Integration of new technology in the ancillary service markets

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Project report

Integration of new technology in the ancillary service markets

Electric Vehicle Group

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Part 0 - Introduction and summarized findings

0.1 Introduction

This report describe the findings of NUVVE and DTU in the pilot “Integration of new technology in the ancillary service market” organized by Energinet to explore the challenges and opportunities in having a range of new technologies participate in the market.

The pursuit towards having aggregated electric vehicles participate in ancillary services have both been part of NUVVE efforts toward commercialization of this technology through pilot activities as well as the research targets of the Danish Parker project (www.parker-project.com) focusing on the EVs possibilities in supporting an economic and stable power system based on renewables.

This report has been delivered to Energinet in February 2018 to document findings of the pilot. Some parts detailing the operation of the NUVVE aggregator, which is confidential in nature, has been removed.

The aim is to describe the barriers currently faced by an EV aggregator when providing FCR. These are both immediate barriers encountered in connection with the first commercial V2G pilot providing FCR-N at Frederiksberg Forsyning - but also barriers which will prevent scalability when moving beyond such early pilots.

Ultimately the pilot project group hope to inform and inspire organisations in denmark and abroad investigating and promoting EV aggregation.

0.2 Background

As part of the Nikola project, and later the Parker project, DTU and the project partners had analyzed and demonstrated on a small scale how electric vehicles can be aggregated to support frequency regulation to the Danish grid.

In 2016 Frederiksberg Forsyning took delivery of 10 Nissan eNV-200 standard electric vehicles equipped with 24kWh batteries as well as 10 Enel V2G charging stations rated at 10kW (up and down).

The participants in the pilot at Frederiksberg Forsyning (FF) are Nissan, Enel and NUVVE and FF. The FF pilot is connected to Parker through its partners and the sharing of data.

The Parker project is a collaboration between DTU, NUVVE, INSERO, ENEL, NISSAN, Mitsubishi Corp, Mitsubishi Motors, FF and PSA ID. http://parker-project.com

The technology used for the pilot activities is based on standard equipment with no additional technical modifications made such as Nissan eNV-200 electric vehicles and ENEL V2G charging stations.
The aggregation is made through Nuvve’s Aggregation Platform which was also used in the NIKOLA project at DTU to demonstrate the capabilities of V2G aggregation for FCR-N product delivery.

The goal of the project was to demonstrate the viability of V2G installations with a commercial vehicle fleet while bidding on the frequency regulation markets in DK2 (FCR-N). The operation is to run 24h a day 7 days a week. This initial fleet of 10 vehicles at Frederiksberg Forsyning is then augmented by successive installations in DK2, both in the wider area of Copenhagen as well as on the island of Bornholm. As the writing of this document over 50 charger units have been committed to customers across DK2 area with more installations to come.

Over the course of the project, V2G has gained wide-spread public awareness, both through national and international television coverage at the launch of the project, as well as through press and web articles as well as multiple public visits to the V2G sites such as Frederiksberg Forsyning by elected officials from Denmark and from the European parliament. Dissemination of the project information is also available on the project webpage http://parker-project.com/#news .

0.3 Purpose

The purpose of the project is to demonstrate that a fleet of electric vehicles with bi-directional capabilities can be aggregated to a Virtual Power Plant (VPP) and provide frequency regulation FCR-N service to the Danish electricity grid in DK2 area.

The main driver behind the project was to show that the solution can fulfill the technical requirements, the market requirements, be profitable for the operator of the aggregated EVs as well as be accepted by the owner/operator of the fleet.

The main purpose was not to study the technical delivery of the product as this was demonstrated by Nuvve's aggregation engine in previous projects in Denmark as well as with other TSOs in other countries such as PJM in the USA (2009) and TenneT in the Netherlands (in 2015). The focus has been on ensuring that the market and operational setup for V2G will function in a real world setting whilst ensuring the technical requirements are being met both for the market access and product delivery.

The real world setting of the project has allowed commercial contractual agreements to be laid out between Nuvve and parties involved (Nuvve to end customers, Nuvve to BRP and market bidding access). The V2G chargers are initially linked to a DSO meter that is registered in Datahub under Nuvve Denmark ApS name. This complete setup has enabled the project team to understand issues and identify the barriers (Part II) for V2G in Denmark.

0.4 Summarized findings

Below the barriers are formulated as recommendations depending on the type of role Energinet may have in addressing them (direct, influence, for information).

Firstly (direct), We recommend that Energinet directly address:

1. **Qualification (**regulatory**, high severity)**, there is an immediate need to address how EV aggregations are qualified and approved both in regards to grid connection through technical regulations as well as the tender conditions for market participation. The aggregated nature may necessitate a shift from the traditional technical regulations aimed at fixed, large plants and support the aggregation of a dynamic, diverse and growing portfolio of EVs and chargers.
2. **Frequency bias (**technical**, high severity)**, Battery storage is a fast, but exhaustible, technology and the utilization of this resource may improve if market products better reflect this type of provider. Short-term, this could mean defining mechanisms like the preferred operational point (POP) to better allow aggregators to provide capacity in the existing market.

