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Service Concepts for DC Fast Charging

A master thesis for ABB Switzerland

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Cover:
Figure 1. ABB Charging station prototype design of the so called “slim pole” (ABB marketing material).

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This master thesis has been written for Chalmers University of Technology, Sweden, and ABB ATP eMobility, Switzerland. The master thesis is the end of a Master of Science within Quality and Operations Management (300 Hp). However, it is also the start of my future working life. I have been part of ABB’s development team for five months. It has been a great adventure. I have gotten to know many amazing people and kick-started a future career. The eMobility field touches on many areas that interest me personally. Two examples are business development and the environment. Electric mobility will hopefully develop within the next years to be part of the solution to the environmental problem originating from oil dependency.

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David Gustafsson

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ABSTRACT

Service development is often an ad-hoc process within companies that follows after a product has been launched. At ABB ATPS, Switzerland, management wants to take a proactive approach to developing services for the DC fast charging product aimed at electrical vehicles (the so called eMobility market). The purpose of this project has been to identify and evaluate different ideas for services around the DC fast charger and finally post recommendations for which service concepts that should be undertaken by ABB. The study was delimited to customers that are potential buyers of complete charging units. Examples are utilities, cities, countries, petrol stations, shopping malls or private fleet owners of electrical vehicles.

The methods used in this thesis include internal brainstorming, customer interviews and industry benchmarks to find ideas for services and inspiration for service evaluation. To evaluate the ideas surveys were distributed to both customers (a Kano survey) and ABB employees. This enabled studying market requirements, internal strategic fit, internal strategic intent and the alignment between customer requirements and strategic fit.

The results of the study includes that customers are most keen on simple services with a clear added value. Technically immature customers, such as cities, have higher requirements for solutions compared to for example utilities. Six service concepts were put together from the service ideas. These service concepts are the answer to the purpose of the report.

- **Action related services** were identified as service ideas related to what the customer can do with the product. A gap was found between ABB employees and customer needs implying that ABB could benefit from focusing on this area. As an example, management and payment systems are important for many customers.
- **Sales service** is pointed out as important both from the market and internally. The service can be executed with relationship marketing or by using information material. Local ABB offices can also be leveraged as for other products. Sales services generate indirect revenues due to increased likelihood of sales.
- **Consulting services** and especially network studies are attractive to some customers (such as cities) and can distinguish ABB from competitors. Knowledge to do network studies should be acquired either by partnerships or hiring internal competence.
- **Project management services** do not have a strong market and business potential. However, installation and commissioning is necessary. Installing and taking the charger in operation must be a simple process that can be executed by local ABB service engineers.
- **Services during the product's operational life** are a key service concept. If the customer has a low maturity and few installed fast chargers, it makes sense for ABB to take the risk of product failure and sell maintenance contracts. If not, the customer is better off with an internal service organization that buys training and spare parts from ABB.
- **End of life services** are a major opportunity once the product has matured. ABB should follow the directives from RoHS and WEEE for recycling. A refurbishment centre could be built within ten years for buying, repairing and re-selling fast chargers.

Keywords: *Service concepts, Service development, Kano survey, eMobility, DC-fast charging*

SAMMANFATTNING

Tjänsteutveckling är ofta en oplanerad aktivitet i många företag som sker efter att en produkt har lanserats på marknaden. ABB ATPS, Schweiz, vill dock arbeta proaktivt med serviceutveckling för snabbladdaren över likström som utvecklas för elbilar (eMobility). Syftet med exjobbet var att utveckla och utvärdera olika serviceidéer för att slutligen rekommendera de servicekoncept som ABB skulle kunna erbjuda. Kunder inkluderar de företag som kan tänka sig att äga en snabbladdningsenhet för elbilar. Exempel är nätbolag, städer, länder, bensinstationer, köpcenters och ägare av privata elbilsflottor.

Intern brainstorming, kundintervjuer och benchmarks har gjorts för att generera idéer och inspiration. För utvärdering av idéerna har två enkäter genomförts, en intern inom ABB och en extern till kunder. Förutom att mäta de två gruppnas åsikter kunde även passningen mellan dem utvärderas och besvara frågan om kunder och anställda prioriterar samma idéer.

Resultatet visar att kunderna är ute efter enkla tjänsteidéer med ett tydligt direkt värde. Det går också att se skillnader mellan olika kunder beroende på teknisk och servicemässig mognad. Städer efterfrågar till exempel ett bredare åtagande från leverantören än elbolag. Följande tjänstekoncept besvarar rapportens syfte:

- **Användningsrelaterade tjänster** anses mer attraktiva av kunden jämfört med hur de värderas av ABB-anställda. Ett styrsystem, statistikverktyg samt betalningssystem är viktiga produktegenskaper som enligt kunderna bör finnas. Övriga kringtjänster var inte speciellt intressanta. Detta är framförallt viktigt att tänka på i produktutveckling.
- **Säljtjänst** – En säljtjänst efterfrågas från både kunder och internt. Säljtjänsten bör differentiera mellan olika kundsegment beroende på mognad och projektstorlek. Att bygga kundrelationer via lokala ABB-kontor bör utnyttjas. Dessutom bör informationsmaterial skapas.
- **Konsulttjänst** – Nätstudier är attraktivt för vissa kunder och skulle kunna differentiera ABB. Tjänsten kan levereras via partnerskap eller genom att skaffa kunskap internt.
- **Installation och överlämnande** har dålig lönsamhet men bör av juridiska anledningar tillhandahållas. Tjänsten bör kostnadsoptimeras och utföras av lokala ABB kontor.
- **Underhållstjänster** identifierades som viktiga av kunder och internt. Att göra underhåll åt kunden är relevant när kunden har få snabbladdare och/eller en omogen organisation. Omvänt, bör kunden ha en egen underhållsorganisation och köpa reservdelar och träning från ABB. Totalt årligt underhåll motsvarar ungefär 8% av hårdvarukostnaden på $20’000. Utryckningstjänster motsvarar 85% av det årliga underhållet. Aktuella reservdelar är till största delen inte ABB tillverkade (86%). Därför är bruttomarginalen för reservdelar relativt låg.
- **Tjänster efter uttjänande** är attraktiva för kunderna och av lönsamhetsskäl. Tjänsten bör tillhandahållas först om tio år. Ett renoveringscenter bör då skapas för gamla komponenter och snabbladdare, atervinning bör också göras och WEEE och RoHS bör tas i beaktande. Lönsamhet kan förväntas på grund av högt råvaruinnehåll.

