacking the quantified models and the profitability evaluation of this introduction.

In order to overcome this research gap, the current paper defines a quantification framework for the introduction of the V2G-enabled Frequency Containment Reserve (FCR) service into the list of the core value propositions of the business model of an archetypical CPO and evaluates its profitability by the means of a set of profitability indicators. Moreover, the same set of indicators is also applied to the quantified business model of the archetypical CPO defined in [5], giving the opportunity to compare its performance before and after the transformation of its business model caused by the addition of V2G-enabled grid balancing service.

2 Literature overview

2.1 Introduction of V2G into CPO business model

The currently existing EV charging business ecosystem includes numerous interrelated actors [3]. It is quite noticeable that the CPO is in the core of EV charging business ecosystem, being directly related to the EV charging process, the core business of the ecosystem. Moreover, the CPOs manage, maintain and often own EV charging infrastructure, providing a set of related services. The V2G technology is able to extend the list of these services, allowing EVs connected to V2G EVSE not only to charge energy, but to discharge it back to the grid [3]. The business model of an archetypical CPO is provided in Fig. 1 where the changes caused by the introduction of the V2G technology are marked in blue colour.

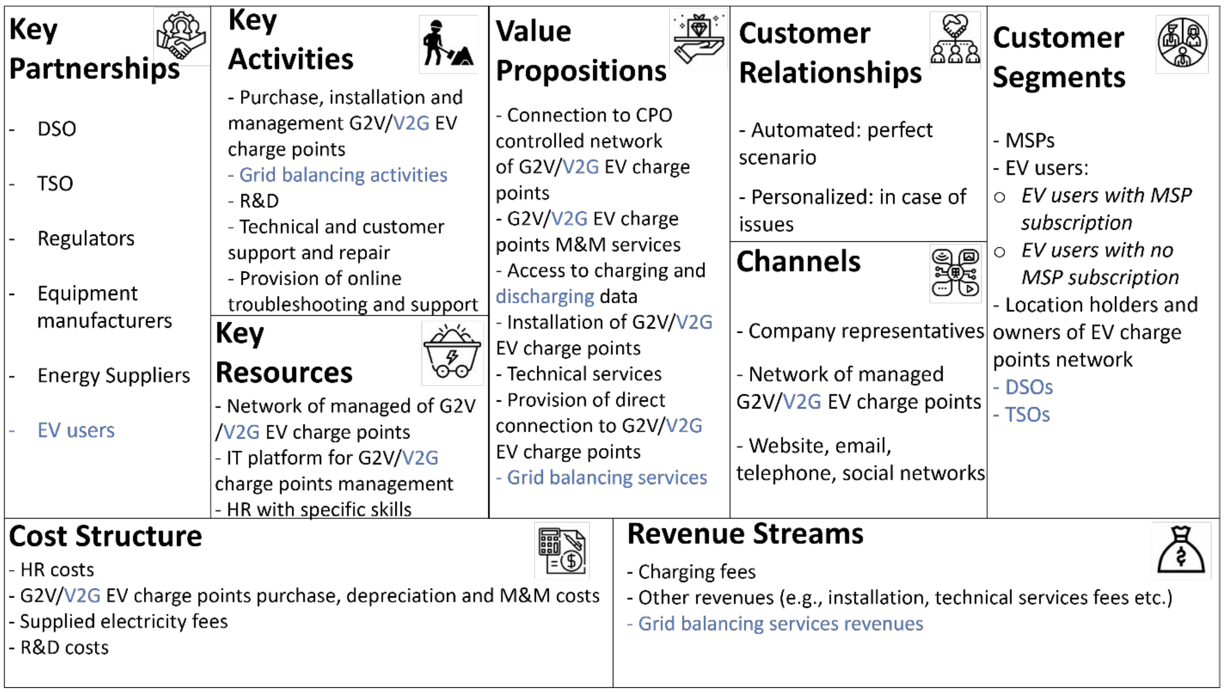

Fig. 1: BMC: CPO + V2G (V2G – caused changes are marked in blue) [3].

As it can be noticed, the introduction of the new technology has influenced all the business model perspectives (including customer, internal business, value propositions and financial perspectives). Following the business model innovation mechanism, described in [3], the introduction of new Key Resource – V2G technology – allows the CPO to offer new Value Propositions related to grid balancing services. This involves the introduction of new Customer Segments into the model, leading to the creation of new Revenue Streams. Obviously, the changes also lead to the introduction of new Key Activities, along with the modification of Cost Structure and other elements of the business model.

