Harnessing the value of EV flexibility

How an electricity provider can create and capture value from EV demand flexibility

Master's thesis in Management and Economics of Innovation

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Abstract

As the energy system undergoes changes, new possibilities to both create and capture value emerges. Among the changes are increases in electricity demand from the electrification of transport. While electric vehicles (EVs) contribute to this increase in demand, their charging can also be used in a flexible manner to alleviate strain on the grid. When the demand flexibility of several EVs are aggregated, they can help support the electricity system through providing ancillary services to the transmission system operator (TSO).

This thesis has examined how an electricity provider such as Circle K can create and capture value from positioning as an EV aggregator, providing ancillary services from demand flexibility. Through combining relevant documents with 19 interviews with industry actors and representatives from Circle K, several findings and implications have been discovered.

First, a total of ten technical, regulatory, and financial barriers faced by aggregators were identified. Then, the ancillary service deemed as optimal for value creation was identified as Frequency Containment Reserve - Disturbance (FCR-D). Four main values were identified as being created for the end consumer: financial, environmental, societal, and information visualization. For value capture, it was found important to communicate the values to the customer efficiently, create a service that is easy to use and seamlessly integrated into the day-to-day charging experience, and to have access to capabilities within statistics and software. Finally, an appropriate revenue model was found to be bundling the service with charging equipment and electricity.

Keywords: Demand flexibility, ancillary services, demand response, electric vehicles, electrification.

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Nomenclature

Below is the nomenclature that have been used throughout this thesis listed in alphabetical order:

aFRR	Automatic Frequency Restoration Reserve
BRP	Balance Responsible Party
BSP	Balance Service Provider
DSO	Distribution System Operator
Demand flexibility	Power consumption which can be moved or abstained based on an external signal
EV Aggregator	Actor gathering flexibility from a fleet of electric vehicles to be sold to system operators
EV	Electric Vehicle
FCR-D	Frequency Containment Reserve - Disturbance
FCR-N	Frequency Containment Reserve - Normal
FFR	Fast Frequency Reserve
Flexibility Service Provider	An actor controlling the electricity consumption of its customers to provide system services
mFRR	Manual Frequency Restoration Reserve
Svk	Svenska kraftnät
TSO	Transmission System Operator

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1

Introduction

In this chapter, the background of the problem and rationale of the thesis are introduced. Subsequently, the purpose, limitations, and research questions of the thesis are presented.

1.1 Background

The global energy sector is facing great changes with regards to innovation and disruption (Sioshansi, 2017). Some of which impacts modern energy systems while inducing demand for change and new solutions to maintain stability and dependability. Among these changes are an increased share of intermittent renewable energy production and increased electrification in several sectors such as transport, heavy industry, and heating (Barbour et al., 2018) (Johannesson, 2021). These changes are nonetheless prevailing in Sweden as the national political goal is set to transform the Swedish energy system to reach 100% renewable energy production by 2040, with an increased share corresponding to intermittent energy sources such as solar and wind (Energimyndigheten, 2018). According to Richardson (2013), large scale implementation of intermittent energy production tends to cause problems within existing energy systems. Jointly, increased urbanization, electrification, and digitalization is predicted, factors that are expected to further increase the strain on energy systems. To enable this transformation towards 100% renewable energy, without the need for immense investments in infrastructure, Energimarknadsinspektionen (2021) [The Swedish Energy Markets Inspectorate] states that the power sources in the system will need to be utilized in an increasingly efficient way through flexible and smart usage.

One sector especially relevant is transport, which is currently witnessing a transformation towards electrification, where the Swedish fleet of personal EVs is predicted to reach 2.5 million by 2030 (Andersson and Kullin, 2018). With an increased number of EVs, there is an expected increase in energy consumption and foremostly a predicted increase in power peaks contributing to the predicted problems revolving the energy system (Ryden et al., 2019). However, while EVs partake in causing the problem they could simultaneously play a part in solving it. Their energy storage capacity enables them to engage in energy systems, balancing them through offering capacity as flexible power resources (Eid et al., 2016). Part of the flexibility EVs are suited to offer is that of providing balancing and ancillary services to power grid operators, i.e. the services purchased by Transmission System Operators (TSOs) to maintain balance and operational reliability in the power grid (Svenska kraftnät, 2022d). A prevailing reason for this is the nature of the integrated batteries in the EVs with their inherent quick load response time, enabling them to quickly respond to changes in the power grid (Vagropoulos and Bakirtzis, 2013). Yet, each individual EV does not offer an adequate amount of load to support the system, nor to technically qualify for participation (Power Circle, 2019). To overcome this barrier and enable EV capacity utilization, actors can take the role of EV aggregators that gather the capacity of multiple EVs to reach adequate load volumes for market participation (Bessa and Matos, 2010). Furthermore, as the nuclear power plants that currently produce 30% of Sweden's yearly energy consumption are being decommissioned (Svenska kraftnät, 2021g), the share of intermittent energy sources will increase. As it is inherently more difficult to predict the supply of energy from intermittent energy sources, the need for ancillary services is expected to increase too, resulting in, together with other factors (Svenska kraftnät, 2020a), significant growth of the ancillary services market (Svenska kraftnät, 2021h) and hence possibly the opportunities for EV aggregators.

As the Swedish energy market transforms and technical solutions progresses, the possibilities for actors to create and capture value in novel ways may occur. Currently, a few modern electricity providers (such as Tibber) and energy solution providers (such as Flower, formerly Krafthem) participate in the Swedish ancillary market through utilization of their customers' aggregate demand flexibility (Tibber, 2020)(Krafthem, 2022). Demand flexibility refers to the ability to control power consumption remotely to decrease or increase power loads based on energy system needs (Energimarknadsinspektionen, 2016). Despite flexible usage of such resources being argued to be a crucial part to enable the increased share of intermittent renewable energy sources (Svenska kraftnät, 2022b), combined with new actors entering this market space, the dynamics are yet unknown. Hence, the ability for private actors to pursue these initiatives and use them to capture value is currently unexplored.

Due to the possible potential of this market space, Circle K has decided to strategically examine the possibilities to participate in the ancillary services market through leveraging their residential customers' aggregated flexibility of electric vehicles (EVs), i.e. operating as an EV aggregator. While the majority of Circle K's operations are not in the electricity space, they launched as an electricity provider in Norway in June 2021 (E24, 2021). Hence, Circle K represents an opportunity to explore the barriers for an electricity provider to participate in this market, and how they can create value for their customers while capturing value themselves.

The study further contributes to research as the literature on demand response is not quite fully mature. Niesten and Alkemade (2016) states how the literature in the field does not give any complete descriptions of business models, instead primarily describing how service providers can create value for consumers while capturing value for themselves. Therefore, this study is expanded to include an examination of revenue models in the demand response space, as it can be considered an important part of every business model.

1.2 Purpose and research questions

The purpose of this thesis is to investigate and present what the current opportunities and barriers are for an electricity provider to create and capture value through positioning as an EV aggregator, offering flexibility services on the balancing markets operated by the Swedish TSO (Transmission System Operator). Hence, the following research questions are formulated to further specify the purpose of this study:

- Which technical, regulatory, and financial barriers are EV aggregators facing in offering ancillary services to TSOs from demand flexibility?
- How can Circle K create value for end-consumers through participating in the ancillary services market?
- How can Circle K capture value through participating in the ancillary services market, and what is important for doing so?

1.3 Delimitations

Some delimitations were made to allow answering the research questions with greater depth, namely:

- The thesis will only examine the Swedish electricity market as there are important differences between different national areas. However, the similarities are large in the Nordics. Due to this, implications and conclusions are to some extent applicable to other Nordic countries.
- The thesis will only consider using EVs as a flexibility resource as requested by Circle K.
- The thesis will answer the research questions only through the perspective of an electricity provider interested in becoming an aggregator, as other types of actors would have different conditions for capturing value.
- The thesis will only investigate the potential of offering flexibility resources through the ancillary services market.
- The thesis will not particularly examine the value created from the perspective of the TSOs through offering of ancillary services, instead the thesis will focus on value created for end consumers through the provision.
- As Circle K at this stage only provides electricity to residential customers, only residential EV charging is considered in the thesis. However, conclusions should be applicable to wider use cases in some aspects.

2
Extended background

An extended background is offered below to facilitate reading and understanding of the thesis. First, the general structure of the Swedish energy system is explained through a concise description of the electricity network in conjunction with the different types of actors operating in the space. Subsequently, balancing and ancillary services are introduced. Finally, the section ends with a description of demand flexibility and how it can be utilized to provide ancillary services.

2.1 Structure of the Swedish electricity network

The Swedish electricity network consists of three types of grids: transmission grid, regional grid, and local grid (Svenska kraftnät, 2021l). These grids transport electricity from producers to consumers, and can be thought of as roads of different sizes with the transmission grid being the largest highway to the local grid being the smallest local roads (Svenska kraftnät, 2021l). What separates them is primarily the purpose of the different grids, and the actors responsible for operating and maintaining them (Svenska kraftnät, 2021l). See Table 2.1 for an overview of the three grid categories.

Table 2.1: Overview of the three grid categories that together constitute the Swedish electricity network. (Svenska kraftnät, 2021l; IVA, 2016)

Type of grid	**Transmission grid**	**Regional grid**	**Local grid**
Purpose	Transports large amounts of electricity from the largest producers to the regional grids. Very large consumers are connected directly.	Connects the transmission grid with the local grids. Large consumers and some medium-sized producers are connected directly.	Connects the regional grids with the majority of consumers and the smallest producers.

Table 2.1 continued from previous page

Responsible actor(s)	Svenska kraftnät.	Larger grid operators, mainly Vattenfall, Ellevio, and E.ON.	Around 170 grid operators are responsible for the different local grids.

2.2 Actors in the Swedish energy system

Several different types of actors operate in the Swedish energy system, and some are of additional relevance to this thesis. These actors are presented below. Furthermore, Figure 2.1 below provides a graphical overview of the Swedish energy system (Svenska kraftnät, 2021d). Note that the "electricity trading company" mentioned in the image is explained under "electricity provider" in the list below. Also, the image illustrates how electricity is transmitted physically through the three different grids explained above, but the financial aspect of electricity trade is handled by electricity providers through electricity markets.

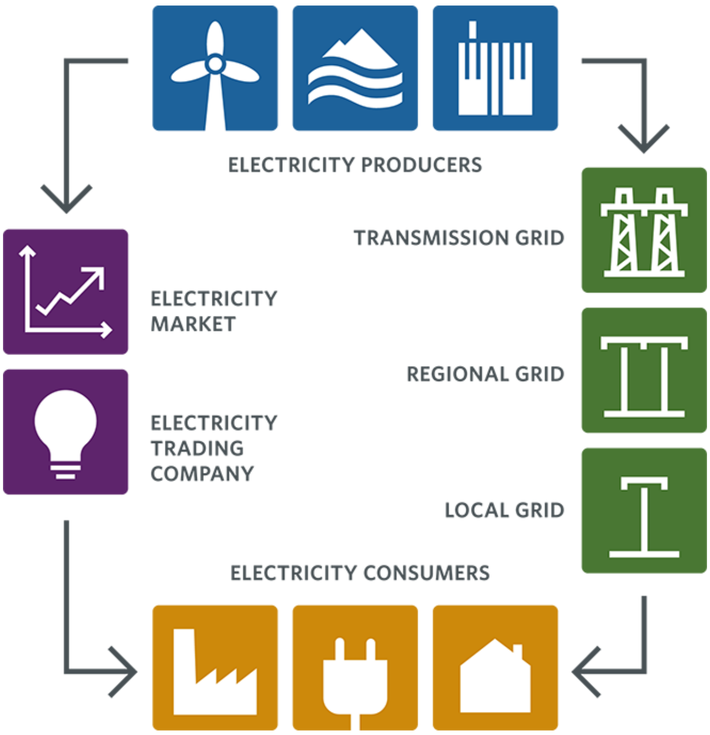

Figure 2.1: Overview of some of the actors in the Swedish energy system (Svenska kraftnät, 2021d).

Transmission System Operator (TSO). The state-owned Svenska kraftnät (Svk) is the national TSO, responsible for the Swedish electricity network at large and for maintaining and operating the transmission grid (Svenska kraftnät, 2021q). The grid responsibility further encompasses ensuring continuous system balance between production and consumption, during both normal operation and large disturbances (Svenska kraftnät, 2021i).

Distribution System Operator (DSO). Both local and regional DSOs exist that operate and maintain the local and regional grids, respectively (Svenska kraftnät, 2021l). The largest DSOs Vattenfall, Ellevio, and E.ON, are responsible for most of the regional grids in Sweden (IVA, 2016). The rest of the regional grids and the local grids are owned by the other 170 DSOs operating in Sweden (IVA, 2016). A majority of those 170 DSOs are in turn owned by their local municipalities (IVA, 2016).

Electricity provider. Consumers purchase electricity from electricity providers, who either produce electricity themselves or acquire it from producers on electricity markets such as Nord Pool (Svenska kraftnät, 2021j). Over 100 electricity providers operate in Sweden (Konsumenternas energimarknadsbyrå, 2020).

Balance Responsible Party (BRP). BRPs are financially responsible towards Svk for adding as much electricity to the system as their customers consume (Energimarknadsinspektionen, 2022). An actor that delivers electricity to customers needs to either be balance responsible themselves, or have an agreement with a BRP (Energimarknadsinspektionen, 2022). Thus, all BRPs are electricity providers, and electricity providers who are not BRPs can purchase the service from other providers (Energimarknadsinspektionen, 2022).