Nyckelord: *Tjänstekoncept, tjänsteutveckling, Kano-enkät, eMobility, DC-snabbladdning*

Contents

Taxonomy

Action related service	Service related to using the product. Examples are selling coffee, having available Wi-Fi with the charger or enabling a payment service with the charger. These services converge with features that need to be developed in product development; however they have been included in the service idea evaluation in this report.
Charging unit	A charging station for electrical vehicle.
Charging system	A complete charging system comprising of a network with multiple *charging units*.
eMobility	Market for products and services connected to the electrical vehicle (EV) or plug-in hybrid electrical vehicle (PHEV). Common term adopted by most companies.
Product related service	A concept for the services related to optimizing the function of the product. Examples are sales service, maintenance and end-of-life services.
Repowering	Technique for getting a fully charged battery. A repowering solution can be based on DC-fast charging, DC-slow charging, battery swapping or some other technique. In contrast to the petrol market it is not evident which repowering solution that is best; the three major technologies have all advantages and disadvantages.
Range anxiety	Concept meaning that EV drivers do not use the full battery range when they are anxious that they cannot repower. Increased possibility for repowering lowers the range anxiety.
Service	In this report the more traditional definition of service will be used as something that is not hardware related or tangible. *"A service is something which can be bought and sold but which you cannot drop on your foot"* (Gummesson 1987, p.22). The reason for this is that a broad view of service concepts has been taken including *action related services* that also tie close to product features. In today's society the border between services and products is vague; music might for example be considered a product despite being intangible. See also *product related service* and *action related service*.
Service concept	According to Meyer-Goldstein et al. (2002, p.121) "The service concept defines the *how* and the *what* of service design". In this report, a service concept will be considered as a business model/concept for <u>one</u> type of service. Service concepts could be combined independently to comprise the *total service offering*.

Service contract	A service agreement setup between a hardware owner and a service organization. If nothing is specified this report defines a service contract as a contract where the supplier's service organization guarantees certain performance in exchange for a recurring revenue stream. Normally this means guaranteeing uptime or response time to accidents (break down risk taken by service organization) but it could also mean a spare part agreement (break down risk taken by customer).
Total service offering	A set of service concepts that comprise a company's offering in a certain market.

ABBREVIATIONS

AC	Alternating Current
API	Application Programming Interface
B2B	Business to Business
B2C	Business to Consumer
DC	Direct Current
DB	Data Base
EOL	End Of Life
EV	Electrical Vehicle
GPRS	General Packet Radio Service
HW	Hardware
IB	Installed Base
IO	Input-Output
IP	Intellectual Property
KPI	Key Performance Indicator
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
TTR	Time To Repair
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PRS	Product Requirement Specification
PV	Petrol Vehicle
QFD	Quality Function Deployment
RFID	Radio Frequency Identification System
RoHS	Restriction of Hazardous Substances
SLA	Service Level Agreement
SW	Software
WEEE	Waste Electrical and Electronic Equipment

1 Introduction

This section presents the background to why the project is conducted. It also defines the specific purpose and the research questions that are based on the purpose.

1.1 Task background

One of today's macro trends in business is that service tends to be a higher part of manufacturing companies' revenues. The percentage of people employed in the service sector as well as the percentage of GDP resulting from services has increased over the past decades in industrialized countries (Grönroos 2007).

The reasons for an increased focus on services are many and they can, according to Nutek (2008), be grouped into financial and market benefits. Financially, services often bring higher margins, increased revenues and are less risky than core product sales. One reason for the financial benefits is the market benefits that include better differentiation which lead to competitive advantage. Customer relationships that are built from services increase the chances of future sales and contribute to an increased understanding of customer needs (ibid).

Even though services have gained increased recognition, few companies lack a service structured development process. Product development processes have been explored by researchers and are nowadays part of every company. So called stage gate models are used for structuring the development from idea to product launch (Wheelwright & Clark 1992). However, the processes used for new service development are to a much greater extent ad hoc or/and not existing in industry. Of the companies studied by Tekes (2003), none had a specified service development process.

The thesis is supported by ABB ATPS, which is the service department within ABB Power Electronics and Medium Voltage Drives in Turgi, Switzerland (ATP). The study is the start of a process where ABB ATPS aims to take control over service development. The department wants to have a proactive approach to development and define what is required to be a market leader in services for the DC fast charging product at an early stage of development. This approach to service development is pioneering within ABB and for many reasons also within industry in general. The results of this project might stimulate an increased focus of proactive service development; both within industry and within ABB.

1.2 Company background

ABB is a global supplier of power and automation technologies. The product offer is diversified and covers power products, power systems, discrete automation and motion, low voltage products and process automation. The ABB group operates in around 100 countries and has about 117,000 employees. ABB's vision and tag line is *"Power and productivity for a better world"* (ABB 2011a). The core of this business concept is that ABB is building products that help customers run their businesses more efficiently, with a higher output and quality.