However, while Fig. 1 concentrates on the qualitative representation of the changes of the CPO business model caused by the introduction of the V2G technology, the point of interest of the current study is its influence on the financial (quantitative) perspective of the business model, representing the company's revenues and costs .

2.2 Frequency Containment Reserve (FCR)

According to Elia [6], the Belgian Transmission System Operator (TSO), there are three types of grid balancing services that could be provided by the entities connected to the grid, after becoming Balancing Service Providers (BSP). These services allow to keep the balance between the energy injection and consumption, and maintain the grid operation at a constant frequency of 50 Hz and are the following: a) Frequency Containment Reserve (FCR), b) Automatic Frequency Restoration Reserve (aFRR), and c) Manual Frequency Restoration Reserve (mFRR). According to Elia [7], the most suitable type of V2G-enabled flexibility service could be the FCR, because of the ability of EV batteries to react immediately to a power request and a relative readiness of the TSOs and policy makers to adopt FCR service conditions for smaller decentralized BSPs [6]. The list of unfavourable conditions for potential smaller decentralized BSPs includes mainly the minimum energy capacity bid size of 1 MW along with the specialized metering equipment on every, so called, “Delivery Point” (Electric Vehicle Supply Equipment (EVSE), in case of a CPO) [8] [9]. However, according to Elia [7] [10] and CREG (Commission for Electricity and Gas Regulation) [11], due to the development of the decentralized energy production technologies, along with the growing popularity of EVs, the FCR service conditions for BSPs have to evolve in the direction of the reduction of minimal contracted capacity and utilization of standard widely accepted smart meters as metering equipment. The changes would allow not only CPOs with V2G EVSE networks, but also smaller prosumers (e.g. SMEs) to enter the grid balancing market [11].

The only remuneration foreseen for FCR services is based on the energy capacity offered by the BSP and reserved by the TSO, expressed in €/MW/h price. This price is defined by the means of capacity bids on the FCR energy capacity auction, organized by the TSO for the involved BSPs. Due to the symmetric nature of the FCR service, requiring rapid upward and downward activations of the contracted energy capacities, the supplied energy payments offset each other. Therefore, the TSO offers no remuneration for the FCR activations and the supplied energy, paying only for the reserved capacity [12].

Concerning the risks for the BSP, the participation into FCR services involves potential penalties for: a) not passing the availability test of the reserved capacity (organized by the TSO) and b) the inability to activate the reserved capacity. However, the potential financial penalty cannot exceed the remuneration paid for the reserved energy capacity, making the grid balancing services market, to a certain extent, risk-free [12] except for risks related to the initial investments into the infrastructure.

3 Methodology

3.1 V2G-enabled FCR services into the financial perspective of the CPO business model

The current paper focuses on the introduction of V2G technology into the business model and V2G-enabled grid balancing opportunities, while more elaborate definitions of a CPO’s revenues and costs can be found in [5]. According to [5], the Revenue Streams of the currently existing business models of the archetypical CPOs can be generally defined as follows (eq. 1):

$$\text{Revenues}_{CPO} = TF_{CPO} + OR_{CPO} \quad (1)$$

- TF_{CPO}: total fee received from the charging activities on the CPO EVSE network.
- OR_{CPO}: other revenues generated by side activities not directly related to the EV charging (e.g., advertisement, technical fees, etc.).

At the same time, the cost structure of an archetypical CPO is defined as follows (eq. 2) [5]:

$$Costs_{CPO} = C_{Infrastructure} + C_{Electricity} + C_{MP} + C_{HR} + C_{Other} \quad (2)$$

- $C_{Infrastructure}$: depreciation, management and maintenance costs of EVSE infrastructure.
- $C_{Electricity}$: electricity costs paid to the energy suppliers.
- C_{MP} : costs for accessing the common marketplace for EV charging business ecosystem.
- C_{HR} : costs related to the human resources.
- C_{Other}: other additional costs, not represented by the previous categories.