Electricity producer. Electricity producers produce and deliver electricity to the system, and are connected directly to either the transmission, regional, or local grid depending on the size of the producer (Svenska kraftnät, 2021j,l). An electricity producer is often also an electricity provider, but not in every case (Vattenfall, 2022).

Aggregator. Aggregators gather flexible resources and package them to offer on flexibility markets (Energimarknadsinspektionen, 2021). They allow customers to participate in flexibility markets and enable the electricity system to operate more effectively as more sources of flexibility can be utilized (Energimarknadsinspektionen, 2021).

2.3 Balance in the Swedish energy system

To ensure system stability, there must be a balance between production and consumption of electricity at all times (Svenska kraftnät, 2022e). The degree of balance is expressed quantitatively through the system frequency, where 50.00 Hz is the target frequency of the Swedish electricity system (Svenska kraftnät, 2022e). If electricity consumption is higher than production in a given moment, the frequency decreases below 50 Hz; if production is higher than consumption, the frequency increases above 50 Hz (Svenska kraftnät, 2022e). Some deviation is acceptable and the frequency fluctuates continuously between 49.90 Hz and 50.10 Hz during what is considered normal operation (Svenska kraftnät, 2019). However, deviations that are more significant, such as disturbances, can damage connected equipment and result in power outages depending on the severity (Svenska kraftnät, 2021b).

To manage this challenge, the responsibility falls upon the Balance Responsible Parties (BRPs) or Svenska kraftnät depending on which phase is considered: the planning phase or the operational phase (ENTSO-E, 2016). During the planning phase, BRPs are contractually obligated to plan for balance between their customers' consumption and the amount of electricity the BRP supplies through either production or trading on e.g., Nord Pool (Svenska kraftnät, 2021a). As the planning phase ends and the operational phase begins, the responsibility is transferred to Svenska kraftnät to manage the system frequency through the use of ancillary services (Svenska kraftnät, 2021c).

Since the actual production and consumption frequently deviates from what the BRPs have planned, for example due to unforeseen changes in weather, there is a need to regulate the frequency throughout every operating hour (Svenska kraftnät, 2021b). This is where Svenska kraftnät uses ancillary services to regulate system frequency during operation. The services are purchased in advance for each operating hour through the balancing markets, and several different services exist that together allow the TSO to regulate the system frequency effectively (Svenska kraftnät, 2021b). When a resource is activated, it can help regulate the frequency in either an upwards or downwards direction depending on the type of ancillary service, type of regulation-providing resource, and what the system needs at the moment (Svenska kraftnät, 2021p). For a production unit to regulate upwards, or increase system frequency, it needs to increase its production of electricity. If a decrease in frequency is needed, it can regulate downwards by decreasing its production. In the case of hydropower, for example, this equals decreasing or increasing the flow of water through the system in order to decrease or increase electricity production (U.S. Energy Information Administration, 2022).

2.3.1 Ancillary services

The ancillary services that Svenska kraftnät have at their disposal can be divided into three categories, presented below.

Frequency Containment Reserve (FCR). The first response to frequency deviations are the FCR services which are used for quick initial stabilization. There are two types of FCR: FCR-N and FCR-D, where the former is active continuously during normal operation (49.9-50.1 Hz) and the latter is activated in the case of larger disturbances. (Energinet, 2022)

Frequency Restoration Reserve (FRR). When FCR has been activated, FRR is called upon to bring the frequency back to 50 Hz, thus off-loading FCR and allowing it to be activated again. FRR is further split into manual FRR (mFRR) and automatic FRR (aFRR). (Energinet, 2022)

Fast Frequency Reserve (FFR). Constituting a fairly recent addition to the

ancillary services, FFR is activated when there is a need for a quicker response to frequency deviations than what FCR provides. (Energinet, 2022)
See the figures below for illustrated examples of how ancillary services are used to regulate frequency during normal operation (Figure 2.2) and during larger disturbances (Figure 2.3) (Svenska kraftnät, 2021p). The “Frequency” graphs show the system frequency, while the “Active power” graphs display the relative amounts of activation of the different services in response to frequency deviations. A more detailed description of the different services is presented later in this chapter.

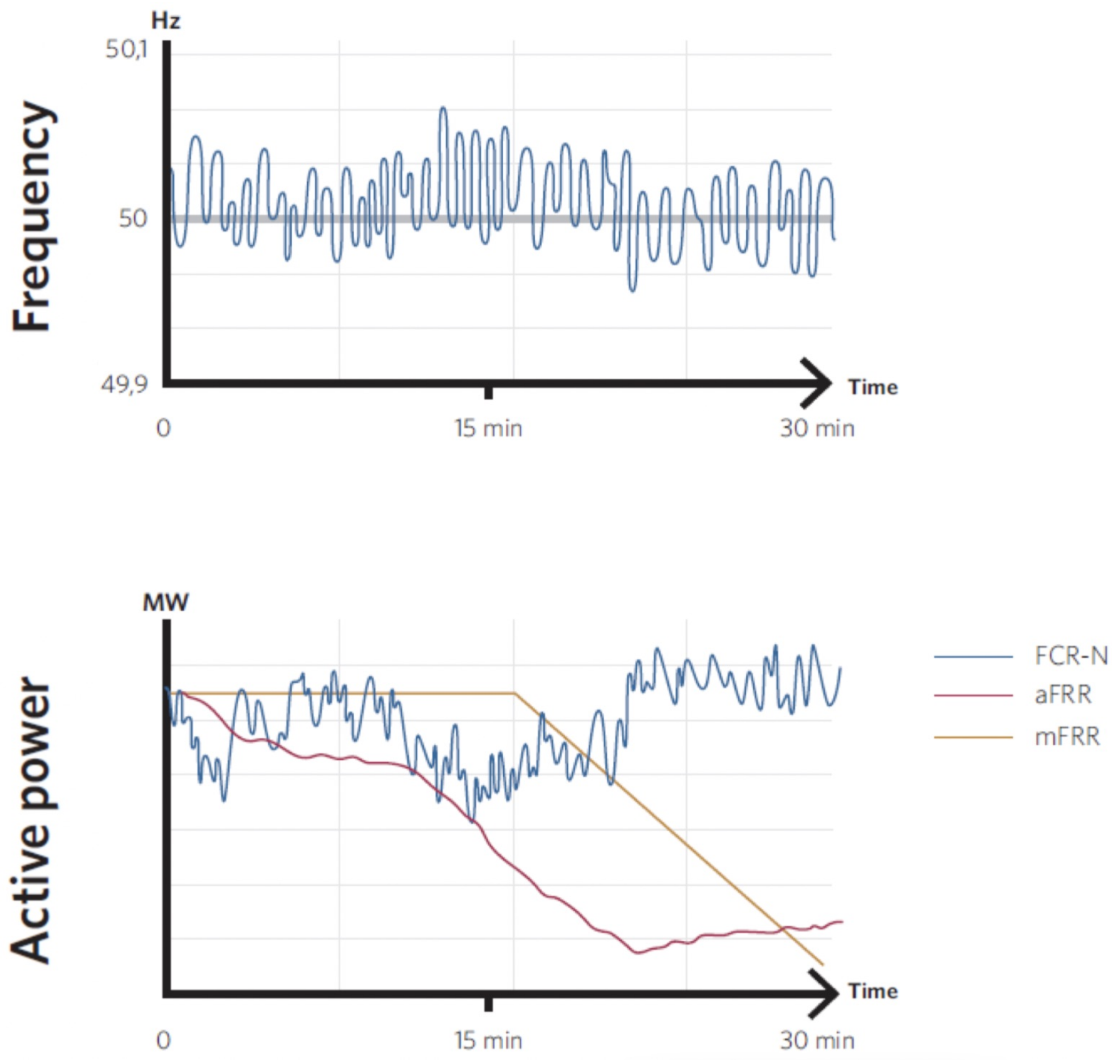

Figure 2.2: Illustrated example of how ancillary services are used to regulate system frequency during normal operation (Svenska kraftnät, 2021p).

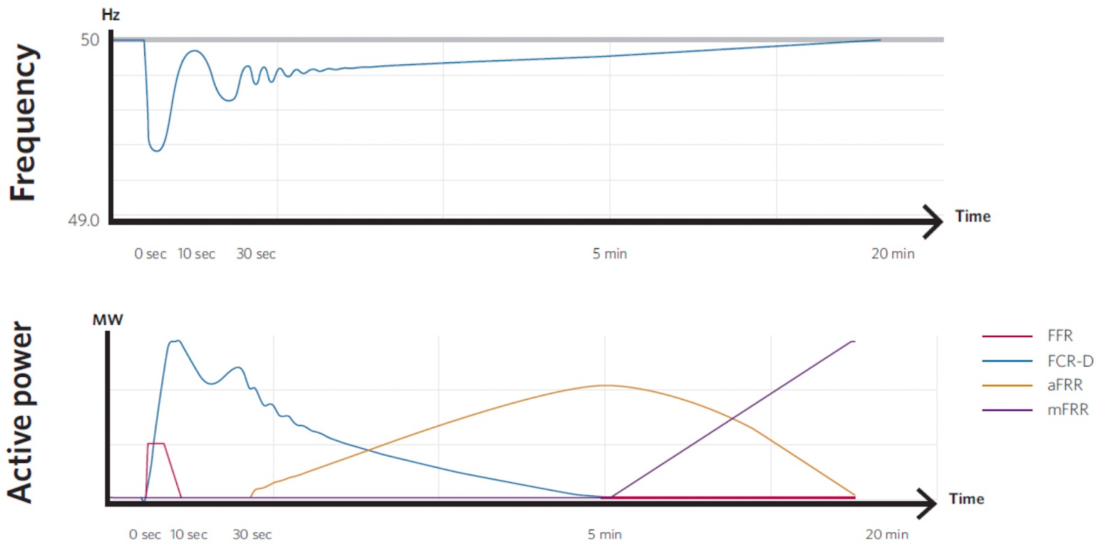

Figure 2.3: Illustrated example of how ancillary services are used to regulate system frequency during larger disturbances (Svenska kraftnät, 2021p).

2.3.2 Ancillary services: procurement, remuneration, and price mechanisms

Since Svenska kraftnät are responsible for regulating the frequency using ancillary services, they are also responsible for ensuring that sufficient volumes are available (Energinet, 2022). Therefore, they have volume requirements that are for example based on the single largest possible point of interruption. In Sweden, this is constituted by the nuclear reactor Oskarshamn 3 (Svenska kraftnät, 2021n). Since the electricity systems in the Nordics are interconnected, volume requirements are also set in agreement between the Nordic TSOs (Svenska kraftnät, 2021n). Two other factors that drive the need for ancillary services are how much of the production is plannable and adjustable, and how much is weather dependent (Svenska kraftnät, 2021h). Due to a decrease in plannable production from the closing of nuclear power plants, and an increase in weather dependent and intermittent energy production through the build-out of wind and solar power, the need for ancillary services is expected to increase further (Svenska kraftnät, 2021h,k). Finally, an increase in overall electricity use also increases the need for ancillary services, which is expected to occur further due to electrification of, for example, transport and industry (Svenska kraftnät, 2021k). The total spending on ancillary services by Svk is forecasted to increase by over 30% from 2021 to 2025, for a total spend of around 3.8 billion SEK (Svenska kraftnät, 2021m).

To become eligible for providing ancillary services, interested parties go through a pre-qualification process with Svenska kraftnät where they demonstrate that their resources fulfill the technical requirements (Svenska kraftnät, 2021e). Once qualified and active, actors providing ancillary services are compensated by Svenska kraftnät through either energy remuneration or capacity remuneration, or a combination of both, depending on which service is considered (Svenska kraftnät, 2022c). Through energy remuneration, an actor is compensated by Svk whenever their resource is activated and delivers frequency regulation, with the amount of compensation depending directly on the amount of energy delivered. With capacity remuneration however, an actor ensures Svk that a frequency regulating resource is available for use during a given operating hour and is compensated regardless of whether the resource is activated or not (Svenska kraftnät, 2022c).

In order to participate in the balancing markets, actors submit bids for each operating hour with the amount of capacity they have available and the price they want to offer it for (Svenska kraftnät, 2022g). The cheapest bids are accepted by Svenska kraftnät until their volume requirements are fulfilled (Svenska kraftnät, 2022g). Depending on the ancillary service, actors get compensated through one of two pricing mechanisms: pay-as-bid or pay-as-cleared (Svenska kraftnät, 2022g). On markets using pay-as-bid, the actors with accepted bids get paid according to the price that each actor has placed their bid at (Scottish & Southern Electricity Networks, 2022). With pay-as-cleared, each actor with an accepted bid gets paid with the same amount as the highest bid (Scottish & Southern Electricity Networks, 2022). Currently, every ancillary service uses pay-as-bid except for mFRR which uses pay-as-cleared (Svenska kraftnät, 2022g).

2.3.3 Ancillary services: detailed descriptions

More detailed descriptions of each ancillary service are presented below.

2.3.3.1 Frequency Containment Reserve - Normal (FCR-N)

As described previously, FCR-N is used to counteract the small deviations that occur continuously during normal operation. The service is symmetrical, meaning that an actor providing FCR-N regulation needs to be able to provide equal amounts of frequency regulation both up and down (Svenska kraftnät, 2022h). Once activated, a resource needs to provide 63% activation within 60 seconds and 100% activation within three minutes (Svenska kraftnät, 2022h). The resource then needs to be able to be activated for one hour (so-called endurance), although the actual activation time can be shorter depending on the current system need and the ancillary service considered (Svenska kraftnät, 2022h). Svenska kraftnät purchases the majority of FCR-N resources two days before the operating hour, and the rest one day before (Svenska kraftnät, 2022c). Provision is compensated with both capacity remuneration and energy remuneration (Svenska kraftnät, 2022c). The minimum bid size is 0.1 MW and the total volume requirement is around 230 MW (Svenska kraftnät, 2022h).