ABB has headquarters in Switzerland. The company was created when Swedish ASEA merged with Swiss Brown Broveri in 1988. ABB Group had revenues of $32b in 2009 and spent the same year $1b on R&D. By investing in R&D, the company aims to continue a history of leading the development within power and automation (ABB 2010a).

ABB ATPS is organized within the Power Electronics and Medium Voltage Drives business unit. Power Electronics makes products for converting between AC/DC current for mid- and low voltage applications. Medium Voltage Drives uses the same core technology for varying frequency of a current (going from AC to DC and back from DC to AC with a new frequency) in the 315kW to 100MW segment. This is used as an electrical gear box in for example trains and large ships since the frequency is directly proportionate to the speed of a motor (ABB 2010b).

eMobility is a new emerging market where ABB ATP aims to be a key player. With a history of supplying power products, such as AC/DC-converters, power electronics and drives, the company has the fundamental knowledge of the technology in the eMobility market. ABB ATP in Turgi, Switzerland, is in this stage developing products and capability to enter the charging equipment market for electrical vehicles (EV) and plug-in electrical vehicles (PEV). First generation product releases are available for prototype installations but there is still work to be done in development before the product is fully launched. A cost optimized mass produced product is planned to be available in the beginning of year 2012.

Traditionally ABB ATP has been selling core products with a service offering limited to installation, sales of spare parts and upgrades of existing installations (both replace and repair solutions). Training and commissioning have also been part of the service offering. This strategy has been appropriate for the market ABB is competing in, which has been adopting the same business model for decades. However, what services that is wise to offer within eMobility is not yet clear.

The current business plan suggests that ABB will enter the market as a business-to-business (B2B) charging unit supplier. This implies that ABB will offer the core charging station product but not own or operate a network of charging stations. However the core product might be network enabled so that many charging units can work together in a system. ABB will however not target the end users/consumers who drive electrical cars. The EV drivers are targeted by one of ABB’s planned customer segments, the charging system owner. Apart from charging system owners there are a range of potential customers. ABB will also deliver assemblies (such as the charging engine or power electronics equipment) and sub components (e.g. transistors) that will be part of charging units for other suppliers. Figure 2 illustrates the DC fast charging value chain and where ABB aims to be positioned.

There is a belief among both the service (ATPS) and the business development (ATP) departments that service has a great potential to be part of ABB’s final value proposition. In the ABB Group, services accounted for 15.6 % of the total sales in 2009 (ABB 2010c). The long term strategy is to increase the service content in ABB's total offering to around 25 % (ibid).

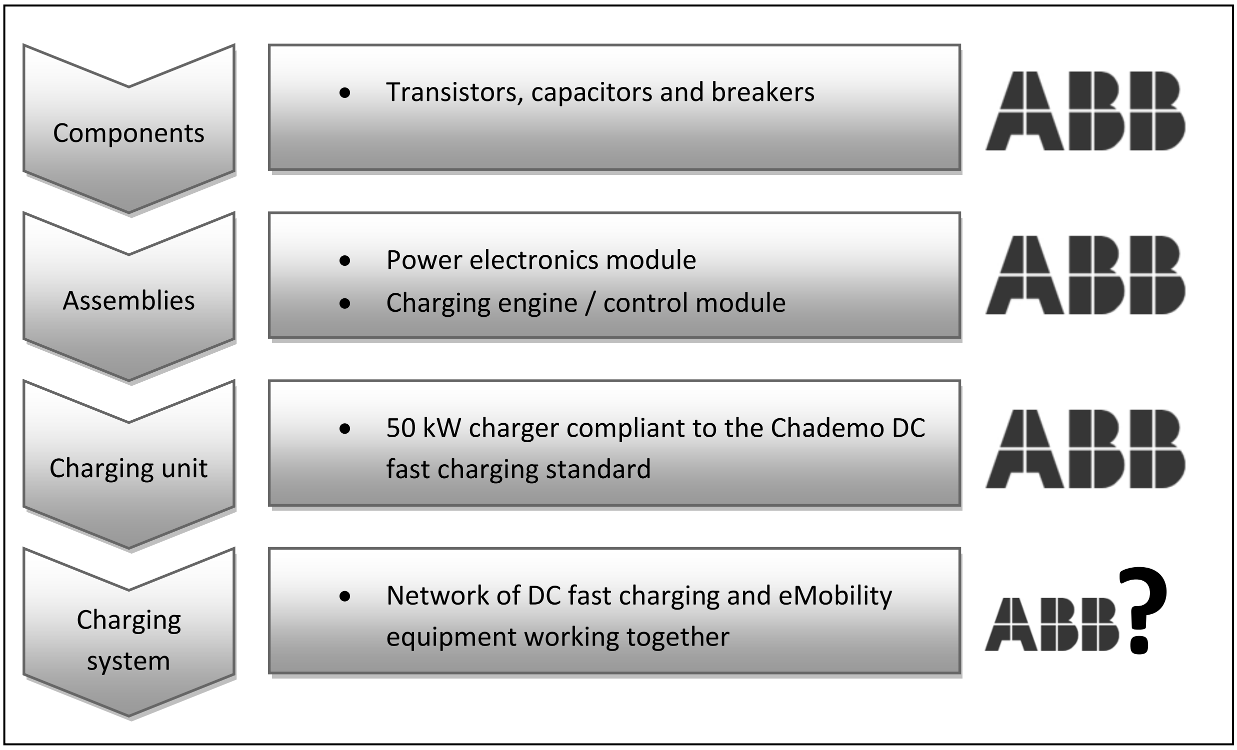

Figure 2. Topology of DC fast charging supply opportunities for industrial companies. ABB aims to deliver solutions for at least the top three layers (author based on internal business plan).