As it is explained in Section 2.3, the most convenient type of V2G-enabled grid balancing service for a CPO is the FCR service, changing the revenue formula of a CPO as follows (eq. 3):

$$Revenues_{CPO} = TF_{CPO} + OR_{CPO} + R_{FCR} \quad (3)$$

- R_{FCR}: revenues generated through FCR flexibility services for TSO

As it is noticeable from eq. (3), the revenues of the CPO after the introduction of V2G technology repeat the original revenue formula represented by eq. (1), adding the revenues generated from FCR flexibility services (R_{FCR}). The revenues generated by the means of the provision of FCR services are paid by the TSO to the BSP, in this case the CPO. The formula for CPO revenues generated by the means of V2G–enabled FCR services can be defined as follows (eq. 4):

$$R_{FCR} = FCR_{Bid} ¿ \sum_{y=1}^{Z} ¿¿ \quad (4)$$

- FCR_{Bid} : average FCR capacity bid (in €/MW/h) during the considered time period (T) on the energy capacity auction organized by the TSO.
- *y*: type of EVSE (e.g. unidirectional, V2G)
- K y: power level of (V2G) EVSE type *y*
- *CR*y: connection rate (in %) of EVSE, being the percentage of the considered time period (T) that the considered EVSE type *y* was connected to an EV.
- *UR*y: usage rate (in %) of EVSE, being the percentage of the considered time period (T) that the considered EVSE type *y* was actively engaged into the EV charging process.
- N_y: number of EVSE type y
- *T*: considered EVSE availability time period

The difference between CR and UR can be considered as the EVSE idle time, available for the provision of the FCR services. Regarding the Cost Structure, while the introduction of V2G technology does not bring any new cost elements to the list, it does increase the existing ones. This rise concerns mainly costs related to the CPO's EVSE infrastructure ($C_{Infrastructure}$), i.e., depreciation, management and maintenance costs (see Table 3).

3.2 Profitability evaluation

The current study's comparative profitability evaluation model of the currently existing archetypical CPO business model with the one providing V2G–enabled FCR services is based on a number of most common profitability indicators. The list of these profitability indicators includes Earnings Before Interests and Taxes (EBIT), Earnings Before Interests, Taxes, Depreciation and Amortization (EBITDA), the margins of these indicators, along with the annualized ROI [13][14][15]. The definitions of the chosen indicators are in Table 2.

Table 2: Profitability indicators with definitions [13, 14, 15]

Indicator		Generalized formula	Definition
EBIT	=	$Revenues - Costs$	EBIT is the difference between company's operating revenues (not including the interest revenues) and costs (before the inclusion of tax-related expenses) [13] [14].
EBITDA	=	$EBIT + Depreciation + Amo$	EBITDA repeats the definition of EBIT, but not including the depreciation and amortization into the costs list [13] [14].
EBIT margin (%)	=	$\frac{EBIT}{Revenue} * 100\%$	EBIT margin is a company profitability ratio, indicating the relative part of the revenues preserved after the deduction of expenses (before interests and taxes) [15].
EBITDA margin (%)	=	$\frac{EBITDA}{Revenue} * 100\%$	EBITDA margin repeats the definition of EBIT margin, but not considering the depreciation and amortization costs [15].
ROI (%)	=	$\frac{EBIT}{Total\,investment} * 100\%$	ROI shows the ratio of company's EBIT to the total amount of the invested capital [15].

It is noticeable that the factors participating into the calculation of the profitability indicators are represented into the financial perspective of a business model as the components of the Revenue Streams and Cost Structure.

The selection of EBIT as a profitability indicator allows to avoid the peculiarities of different taxation mechanisms, providing the opportunity to extrapolate the results of the current study to different geographic regions [5]. The use of EBITDA allows the capital-intensive companies (e.g. CPOs owning the EVSE network) to get an alternative view on the operating financial perspective of their business models, taking the costly assets with long writing down periods out of scope and concentrating on the current situation [14]. High EBIT and EBITDA margins indicate a higher efficiency of the company, where the significant part of revenues are retained by the company [15]. Finally, the ROI, one of the capital return profitability ratios, takes into account the total investment and allows to evaluate the profitability of the company with respect to the total invested capital [15].

4 Results

The current section provides the results of the calculations of the aforementioned profitability indicators for two types of CPO business models, namely the currently existing archetypical CPO operating a network of unidirectional EVSE and a CPO providing V2G-enabled FCR services. The values of the factors participating into the calculations, along with the sources, validating these values are provided in Table 3.