Long term, Energinet may consider working with international parties to explore new product aimed at fast-responding resources.

Secondly (influence), Energinet may engage with other danish industry parties in influencing:

1. **Market models for aggregators (**market**, medium severity)**, supporting the development of market models for aggregators can encourage more flexibility in the market. New models can be tested in Denmark while concurrently working on harmonization across the nordic countries and europe.
2. **Settlement meters (**regulatory**, high severity)**, operational costs of settlement meters may hinder the aggregation of smaller units, limiting the utilization of flexibility from end users. It may be necessary to collaborate with the industry towards relaxation of metering requirements.

Thirdly (information), outside the direct scope of Energinet, are some technical/economic barriers which influence EV aggregations possibilities in the Danish FCR markets.

1. **Potential battery degradation (**regulatory**, medium/high severity)**
2. **Two-way energy loss (**regulatory**, medium severity)**
3. **Energy tariffs and taxation (**economic**, high severity)**

All of the above are technology-specific regulatory or economic challenges. However, the type and design of FCR products may influence how large a challenge each of the three represent.

0.5 Final recommendation

To allow EV aggregators to participate in the market, the EV group recommends:

- Proactively addressing the barriers listed in this document starting with those of highest severity.
- To truly utilize the flexibility of distributed storage resources it may be necessary for energinet to consider a compromise between technology neutrality and the informed design of products and regulation to utilize technologies vastly different from traditional providers of FCR services.
- The group recommend continuing pilot activities until at least the pre-qualification process has been finalized and tested as it represents the most immediate barrier for EV aggregators.
- The pilot was completed based on a commercial fleet of electric vans, the next step may be to encourage pilots including private households.

NUVVE and DTU would like to thank Energinet for the opportunity to participate in the pilot and the many constructive meetings and workshops.

1 Barriers for electric vehicle aggregators

Part 2 seek to describe the barriers faced by EV aggregators which may currently hinder the introduction of this technology into the Market.

The barriers described here goes beyond the regulatory domain of Energinet as the main objective have been to make a comprehensive description of all major factors that may hinder the capacity offered by the technology - aggregated EVs - in becoming accessible to the market.

Barriers outside the immediate control of the partners may still be addressed indirectly - by contacting the organizations able to address such factors (example: tax authorities) - or it may inform changes on market rules to take technical considerations into account (example: metering requirements, service duration).

This section is organized as follows. The first section will describe the special characteristics of electric vehicles which must be understood when using them as a power capacity resource. Then the next section will present a more detailed description of each identified barrier along with some possible solutions to be pursued and a description of current groups and activities tasked with addressing them. The main conclusions of Part 2 are presented in Part 0 of this report.

1.1 EV special characteristics

If distributed EV batteries are to be used as a capacity resource for the ancillary service markets some considerations has to be made to this new type of technology - a technology which differ from traditional thermal plants for which the regulations and markets was originally designed.

This will insure that the potential capacity of the technology is made available to the market as intended in MM 2.0.

The main characteristics for EV aggregations - similar in some aspects to fixed battery installations and other distributed resources:

- Resources are distributed
- Can react very fast
- Can both consume and return power
- Are exhaustible (has a certain battery capacity, cannot produce energy)
- Are stochastic in nature (due to user behavior)
- Have a rebound effect, (A change in behavior now, may necessitate an opposite, compensating behavior at a later time)

The above characteristics represent both challenges and opportunities in using this new technology.

1.2 Barrier overview

Through the pilot project the partners from NUVVE and DTU have worked together to identify a total of seven main barriers that may hinder the use of aggregated EVs in the ancillary service markets. Four of these barriers, **Long duration frequency bias**, **Requirements for settlement meters, Pre-qualification** and **Energy tariffs and taxation** have been identified as "**high severity** barriers" and must be addressed proactively if the technology should be made available to the market.

The barriers have been subdivided according to the categories Technical, Market, Regulatory and Economic based on their nature and are listed in table 2.2.1 below.
Severity is set as either '**Medium**' or '**High**'.