1.3 PURPOSE

The purpose of the thesis is to develop a set of service concepts for ABB's DC fast charger, which combined make up ABB's recommended totals service offering.

1.4 DELIMITATIONS

A service concept should be seen as a prototype for a particular service (Edvardsson & Olsson 1996). According to Grönroos (2007) a service concept has two parts. The *what* part of the concept identifies the needs and requirements that the service will satisfy. The *how* part describes the offering that will give the intended output (ibid).

In Figure 3 a hierarchical model of service development is presented (Edvardsson & Olsson 1996). The service concept is part of this model. At the lowest level of detail a service idea exists as a tagline for the service. The service concept is slightly more detailed describing what is required by the service (what needs it covers) and how the service fulfills these needs. On the next level of detail, service processes define with higher details how the concept is delivered. The service process layer often uses service blueprints (or process maps) to map out the detailed activities that comprise the service delivery.

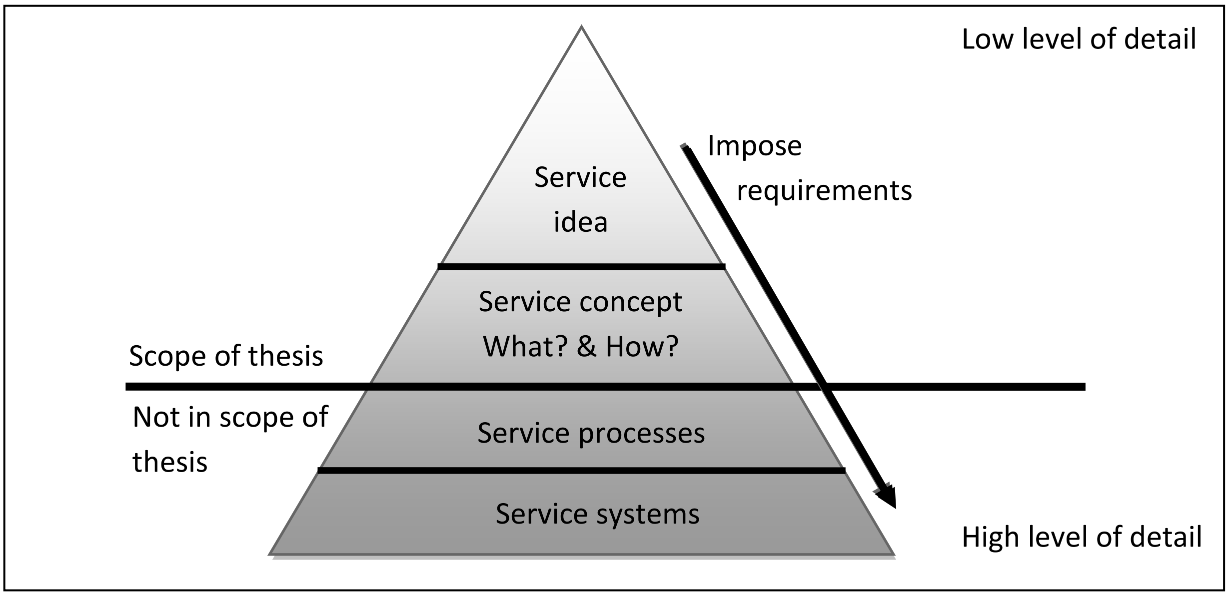

Figure 3. Model of the prerequisites of the service. Adapted from (Edvardsson & Olsson 1996, p. 157).

This thesis is delimited from developing detailed blueprints for how the service delivery should be made. The thesis resides at a strategic service concept level. In this report, a service concept is considered as a business model for one type of service. Service concepts could be combined independently to comprise the total service offering.

The DC-fast charger has the capability of charging a car battery in a time frame of 10-30 minutes using the Chademo protocol. The master thesis only studies the DC-fast charger product and its market. The thesis is thus delimited from the slow charger and other products in ABB’s total eMobility portfolio.

ABB is looking at potential customers in a range of different segments. One example is that battery suppliers need charging for testing at the end of each assembly line. This thesis is constrained to only study customers that will buy fast chargers for charging of electrical cars (i.e. not for industrial charging applications). The thesis also only focuses on customers of the at least the charging unit level. Charging assemblies and components is left outside the scope of the thesis. One justification for this is that it is unlikely that the charging unit supplier will buy service contracts for particular components or assemblies within the unit. However, it could potentially be the case, but if so the services that might be requested from this customer would also likely be a subset of ABB’s total service offering. Another reason for leaving these customers outside the scope is confidential supply agreements.

The aim for the product development project is to sell to customers on a worldwide market. To do a worldwide study customers need to be stratified over different regions of the world. This is however outside the scope of the thesis, since it requires too much time and resources. It is also infeasible due to the immatureness of the market.

1.5 PROBLEM ANALYSIS

Many authors have come up with frameworks for new service development, Table 1 presents some examples. The similarities to product development frameworks are many and authors of product development literature often argue that frameworks for product development could also apply for service development (e.g. Wheelwright & Clark 1992).

Table 1. A selection of frameworks for service development (author).