Table 3: Values of the parameters participating into the profitability evaluation of CPO business model [16-33]

#	Parameter	Symbol	Unit	Value	
1.	EVSE type	*y*	/	Unidirectional AC charger	V2G DC charger

<table>
<tr><td>2.</td><td>EVSE power level [16]</td><td>Ky</td><td>kW</td><td colspan="3">11</td></tr>
<tr><td rowspan="4">3.</td><td rowspan="4">EVSE price [16] [17] [18] [19]</td><td rowspan="4">Py</td><td rowspan="4">€</td><td rowspan="4">1200</td><td>Current</td><td>5000</td></tr>
<tr><td>Break-even</td><td>3999</td></tr>
<tr><td>Estimated</td><td>3500</td></tr>
<tr><td>Unidirectional</td><td>1200</td></tr>
<tr><td>4.</td><td>EVSE installation cost [20] [21]</td><td>Iy</td><td>€</td><td colspan="3">1000</td></tr>
<tr><td>5.</td><td>Charging fee [21] [22] [23]</td><td>CFy</td><td>€/kWh</td><td colspan="3">0.35</td></tr>
<tr><td>6.</td><td>Maximum yearly availability time</td><td>T</td><td>hours</td><td colspan="3">8 760</td></tr>
<tr><td>7.</td><td>Maximum yearly charging capacity</td><td>MCy</td><td>kWh/year</td><td colspan="3">96 360</td></tr>
<tr><td>8.</td><td>Connection rate [23] [24] [25] [26]</td><td>CRy</td><td>%</td><td colspan="3">42</td></tr>
<tr><td>9.</td><td>Charging usage rate [23] [24] [25] [26]</td><td>UR_y</td><td>%</td><td colspan="3">7</td></tr>
<tr><td>10.</td><td>Electricity price [27]</td><td>$C_{Electricity}$</td><td>€/kWh</td><td colspan="3">$0.9636*(MCy*URy*Ny)^{-0.126}$</td></tr>
<tr><td>11.</td><td>Average FCR capacity bid [28]</td><td>FCR_{Bid}</td><td>€/MW/h</td><td colspan="3">16.6</td></tr>
<tr><td>12.</td><td>Useful lifetime [29] [30]</td><td>Ly</td><td>years</td><td colspan="3">10</td></tr>
<tr><td>13.</td><td>Salvage value [20]</td><td>Sy</td><td>%</td><td colspan="3">5</td></tr>
<tr><td>14.</td><td>HR cost [21]</td><td>C_{HR}</td><td>€</td><td colspan="3">$1000*Ny$</td></tr>
<tr><td>15.</td><td>Cost of accessing the marketplace [31] [32]</td><td>C_{MP}</td><td>€</td><td colspan="3">15 000</td></tr>
<tr><td>16.</td><td>Miscellaneous costs [21]</td><td>C_{Other}</td><td>€</td><td colspan="3">100 000</td></tr>
<tr><td>17.</td><td>Management and maintenance costs [21]</td><td>$C_{M\&M}$</td><td>€</td><td colspan="3">$10\%*(Py+Iy)$</td></tr>
<tr><td>18.</td><td>Total investment</td><td>/</td><td>€</td><td colspan="3">$(Py+Iy)*Ny$</td></tr>
<tr><td>19.</td><td>Number of EVSE</td><td>Ny</td><td>Units</td><td colspan="3">Variable</td></tr>
</table>

Having defined the values of the parameters of Table 2, a justification of their chosen values is provided below as their retrieval is not always straightforward. First, since the V2G technology is not yet in its maturity phase, the price of V2G EVSE (*Py*) has not yet reached its mass market value. Therefore, the current research uses four different V2G EVSE pricing methods (see Table 3, #3). The first one is the currently existing market price, which is considered to be too high over a longer period of time due to the current lack of mass production and potential future economies of scale [17]. The second is, a so called, “break-even price”, indicating the V2G EVSE price ceiling where the EBIT of the CPO owning a network of unidirectional EVSE equals the EBIT of the CPO providing V2G-enabled FCR services. The third one is the estimated V2G EVSE price in its maturity phase. Finally, the fourth price setting equalizes V2G EVSE price with the current price of unidirectional EVSE of comparable power level.