Barrier	Severity	Description	Possible solution
Technical			
Two-way energy loss	**Medium**	Energy losses in EV and EVSE when charging or discharging during service provision.	Improvement in equipment from OEMs and in aggregator power setpoints (using most efficient power range of equipment)
Long duration frequency bias	**High**	Battery-based storage is an exhaustible resource which can not serve a non-balanced frequency for long durations.	Relax service duration requirement and/or allow for use of a preferred operating point or recuperation period.
Potential battery degradation	**Medium/ High**	Cycles following from the provision of services will, to some extent, reduce the capacity of a battery.	Technological improvements in battery chemistry. Ensure that requirements to service provision (response time, duration) doesn't go beyond what is needed.
Market			
Future market models for aggregators	**Medium**	No common (European/Nordic) model for how an aggregator may act in the ancillary service markets in in terms of roles and responsibilities.	Based on Danish suggestions on an aggregator market model (MM 2.0 group) attempt harmonization in first Nordic – then European scale.
Regulatory			
Requirements for settlement meters	**High**	Costly settlement meter requirements (technical / operational) prevents the use in distributed resources – in this case chargers installed in meters	Relaxed requirements to meters (perhaps by publishing an approved-list).
Pre-qualification	**High**	Pre-qualification of aggregated EVs to provide FCR can be challenging in that technical regulations are not fully defined for this type of resource and that aggregators can have dynamic and diverse portfolios of EV and chargers under their control.	It may be desirable for the pre-qualification to emphasise the performance and reliability of the aggregator instead of the individual EV-charger combinations in the portfolio. If individual assets has to be approved, perhaps a type approval, could be considered so that "known" types of EVs/Chargers can be seamlessly added without the need of repeated qualification.
Economic			
Energy tariffs and taxation	**High**	Heavy energy tariffs and taxation costs associated with two-way energy flow following service provision.	Apply taxes only to energy transferred for the purpose of driving. Two-way energy costs associated with service provision should be cancelled out.

Table 2.2.1: Barrier overview

The barriers above are described in more detail in the following sections.

1.3 Barrier - Two-way energy loss (Technical)

Roundtrip energy losses occurring in power converters during charging and discharging cycles resulting from FCR provision can, accumulated over time, be substantial.

This is especially true in early deployment where the supply equipment is not yet optimized and the charger may not be used at its optimal (most efficient) power level by the aggregator.

The figure below shows how (dis-)charging at power levels lower than the rating of the charging equipment can result in low efficiency and high losses. The losses are measured using an electric vehicle connected to a 10 kW bi-directional charger providing FCR.

Added to conversion losses is a fixed “parasitic” loss from running the equipment.

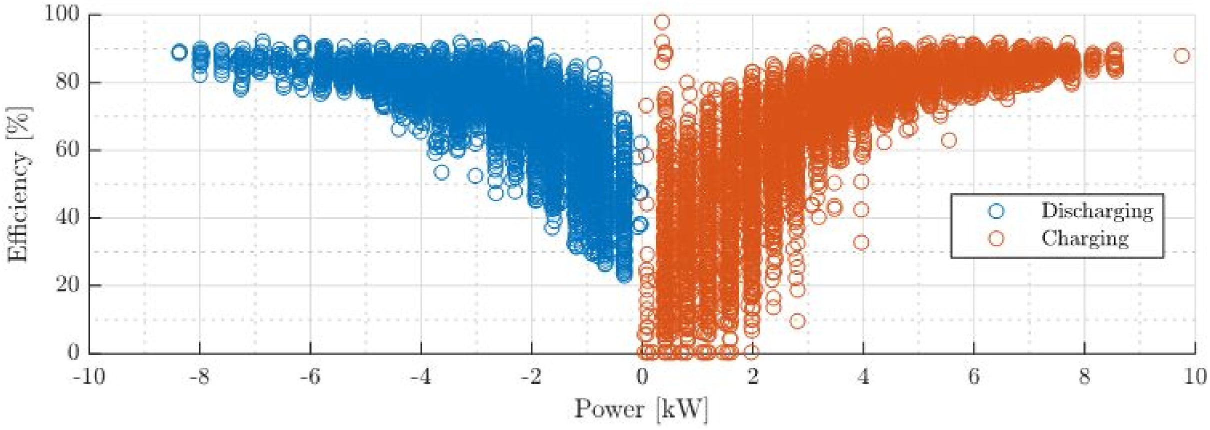

Figure 2.3.1: Efficiency as function of power, measured on AC and DC side. A. Thingvad et al. [1]

For the highests efficiency (up to 90%) charging must be set as high as possible. Such considerations can be taken by aggregators when calculating a dispatch to individual EV/EVSE paris.

The severity of this barrier is connected to the potentially high costs of energy, including taxes and tariffs, described as a separate barrier below.

Proposed solution

The severity of this barrier can be reduced both by technical improvements in EVs/EVSEs and the optimal dispatch by aggregators.

However a certain energy loss will always be inherent to this technology and part of the operational costs of an aggregator. An efficiency of 90%+ can be expected in future uses.

This is primarily seen as a barrier short term but should be counted among the initial obstacles for EV aggregation for FCR services.

1.4 Barrier - Long duration frequency bias (Technical)

For all frequency containment (FCR) type services the state-of-charge of the battery storage will depend on the behavior and symmetry of the frequency deviations which influences the power setpoint/dispatch in accordance with a predefined droop curve.

While the system frequency of both DK1 and DK2 keep close to the average 50 Hz when seen over longer time durations (days, weeks) there may be a bias towards either over- or under-frequencies when considering individual hours - or even several consecutive hours. This occurs especially in DK2 belonging to the nordic regional group.