(Browers 1986)	(Scheuing & Johnson 1989)	(Tekes 2003, p.38)	(Grönroos 2007, p.192)
1. Develop a business strategy 2. Develop a service strategy 3. Idea generation 4. Concept development and evaluation 5. Business analysis 6. Service development and evaluation 7. Market testing 8. Commercialization	1. New service strategy & objectives (external analysis) 2. Idea generation 3. Idea screening 4. Concept development 5. Concept testing 6. Business analysis 7. Project authorization 8. Service design and testing 9. Process and system design and testing 10. Marketing program design and testing 11. Personnel training 12. Service testing and pilot run 13. Test marketing 14. Full scale launch 15. Post launch review	1. Innovation and idea 2. Concept planning 3. Service development 4. Business concept 5. Service implementation and delivery	1. Analysis of customers' everyday activities and processes 2. Assessment of customer benefits sought to support these activities and processes 3. Defining overall features of an augmented service offering 4. Defining a service concept which guides the development of the service offering 5. Developing the core, enabling and enhancing services 6. Planning the accessibility, interaction and customer participation elements of the augmented service offering 7. Planning supporting marketing communication 8. Preparing the organization for producing the desired benefits…

As for product development there are many different ways to reach an end result. Bitran and Pedrosa (1998) describe how development starts with ideas and gradually evolves to more information rich formats as knowledge is added to the design with the help of methods and tools. This is a commonality between the frameworks above. The following process framework (Figure 4) is used in the thesis.

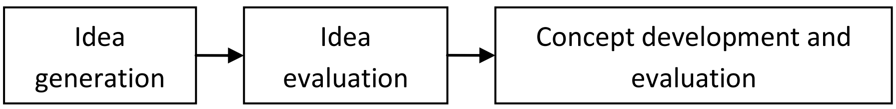

Figure 4. The framework for breaking down the purpose of this thesis into process steps. Each step is addressed separately (author based on the frameworks in Table 1).

The process starts with generating ideas for different services. The following research questions have been addressed under this process stage.

IDEA GENERATION

RQ 1.1. What service ideas can be found in the eMobility market for the DC fast charger product?

RQ 1.2. What requirements do the customers have on service concepts for DC fast charging?

RQ 1.3. What service ideas and success factors can be found from service benchmarks?

These service ideas have to be evaluated based on certain criteria. Bitran and Pedrosa (1998) recommend that an internal and external perspective should be used to make a strategic assessment of service ideas. During a brainstorming activity four dimensions were found to be important for the strategic evaluation. The dimensions are customer value, internal strategic fit and competitive benchmarks. The following research questions are asked based on the criteria to evaluate service ideas.

IDEA EVALUATION

Customer

RQ 2.1. What is the customer feedback of the service ideas?

RQ 2.2. How do requirements differ between customer segments?

Internal

RQ 2.3. What strategic fit does each of the service ideas have?

RQ 2.4. What strategic intent does ABB have for each of the service ideas?

Customer compared to internal

RQ 2.5. How does ABB's perception of strategic fit align with customer value?

Competitive benchmarks

RQ 2.6. What services are competitors offering?

Based on this evaluation, requirements have been put on the service concepts. It is now possible to go from service ideas to more defined and exclusive service concepts. The requirements from the service ideas that make up the concepts define the *what* part that should be delivered in each service concept. The concept development and evaluation phase tries to answer the *how* part of each service concept. Each concept is also evaluated from a profit standpoint. The profit evaluation is done in the concept stage since it reduces the need for making assumptions already on the idea level.

CONCEPT DEVELOPMENT AND EVALUATION

For each service concept the following questions are asked:

What

RQ 3.1. With the given idea evaluation and requirements in mind, what needs to be delivered in this service concept?

How

RQ 3.2. How can/should the *what* part of the service concept be realized?

Profit potential

RQ 3.3. What is the profit potential for the service concept?

1.6 Disposition of the report

Figure 5 depicts the structure of the report. The last part of the introduction, chapter 1.7, gives a presentation of the eMobility market. The market has two sides of dynamics. On one hand electrical cars have to be bought by customers. A prerequisite for this is that infrastructure to repower the cars exists. The infrastructure, on the other hand, needs electrical cars to find a profitable business model. Both the electrical car and infrastructure will hence be described. Describing the market is important to get an understanding of the business dynamics.

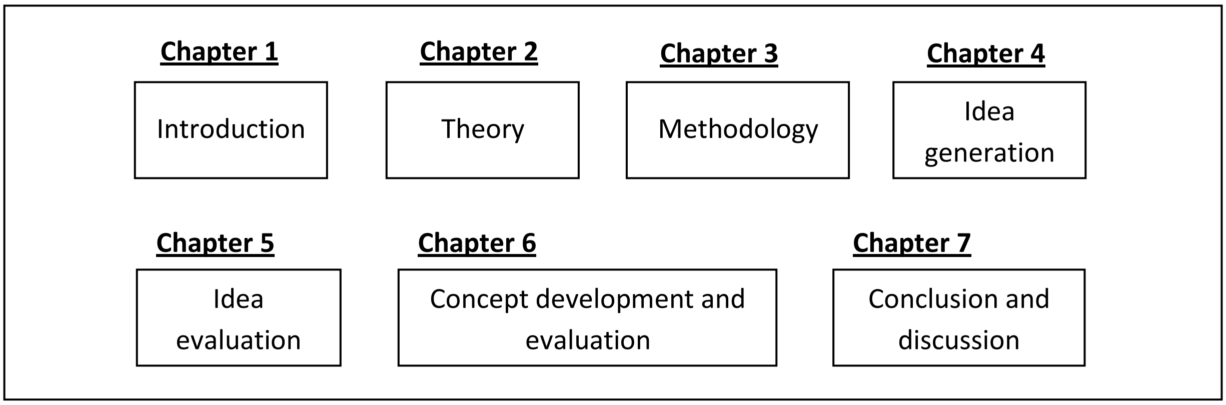

Figure 5. Disposition of the report (author).