2.3.3.2 Frequency Containment Reserve - Disturbance (FCR-D)

FCR-D is activated during larger disturbances as mentioned earlier. As opposed to FCR-N, the service is asymmetrical and instead split into FCR-D (up) and FCR-D (down) (Svenska kraftnät, 2022h). The former provides only upwards regulation and the latter only provides downwards regulation. Resources that are bid into the different markets are therefore only expected to provide one direction of frequency regulation. The required activation times are shorter than FCR-N, with five seconds to 50% activation and 30 seconds to 100% for both FCR-D (up) and FCR-D (down) (Svenska kraftnät, 2022h). Endurance is set to a minimum of 20 minutes, but the actual activation time can be shorter as mentioned. The purchase period and minimum bid size is identical to FCR-N (Svenska kraftnät, 2022c). The total volume requirement is higher at around 530-560 MW (Svenska kraftnät, 2022h).

2.3.3.3 Automatic Frequency Restoration Reserve (aFRR)

aFRR is used to restore the frequency to 50 Hz and off-load activated FCR resources to allow for new activation. Like FCR-D, it is asymmetrical (Svenska kraftnät, 2022h). Activation time is 100% within two minutes and endurance is one hour, with Svk purchasing the service one week before operation (Svenska kraftnät, 2022c). Minimum bid size is 5 MW, and total volume requirement is around 140 MW (Svenska kraftnät, 2022h).

2.3.3.4 Manual Frequency Restoration Reserve (mFRR)

mFRR is in contrast to the other ancillary services not activated automatically in response to frequency deviations, but rather manually at the request of Svk (Svenska kraftnät, 2022h). Purchase period is 45 minutes before operation (Svenska kraftnät, 2022c). The activation times are longer, with 100% within 15 minutes, and bid sizes larger at 10 MW. Endurance is one hour, and no volume requirements exist (Svenska kraftnät, 2022h).

2.3.3.5 Fast Frequency Reserve (FFR)

FFR constitutes the fastest of the ancillary services, with a required 100% activation within 0.7-1.3 seconds (depending on the size of the deviation) (Svenska kraftnät, 2022h). The service is procured on a yearly basis (Svenska kraftnät, 2022c). Endurance is either five seconds or 30 seconds, minimum bid size is 0.1 MW and the volume requirement is around 100 MW.

The technical specifications described above are summarized in Table 2.2 below.

Table 2.2: Summary of the technical specifications of each ancillary service. (Svenska kraftnät, 2022h,c)

Service	FCR-N	FCR-D	aFRR	mFRR	FFR
Activation	63% within 60 seconds, 100% within 3 minutes	50% within 5 seconds, 100% within 30 seconds	100% within 2 minutes	100% within 15 minutes	100% within 0.7-1.3 seconds
Endurance	1 hour	Minimum 20 minutes	1 hour	1 hour	5 seconds or 30 seconds
Purchase period	1-2 days before operation	1-2 days before operation	1 week before operation	45 minutes before operation	Procured yearly
Minimum bid size	0.1 MW	0.1 MW	5 MW	10 MW	0.1 MW
Volume requirement	Around 230 MW	Around 530-560 MW	Around 140 MW	None	Around 100 MW

2.3.4 Providing ancillary services from demand flexibility

As described earlier, the need for ancillary services is expected to increase. Historically, the actors that have provided ancillary services have been few and concentrated (Statens energimyndighet, 2014). For example, the number of actors supplying the entire amount of FCR amounted to ten in 2020, up from six in 2019 (Svenska kraftnät, 2021k). The main source for both FCR and FRR has been hydropower due to its ease of regulating production when needed (Statens energimyndighet, 2014).

One strategy that Svenska kraftnät is employing to increase frequency regulation capabilities is through controlling not just production, but also the consumption of electricity (Svenska kraftnät, 2021c). In line with this, Svk opened the last of the balancing markets for provision from demand flexibility in 2019. The term demand flexibility describes the control of electricity consumption through an external signal (Svenska kraftnät, 2017). The controlling can be indirect, through changing a customer's consumption patterns, or direct, through having electronic equipment automatically respond to signals and move consumption in time (Energiforsk, 2021). Such direct and automatic control of equipment can be suitable for providing ancillary services. As the properties of different types of equipment can vary, they can be suitable for different ancillary services (Energiforsk, 2021).

The basic principle is that in order to provide upwards regulation in a given moment, consumption is decreased, and in the case of downwards regulation, consumption is increased. For example, a large industrial customer with the possibility of reducing the consumption from their equipment for a period can provide ancillary services. One practical example are sawmills using electricity to dry wood, where the drying process is not impacted significantly by a temporary reduction in power (Vattenfall, 2021). Smaller consumers, such as individual households, also have resources where their consumption can be reduced. Examples of these include electric vehicle (EV) chargers, heat pumps, fridges, and dishwashers (Energiforsk, 2021). They are however suitable to different degrees, for example being limited by having too significant impact on comfort for the residents or requiring additional hardware in order to be controlled remotely (Energiforsk, 2021). Both maintained comfort and simplicity are shown to be important factors for ensuring customer participation (Högström and Falkenberg, 2019). Important to note is that while smaller consumers may have resources whose consumption can be reduced easily and momentarily without significant impact to comfort, their individual consumption is not large enough to be directly bid into any of the balancing markets (Energiforsk, 2021). This is where aggregators become of interest.

2.3.4.1 Aggregators

Aggregators are, as described previously, actors that aggregate flexible resources to bid them into flexibility markets, e.g., balancing markets. This allows smaller consumers' flexibility to be unlocked, increasing the total amount of flexibility in the system and thus the potential for integrating renewable and intermittent energy production (Niesten and Alkemade, 2016).

Instead of pre-qualifying a single resource for providing ancillary services, aggregators qualify groups of resources (Svenska kraftnät, 2021e). They can then add new resources to the pre-qualified group as long as the new resources in total do not exceed a capacity of 1 MW. Once they do, the aggregator has to apply for a new pre-qualification (Svenska kraftnät, 2021e). Another requirement is that the aggregator needs to be a BRP in order to submit bids to balancing markets (Svenska kraftnät, 2020b). This is expected to change though, as plans exist from Svenska kraftnät to introduce a new type of actor: Balance Service Provider (BSP). The actor type will be created by splitting the Balance Responsible Party (BRP) role into BSP and BRP, where BSPs will be responsible for handling the activation and bidding of flexibility resources without also needing to be BRPs (Svenska kraftnät, 2021o).

2.3.4.2 Demand flexibility from EV charging

The resource that will be further examined for aggregation in this thesis is demand flexibility from EV charging, by the request of Circle K. The feasibility of using EVs as flexibility resources is high for several reasons. The cost for controlling their consumption is practically zero, and the activation time is quick when compared to thermal generators which enables provision of more types of ancillary services (Vagropoulos and Bakirtzis, 2013). Also, customers have shown a high willingness to move their charging as long as they are not impacted negatively (SINTEF, 2019). Since the number of EVs are expected to grow in the coming years, forecasted to reach 2.5 million vehicles by 2030 (Andersson and Kullin, 2018), the possibility to use them as a flexible resource will increase. At the same time, the increase in energy consumption and power peaks from increased EV charging is expected to contribute to earlier mentioned problems for the energy system (Ryden et al., 2019). Thus, harnessing the flexibility from EVs can bring them from being only a part of the problem to also providing a part of the solution. For the sake of brevity, demand flexibility refers from this point to demand flexibility from aggregated residential EV charging, unless otherwise stated.

3

Literature

In order to give an academic context and create a collection of concepts that can be used to discuss the findings, concepts from literature are presented. The main concepts examined in this chapter are value creation and value capture, due to their significant relevance for the research questions at hand. Related to value capture is additionally revenue models, where the relevant ones are presented. Lastly these concepts are examined from the perspective of demand response services.

3.1 Business models

Modern literature covering value capture and value creation often utilizes the concept of business models to describe these processes within firms. Amit and Zott (2001) propose the business model to depict how value is created through a wide array of actions enabling exploitation of business opportunities. This is further supported by Morris et al. (2005), stating that a strong business model constitutes an unique weave of activities resulting in superior value creation. However, the author additionally states that an effective business model enables a firm to generate above average returns. Hence, Morris et al. (2005) describes the business model to be a means for value creation and value capture. Amit and Zott (2001) on the other hand, express that the process of value capture can be described through a revenue model. The concept revenue model itself is described by the authors to offer a detailed description of the specific measures taken by a firm to generate revenue.

This work will further utilize the definitions offered by Amit and Zott (2001). Hence the following sections will further cover aspects of value creation, value capture and revenue models.

3.2 Value creation

The concept of value creation is considered central to literature regarding management and organization, while at the same time being subject to considerable disagreement with respect to both its definition and how it is conducted (Lepak et al., 2007). Hallberg (2017) defines the concept as being a process in which companies deliver products with a certain value to buyers through resources. This definition is similar to that of Mizik and Jacobson (2003), who defines it as the process where a company innovates, produces, and delivers value to a market.

The firm-centric views above can be contrasted by Lepak et al. (2007) who suggests that value creation stems not only from firms or organizations, but also from individuals and societies. The make-up of the value creation process then depends on which of these levels of perspective is adopted at a given time (Lepak et al., 2007). Further, Lepak et al. (2007) suggest that the level of value creation is determined by how much a user realizes the value that is created, herein focusing more on the user than the company providing the value. In order for a user to trade payment for value, the user's perceived value has to be at least equal to their willingness to pay (Lepak et al., 2007).

The perceived value of the user mentioned above is also described by Bowman and Ambrosini (2000), who defines value through two dimensions: use value and exchange value. The former term relates to the value that users perceive a product or service to have, while the latter is concerned with the amount a user pays to the provider of a product or service (Bowman and Ambrosini, 2000). Sweeney and Soutar (2001) further describes how this use value (or perceived value) can consist of four different dimensions of value: social, emotional, quality/performance, and price/value for money. According to the authors, every customer experiences the different dimensions but to varying degrees (Sweeney and Soutar, 2001).

3.3 Value capture

Lepak et al. (2007) states that scholars of strategic management often make a distinction between the concept of value creation and value capture. Pitelis and Teece (2009) elaborates that value is often co-created by several different actors and agents, for example customers, suppliers, users, and competitors. Due to this, the value created by one actor does not need to correspond with the value captured by that same actor. Lepak et al. (2007) describes this phenomenon as value slippage, i.e., when a value creating party is unable to harness all of the value created.

Lepak et al. (2007) further propose two key concepts that can be used to analyze and determine value capture between different actors: competition and isolating mechanisms. Competition is described as replications of the product and or service, and the corresponding value created. Replication in turn results in a decline in exchange value as other actors, such as competitors and customers, capture a larger share of the created value. This is in line with the reasoning of Porter (1980) as he argues that the presence of substitutes, offering similar value, reduces the possibilities for the producer of goods or services to maintain high prices and thus capture exchange value. Lepak et al. (2007) further argues that isolating mechanisms are mechanisms preventing the replication of value creation. He describes them as mechanisms increasing the difficulty of replicating the creation of value, hence, acting as a barrier of value slippage, increasing the value captured by the originator. The author further expresses that isolating mechanisms can be any barrier related to knowledge, physical or legal matters, acting as an obstacle for any competitor to replicate the value created from the product or service. Barney (1991) adopts a research-based view of isolating mechanisms, identifying different types of resources that can act as an isolation for competitors to replicate products or services. He further argues that resources can serve as isolating if they are rare, hard to imitate, non-substitutable, and valuable. Hence, isolating mechanisms are from this point of view the key to value capture in a competitive environment.

In relation to the above, Teece (1986) can be argued to have laid the foundation for scholars studying value capture through introducing the concept of appropriability regimes. According to Teece, the strength of an appropriability regime, and hence the possibility to profit from innovation, is based on three main things: the nature of the technology, the legal means to protect the technology, and the access to complementary assets. Further, he argues that when imitation of a product or service is easily achieved by competitors, complementary assets play an important role in ensuring that value is captured from innovation. The framework created by Teece presents three categories of complementary assets: generic, specialized and co-specialized. Generic assets are those that do not need any tailoring to fit the specific innovation, specialized assets are those where the innovation is dependent on a specific asset tailored for that use solely, and co-specialized assets are those where there is mutual dependency between the innovation and the asset itself. The main conclusion by Teece (1986) is that the easier the product or service is to imitate, the greater the importance of complementary assets such as those for distribution, manufacturing, service, or technological assets, in order to be able to profit from the innovation, or the value created.

Pitelis (2009), defines value capture as the amount of value created by a firm that can also be attained by that same firm. Mizik and Jacobson (2003) defines value capture in a more tangible way, arguing that captured value is determined by profit. Pitelis (2009) further states that the share of the value captured is dependent on several factors such as entry barriers, generic strategies, niche strategies, and differentiation strategies. He further argues that some important factors for increasing value capture can be economies of scale, product or service differentiation, and cost leadership. Regarding the last factor, Pitelis states that firms which are more efficient can benefit from cost leadership through capturing higher profits than their competitors while charging average market prices.

Hence, the overall view of value capture presented revolves around protecting the value created through different means of isolating mechanics, to reach an appropriability regime strong enough to generate profit. However, as previously stated, some modern literature describes the process of value capture through the concept of revenue models, e.g., Amit and Zott (2001). This perspective is further presented in the following section.