Figure [X] below show histograms of the measured frequency (top) for the nordic regional group and hourly energy bias (bottom) of 2016. The frequency graph (top) illustrates that, seen over a year, the frequency follows a Gaussian distribution and is largely symmetrical around 50 Hz.
Looking at individual hours in 2016, however, short-duration trends in the frequency may cause a net charge or discharge of energy for that hour. In figure X (buttom) $E^{1}_{bias,k}$ denotes the energy bias for 10 kW bid in the FCR-N market i.e. the net amount of energy added or removed from the battery due to a frequency bias (not considering losses).

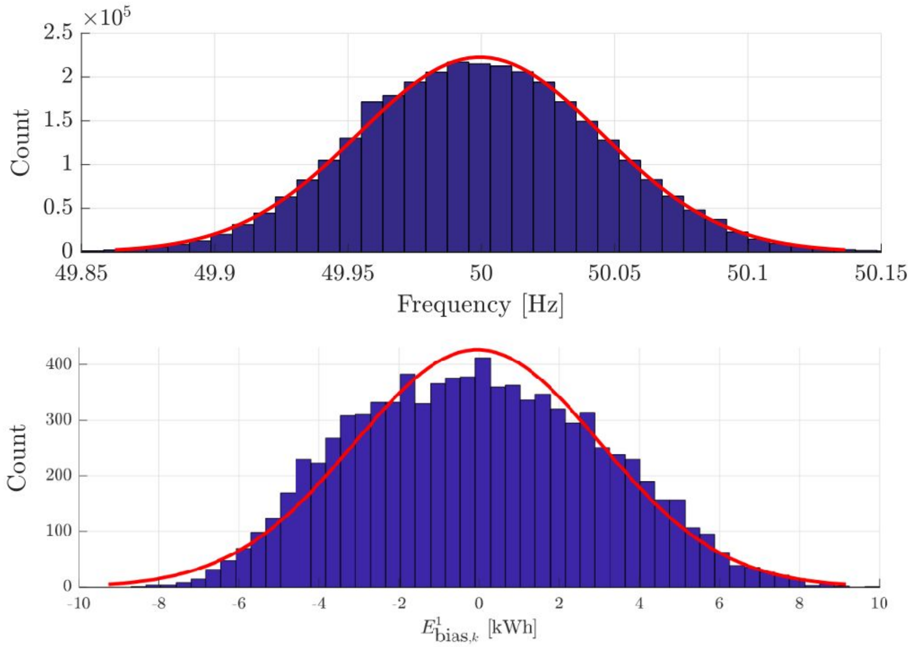

Figure 2.4.1: Histograms, frequency measurements (RG-Nordic) for 2016 (top), hourly energy bias for 1kW bids for 2016 (bottom). A. Thingvad et al. [1]

Consecutive hours of energy bias is a challenge for exhaustive battery storage-based resources such as electric vehicles,

This is illustrated in figure X which simulates the battery SOC (30 kWh) over 15 hours subject to the frequency measured 30 individual days of 2016. It can be seen that when the full capacity is bid (10 kW) the frequency would cause the SOC to exceed the capacity-limits of the battery. The minimum SOC the Nissan EV can be discharged to is 35% and the maximum is 95%, both marked on the figure. It is clear that the energy requirements in most of the cases extend the capacity of the EV.[AT1]

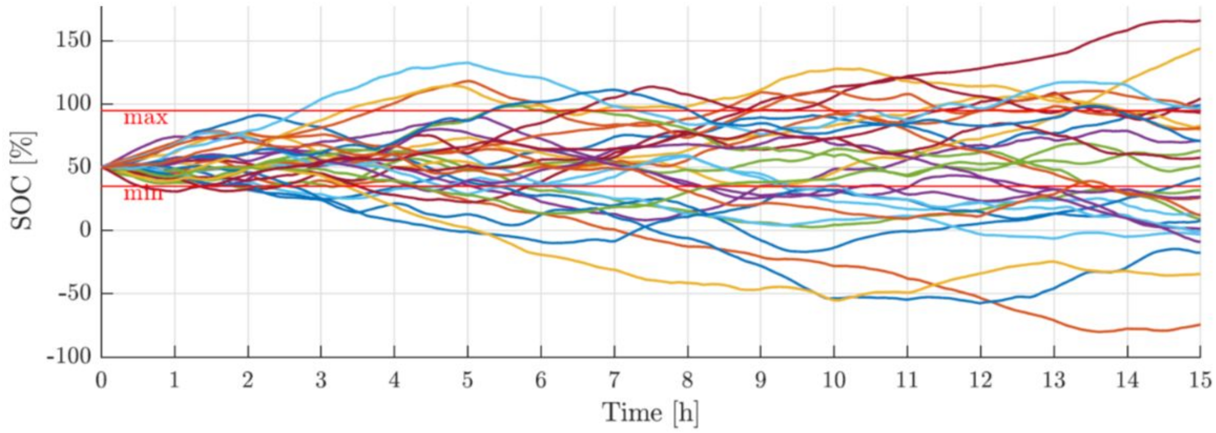

Figure 2.4.2: SOC over time as a function of frequency bias. A. Thingvad et al. [1]

As part of the Parker project, FCR-N has been delivered with Nissan LEAF with a battery capacity of 30 kWh, Nissan E-NV200 with a capacity of 24 kWh and Mitsubishi Outlander with a capacity of only 12 kWh. The battery size of the EV is a critical parameter when it comes to how often the service can be delivered without exhausting the battery.