After the introduction, theory (chapter 2) that later will be used to address the problem is presented followed by the methodology (chapter 3) of the study. The methodology explains how the purpose has been addressed. Just as for the rest of the report the methodology is structured according to Figure 4. The methodology ends with a discussion about reliability and validity.

The main part of the thesis combines data presentation and analysis. First of all the results of the idea generation stage is presented in chapter 4. These results serve as input to the idea evaluation (chapter 5) stage which in turn provides input into concept development and evaluation (chapter 6). As far as possible the analysis is made objectively from the data; however it is inevitable to make certain interpretations and decisions in early process stages in order to make further analysis later. Conclusion, presenting the service concepts sought for in the purpose, and a discussion about the concepts, end the thesis in chapter 7. Chapter 7 also discusses the implications the study has for research and suggestions for future research in order to deepen the knowledge in the topic.

1.7 THE EMOBILITY MARKET

The eMobility market is a complex network with many stakeholders. Figure 6 draws a canvas depicting the market. The EV user, buyer and owner are in the middle and the actors further downstream in the value chain.

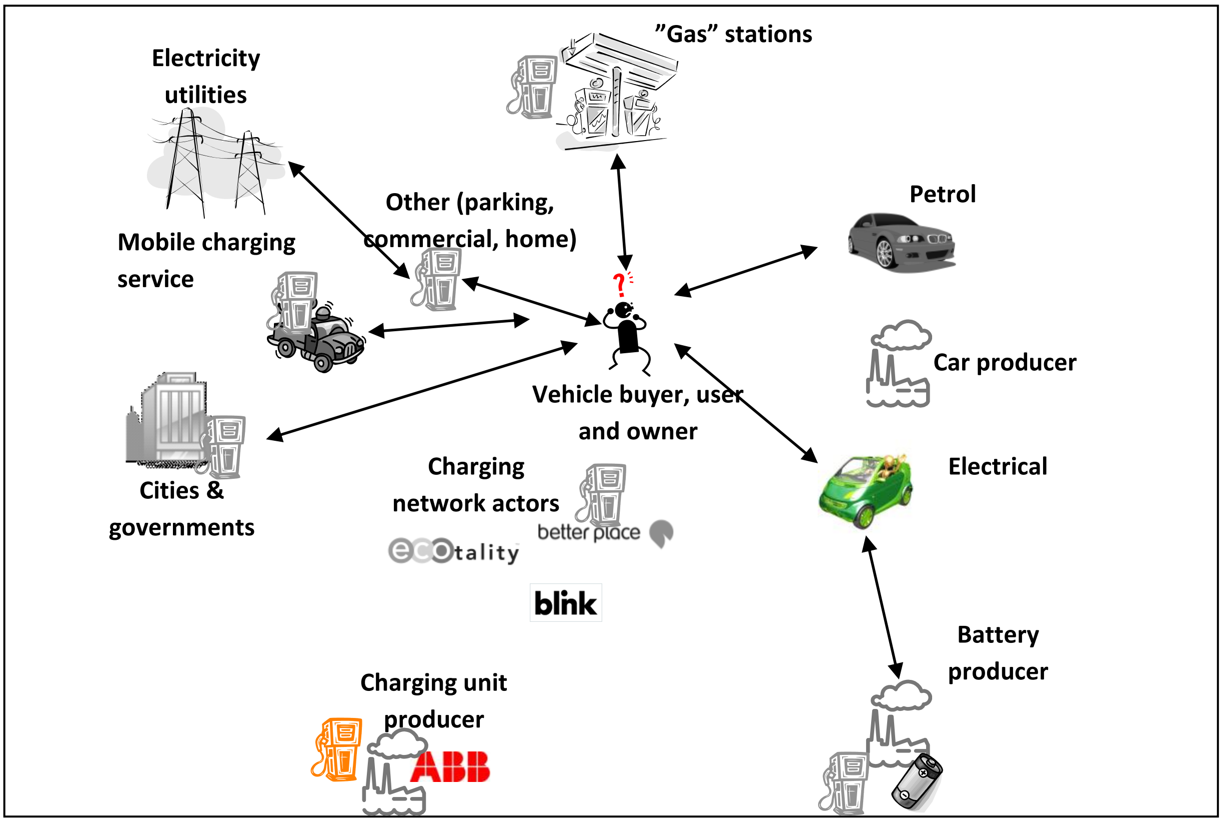

Figure 6. An eMobility market canvas (author).

The EV customers will be the drivers of the eMobility market since they will in the end be using and paying for the development and operation of the network. The first part of this section examines the dynamics for when drivers will start to prefer electrical over petrol vehicles. After this, the infrastructure to repower the vehicles is looked at. It is important to get a background of the market before moving on to interview customers and develop service concepts for them.

1.7.1 Hybrids, plug-in hybrids and full electric vehicles

Apart from full electrical vehicles there are combinations of petrol and electrically propelled vehicles. Hybrid electrical vehicles (HEV) have a petrol engine and an electrical motor with a small battery. The electrical motor runs in city traffic but petrol is used for longer distance drives. The HEV is not charged off the grid, charging is done when breaking and using the car. A plug-in hybrid electrical (PHEV) vehicle is similar to a HEV but has a larger battery (Chevrolet Volt has 16kWh capacity) that can be charged off the grid. The electrical range of a PHEV, like Chevrolet Volt, is 65 km (Chevrolet 2011), which is the same as the average distance that 78 % of all Americans commute per day presented by Jobin et al. (2009). Since the PHEV has a range that is sufficient to cover one day's commuting it is unlikely that fast charging will be used for those vehicle owners. Especially since the charging cost is likely to be lower when plugging in at home compared to charging at a fast charging station. If running out of power the PHEV owner would go the last distance with petrol and then charge at the destination. The EV owner must, on the other hand, have power in the battery since no petrol reserves exist. Using fast charging would hence be more applicable for this segment. Appendix 1 provides a list of full electrical vehicles that can be bought today.