3.4 Revenue models

Modern literature covering value capture and value creation often utilizes the concept of business models to describe these processes within firms. From the business model perspective, the concept of value capture is often described through revenue models and cost structures (Clauss, 2017). Osterwalder et al. (2011) describes revenue models as how a company makes money through different streams of revenue and cost structures, with the latter being the sum of monetary means needed to deploy the business model itself. DaSilva and Trkman (2014) further describes revenue models as a description of the way a firm appropriates revenue through sales of goods and/or services. Lastly, the definition most closely related to the concept of value capture is presented by Amit and Zott (2001), describing the revenue model as a part of the business model that describes by which means a firm captures value. The definition of revenue model used in this thesis is closely linked to this definition: the model describing how to effectively capture value through focusing on how a service is sold and how the customer is being charged. In the following subsections, the revenue models of relevance for this thesis are presented and elaborated upon.

3.4.1 Subscription model

A subscription model is defined by Deloitte (2020) as customers getting access to a product or service through paying a fixed price repeatedly on a yearly, monthly, or weekly basis. The authors further express that the subscription revenue model is commonly used for digital services, as access is easily removed once a customer decides to end their subscription. McKinsey (2017) states that subscription models can be beneficial for two reasons. First, they tend to increase the lifetime value of customers when compared to an up-front payment method. Second, they can be helpful in regards to attracting customers that prefer small and recurring expenses over large one-time expenses. However, McKinsey (2017) further explains that it is important to keep delivering value to customers if they are to keep their subscription. In relation to this, Iveroth et al. (2013) describes that subscription model businesses that offer digital services are often expected to continually deliver new features and functionality to their customers. This emphasizes the increased importance for vendors to frequently deliver new value when utilizing this revenue model.

3.4.2 Commission model

The commission revenue model is described by Schlie et al. (2011) to require at least three parties: a seller, a buyer, and an agent (or broker). The model only generates revenue for the agent when a transaction takes place. Schlie et al. (2011) further describes that the commission revenue model is suited for generating aligned goals between two parties and hence appropriate for many internet-based businesses and business models that revolve around a large amount of interactions between different buyers and sellers. As a result, this is the revenue model used by eBay, for example. Further, this model is expressed to be particularly appropriate when the agent plays an important role in the transaction. The largest weakness of the commission revenue model is argued by Schlie et al. (2011) to be that buyers and sellers often have the possibility to act without the agent as an intermediary. By doing this, the buyer and the seller avoids the commission fees, thus capturing a larger share of the value themselves. As a result, this emphasizes the importance for agents to provide superior service and customer experience (Schlie et al., 2011).

3.4.3 Bundling model

Bundling is the concept of combining two or more products or services and offering them as one unit for a single price. According to Chung et al. (2013), there are three strands of literature regarding bundling. The first strand considers bundling of independent products without further coupling between the different products. This type of bundling is further expressed to exploit consumer surplus and can act as a deteriorating mechanism by incumbents towards new entrants. Due to this, it can be used by incumbents to maintain monopoly positions. The second strand of literature assumes that the products bundled are complementaries, resulting in the value of the bundle being higher than the sum of the products themselves. This type of bundling was shown by Telser (1979) to increase returns for monopoly positioned actors. The third strand considers bundling of both complementary and substitute products, where existing literature shows that with decreasing substitutability between products the value of bundling increases (Chung et al., 2013).

Further, Telser (1979) displays that profits can be increased through bundling for products with low to no marginal production cost. This is explained by the authors arguing that predicting customers' valuation of bundles is less difficult than when products are sold separately. Lastly, Iveroth et al. (2013) argues that the main goal of bundling is to increase the customers' total willingness to pay for the products, accomplished through delivering increased value to the customer through combining said products.

3.5 Value creation and capture in demand response services

One of the papers that investigated value creation and value capture with a focus on smart grid services is the article authored by Niesten and Alkemade (2016). They reviewed 45 articles about smart grids and analyzed information from 434 smart grid pilot projects throughout the U.S. and Europe, identifying three types of value generating smart grid services: (1) grid-to-vehicle and vehicle-to-grid services, (2) services to integrate renewable energy into the grid, and (3) demand response services. This thesis focuses on the last of these: demand response services. In the article, Niesten and Alkemade (2016) defines value creation from smart grid services as the value created for the end consumer when using the service or product, where the benefits can be related to financial benefits, environmental benefits, or improved overall service quality. Furthermore, the authors define value capture as the value captured by the actor providing the smart grid service to the end consumer, often including benefits relating to reduced costs and increased revenues, and thus increased profits. Moreover, it is clear that the literature regarding demand response is not yet fully mature as mentioned earlier. Niesten and Alkemade (2016) states how the literature in the field fails to offer complete descriptions of business models, instead mostly describing in what ways service providers are able to create value for consumers while capturing value for themselves. Henceforth, whenever the terms value creation and value capture are used in this thesis, the definitions are strongly influenced by those of Niesten and Alkemade (2016) and correspond to the following:

- Value creation is defined as the value created for the end consumer when using the service or product, where the benefits can be related to financial benefits, environmental benefits, societal benefits, or improved overall service quality.

- Value capture is defined as the value captured by the EV aggregator providing the smart grid service to the end consumer (EV owner), often including benefits related to reduced costs and increased revenues, and therefore increased profits.

Regarding which values are created for the end consumer, Gordijn and Akkermans (2007); Curtius et al. (2012); Verbong et al. (2013), exemplifies that demand response services can lower energy consumption and electricity bills. Welsch et al. (2013); Siano (2014) illustrates that demand response services can improve power quality, and Welsch et al. (2013); Giordano and Fulli (2012); Woychik (2008) shows that it can further improve choice and control for customers related to electricity consumption, costs, and carbon footprint. When it comes to the value created or captured by the service provider from demand side flexibility, Warren (2014); Dave et al. (2013) shows that revenue can be retrieved from selling ancillary services while Markovic et al. (2013); Shen et al. (2014); Giordano and Fulli (2012) display that services can lower the overall electricity sourcing costs for electricity retailers. In addition, Niesten and Alkemade (2016) state that seven out of the 434 reviewed smart grid pilot projects explicitly illustrated environmental benefits for the consumer.

4
Method

This chapter introduces and discusses the method used to conduct the study presented in this thesis.

4.1 Research approach

Since the study concerned subjects that are difficult to measure precisely, a qualitative research design was employed in line with what Bryman and Bell (2015) suggests. The method used was a single case study. The most significant strength of such studies are that they offer a possibility to conduct a thorough investigation of an object (Bryman and Bell, 2015). The case-specific findings produced can sometimes also be used to produce broader insights - although the degree of such external validity is considered a weakness of the method (Bryman and Bell, 2015). This weakness is discussed further below. Considering the goals of the study, this method was therefore considered appropriate. Further, the research is centered around a broad subject but for a specific case, indicating the suitability of a qualitative study design (Bryman and Bell, 2015). As the starting point for the study were hypotheses which theory was generated from, an inductive research approach was utilized as recommended by Bryman and Bell (2015).

4.2 Data collection

The data that was collected for the study is of both primary and secondary nature. Primary data refers to information acquired directly from the source, while secondary data is information acquired one step from the primary source (Bryman and Bell, 2015). In this study, the former mainly relates to interviews, while the latter concerns documents.

4.2.1 Interview data

Interviews were conducted as a means to collect primary data. The main motivations were to uncover information not available in the public domain and bring depth and nuance to the thesis. Interview data can therefore complement secondary sources in a satisfactory fashion. Interview subjects include industry experts and representatives from different aggregators, Circle K, electricity providers, Svenska kraftnät, academia, and other professionals of value to the thesis subject. For example, in order to understand how Circle K can add value to end consumers, it is necessary to understand both what the market values and what the current position of Circle K is. Such information was deemed to be best acquired through interviewing company representatives and industry experts. See Table 4.1. below for an overview of the conducted interviews.

Table 4.1: Overview of every interview conducted during the data collection.

Interviewee type	Interview ID	Professional role	Date	Length
EV Aggregator	A1	Business Development Manager	18/2-2022	45m
Aggregator	A2	Partnership Manager	2/3-2022	45m
Aggregator	A3	Strategic Development Manager	16/3-2022	45m
EV Aggregator	A4	CEO	17/3-2022	60m
Aggregator	A5	Energy Engineer	22/3-2022	60m
Circle K	CK1	Director	8/3-2022	30m
Circle K	CK2	Manager	9/3-2022	45m
Circle K	CK3	Director	9/3-2022	30m
Circle K	CK4	Senior Specialist	10/3-2022	45m
Circle K	CK5	Business Architect	10/3-2022	45m
Circle K	CK6	Senior Specialist	9/3-2022	30m
Electricity Provider	EP1	Senior Project Manager	25/2-2022	30m
Electricity Provider	EP2	Portfolio Manager	14/3-2022	45m
Electricity Provider	EP3	Sourcing Manager	24/3-2022	30m
Research Institute	RI1	Unit Manager	24/2-2022	45m
TSO	T1	Balancing Markets Analyst	22/2-2022	45m + email
TSO	T2	Balancing Markets Director	26/1-2022	Email
University	U1	Researcher	25/1-2022	60m
University	U2	Researcher	21/3-2022	45m

The interview subjects were contacted based on what expertise they possess and which information was needed for the study. As the thesis is written in large part for the benefit of Circle K, it somewhat limited the realm of interviewees interested in participating due to competitive reasons. Since many aspects of the research are quite general, several aggregators still agreed to participate although with the promise of anonymity. Every interview was therefore anonymized for the sake of consistency.

The format for the interviews were semi-structured to match the qualitative research design in accordance with what Bryman and Bell (2015) recommends. The other form of interview structure suggested by Bryman and Bell (2015) are unstructured interviews, but the semi-structured format was preferred to include some structure and, among other things, enable the possibility of sharing the interview questions with the subjects beforehand. See Appendix A.1 for the semi-structured interview guide used. Interviews were recorded, as long as the subject agreed to be recorded, and then transcribed. If the subject did not agree to be recorded, extensive notes were taken. The reason for recording and transcribing is to make sure the subject's answers were documented accurately, as it is easy to lose nuance when note-taking (Bryman and Bell, 2015). Further, it allows for both interviewers to engage with the interviewee to a greater degree when no attention is reserved for writing notes. Both authors participated in every interview to better create a shared understanding of the subject and since the amount of interviews were not so many that they had to be split between the authors.

4.2.2 Document data

Non-academic documents such as industry reports and material from Circle K and industry organizations (e.g., PowerPoint decks and project reports) were used to provide knowledge specific to the case. When a relevant document was found, the references used to write the text were explored to find additional documents of relevance. This is what is commonly referred to as chain searching (Ejvegård, 2009).

4.3 Data analysis

As the information acquired from a qualitative research design can be abundant in size, the choice of analysis tools is important (Bryman and Bell, 2015). Since the study is exploratory in nature, constant comparison between data and analysis was deemed to be highly suitable. With such a method, it becomes possible to e.g., let the analysis of an interview direct subsequent information collection. This allows a study to hone in on answers to the research questions iteratively (Bryman and Bell, 2015).

In this study, coding was used to facilitate the process of finding themes and insights from the interviews. The coding method breaks data down into its components for easier processing (Bryman and Bell, 2015), and was deemed useful for this study to structure the large amount of information expected.

To analyze the document data, a similar way to structure information and find themes was needed. The method employed was to create short summaries of relevant documents, in order to create an overview and simplify information retrieval. This approach is recommended for qualitative research with large amounts of documents (Jackson et al., 2015).

4.4 Research quality

This section considers the quality of the research conducted for the thesis. As the research is of qualitative nature, only aspects applicable to qualitative research will be discussed.

4.4.1 Validity

Validity concerns whether a chosen research method and design is appropriate for the purpose at hand (Bryman and Bell, 2015). It can further be split into several forms of validity, where internal and external validity are the most relevant for qualitative research (Bryman and Bell, 2015). Internal validity refers to whether the observations in a study matches the theoretical ideas developed by the researchers (Bryman and Bell, 2015). To ensure internal validity in this study, interviews were conducted independently of one another and compared with secondary sources. This creates several points of reference and increases internal validity (Bryman and Bell, 2015). External validity concerns whether the findings can be generalized to settings outside of the original one (Bryman and Bell, 2015). While the findings will be specific to Circle K to some degree, electricity providers are similar in terms of capabilities which increases the generalizability significantly.

4.4.2 Reliability

The concept of reliability refers to whether a recreation of the study is likely to produce the same results or not (Bryman and Bell, 2015). Like validity, it can be split into internal and external reliability. Internal reliability concerns whether researchers agree over an observation within a study (LeCompte and Goetz, 1982). This was ensured by recording and transcribing interviews whenever possible, instead of relying on memory or notes taken during an interview. External reliability refers to how well a study can be replicated (LeCompte and Goetz, 1982) and is considered a challenge in qualitative research as the circumstances surrounding a qualitative study are rarely static (LeCompte and Goetz, 1982). This study is no exception, and especially as the role for aggregators on the ancillary services market is both new and expected to develop significantly over the coming years. At the same time, this decreases the importance of external reliability in this case.

5

Findings

In this chapter, the findings generated from data analysis of interviews and documents are presented.

5.1 Barriers to providing ancillary services from EV demand flexibility

The data shows that electricity providers can face a number of barriers when providing ancillary services from EV demand flexibility. These can be categorized into technical barriers, regulatory barriers, and financial barriers. These barriers are presented in detail below.