Long-duration frequency bias, may thus result in the aggregator having to provide significantly lower bids than the rated capacity of the EV-EVSE pair not to exceed battery limits.

Proposed solution

Frequency bias may best be handled by a combination of the aggregator carefully managing bids to reflect historic knowledge of bias, as well as adding mechanisms (e.g. POP described below) in the market which supports battery based providers in high-bias frequency regions.

Not allowing any mechanisms compensating for frequency bias may reduce the business case for battery-based aggregators and altogether limit the exploitability of this type of resource for the purpose of flexibility.

For regions where larger frequency bias occur it may be desirable to introduce measures to allow battery-based suppliers to compensate for bias by using a flexible power baseline - also referred to as a preferred operating point (POP). In cases where frequency bias causes storage to approach its upper or lower capacity boundaries the POP will represent the power setpoint -either charging or discharging - which will be the storages ‘preferred’ behavior to either reduce or increase the batteries SOC. The frequency response required by FCR can then be provided either symmetrically or asymmetrically (if allowed) around this value.

If periodical asymmetrical delivery is allowed, it would make it possible for the aggregator to bid the full power capacity and when needed use some of the power for changing the set-point. If symmetry continues to be a requirement, the aggregator would have to bid less than the full power capacity for FCR such that the remaining power can be used for changing the setpoint.

1.5 Barrier - Potential battery degradation

Battery degradation happens as a function of time (calendar aging) and use (cycles, cycle depth and c-rate) as well as the temperature to which the batteries are exposed . The exact wear on batteries from performing V2G services are subject to uncertainty and can differ significantly depending on model and parameters used [2]-[3].

It must, however, be considered likely that the additional cycles from performing FCR will impact the EV batteries lifetime.

Figure [x] illustrates the cycle life of a lithium-ion battery based on the cycle depth.

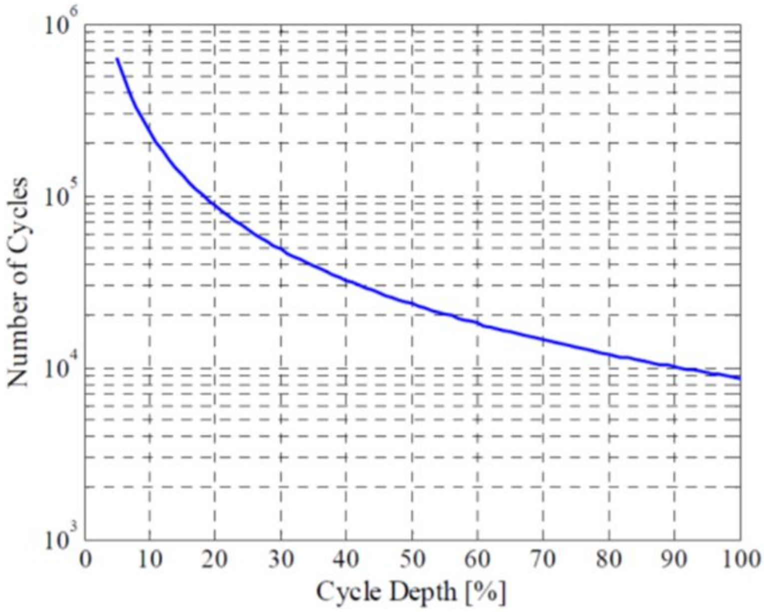

Figure 2.5.1: SOC over time as a function of frequency bias. D.-I Stroe, et. al. [4]

The number and depth of cycles may depend on the FCR market in which the aggregator participates in.

Especially in regions with large frequency biases, no deadband and with fast response requirements the battery use - and resulting battery wear - may be larger than for other regions/markets.

Proposed solution

Battery wear may primarily be a technical challenges and be addressed as such. New battery technologies and optimized aggregator dispatch strategies may decrease this inherent cost of being a battery-based aggregator.

It may, however, also be desirable to consider that market rules does not introduce undue burdens on battery-based providers. This could for instance by allowing for POP mechanisms which could theoretically reduce the cycle depth of batteries. Also the fast response time of batteries may result in additional battery cycles and should therefore only be required if there is a corresponding technical need and economic compensation.

1.6 Barrier - future market models for aggregators

As of this writing, the consumer flexibility aggregator is not a clearly defined and integrated player in neither the Danish, Nordic or European power and energy markets - although efforts has been started towards this end.