Another parameter value that requires further explanation is the electricity price ($C_{Electricity}$ in Table 3, #10). The formula provided in Table 3 represents the following exponential trendline (Fig. 2) of the electricity price data of annual consumption bands for non-households in Belgium, provided by Eurostat [27].

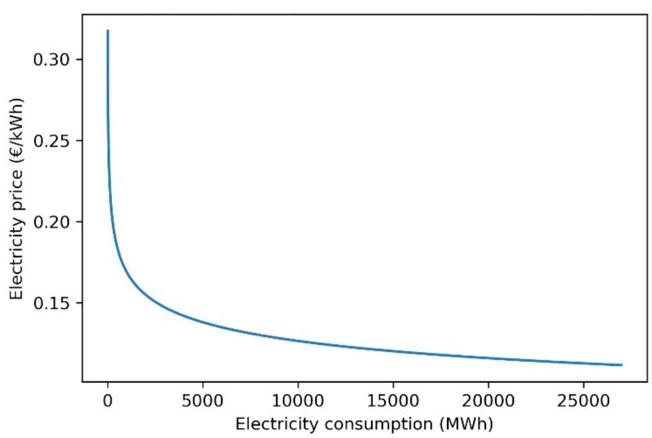

Figure 2: Electricity price for Belgian non-household users in function of consumption. [27]

The trendline shown on Fig. 2 shows a clear negative relation between the electricity price and consumption, where the increase in consumption causes the decrease of electricity price per kWh. It is also important to notice that curve is steeper on the left side of the graph at a relatively small level of electricity consumption, while further stronger increase in consumption has a noticeably smaller effect on price. For instance, considering the values of the parameters presented in Table 3, a small network of 5 EVSE generates the consumption of 34 MWh per year and can count on the price of 0.26 €/kWh, while the expansion of EVSE network to 2000 units, consuming 13500 MWh, decreases the electricity price to 0.12 €/kWh. However, doubling of the network size to 4000 EVSE, consuming 27000 MWh, would cause only a minor reduction of electricity price to 0.11 €/kWh. Moreover, this effect is not infinite, and the energy price stabilizes at a very high level of consumption of around 500 GWh (e.g. at large energy-intensive industries) [33].

Drawing back to the $C_{Electricity}$ formula from Table 3, the trendline provided by Fig. 2 shows the following dependency between the electricity consumption and the price (eq. 5):

$$C_{Electricity} = 0.9636 * Electricity\ Consumption^{-0.126} \quad (5)$$

Translation of the eq. (5) in terms of the model used by the current paper leads to eq. (6), provided in Table 3:

$$C_{Electricity} = 0.9636 * (MCy * URy * Ny)^{-0.126} \quad (6)$$

4.1 EBIT and EBIT margin

The first profitability indicator to be evaluated by the current study is EBIT of the analysed CPO business models, presented on Figures 3 and 4:

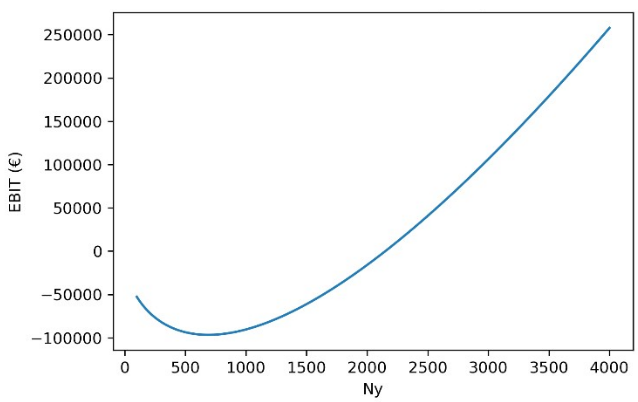

Figure 3: EBIT of a CPO, owning a network of unidirectional EVSE in function of *Ny*