5.1.1 Technical barriers

A prevailing issue mentioned by interviewees A1 and A2, from the perspective of EV aggregators, was the current state of the home charging market when seen from a hardware standpoint. First, as the market is scattered with multiple OEMs (Original Equipment Manufacturer) supplying chargers with varying technical and software specifications, each charger requires unique software integration. The second, and most prominent, issue mentioned was the incompatibility of most chargers with the high resolution measurements required to deliver ancillary services. Interviewee A1 further reported that only two out of the many EV home chargers on the market could fulfill these requirements, stating that "this is making a lot of the current capacity difficult to harness for ancillary services." This results in a number of EVs being unable to provide grid services from home charging without supplementary hardware installations.

As the capacity bidding for the balancing markets mostly takes place 1-2 days prior to each operating hour, barriers and difficulties relating to the development of software and statistical models were mentioned. Due to the bidding scheme, software and statistical models were mentioned to be needed to predict the driving and charging patterns of aggregated residential EV fleets in order to accurately predict available fleet capacity during each operating hour. Interviewee A2 and A4 emphasized that this increases the need for both statistical capabilities and developing scalable systems with the capacity to handle large amounts of data.

Additionally, as the remuneration schemes for all ancillary services except mFRR are pay-as-bid, statistical capabilities were additionally stated as necessary to optimize bidding strategies. This was further emphasized by most aggregators to manifest as a barrier due to the current low degree of transparency regarding prices and volumes purchased in the balancing markets. While Svenska kraftnät continuously publishes data of volume weighted mean prices (Mimer, 2022), interviewee A1 and A4 expressed that due to the pay-as-bid pricing, mean pricing data lacks information about price spreads. This in turn resulted in more difficulty developing appropriate bidding strategies. Finally, interviewee A2 summarized much of the above by stating that “creating statistical models is difficult.”

The last technical factor expressed by most aggregators, experts and scholars as a barrier, were the minimum bid sizes required to offer particular ancillary services. As some services require minimum bid sizes of up to 10 MW, these services were expressed to be difficult to provide from EV demand flexibility as such large volumes of capacity are currently difficult to aggregate from EV fleets.

5.1.2 Regulatory barriers

Across all interviews with aggregators, the current regulations requiring balance responsibility to participate in the balancing markets was regarded as a prevailing barrier. The interviewees stated that due to this requirement, an agreement needs to be negotiated with the BRP of each EV owner whose capacity is to be aggregated and offered to TSOs. This in turn was expressed to act as a barrier in reaching and converting EV owners to customers while also incurring costs. Additionally, this barrier was expressed to be emphasized by the fact that every vehicle in an aggregated bidding group needs to be connected to the same BRP (Svenska kraftnät, 2021e). However, interviewees further mentioned that the plans presented by Svenska kraftnät to divide the balance responsible role into two parts, balance service provider (BSP) and balance responsible party (BRP), were largely expected to eliminate this barrier. Such a move would allow aggregators to deliver ancillary services without balance responsibility through registering as a BSP. Yet, it was expressed by the aggregators that it is unclear when this new role is implemented despite previous roadmaps pointing towards early 2022. According to the latest statements from Svenska kraftnät, 2024 is stated to be the new preliminary year for implementation of the role Svenska kraftnät (2022a). Also, interviewee A2 mentioned that “even when the BSP-role is implemented, it will be a challenge in finding and educating customers.” Also, it is still unclear whether every vehicle in a bidding group needs to be connected to the same BRP after the BSP role is introduced, confirmed by Svenska kraftnät through email correspondence (personal communication, April 6, 2022).

Another regulatory concern mentioned by interviewees A1 and A2 regarded the pre-qualification process to participate in the balancing markets, which was expressed to be lengthy. Another concern with the pre-qualification process mentioned was the need to re-complete it whenever the capacity of aggregated resources were expanded by more than 1 MW.

Lastly, interviewee A2 expressed that Svenska kraftnät currently has an upper limit determining how much capacity can be procured for each ancillary service from demand flexibility resources, which in the future could act as a barrier as the amount of demand flexibility resources is expected to increase. Also, A2 mentioned how “several actors have expressed concerns regarding this, with Svenska kraftnät offering no real explanation for the limits.” Through interviews with T1 from Svk, it was expressed that these limits are applied to centrally measured resources, i.e., resources not connected to a dedicated and decentralized frequency metering device monitoring the frequency in the power grid in real time, allowing resources to be activated based on the local grid frequency. Decentralized resources having dedicated decentralized measurement equipment were mentioned to usually be larger utility facilities offering ancillary services, for example hydropower plants. Svenska kraftnät expressed that the limits apply to FCR-N, FCR-D (up) and FCR-D (down), with the limits currently being 24 MW, 73 MW and 50 MW, respectively.

5.1.3 Financial barriers

During interviews with U1, U2, RI1, EP1, and CK5, financial barriers were expressed to exist. Interviewees stated that the revenues from EV flexibility might be too low for each vehicle to incentivise EV owners to participate with their flexibility from a monetary perspective. This was emphasized by interviewees U1 and U2 especially, stating that monetary incentives might be too small to incentivise all parties, as revenue likely will be shared between the end consumer and the aggregator. In addition to this, one recurring and related concern was that the average consumer might lack interest and/or the monetary incentives to participate with their EV as a flexible resource, due to the historically low costs associated with energy and charging when compared to other costs related to car ownership.

Yet, interviewees U1 and RI1 also expressed that the recent surge in electricity prices during 2021 and early 2022 might result in increased awareness of energy related costs. Additionally, the scholar U2 expressed that the current customer base of EVs are likely more interested in technical and environmental solutions compared to the average consumer, making them “more likely to opt-in to flexibility services for reasons other than monetary gains.”

From further interviews with aggregators A2, A4, and A5, two main financial barriers were expressed: the pricing mechanisms on most balancing markets and uncertainty regarding the future prices on those markets. The common pricing mechanism pay-as-bid was expressed by aggregators to both increase the need for intelligent bidding strategies and to reduce overall profitability. This pricing mechanism has further been mentioned as a barrier by Energimarknadsinspektionen (2016), expressing that it limits the possibilities for competition on the associated balancing markets. To mitigate this, Svenska kraftnät has established the goal of transitioning to pay-as-cleared pricing (Svenska kraftnät, 2021f). With or without this transition, the overall balancing markets are expected to grow rapidly until 2024 with Svk anticipating a large increase in balancing market prices when transitioning to the new pricing mechanisms (Svenska kraftnät, 2021m). However, interviewee T2 from Svk, expressed through email communication that prices are expected to decrease at some point due to an increased supply of ancillary services and thus competition on the balancing markets. This was further supported by interviewee EP3 who stated that "if the demands of the balancing market are saturated through cheap demand flexibility, prices could potentially plunge."

The uncertainty regarding future balancing prices expressed above constitutes the second barrier, described further by interviewees CK3, CK6, and EP3. The interviewees expressed the balancing market prices to be a crucial factor for profitability and the overall business case. Hence, the lack of certainty about the future prices was perceived as a barrier for participation. The aspect of pricing uncertainty is further supported in a report published by Accenture (2017) based on the American market, expressing that while ancillary services are currently the most lucrative value pool for flexibility, prices are likely to drop if demand becomes saturated by cheap supply. This is in line with previous statements presented by EP3, that prices could decrease once a large share of the demand is covered by cheap resources.

5.2 Value creation

In this section, findings related to how value can be created and what value can be created will be presented. First, how to create value is determined through presenting which ancillary service interviewed actors consider suited for demand flexibility. Second, it is described what value is created for end consumers.

5.2.1 The ancillary service best suited for demand flexibility

The ancillary service considered by every interviewed aggregator to be best suited for delivering demand flexibility from aggregated EV charging is FCR-D (up). The reasons for this are several, but the main reasons are as interviewee A2 mentioned: "FCR-D (up) is activated very rarely, offers the best prices, and has capacity remuneration." These reasons can be summarized as minimal charging interference and significant financial compensation. Additional technical reasons for why FCR-D (up) is suitable are also presented below.

5.2.1.1 Minimal charging interference

As mentioned by interviewee U1, the most important factor for the end consumer is having their vehicle charged when they need it for transportation. It therefore becomes critical to guarantee that offering flexibility does not interfere with charging in any significant way. The benefit of FCR-D in this regard is that it is activated only when larger disturbances in grid frequency occur, and thus the least of all the ancillary services. Lindgren (2019) showed that there was a need for FCR-D (up) activation during 33 percent of all hours in 2018. However, the degree of activation averaged 0.05% during those hours, with a maximum single activation degree of

5.2% (Lindgren, 2019). As these numbers refer to the entire pool of capacity available on FCR-D (up) of around 560 MW (Svenska kraftnät, 2022h), the activation frequency for each individual resource becomes minuscule. For a single charger, this equals around 10-20 activations per year, for a period of 10 seconds to 15 minutes per activation according to interviewees A1 and A4. Such low activation frequencies and periods are described by the interviewed aggregators as practically unnoticeable for the end consumer, and neither does it jeopardize the guarantee of having the customer's vehicle charged to desired percentage by departure.

Interviewees A1, A2, and A4 expressed that while FCR-N is the ancillary service most similar to FCR-D (up) in many aspects, the charging interference is the largest point of dissimilarity. Since FCR-N is used to regulate frequency during normal operation instead of disturbances, it is activated more frequently. Interviewees A1, A2, and A4 describe FCR-N provision as interfering with charging to a degree that makes it considerably less attractive for EV aggregation than FCR-D (up).

5.2.1.2 Significant financial compensation

The other main reason why interviewees consider FCR-D (up) well suited is the financial compensation. Interviewees A1, A2, and A4 mentioned FCR-D (up) having the highest average price per megawatt, while also compensating flexibility providers through capacity remuneration. As expressed by interviewees A1, A2, and A4, having the highest prices per megawatt in combination with capacity remuneration makes for the most significant financial compensation in total when compared to the other ancillary services.

Regarding another key difference between FCR-N and FCR-D (up), interviewee A2 mentioned the symmetrical design of FCR-N as a hurdle. Since resources on FCR-N need to be able to regulate by equal amounts both up and down, baseline charging speed has to be limited to 50% which halves the available capacity to bid with from every EV.

5.2.1.3 Additional technical reasons

To further explain why FCR-D (up) is considered the most suitable ancillary service for demand flexibility from aggregated EVs, additional technical reasons are presented below.

Low bid sizes. With a minimum bid size of 0.1 MW, the requirement can be reached with a smaller fleet of EVs than aFRR and mFRR. Since the number of aggregated chargers is a barrier as mentioned earlier, interviewee A1 describes that the low bid sizes allows for easier participation.

Purchase period is sufficiently close to the operating hour. The longer the period is from procurement to operating hour, the larger the safety margins and the better the statistical models need to be, according to interviewee A1.

Response times are long enough. While the activation times are short when compared with most other ancillary services, they are long enough as interviewees A1, A4, and A5 mentioned average response times of around two seconds from aggregated EVs. Such response times would not be sufficient for the fastest service FFR which requires 0.7-1.3 seconds (Svenska kraftnät, 2022h).

To summarize, FCR-D (up) is deemed by interviewees to be the most suitable ancillary service for offering demand flexibility from aggregated EVs due to a combination of minimal charging interference and significant financial compensation, in addition to other factors of technical nature. This therefore describes how to create value from offering demand flexibility on balancing markets. In the following section, it is described what value is created for the end consumer.

5.2.2 The value created for the end consumer

Interviewees A2, A4, A5, U1, RI1, and EP3 all stated that the financial value created from utilizing the flexibility likely will be the most important and significant value transferred to the customer. The total average compensation from offering flexibility from a single EV on FCR-D (up) is estimated to be around 820 SEK per EV per year.[1] Additionally, interviewee A1 stated that the average revenue generated from an EV supplying FCR-D (up) is 400-800 SEK per year. However, this compensation will be shared in some way between (at least) the aggregator and the end consumer, therefore possibly lowering the amount that the end consumer receives. Different revenue models of relevance are presented in the next subsection and later discussed in Section 6.5.

Interviewees A4, U2, and RI1 further mentioned how different incentives will appeal to different types of end consumers. While some may only be interested in the financial aspect, others may be more enticed by feeling that they contribute to society and/or the environment. Interviewees A3, A4, and U2 stated that for some customers, some of the most prominent value might be manifested through the societal and environmental gains received from supporting the power grid and enabling larger shares of renewable energy production to be incorporated into the national energy mix. To the contrary, interviewee A5 stated the following: “there is often a lot of talk about environmental contributions, but once it comes down to it everything is about the financial compensation.” Lastly, interviewees EP3 and CK5 mentioned that visualization of data, such as consumption, prices, and savings could be important for some customers. In relation to this, interviewee CK5 stated that “some customers like to be able to know what’s going on and feel smart.”

[1]Based on the average driving of Swedish car owner (Trafikanalys, 2020), the usual energy consumption for an EV per driven kilometer (Hartvigsson et al., 2021) and the average price of FCR-D (up) during 2021 (Mimer, 2022), assuming all charging being used to supply FCR-D (up).

5.3 Value capture

This section presents findings regarding how to capture the value created by demand flexibility from aggregated EV charging. The first subsection presents findings regarding possible revenue models and the second section presents findings regarding important elements to capture that value.

5.3.1 How to charge the customer

Several interviewees (A1-A4) mentioned that a reasonable revenue model would be to charge the resource owner for a percentage of the generated value. Interviewee A3 expressed that this was their current model in use to generate revenue, and another resource aggregator state on their website that it is the model they use (Checkwatt, 2022).

Aggregator A5 mentioned utilizing a model where the customer, or resource owner, pays either a monthly or yearly fee or an up-front payment, while all of the value generated from flexibility is transferred directly to the customer.