The Dutch organisation Universal Smart Energy Framework (USEF) [5] has made a thorough analysis of the ways in which aggregators can be introduced in the european power markets.

A Danish workgroup 'Market Models for Aggregators - activation of flexibility' consisting of the Danish Energy Association, Energinet, the Confederation of Danish Industry and the Danish Intelligent Energy Alliance has been formed to identify and recommend models for introducing aggregators in the danish energy market as a means to activate consumer flexibility (Figure 2.6.1).

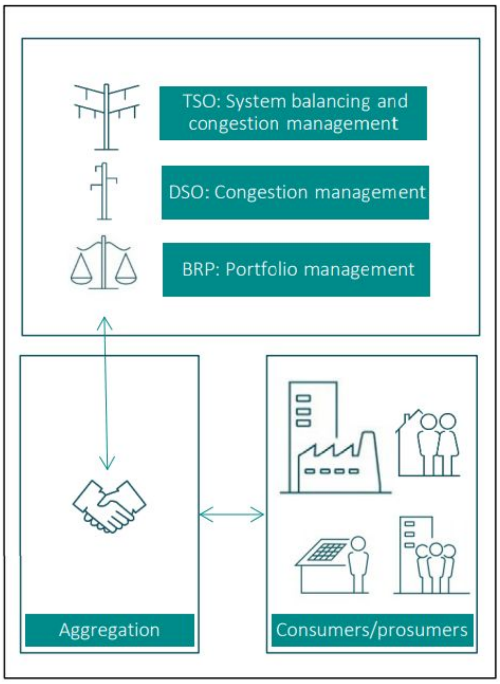

Figure 2.6.1: Flexibility aggregator as a new role to bridge consumers with the power market and its players. Workgroup [6]

In Denmark, under current rules,only a balance responsible party (BRP) is allowed to offer FCR products in the market. Therefor an EV aggregator, technically able (and legally allowed) to influence a number of electric vehicles, would have to partner with a BRP to provide FCR. The BRP would be the only interface to the market and would include the cars, controlled by the EV aggregator, as part of its existing portfolio.

This solution is referred to as 'model 0' by the Danish workgroup 'Market Models for Aggregators - activation of flexibility' where an existing market participant is both fulfilling the role of electricity supplier, balance responsible party and aggregator.

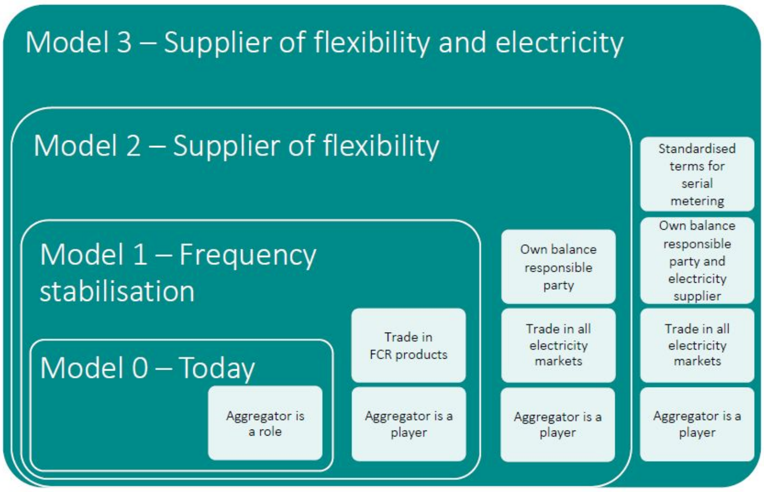

Figure 2.6.2: Models to have aggregators activate consumer flexibility. Workgroup [6]

Model 0 already works and allows FCR trough aggregation. Therefor the barrier of not allowing aggregators to directly trade with FCR is only set to medium severity.

Another of the suggested models of the aggregator market group - Model 1 - would allow an aggregator to trade FCR products without a BRP. This would only apply if the hourly energy content would be sufficiently small as not to incur imbalances in the consumption schedules of the balance responsible for consumption covering the vehicle's energy supply.

Proposed solution

Dissemination of model 0, including its use in real-world applications, may encourage more EV aggregators to join the market.

As per the recommendation of the aggregator workgroup, it could be considered to allow EV aggregators direct access the FCR market (Model 1). Model 3 and model 4 can also be promoted and supported to further extend possibilities of flexibility aggregators.

1.7 Barrier - Requirements for settlement meters

Meters are currently needed for EVs performing FCR for two distinct purposes.

Firstly meters are needed to accurately measure the power charged and discharged as to document the agreed delivery of FCR towards the TSO. These meters can be integrated inside the EVs or EVSEs, as long as the meters used satisfy requirements by Energinet DK on precision and time resolution.

The second metering issue is that of energy settlement. Such meters measure energy (kWh) used to determine both the energy bill of the consumer - but is also a tool to establish if energy produced or consumed match the quantity traded in the energy market by a production or consumption BRP.