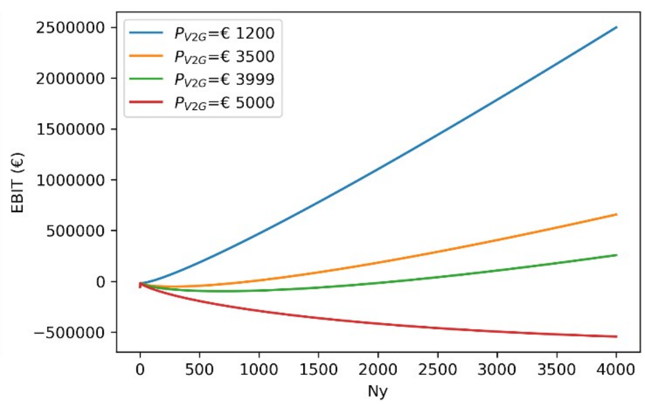

Figure 4: EBIT of a CPO, owning a network of V2G EVSE in function of *Ny*

Figure 3 shows the EBIT of a CPO owning and operating a network of unidirectional EVSE in function of the number of EVSE into the CPO's network (*Ny*). It is noticeable that the EBIT in Fig. 3 shows a negative trend for low *Ny* values. The reason behind that is twofold. First, the revenues from a small EVSE network are not able to cover high initial costs (C_{HR}, C_{MP}, C_{Other}), that have to be paid from the very beginning. Secondly, CPO EBIT is highly sensitive to the electricity price, which diminishes with the growth of consumption. Thus, a smaller EVSE network is not able to generate sufficient electricity consumption to negotiate a favourable electricity price. However, as the number of EVSE grows further, the EBIT trend switches to positive, reaching the break-even point at 2150 EVSE units. After the point where EBIT becomes positive, it begins to grow even stronger, due to the growing energy consumption causing higher revenues and diminishing electricity price per kWh.

However, it is also important to mention that the changes in the electricity price can be also caused by the factors external to the company (e.g. limited supply of energy resources). Therefore, a strong dependency of the CPO EBIT from the current electricity market prices can be also considered as a certain risk. Another important external factor influencing CPO EBIT is the number of EVs on the roads, present only indirectly in the current model as *URy*. Thus, the presented figures remain valid only in case if all the assumed values of parameters presented on Table 3 not change.

Figure 4 shows the EBIT of a CPO owning a network of bidirectional EVSE, including four different EBIT curves, each of which represents a different V2G EVSE pricing method (described in the previous section). It is noticeable, that with the currently existing V2G EVSE market price, the CPO EBIT shows a negative trend and is not able to reach the break-even point (see Fig. 6, red curve). However, the decrease of V2G EVSE price to € 3 999 (see Fig. 4, green curve), would already lead to the equalization of EBIT with the one presented in Fig. 4. The further decrease of V2G EVSE price, estimated by the currently existing literature (Fig. 4, yellow curve), would intensify the CPO EBIT growth, allowing to reach the break-even point at 929 V2G EVSE units, participating into the CPO network. Finally, the equalization of the price of V2G and unidirectional EVSE of a comparable power level (Fig. 4, blue curve) could give an enormous boost for the CPO EBIT, switching the break-even quantity to 89 V2G EVSE units into the network.

The EBIT margin, being the ratio of EBIT to its revenue component, is presented below in Figures 5 and 6.

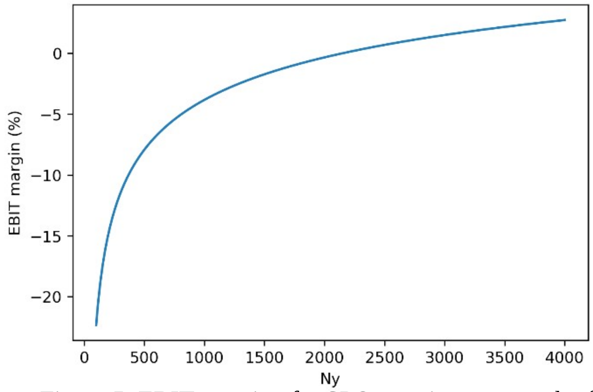

Figure 5: EBIT margin of a CPO, owning a network of unidirectional EVSE in function of *Ny*