Two interviewees (CK3 and U2) expressed that a possible model could be to give EV owners a discounted or free charger if signing up for the service for a fixed minimum period of time. Meanwhile, the aggregator obtains all of the revenue generated from the flexibility itself. The interviewees further proposed that this model could be beneficial if the monetary value generated from flexibility would be too low to incentivize customers to participate.

The last revenue model proposed by interviewees CK3, CK6, CK4, A2, A5, and U1 was related to bundling. The aggregator itself gets the value generated from flexibility as revenue while offering the customer an overall lower price or discounts on other goods. For example, if an electricity provider offers the service, opting in to offer flexibility as a customer could be rewarded with discounts on their electricity bill. This model is used by at least one EV aggregator and electricity provider (Tibber, 2022). Interviewee CK3 expressed that from the perspective of a charging point operator, this bundling could be related to lower charging fees or a number of free charging minutes for a customer opting in with their EV.

Lastly, interviewees CK3, CK6, and A5 expressed the importance that the model incentivises customers to offer as much flexibility as possible once they have agreed to participate. Flexibility from an EV can only be harnessed when charging can be controlled, i.e., when the EV is plugged into the charger. Hence the value from flexibility increases not only if an EV owner drives longer distances, and consumes more energy, but also if a vehicle is plugged in for longer periods of time. Because of this, interviewees expressed that ladders of compensation could be beneficial, i.e., increasing compensation for the EV owner based on how much value the flexibility actually generates.

5.3.2 Factors for capturing value

Regarding what is important for capturing value, interviewees mentioned four themes recurrently: volume, regulatory position, technical capabilities, and customer centricity.

5.3.2.1 Volume

An important factor to capture value stated by interviewees U1, RI1, EP1, and A1-A5 is the total number of aggregated EVs. Scholars and aggregators both express that aggregating a large number of EVs and thereby a high volume of capacity (measured in megawatt) is important. Additionally, Vagropoulos and Bakirtzis (2013) state that the cost to offer ancillary services from EVs is practically zero, in turn resulting in low marginal costs associated with increasing volume and thereby revenue. A report from PowerCircle (2021) establishes that with the current Swedish regulations, larger bid volumes are favored as the safety margin in absolute terms decreases. Few but large bids are therefore favorable when compared to the same volume scattered throughout smaller bids, further emphasizing the benefit of having large aggregated volumes. In relation to this, one interviewee from academia, U2, expressed that due to the benefits of large aggregated volumes, "actors well positioned to reach a large base of EV customers are likely among the most well positioned actors." This is further supported by a report published by McKinsey (2021), covering how to capture value from EV charging, where the author states that actors who are able to control a large base of charging EVs are in a good position to capture related opportunities. The authors further emphasize that the value increases with higher charger utilization rates.

5.3.2.2 Regulatory position

Another important factor for value capture, as expressed by interviewees A1-A5, was for an actor to be a Balance Responsible Party (BRP). As the current regulations require the aggregator or any other actor delivering ancillary services to be a BRP or have a negotiated contract with a BRP, aggregators need to be either the BRP, or have a negotiated deal with the BRP, of each EV customer whose flexibility is to be aggregated. Interviews with aggregators revealed that this was a prominent barrier to reaching customers, as presented earlier. In relation to this, A1, A2, and A4 expressed that actors being balance responsible for large amounts of customers with EVs are in a good position to reach end customers. Usually, actors in this position were expressed to be electricity providers, hence being a provider or partnering with one was stated to likely be beneficial.

5.3.2.3 Technical capabilities

From the interviews, some important technical capabilities were identified. As explained earlier, the bids for the balancing markets are in most cases placed 1-2 days prior to the actual operating hour. Therefore, aggregators need to predict how much capacity will be available 1-2 days prior to each operating hour. These predictions need to be based not only on the number of EVs available at a given time, but also the amount of charging each EV needs and the expected charging speeds. As a result, A1, A2, A4, and A5 expressed that software and statistical capabilities are needed to build predictive models to be able to predict aggregated capacity from an EV fleet to efficiently place bids in these markets. Additionally, predictive models were expressed to be needed to determine bidding strategies which can be especially difficult due to the current pricing design of the balancing markets, as described earlier. Interviewees further expressed that the better the predictive models are, the more of the actual aggregate capacity can be utilized to bid on the balancing markets and thus more value can be created and retained. Additionally, interviewee A4 further expressed that software capabilities can play a role in competitiveness, as “the cheaper an actor is able to develop models and build scalable solutions, the more value they will be able to capture themselves.”

5.3.2.4 Customer centricity

The interviewees U1, U2, RI1, CK1, CK3, and A5 emphasized the importance of creating flexibility services that are easy for the EV owner to use. One interviewee, A5, expressed that “It is important that the solution is very easy to use and does not create any extra work for the EV owner, it needs to be seamlessly integrated with the standard EV charging experience.” In relation to this, the same interviewees further expressed that it is important to be able to package and communicate the value of the product offered to the EV owner in an effective way. The importance was further highlighted by the interviewees expressing that customers perceive the subject and the revolving products as complicated. Because of this, actors with high degrees of customer centricity were expressed to have a “head start.” Actors well positioned in this regard were mentioned to be start-ups.

6
Discussion

In this chapter, the findings are discussed with regards to the research questions and the literature presented previously in the thesis.

6.1 Identified barriers

Three types of barriers were examined through the conducted interview study: technical, regulatory, and financial barriers. They are further examined and discussed in this section.

6.1.1 Technical barriers

The technical barriers identified were related to four different matters: (1) the lack of OEM chargers compatible with ancillary service provision, (2) the challenge of predicting available capacity prior to the operating hour, (3). the pay-as-bid pricing mechanisms and opaque pricing information, and (4) the large minimum bid sizes for some ancillary services.

The first barrier, related to incompatible chargers, can be argued to act as a barrier as fewer customers can participate in ancillary service provision without investing in new and compatible chargers. Due to the low financial compensation from a single EV from providing ancillary services compared to the cost of a compatible charger (discussed further later, in Section 6.2 *The values created*), it is likely difficult to convince EV owners with incompatible chargers to purchase a compatible one. However, it is deemed likely that an increasing amount of chargers will be compatible in the future as the car industry overall seems to move towards including smart charging capabilities in their offerings. For example, Volkswagen has expressed that mass production of vehicles with a higher degree of smart grid compatibility will be initiated during 2022 (Handelsblatt, 2021). This indicates a trajectory towards a future adapted for smart grids and thus an increase in the number of compatible chargers, implying that this barrier might be diminishing over time. However, currently and in the near future, it will be a barrier limiting the attractiveness of the market.

The second barrier revolves around the challenge of predicting available capacity from EV fleets. As it can be considered mostly a statistical modeling problem, the barrier will likely lose significance as models improve and the available data used to train the models increases. Hence, this barrier will likely act as a differentiator in the competitive market, as actors with stronger statistical capabilities can achieve better resource utilization and thus profitability. This matter is further discussed below, in Section 6.4.3.

The third barrier is constituted by the current pay-as-bid pricing mechanism used for most ancillary services. It is considered to lower the overall profitability for actors providing ancillary services, while increasing the necessity of carefully considered bidding strategies. However, as previously stated, Svenska kraftnät has established the goal of transitioning to pay-as-cleared pricing. Thus, it is likely that the impact of this barrier will decrease in the near future. The financial implications of this barrier are further discussed in Section 6.1.3 below.

The fourth and last technical barrier concerns the large minimum bid sizes for some ancillary services. This is especially relevant for aFRR and mFRR as 5 MW and 10 MW are the minimum bid sizes required to participate, respectively. In theory, this requires roughly 1350 respectively 2700 EVs charging with a power of 3.7 kW, or 455 respectively 910 EVs charging with 11 kW, two of the most common charging speeds in Sweden (Power Circle, 2022). However, this also assumes that all of the EVs are charging simultaneously. Hence, the aggregated number of vehicles need to be several times larger in order to reach such bid volumes in actual operation. While precise information regarding the sizes of EV aggregators' car fleets are sensitive to reveal, these minimum bid size volumes can be considered to constitute a barrier for participation. However, the total EV fleet size is expected to increase in the future as previously mentioned, and increased volumes of aggregated EVs might help bridge this barrier. This matter and extended effects from large EV volumes, are further discussed in Section 6.4.1 below.

6.1.2 Regulatory barriers

Three regulatory barriers were identified relating to providing ancillary services as an EV aggregator through the conducted interviews: (1) the requirement of balance responsibility, (2) the lengthy and recurring pre-qualification process, and (3) the upper limit of capacity (MW) that can be provided from centrally measured resources.

The first barrier constitutes a problem for EV aggregators as they have to be the BRP for the residence of each EV owner due to the current regulatory framework. As described in the interviews, this requires the aggregator to negotiate a contract with the electricity provider being the BRP of the residence for every single aggregated vehicle. This was expressed by the aggregators to harm the profitability and hence the business case for EV aggregators at large. Assuming the expected total revenue from an EV is around 400-800 SEK per year, the costs related to each customer and its acquisition likely needs to be low to reach profitability. Hence, it is reasonable that the added costs related to negotiating a contract with the BRP of each EV significantly weakens the business case. Additionally, since all aggregated

EVs pre-qualified as a single unit have to be regulated by the same BRP, the overall amount of EVs that are needed to reach a MW limit in a fleet increases. This is due to the fact that the EVs under different BRPs need to be divided into different bids. Based on reasoning presented later in The importance of volume, that large bids are favorable, this likely lowers the overall value retrieved from an EV fleet.

While the above is a prevailing barrier for actors that are only aggregators, it could instead manifest as an opportunity for Circle K, as it acts as an entry barrier for competing aggregators and a complementary asset for Circle K. Since Circle K is positioned as an electricity provider, they are inherently the BRP for each residence they provide electricity to, which implies that there could be synergetic benefits related to being both an electricity provider and an EV aggregator. This is further supported by the findings from the conducted interviews and further discussed in later sections. Additionally, if the EV owner already is an electricity customer, getting access to the service should not require more than a simple opt-in. In the contrary case, acquiring this service would require signing up for a service from an entirely new service provider. As the literature emphasizes the importance of simplicity and comfort to get customers to participate in demand flexibility services, this further strengthens the argument of synergistic effects between being an aggregator and electricity provider.

The regulations regarding the requirements to be a BRP to deliver ancillary services has been announced by Svk to be altered through the planned introduction of the BSP role, as mentioned earlier. The introduction of the new role is expected to reduce the barrier for EV aggregators to participate in ancillary service provision, through removing the need to negotiate contracts with the BRP of every EV owner. Despite this, electricity providers could still be favorably positioned due to their already established relation to customers. Benefits related to positioning as an electricity provider and aggregator are further discussed in later sections.

The second barrier stated by the interviewees regarded the lengthy pre-qualification process to provide ancillary services. Additionally, the process has to be re-completed whenever more than 1 MW of additional maximum capacity is added. In theory, this results in the need for a re-qualification whenever the new number of EVs added to the fleet are enough to result in an additional 90-270 EVs charging simultaneously during capacity peaks (assuming average charging speeds between 3.7-11 kW). However, it still implies that the actual EV fleet likely needs to be increased by several times this number as described previously. Nevertheless, it could possibly occur frequently enough to limit a large EV aggregator from expanding as rapidly as desired.

While this is the present situation, Svenska kraftnät clearly communicates their continuous efforts and wishes to enable new technologies to supply a larger share of the total provided ancillary services (Svenska kraftnät, 2022d, 2021m). Hence, the future implications of this barrier are not entirely clear although the trajectory points towards diminishing negative impact.

The third and last regulatory barrier identified was the upper limit of capacity (MW) that can be provided from centrally measured resources, a category which demand flexibility from EVs adheres to. While the interviewees expressed that this is currently not an issue, it could manifest itself as a limit in the future. This could potentially result in increased competition between this type of resource for provision of FCR-N and FCR-D. However, the actual implications are unclear at this point in time.

6.1.3 Financial barriers

Three barriers were identified related to the financial aspects of providing ancillary services: (1) possibly too low revenues to incentivise customers to participate while being a profitable business case, (2) the current pricing mechanisms in place, and (3) the uncertainty of future ancillary service prices.

The first barrier identified is the lack of confidence actors have in that the revenue from ancillary services will be enough to both incentivize customer participation and be profitable. As further stated in the findings, this is especially prevailing once the generated revenue is to be split between different parties, such as aggregator and EV owner. This might point toward the need for this type of service to be part of a product or service package, where the provision of ancillary services is a supplementary service as part of a service or product bundle, as proposed by some interviewees. However, despite the monetary values being possibly too low to incentivize customers to participate while maintaining profitability, there are other types of values created which can be utilized to incentivize participation. These values are further discussed in Section 6.2 *The values created*. Lastly, it is important to remember that while the revenue might be perceived as low, the variable costs to provide the service should be close to zero. Thus, assuming that no charging interruption is perceived by the EV customer that might have to be compensated for, the only variable costs are software maintenance. One could therefore argue that even if the revenue is perceived as low, an absolute majority of revenue can be turned to profit if costs are kept low enough and depending on the revenue model.

The second barrier identified from the interviews was the pricing mechanism used on most balancing markets. The current mechanism is as previously mentioned based on pay-as-bid pricing, resulting in limited profitability and increased importance of smart bidding strategies. As mentioned in the findings, Svenska kraftnät has established the goal of transitioning to pay-as-cleared pricing in the near future. Hence, this barrier is expected to be removed soon. However, this transition will greatly affect the prices on the balancing markets. This leads into the third and last barrier: the uncertainty of future ancillary service prices.