In a future where several aggregators may operate under the same consumer/connection point, a number of meters may be necessary to separate the different types of (flexible) energy consumption for billing and balancing purposes.

There is relatively high requirements for both the type and operation of such meters. I.e. the meters have to be ‘utility-grade’ MID-approved meters and be regularly inspected and tested.

Requirements for settlement meters:

- Must be MID-approved (Bek. 1035 from 2006)
- Support remote metering (Bek. 1358 from 2013)
- Main and serial meters must support hourly readings (Future requirement will be 15 min)
- Must be able to store data for 5 ½ month of measurements.
- Stored measurements should be accessible via a display. (WELMEC guide 11.2)
- The accuracy of the meter is to be ensured via a control system (Bek. 1035 from 2006 and Måleteknisk vejledning from 2012)
- Measurement data must be validated and forwarded to the data hub within a certain deadline.
- Fulfil requirements on personal data protection

The requirements and associated costs for settlement meters are not a large barrier short-term as aggregators may initially base their portfolio on a, few, large demand types (EV fleets connected through the same utility meter, large commercial loads etc). But the barrier may become substantial over time and hinder the use of flexibility provided by small aggregated demand units where the per-unit value of flexibility may not be enough to compensate for the high cost of the settlement meter and its operation. Specifically, this could become an issue when considering individual home chargers which would require an additional meter.

Proposed solution

It should be considered if small integrated meters (meters inside charging stations, heat pumps etc) can be used for energy settlement as it would lower the cost for small units to participate in flexibility services and FCR.

It has to be agreed between parties (DSOs, Retailers/producer BRPs) whether such meters will be sufficiently accurate and reliable and it should also be established how data can be collected and processed.

Following the aggregator workgroups model 1 would do away for this challenge specifically for FCR provision while not solving the challenge for other types of energy flexibility services.

1.8 Barrier - qualification

Before taking part in FCR provision in Denmark, an EV aggregator has to adhere both to regulations governing the connection to the power system as well as the specific conditions for providing FCR.

The two main documents describing such requirements are::

1. Technical regulation 3.3.1. for battery plants
2. Ancillary services to be delivered in denmark tender conditions

The new technical regulation 3.3.1. for battery plants has been developed to address the technical requirements for grid connection of both permanently and temporarily connected batteries, which in both cases may be aggregated. Considering the early version of 3.3.1. the EV group has identified some potential challenges in that such regulations may not fully reflect that:

- EV aggregations may consist of different types/brands of EVs and chargers
- Power converters, communication controllers and electronics may be located either in EVSE or EV depending on whether it is AC or DC charging.
- EV aggregations may continuous grow as more EVs/EVSEs are added to the portfolio
- EV aggregations may be distributed and connected at various parts of the grid.
- Some technical requirements may be a larger economic burden on EV aggregations considering many distributed units (requirements has to be met per car/location) vs cases with a single or few larger battery plants.

The figure below illustrates an EV portfolio consisting of a diverse set of EVs/EVSEs.

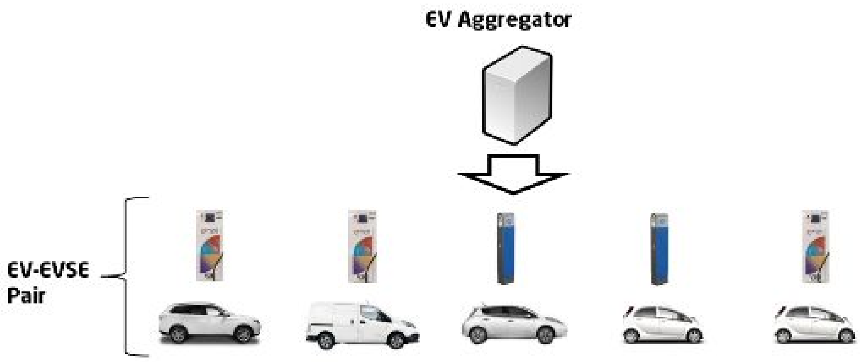

Figure 2.8.1: EV aggregator with a mixed portfolio of units

The conditions for delivering ancillary services in Denmark are, in general, well suited for aggregated EVs - e.g. the relatively short delivery time and small minimum bid size. The largest obstacle here is the separation between production and consumption units which does not suit storage technologies.

Proposed solution

Current requirements for grid connection and delivery of FCR are not yet fully updated or tailored for EV aggregation. Before requirements has been clarified and updated for battery-based aggregators, this represent a very immediate barrier.

The technical regulation for grid connection may put a undue administrative burden on the aggregator due to its distributed nature dealing with may small and diverse units.

The addition of new cars/chargers to the aggregation should ideally be so seamless as possible - Possibly through the use of a pre-approved whitelist of equipment.

Regarding the tender conditions for FCR an option may be to emphasis the performance and reliability of the aggregator as a whole, rather than setting individual technical requirements for the equipment making up the aggregators portfolio.