1.7.2 What is driving the shift to electrical vehicles and when is it coming?

In the beginning of the 20th century electrical cars were ahead of competition from substitute products. The EV had low vibration, smell and sound, together with a relatively competitive range (better than the steam car). The electrical car holds the record of being first over the 100 kilometer per hour speed barrier (Wikipedia, *Electric Car*). By 1910 the shift started from electrical to petrol vehicles led by the development of the internal combustion engine, cheaper access to oil and the era of mass production (Jobin et al. 2009). It all came down to a matter of performance; the petrol-car eventually had a longer range, was faster and became the cheapest alternative.

Today transportation is a major industry. The car fills a very important need in most developed countries. Petrol prices have risen ever since the combustion engine was invented but our need for transportation is so strong that it does not fall with rising prices; instead rather the opposite has been true (GP 2011-03-14). So will a shift in propulsion technology happen again? Table 2 provides an overview of both the drivers and the obstacles towards change.

Table 2. Factors influencing the transition to eMobility.
Source: Compounded from research reports by Pike Research (Gartner & Wheelock 2010), Morgan and Stanley (Steinmetz & Shanker 2008), Credit Suisse (Jobin et al. 2009), Boston Consulting Group (Dinger et al. 2010) and Roland Berger (Valentine-Urbschat & Bernhart 2009).

Drivers of change	Obstacles towards change
Environmental forces - CO_2 emission requirements on car manufacturers force a change. - More environmentally conscious customers. - Efficiency (well-to-wheel) beats alternatives with factor two (even when power comes from coal). **Political** - Government grants and support programs. **Mileage price** - Oil/petrol prices rising. - Green kilometer/mile cheaper. **Performance** - No sound or fumes.	**Higher costs** - Of electrical vehicles - Of batteries **Battery** - Safety - Lithium availability - ability to scale production - Lifetime issues **Infrastructure to recharge** **Performance** - Range - Speed - "Car feeling" – sound and smell - Size limitations
← Total cost of ownership →	

Many research institutes indicate that the transition to EVs will start in this decade. However it is uncertain in which form the market will shape and in what speed.

> ***"We wish we had all these answers but at this stage we do not, as in many countries politics may play as important a role as economics. However, what we can calculate is the economics of the electric car, which we find quite compelling, and when one adds to that the potential CO_2 benefits as well as the security considerations, we have no doubt that some form of either EV or HEV transport will grow rapidly in the next decade."(Jobin et al. 2009, p.9).***

The major issue in the transition will be the total cost of ownership (Jobin et al. 2009), just as it was when the transition in the early 20th century took place. Jobin et al. (2009) indicate that there will be a few customers who are willing to pay uneconomical prices for electrical vehicles, but that the majority will make the switch when it is cost efficient. The economics depend on a few factors including payback period, battery cost per kWh, petrol price, how often/far the vehicle is driven and tax subsidies from governments. With today's (2011) situation, the EV is not cost efficient and some of these variables have to change. Everything points towards that a change will eventually happen in petrol and battery prices. Petrol is a finite resource and economics of scale will drive battery prices down. The question is when it has changed for the transition to EVs to be cost efficient?

Valentine-Urbschat and Bernhart (2009) write that governments have had and will have a big role to play in the transition towards EVs. Two examples of today are Portugal and Ireland that provide subsidies for buyers of electrical vehicles. In Portugal EV buyers get $7k in tax incentives and $10k for trading old vehicles (Darragh 2010) and in Ireland the grant is on €5k (The Irish Times 2010). With the current petrol price ($3/gallon) and battery technology, these grants are sufficient for a transition to EVs to be economical in those countries according to Jobin's et al. (2009, p.19) analysis of breakeven (see appendix 2). Other governments, such as Denmark, have the strategy of placing high taxes on petrol vehicles to make EVs more competitive. Giving away charging and parking for EVs is another shifting strategy used in the city of Amsterdam.[1]

Apart from the cost issue, the performance of EVs compared to petrol vehicles must be discussed. Nissan Leaf is an EV with a 100 mile range (Jobin's et al. 2009) which already today is sufficient for a large portion of the market. However this is still a main concern for many drivers who do not want to restrict their options even though the vast majority of travels can be covered within the 100 mile range. European Automobile Manufacturer's Association (2010) writes that the combustion engine will be the preferred choice applications that require range, light weight and speed. The EV is also less reliable in cold weather.

[1] Interview with city of Amsterdam, Ronald de Haas, Project manager for eMobility, 2011-03-10.

The environmental considerations are the basis for governments favoring electrical vehicles which emit less CO_2 and other particles leading to greener city centers and less global warming. Air pollution is today a major problem in large cities around the world. Another problem with petrol cars is the dependency on imported (for most western countries) oil. The global transportation sector accounts for 72% of the world's oil dependency and 30% of all CO_2 emissions (Jobin et al. 2009). With the current fleet of power plants that will charge the EV infrastructure, the EVs generate the least amount of CO_2 emissions per km. Looking at efficiency, EVs are also more efficient than other forms of powering cars with more than twice the efficiency of a hybrid car when it comes to km/kWh (Jobin et al. 2009). This is because the energy that powers an electrical vehicle is generated in a highly efficient plant and there are comparably low losses from generation in the plant until consumption in the car. The EV charging also does neither have to refine a propellant, which is the case for hydrogen or petrol powered vehicles. Brown, Atherton and Lawson (2009) present an analysis of the well-to-wheel efficiency of petrol versus electricity when both are generated from fossil fuel. The efficiency is 20-40 % for EVs and 12-30 % for petrol vehicles.