The last barrier is expressed as a concern due to the fact that the prices on the balancing markets currently reflect the “value” of flexibility. As these are the markets where flexible capacity currently has the highest price per MW (Mimer, 2022; Nord Pool, 2022b), they determine the maximum value that can be retrieved from offering flexibility services. Because of this, the prices on these markets are closely related to profitability. Consequently, future prices are also an important factor for actors considering entering this space and position as an EV aggregator as it to some degree determines the return on investment.

Svenska kraftnät's own analysis points towards the market for ancillary services growing rapidly until 2024, and then slightly decreasing in 2025. According to Svk, the overall decrease in market size between 2024 and 2025 is expected to occur due to stable demand but decreased prices, resulting from an increased supply of ancillary services and therefore increased competition. As previously stated, Svenska kraftnät expresses that the prices on the balancing markets are expected to increase rapidly once pay-as-cleared pricing is implemented (Svenska kraftnät, 2022f). As prices increase, the number of actors interested in supplying ancillary services is expected to increase as well. Then, as competition increases, prices could potentially be pushed towards the production cost. Following the previous logic that the variable cost for demand flexibility is close to zero, prices could drop significantly if the supply of demand flexibility is large enough to cover the balancing needs of the system. While this is technically a possibility, it is unclear whether it will occur in the long term. However, it seems inevitable that prices will be increasing in the short term. Additionally, it is important to remember that as different ancillary services have different functions and prerequisites for participation, they vary in price. This might imply that the long term goal for actors such as Circle K, should not be to deliver only one ancillary service, but to utilize the capacity available from flexible resources in an agile manner, providing it where the most value can be captured in each given moment.

6.2 The values created

Overall, the case described in this thesis illustrates an interesting contrast to the traditional situation of customers offering monetary resources to receive value. Instead, the reverse is true as customers give up value in exchange for (primarily) monetary resources. The value that the customer trades can be argued to consist of emotional value (from releasing their complete control of their charging), but primarily the access to control their resource. As the interference from releasing this control is deemed to be practically unnoticeable, this value component becomes practically insignificant as well. In such a situation, one can argue that the emotional value becomes of greater importance, e.g., the worry that their car will not be charged when they need it to.

As described in the findings, the incentives that customers value the most are different for each individual. This is stated the most clearly by interviewees, and is supported by what Sweeney and Soutar (2001) mention regarding appealing to different customers through the four value dimensions. As interviewees expressed concern that the financial incentives may be too small, other incentives can become of greater significance.

First, the financial incentives are considered. Interviewees operating in the space have stated these to be between 400-800 SEK per year and EV when operating on FCR-D (up), which is further supported by assumption-based calculations pointing at roughly 820 SEK per year and EV on FCR-D (up). This value can be put into perspective through the cost of charging. First, the price of a home charger such as Zaptec Go is about 6 500 SEK (Eways, 2022), excluding installation fees. Hence, each year around 6-13% of the charger value could be retrieved as revenue. Further, if the full value were transferred to the EV owner, the payback time for a charger would be around 8-16 years, without accounting for discount rate. Second, the average charging costs in Sweden are estimated to be around 2 865 SEK yearly[1]. Hence, 14-29% of yearly charging costs for an EV could be covered. How this retrieved value can be utilized and packaged to incentivize customers to participate and for Circle K to capture value will be further discussed in Section 6.5.

The other values that can be created for customers, as identified through the interviews, are the following: environmental, societal, and informational. These values are closely related to the social and emotional dimensions of value presented by Sweeney & Soutar (2001). The environmental and societal gains from providing ancillary services are derived from two main things. First, as described earlier, the need for ancillary services increases as the share of intermittent and renewable energy increases in the system. As this is the case, provision of ancillary services contributes to society by offering a more stable and reliable power grid while contributing environmentally through enabling the transition to a larger share of renewable energy production. Second, increased supply of ancillary services will in the long term result in lower prices, *ceteris paribus*. Since all of the costs for grid and power stability are covered by Svenska kraftnät which is a state-owned public utility company, these costs are transferred to the consumers in the end. As a result, increased supply and competition in the balancing markets indirectly lowers the costs for all consumers who use electricity, i.e., all citizens, leading to societal gains.

Lastly, these values are not as clear or directly tangible as those made up by direct monetary compensation. As a result, the way in which they are communicated and bundled together are important. Hence, the matter will be discussed further in Section 6.4.4 and 6.5.

6.3 FCR-D (up) as a starting point

As stated by every interviewed aggregator, FCR-D (up) is optimal for demand flexibility from EVs. However, other services are also interesting but to a limited degree due to factors such as charging interference and bid size requirements. One can argue that for sufficiently high financial compensation, higher degrees of charging interference could be accepted by some customers. Since the prices per megawatt for

[1]Based on the average driving of Swedish car owners (Trafikanalys, 2020), the usual energy consumption for an EV per driven kilometer (Hartvigsson et al., 2021), the percentage of charging happening at home (Stenquist, 2019), the average electricity prices per hour in Gothenburg 2021 (Nord Pool, 2022a) and the average taxes and fees (Energiföretagen, 2021)

each ancillary service have varied historically (Mimer, 2022), it is not unreasonable that other markets will be preferred over FCR-D (up) in the future as their relative prices change. One example of this can be found in FCR-N which, due to its symmetrical design, requires double the amount of EVs to provide the same capacity as if operating on FCR-D (up) as mentioned previously. This directly halves the estimated revenue per vehicle, given the same price per megawatt as FCR-D (up). In order for an aggregator to offer capacity on FCR-N instead of FCR-D (up), the prices therefore need to be at least twice as high in order to compensate. The need for higher prices increases further when taking the increased charging interference into account. This illustrates how different services can be relevant if market conditions were to change, and implies a need for Circle K to follow price developments on the ancillary services of highest interest as well as if the technical requirements change, e.g., with regards to bid sizes.

To add to the above, a benefit of the flexibility concept at a higher level is that many of the capabilities are directly transferable between different demand response markets. Since FCR-D (up) is considered to impact the customer the least, it therefore becomes a suitable starting point for acquiring such capabilities as the risk of negative impact to the customer is lower. As the demand for flexibility grows and other types of markets become more mature and relevant, experience gained from providing ancillary services can be applied to these other markets as well. An implication for Circle K is that FCR-D (up) provision should not be seen as merely an additional and isolated revenue stream, but rather the first step towards offering flexibility in a variety of markets and geographies.

6.4 Important factors for value capture and their implications

Four types of important factors to effectively capture value were identified through interviews and presented in the findings. These four identified elements are: (1) volume, (2) regulatory position, (3) technical capabilities, and (4) customer centricity. In this section, these factors will be discussed further.

6.4.1 The importance of volume

As presented in the findings, large volumes of EVs were expressed by interviewees to be an important factor for value capture. Due to the close-to-zero marginal cost incurred by adding additional EVs and the benefits related to the decreased safety margins needed for bids with large volumes, both economies of scale and increased resource utilization are likely to be results of larger volumes. Additionally, while not explicitly expressed by any interviewee, it is reasonable to assume that larger EV fleets could pave the way for more efficient fleet capacity predictions. As stated previously, bids in the balancing markets are placed 1-2 days prior to the actual operating hour, creating a need for statistical models to predict aggregated EV capacity. Because of this, larger fleet sizes result in more available data which could be used to train and develop more accurate statistical models and predictions. This further strengthens the argument that increased volume is likely to increase resource utilization rate. As a result of the above, actors aggregating larger EV fleets than their competitors could potentially capture value through cost leadership while increasing created value through higher resource utilization.

In addition to the above, larger volumes of aggregated EVs could enable bridging of an identified barrier, potentially resulting in additional value creation. One of the expressed technical barriers presented in Section 5.1.1 *Technical Barriers*, were the large minimum bid size requirements, expressed by interviewees to hinder provision of several ancillary services. EV fleets of sufficient size could therefore overcome this barrier. As such fleets would offer enough capacity to offer provision of all ancillary services, there would be a wider array of choices when deciding which of the balancing market offers the most attractive choice for each operating hour. Overall, this results in potentially larger financial benefits over time and thus increased value creation.

The above implies that it is of importance for Circle K to establish a position where they control a large amount of EVs, aggregating a large amount of capacity to sell on the balancing markets.

6.4.2 Implications of the current regulatory framework

With the current regulations on the Swedish power market, the aggregator providing ancillary services need to be either balance responsible or have a contractual agreement with the balance responsible party for each EV customer whose flexibility is to be harnessed. This was expressed by the interviewees to act as a barrier in regards to reaching customers and hence as an important factor for capturing value. For Circle K as an electricity provider, this implies that it is likely valuable to both be a flexibility service provider and an electricity provider for the customers whose EVs are to be aggregated. The main reason is that the electricity provider is responsible for the balance of their customers. Due to this, if Circle K would position as both an electricity provider and a flexibility service provider, they would avoid the need to negotiate separate agreements for the BRPs of each EV customer opting in for flexibility services. In turn, this would result in an overall lower customer acquisition cost. In addition, assuming that all EVs aggregated also are electricity customers, this would directly result in the entire EV fleet being positioned under the same BRP. Following the logic presented in Section 6.1.2, this likely results in increased overall value retrieved from an aggregated EV fleet. Simultaneously positioning as an electricity provider additionally generates further possibilities as this is a presumably profitable business on its own, although those benefits are outside of the scope for this thesis.

As per the above, being positioned as an electricity provider can be seen as an advantage and the current electricity customers, especially those owning EVs, can be viewed as a valuable resource. From a resource point of view (Barney, 1991), these are likely rather hard or at least expensive to imitate. This could therefore serve as an isolating mechanism, increasing possibilities for value capture for Circle K.

6.4.3 Technical capabilities for maximal value creation

Expressed by the interviewees in Section 5.1.1 *Technical barriers*, it is a prevailing hurdle that most residential charging OEMs produce chargers unable to deliver ancillary services due to their lack of measurement capabilities. Hence, the right charger needs to be in place at the target residence for flexibility to be harnessed by an aggregator, if it is to be sold on balancing markets.

Further, statistical models and software capabilities were stated by interviewees to be important. As expressed, these are needed to predict available capacity from the aggregated EV fleet, as well as to derive bid-pricing strategies. The need for advanced predictive models are further supported by Andersen et al. (2018), showing in a study that using predictive models adapted for each individual EV driver increases revenue from ancillary service provision compared to using predictive models for an entire vehicle fleet. It was further expressed from the interviewees that electricity providers often lack the software skills and assets needed to develop these solutions in-house. However, as more advanced predictive models could result in additional resource utilization and hence additional value creation, following the same argument as in Section 6.4.1 *The importance of volume*, it is deemed important to access these capabilities either through building them in-house or through a strategic acquisition. As further expressed in the findings regarding customer centricity, it is also important that the solution is easy to use, integrated into the standard charging procedure and does not require any substantial effort for the customer. Thus, opt-in and usage should be integrated within the charging solution, which is often partially controlled via software interfaces in the form of mobile applications. Due to this, the competences related to building user-friendly software are likely also important and needs to be acquired or built in-house.

Additionally, as shown in Section 5.2.2 *The value created for the end consumer*, some customers are likely to find visualization of data regarding consumption, savings, and prices as important value-adding features. This is likely due to the fact that this offers extended knowledge about their charging behavior and how it can be altered, hence increasing the emotional value of control. This is already present in the solutions of actors on the market that offer flexibility services on balancing markets, such as Tibber and Greenely (Tibber, 2020; Greenely, 2022), indicating the possible importance of these features for some customers.

Overall, the above emphasizes the importance of capabilities related to building user friendly software to generate value for some customers. Hence, for electricity providers acting as aggregators and Circle K, it is important to possess both the statistical modeling and the software development capabilities needed to supply these services to increase both use value and exchange value for customers. In line with the definitions of use value and exchange value by Bowman and Ambrosini (2000), a well built software experience should increase use value while more efficient models that result in higher resource utilization could enable the aggregator to offer larger financial incentives to the end consumer while maintaining their profit margin. The latter is likely to increase exchange value. Additionally, it is important to ensure that targeted customers are those owning compatible OEM equipment with the specifications in place to fulfill the requirements needed to provide ancillary services on the balancing markets. Otherwise, additional hardware installations would be needed to provide ancillary services, impacting the overall business case if the cost were to be carried by the service provider and significantly reducing the value created for the customer if the cost were to be transferred to them.

6.4.4 The importance of communication

In the findings, the importance of clear communication towards customers was suggested. Of additional importance was to communicate all the different customer incentives: financial, environmental, and societal, as they can all be used to attract customers to participate while delivering value. Therefore, communicating the possible benefits while addressing concerns can be considered important. One could further argue that the need for clear communication, and the difficulty of communicating clearly, both increase the more complex the subject and the product is. In the case of a service regarding the aggregation of flexibility for balancing markets, as this thesis covers, it is clear that the subject is rather complex. This is further supported by the findings, as one interviewee expressed that customers view the products as being complicated. This implies that it is important for Circle K to not only communicate the possible benefits clearly, but also to package the product in a concise and simple way, enabling customers to understand the product to a degree sufficient for opting in. This is further in line with the value creation reasoning by Lepak et al. (2007), stating that the willingness to pay increases if the customer realizes the value of the product or service.

6.5 Revenue models as a means of value capture

From the interviews, different types of revenue model proposals were identified and presented. These revenue models were the following:

1. A percentage of the value generated from the flexibility is charged for the service
2. A monthly or yearly fee is charged for the service and the generated value from flexibility is transferred to the EV owner
3. The EV owner receives a discounted or free EV charger and the service provider receives the revenue generated from flexibility
4. Flexibility services are combined with other products to create a package, for example offering a discounted price for electricity if the aggregator is an electricity provider.