Regarding the tender conditions for FCR, it should be considered to update the document to reflect services provided by batteries. i.e. consider how batteries are seen in relation to the tender documents distinction between production and consumption units.

1.9 Barrier - Energy tariffs and taxation

The energy measured at the settlement/utility meter will both measure:

1/ The energy consumed by the EVs from the grid
2/ The energy delivered from EVs to the grid

Within these energy measurements, subcategories must be made to understand the use of the energy:

- Energy consumed for driving,
- Energy consumed for down-regulation
- Energy delivered for up-regulation

All of the above will be subject to losses

Currently a V2G installation is viewed from a taxes and tariffs point of view as a consumer installation As per default all consumed energy will be subject to Danish taxes and tariffs (see figure below). V2G activity on the meter will create much larger energy flows than with a regular EV charger, this energy is used for grid stabilization, however if billed as a consumer, the V2G activity is not initially profitable without profound changes in the way taxes and tariffs are applied.

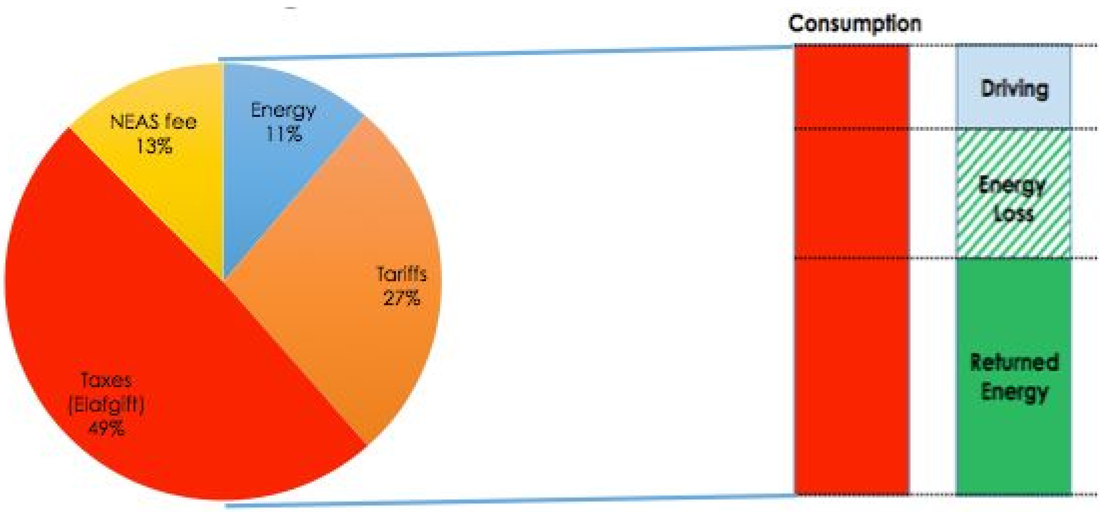

Figure 2.9.1: source Nuvve's June 2017 Settlement bills from NEAS Energy (BRP)

Removal of Elafgift yields a mildly positive result but will be about flat over the year once seasonal variations in FCR-N pricing are taken into account, thus still not enabling profitability due to the tariff structure applied on consumption. Running a V2G activity also implies service, maintenance and overheads which are not taken into consideration here.

According to the act No. 687 passed by Danish parliament on 8th of June 2017, further deductions of taxes linked to V2G system losses are possible to the level of 460kWh per vehicle after 1st of January 2020. However at that time of application (after January 1st 2020) a large portion of Elafgift will be reapplied to EVs thus minimizing the effect of this new law that allows to deduct losses. Overall the situation will be improved by law 687, but the overall business case remains affected by the consumption tariffs applied to distributed resources on the grid.

Since the bi-directional energy flow resulting from FCR can be substantial - and doesn't constitute ‘normal’ consumption and production. The taxation of energy used for delivering FCR may not be suitable.

This severity of this barrier is increased by:

- Substantial energy flow for FCR service.
- The aforementioned barrier of bi-directional losses will add to the energy costs
- The high energy taxes and tariffs in Denmark

Proposed solution

As a first step, it may be necessary to separate the energy consumed for driving from the energy transfer resulting from FCR provision. The question would then be how to deal with the FCR energy transfer in terms of fees and taxes.

One approach would be a kind of net-metering (hourly, daily) which would net out the energy used against the energy produced. This would reflect the fact that for batteries, it would be the same energy being charged and discharged. In this scenario, the energy used for regulation would not have taxes or tariffs applied to it. Taxes and tariffs would only apply to the energy used to drive the car as well as a portion of the losses.

Taxes and tariffs are currently reduced under existing laws. Deeper tariff structural changes and regulations are required to ensure distributed resources (such as batteries) providing ancillary services to the grid are treated in a competitive way to incumbent generators such as the Market 3.0 discussions taking place in Denmark and with Dansk Energi currently.

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