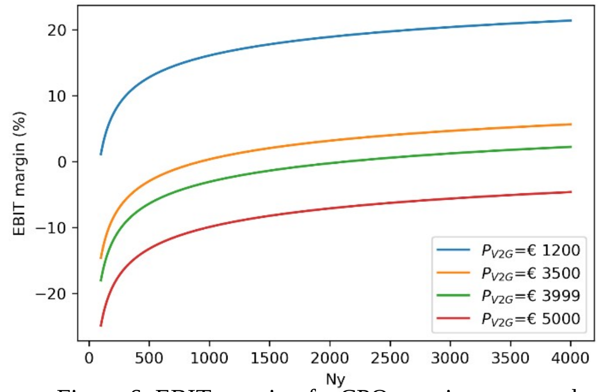

Figure 6: EBIT margin of a CPO, owning a network of V2G EVSE in function of *Ny*

It is noticeable that the EBIT margins of the described CPO business models are in general relatively low. In the majority of the cases, they are not able to reach 5%, at a reasonable EVSE network size. This is due to high operational costs, cutting the major part of the revenues and indicating a low profitability efficiency. However, there is also an exception, represented by the case where the price of V2G EVSE is equalized with the unidirectional one (see Fig. 6, blue curve). Lowering of the EVSE price, significantly cuts the depreciation expenses and gives a relatively high EBIT margin of 20% within the network size of 4000 EVSE.

4.2 EBITDA and EBITDA margin

As it is described in Section 3.1, EBITDA is the profitability indicator not considering the depreciation and amortization costs. Therefore, the division of V2G EVSE pricing methods, present in the EBIT calculations in the previous section, becomes irrelevant for EBITDA calculations. The following figures present EBITDA and EBITDA margins (Fig. 7 and 8, respectively) both for business models of CPOs owning a network of unidirectional and V2G EVSE:

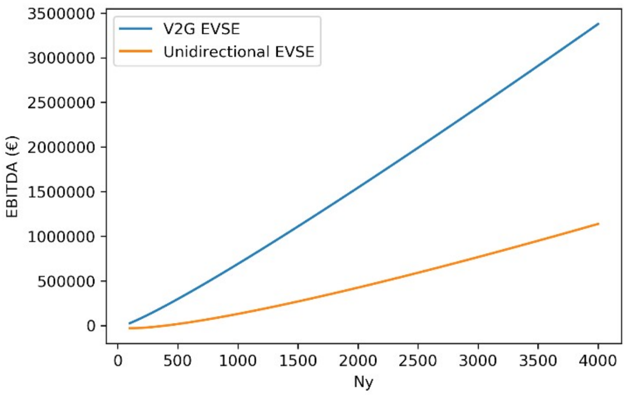

Figure 7: EBITDA of CPOs, owning a network of unidirectional and V2G EVSE in function of *Ny*

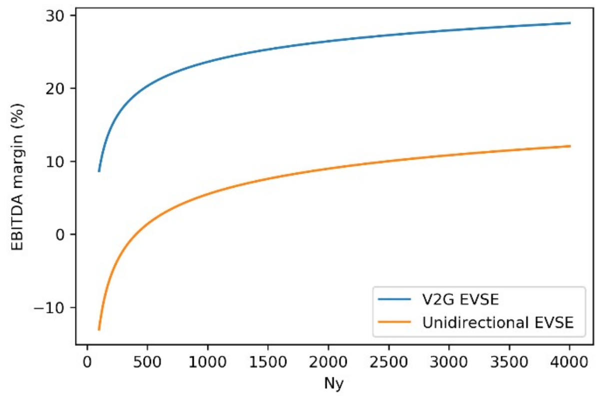

Figure 8: EBITDA margins of CPOs, owning a network of unidirectional and V2G EVSE in function of *Ny*

A typical business model of a CPO, owning and maintaining numerous assets (e.g. EVSE network) with long writing down periods, is relatively capital-intensive. Therefore, it becomes difficult to define the operational profitability of the company, as every asset has to be depreciated and becomes the part of costs. In this case, EBITDA can become and interesting profitability indicator, concentrated on the current situation. As it becomes clear from Figures 7 and 8, the business model of a CPO providing V2G-enabled FCR services is significantly more efficient in terms of this profitability indicator, generating a positive EBITDA from relatively small EVSE network sizes and reaching the EBITDA margin of 30% at the network size of 4000 EVSE.