These four proposed ways of charging the customer can be mapped against three different revenue models: a commission revenue model, a subscription revenue model, and a bundling revenue model.

The first of the proposed models, where a percentage of the generated value is charged by the service provider, can be linked to a **commission revenue model**. This is enacted by the aggregator acting as a middleman (broker) between the EV owner and the TSO (Svenska kraftnät), charging a percentage cut from the sales value of the transaction. As commission models are especially appropriate when the broker plays a significant part in the sales process (Schlie et al., 2011), it could be suited for aggregators of flexibility as they enable the deal to take place at all, since the capacity from one EV is too small to be sold on its own. Two additional benefits with the commission model are the alignment of incentives and the avoidance of financial risk for the EV owner. Both of these arise as the commission model only generates revenue when a transaction is completed. Further, as no party receives any benefit unless a transaction is made, the incentives for the aggregator and the customer are completely aligned, which is stated as one of the benefits of the bundling model by Schlie et al. (2011). For the applied case, it creates a strong foundation for maximizing the value of flexibility. This could be constituted by e.g., the EV owner keeping the vehicle plugged in at all times when it is parked. Additionally, due to the transaction-based commission, there are no financial stakes for the EV owner as zero cost is incurred unless a beneficial transaction is completed, leaving no room for negative financial consequences. However, as the findings present, the financial compensation might be too low to incentivize EV owners on its own even if all of the generated revenue from the transaction is transferred. Thus, it might be suboptimal to further reduce these incentives by utilizing a commission revenue model as it would further lower the financial incentives.

The second proposed model, made up of a periodic fee, could be viewed as a **subscription revenue model**. This model has the benefits of offering continuous, stable, and predictable revenue for the aggregator while, like the commission model, requiring little direct financial investment from the EV owner (McKinsey, 2017). However, as further stated by McKinsey (2017) in the literature, the consumer makes continuous payments, which tend to constantly serve as a reminder of what they pay for, hence increasing the demand on the service to deliver continuous value. This could potentially be a problem for the service in question, as the monthly value generated can differ between periods and months as the prices offered for capacity in the balancing markets differ over the year (Svenska kraftnät, 2020a). This revenue model also incentivizes the customer to maximize the value from flexibility, as all generated value is transferred to the customer. Lastly, the same problem related to the possibly low financial incentives as mentioned for the commission model applies, since the financial value generated might be too small for EV owners to be encouraged to pay a monthly fee.

Both the third and fourth proposed models can be linked to a **bundling revenue model**, where different products or services are combined and sold in a package. The concept of bundling could be beneficial as it can tend to make customers pay more for the total package than for the products separately, as the value or the appreciation of the products used together increases, compared to if they both were purchased and used separately (Iveroth et al., 2013). Regarding the case of bundling the flexibility service with a discounted EV charger, synergies are created as a compatible charger is a prerequisite to supply ancillary services with the current regulations. Therefore, it is an efficient way to further nudge customers to purchase the compatible chargers and assist in overcoming the barrier of incompatible chargers expressed by interviewees. Thus, it could serve as a way to increase the shares of customers having the right charger in place, i.e., the number of targetable customers. If considering when flexibility services are bundled with retail electricity sales to offer a discounted electricity price, the synergies created instead stem from overcoming the barrier of reaching agreements with the separate BRPs of each EV customer. Thus, since balance responsibility is included in the role of electricity provider, this results in a beneficial position as discussed in Section 6.4.2. Due to this, more monetary value is left to be shared between the aggregator and the EV owner.

While both these bundling revenue models generate synergies together with the flexibility service, they could possibly also help alleviate the problem of limited financial incentives that the two prior revenue models were unable to. As these revenue models are bundled with products an EV owner likely needs to purchase whether they are interested in flexibility or not, such as electricity or an EV charger, solely receiving a discount should be incentivizing. Since opting for the service should result in no noticeable charging interference or associated extra cost, such an incentive is strengthened further. Hence, this could result in a situation where the buying decision is already done by the EV owner and opting in for flexibility services is merely seen as receiving a discount on the purchase. As a result, it might contribute to overcoming the hurdle of low financial incentives and make the overall offer more appealing.

Additionally, the bundling revenue models, just as the commission and subscription model do not require any large direct investment as required by an upfront-payment model. This feature is expressed by McKinsey (2017) to be a benefit. One could however argue that the EV charger constitutes an investment, if it is seen as something to be purchased by the EV owner independent of the flexibility service and thus can be seen as a separate investment. Lastly, the bundling model could also likely assist in overcoming the hurdle of low financial incentives for customer participation. This argument is further strengthened by Iveroth et al. (2013), arguing that bundling increases the willingness to pay of customers. This could itself imply that this revenue model is the most promising out of the proposed ones. However, there is low or no reason to propose these two bundles as separate packages, as the synergies from bundling flexibility services with electricity are different from the synergies when bundling it with a charger. Thus, the optimal package is likely a combination of all three parts - offering a bundle with a flexibility service, retail electricity, and a charger discount, as all components play an important part in creating and capturing value. Ultimately, what the bundling revenue models inherently lack is the component incentivizing the EV owner to maximize value from flexibility, as the EV owner is not directly awarded based on the value created from flexibility. Hence, to maximize value creation, this aspect should be considered and, if possible, elements should be added to the model to achieve adequate incentives.

7

Implications for Circle K

In this section, the final implications for Circle K are synthesized and presented. The implications are based on the findings presented and the related discussion.

FCR-D (up) is the optimal starting point for providing ancillary services on the balancing markets.
Due to the current balancing market conditions, FCR-D (up) is deemed the most suitable ancillary service because of its high prices, capacity remuneration scheme, low bid volumes, and having minimal impact on EV charging. However, the currently favorable market conditions are subject to change. Hence, it is important to note that even though FCR-D (up) is the optimal starting point when offering ancillary services from aggregated EVs, it should be seen as a starting point. From a long term strategic standpoint as a flexibility service provider, it should be seen as a springboard where capabilities can be developed in order to deliver flexibility services in an array of markets and geographies. Furthermore, the goal is to be agile in harnessing the flexibility from EVs, providing it where the most benefits can be realized in a given moment.

The value created from aggregated flexibility provided by EVs needs to be clearly communicated to the EV owners.
As a result of the possibly low overall financial compensation that can be utilized to incentivize customer participation, it is important to communicate the other values created. EV owners need to be informed that participation brings not only monetary benefits, but also societal and environmental benefits. Furthermore, it is necessary that the communication is clear and simple, especially as the nature of the product itself can be considered quite complex. Lastly, as important as it is to communicate the values created, it is important to communicate the close-to-zero impact on EV charging from providing ancillary services such as FCR-D (up). In the optimal case, it is a part of the day-to-day EV charging experience where the EV owner practically never notices the service at all, besides the communicated benefits.

The service should be easy to use and seamlessly integrated into the day-to-day charging experience.
The optimal service utilizing EV flexibility for ancillary service provision should impact the EV in the least possible way. Hence, it should be a part of the day-to-day charging experience through for example offering an opt-in feature in the same interface used to control other charging features. Lastly, it is essential that regardless of which ancillary service is provided, the vehicle is charged to the user's desired

level when needed.

Getting access to capabilities within statistics and software is important.
Statistical and software capabilities are essential to increase resource utilization and create enjoyable EV customer experiences. As earlier stated, having these capabilities can likely be important to maximize value creation and develop an easy-to-use service, while also being important in regards to capturing value. Thus, these capabilities are important to obtain, whether through building and developing them in-house, or through a strategic acquisition.

A bundling revenue model combining sales of EV chargers, electricity, and flexibility services should be utilized.
Through the use of a bundling revenue model, barriers relating to balance responsibility, incompatible chargers, and low financial incentives for EV owners can be reduced. As previously covered, supplying the electricity to customers diminishes the barrier related to contractual negotiation with the BRP of each EV owner. The sales of compatible chargers on the other hand increases the number of addressable customers owning the hardware needed to deliver ancillary services, hence diminishing the barrier of incompatible chargers. Additionally, since both electricity and EV chargers are purchased by EV owners whether they are interested in offering their EV flexibility for ancillary service provision or not, receiving discounts on those items could be compelling. Hence, this could likely reduce the barrier related to low financial incentives for EV owner participation as it shapes the incentives towards something rather tangible. Lastly, a component incentivizing customers to maximize the value from flexibility should be added to the revenue model, to maximize the overall value created.

8
Conclusion

As the energy system undergoes changes, new possibilities to both create and capture value emerges. Among the changes are increases in intermittent energy production and greater electricity demand from the electrification of e.g. transport and industry. These changes put greater strain on the electricity grid, but can be alleviated through increasing the amount of flexibility utilized in the system. While electric vehicles contribute to this increased strain, they can also act as a part of the solution through using their demand flexibility. When the demand flexibility of several EVs are aggregated, they can help support the electricity system through providing ancillary services.

Thus, this thesis has examined how an electricity provider such as Circle K can benefit from positioning as an EV aggregator, providing ancillary services from demand flexibility. First, through identifying the technical, regulatory, and financial barriers such actors face. Then, by finding the optimal ancillary service for value creation, and which value is created for the end consumer. Finally, how to capture value is described by identifying the most important factors for value capture, as well as proposing an appropriate revenue model.

Through the use of interviews and documents, several findings and implications have been discovered. First, a total of ten different barriers were identified. While varying in nature, some were expected to diminish over time and others can possibly be mitigated through the recommendations offered in this thesis. Then, the ancillary service deemed as optimal for value creation was identified as FCR-D (up). However, the service should be considered a starting point as market conditions may change, but can be utilized to build the capabilities necessary for profiting from flexibility in other markets.

Regarding the value created for the end consumer, four main values were identified: financial, environmental, societal, and information visualization. For value capture, it was found important to communicate all of these values to the customer efficiently, as the values may individually be too small and the service can be considered difficult to understand by the average customer. For similar reasons, the service should be simple to use to incentivize customer participation. To facilitate a satisfactory user experience and to make efficient use of aggregated resources, capabilities within statistics and software were considered important. Finally, an appropriate revenue model was found to be bundling the flexibility service with charging equipment and electricity.

8.1 Future research

This thesis provides a contribution to the understanding of how actors can begin utilizing the demand flexibility offered by EVs, and provides practical recommendations to consider when doing so. Future research could build upon the conclusions drawn in this thesis, and possibly complement and compare the results with research that focuses more on the customer. Since the interviews conducted in this thesis were with industry actors and academics, a consumer perspective could be valuable in creating a more nuanced understanding.

Another aspect that should be considered is how this being a single case study limits the generalizability of the results. Therefore, further research that could be conducted includes examining multiple cases in order to create a more solid foundation for generalizable results. Finally, differences between countries create avenues for future research as many nations have e.g., different designs of their electricity systems. Thus, the study could be repeated with other geographies in focus.

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A
Appendix

A.1 Interview guides

The questions in the following interview guides were used as a basis for the interviews conducted in the thesis. As the interviews were semi-structured, other questions were added either in order to follow up on what an interviewee responded, or if they possessed specific knowledge of interest to the thesis. The questions are divided into one guide specific to aggregators, and one to non-aggregators.

A.1.1 Interview guide for aggregators

- How is demand flexibility expected to impact the electricity system?
- What role are aggregated resources expected to have in the electricity system?
- What are your previous experiences of delivering ancillary services from demand flexibility?
- Which are the largest barriers obstructing actors from delivering ancillary services from aggregated EVs?
  - Have any technical barriers been identified?
  - Have any regulatory barriers been identified?
  - Have any financial barriers been identified?
  - What are the biggest implications of these barriers?
- Which ancillary services are deemed by your organization suitable for providing through demand flexibility?
  - What are the most important factors taken into consideration when deciding what ancillary service is the most attractive?
  - What ancillary services are you currently providing and what is the reasoning behind that decision?
- Which incentives are important for customers to participate with their EV?
  - Which of the incentives are the most important to make customers participate?
- How can aggregators create value for EV owners?
  - How large are the monetary values that could be created from providing ancillary services from one EV?
  - What factors determine the magnitude of the monetary value created?
  - Are there any values beyond those monetary that could be created?
- How do you think aggregators can capture value for themselves?
  - How can aggregators charge their customers for EV flexibility services?

  - In your organization, what model is currently used to charge the customer?
- Which actors are best positioned to become aggregators?
  - Are there any important assets needed by an actor to successfully deliver ancillary services from aggregated EVs?

A.1.2 Interview guide for non-aggregators

- How is demand flexibility expected to impact the electricity system?
- What role are aggregated resources expected to have in the electricity system?
- What do you believe are the largest barriers obstructing actors from delivering ancillary services from aggregated EVs?
  - Are there any specific technical barriers?
  - Are there any specific regulatory barriers?
  - Are there any specific financial barriers?
  - What are the most significant implications of these barriers?
- Which ancillary services do you believe are the most suitable for provision through EV demand flexibility?
  - What are the most important factors to consider when assessing attractiveness of an ancillary service?
- Which incentives do you believe are important for customers to participate with their EV?
  - Is there any specific incentive that you believe to be of greater importance?
- How can aggregators create value for EV owners?
  - How large are the monetary values that could be created from providing ancillary services from one EV?
  - What factors determine the magnitude of the monetary value created?
  - Are there any values beyond those monetary that could be created?
- How do you think aggregators can capture value for themselves?
  - How can aggregators charge their customers for EV flexibility services?
- Which actors do you believe are the best positioned to become aggregators?
  - Are there any important assets needed by an actor to successfully deliver ancillary services from aggregated EVs?

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