4.3 ROI

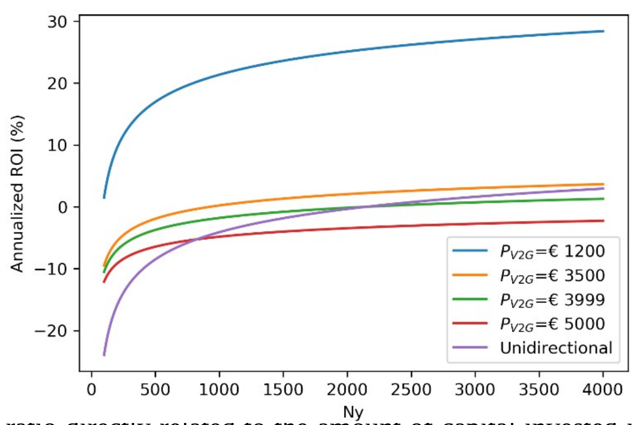

Figure 9: ROI of CPOs, owning a network of unidirectional and V2G EVSE in function of *Ny*

In contrast to the profital … ent section evaluates the ROI (Fig. 9), the profitability ratio directly related to the amount of capital invested into the company, both for the business models of the CPOs owning a network of unidirectional and V2G EVSE.

As it was already mentioned, CPOs participate in a capital-intensive industry, having, in general, a relatively low EBIT margin (as described in Section 4.1). The combination of these two factors leads to a relatively low ROI, barely differentiating from zero, at the network size of 4000 EVSE. The obvious outlier with significantly higher ROI is the blue curve, indicating the V2G EVSE pricing method equalizing the V2G EVSE price with the current price of unidirectional EVSE of a comparable power level. The lower capital cost allows to create a relatively high ROI of 30% within the network size of 4000 EVSE.

It is also noticeable that the ROI curve of a CPO owning a network of unidirectional EVSE (Fig. 9, purple curve) shows a slightly different behaviour, than the ROI curves related to CPO providing V2G-enabled FCR services. At a small network size, the ROI values shown by the purple curve are significantly lower than the rest, while the growth of EVSE network gives it a stronger boost, outperforming the curves indicating the application of current and break-even V2G EVSE prices, and almost crossing the yellow curve (indicating the estimated long-term V2G EVSE price) at a network size of 4000 EVSE. From this observation, it can be concluded that V2G-enabled FCR services allow the CPO to reach the profitability faster, but the less capital-intensive unidirectional EVSE can generate a higher ROI on bigger network sizes.

5 Conclusions

The current paper has defined a quantitative framework for the introduction of the vehicle-to-grid (V2G)-enabled frequency containment reserve (FCR) services into the charge point operator (CPO) business model and evaluated the profitability of this introduction by the means of a set of profitability indicators. Moreover, the current study provides the comparison of the values of these indicators for the archetypical business model of a CPO owning and managing a network of unidirectional electric vehicle supply equipment (EVSE), and the business model of a CPO after the introduction of V2G-enabled FCR services.

The performed analysis of the profitability indicators allows to conclude that under the current market conditions, shaping the current V2G EVSE market price (€ 5 000), the archetypical business model of a CPO owning a network of unidirectional chargers is more profitable than the business model of a CPO after the introduction of V2G-enabled FCR services. However, the V2G technology has not yet reached its maturity phase and lacks the benefits of economies of scale. Therefore, the estimated target price of V2G EVSE (€ 3 500) is significantly lower than the one currently existing on the market. In fact, the reduction of V2G EVSE price below the break – even level of € 3 999, would, ceteris paribus, generate a higher profitability than the traditional CPO business model. Moreover, if the V2G EVSE reaches the current level of prices of unidirectional EVSE on the long term, the CPO business model with V2G-enabled FCR services would strongly outperform the traditional CPO business model in terms of profitability.

Obviously, the described results are valid only in case if the other factors participating into the calculations of CPO revenue streams and cost structure remain equal. For instance, the increase of EVSE usage rate (URy) has a positive influence on both the EBITs of archetypical CPO and CPO offering V2G-enabled FCR services. At the same time, the increase of connection rate (CRy), would rise the available energy capacity for grid balancing services, increasing the revenues generated by FCR services, but not influencing the EBIT of CPO owning and managing the network of unidirectional EVSE. Thus, it becomes an interesting future research step to study the impact of the potential changes of other factors participating into the calculations from their current values.

Finally, as it was already mentioned in Section 2.1, FCR is only one of the three existing grid balancing services. Therefore, another interesting research step would be to study the potential integration of aFRR and mFRR into the CPO business model.

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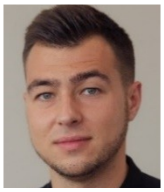

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