A current debate is whether it is worth investing vast amounts in EV development and infrastructure when small incremental developments of the petrol vehicle can reach CO_2 targets for a long time ahead. It is also not certain if electricity is the choice of the future when hydrogen and fuel cells could be other good alternatives. Valentine-Urbschat and Bernhart (2009) mean however that petrol development has certain limits and even if petrol and diesel engines improve by 40% until 2030 the targets set by for example EU will not be met. The current OECD average emission for light duty vehicles is 176 g CO_2/km and the goal set for 2030 is below 90 g CO_2/km (Valentine-Urbschat & Bernhart 2009). This EU goal is set for the vehicle fleet on average which means that new vehicles sold 2030 must have emissions below 60 g CO_2/km for the total average target to add up (ibid). 60 g CO_2/km represent an average fuel consumption of the car manufacturer's fleet to be 2.5 liter per 100 km. Today 176 g CO_2/km represent an average fuel consumption of 7.4 liter per 100 km. The EU targets are slightly harder than US and Japanese restrictions. It indicates that governments take environmental impact increasingly more serious. However, there is today no European legislation for emissions that are binding. The figures are only targets set up together with manufacturers. Small car manufacturers such as Fiat follow the targets, but for example BMW, Porche and Audi do not. Discussions are held in EU if binding legislation should be put in place (Wikipedia – *European emission standards*).

Jobin et al. (2009) mean that the industry has reached a plateau of efficiency at about 25 miles per gallon and with petrol engines alone it is not likely that great improvements will occur. Jobin et al. (2009) further writes that even if efficiency will increase in petrol vehicles this does not solve the dependency of oil. The number of cars in the world is steadily increasing. This further favors a transition towards electrical vehicles that might be the solution to the transportation efficiency dilemma.

47'952'995 cars were produced in 2009 and this figure has been increasing with 2% annually for the past ten years (OICA n.d.). In 2015, researchers believe that about 1 million of the 53.6m cars produced are electrical (roughly 2% of sales). Figure 7 shows three research reports that have looked at EV sales forecasts. The projections made on the electrical vehicle market shows an exponential growth rate that takes organic growth and available raw material/resources into account.

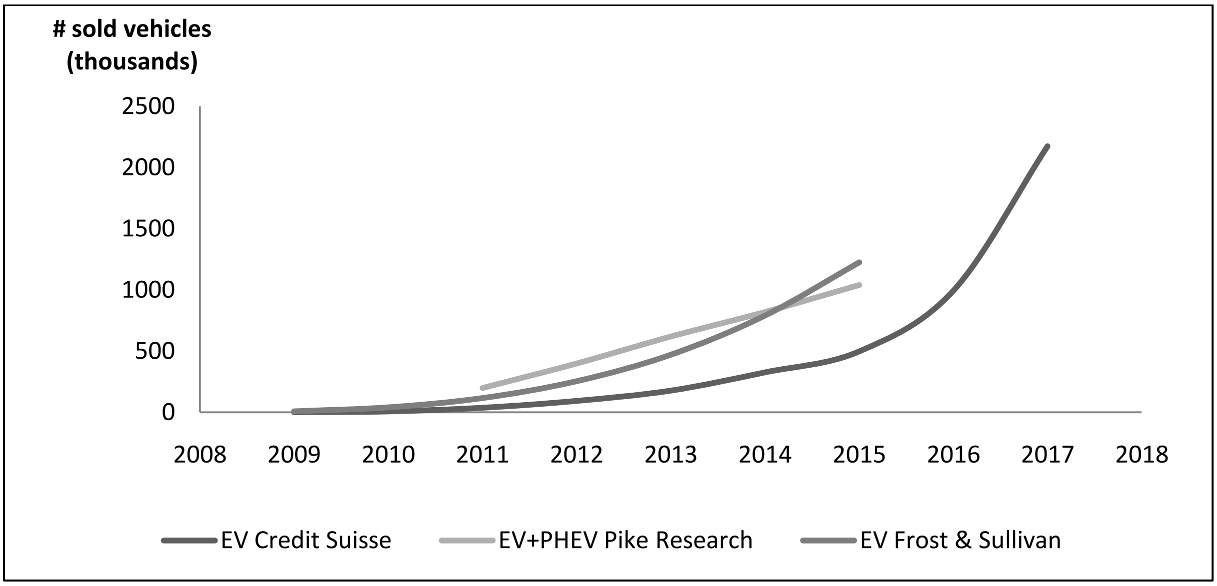

Figure 7. Initial projections of market take off for electrical vehicles
Source: Author based on Pike Research (Gartner & Wheelock 2010), Credit Suisse (Jobin et al. 2009) and Frost and Sullivan (2009).

In 2020-30 the electrical car will be economically viable and emission targets so hard that the percent of sales rises above 10%. Citigroup Global (Brown et al. 2009) is the biggest optimist and believes that PHEV sales can be as high as 70% by 2020 in their best case scenario. However a time frame this far ahead is very hard to project. Table 3 shows a summary of projections at different time frames.

Table 3. Projections of the electrical vehicle market from several research institutes (author).
** All cars sold of any propellant technique (OICA n.d.).*
The research reports in this table can be found in the reference list.

	1‘000 of cars sold and (% of all cars sold)							
Year	**2010**		**2015**		**2020**		**2030**	
Credit Suisse EV	8	(0%)	498	(1%)	4'997	(8%)	8'025	(11%)
Pike EV+PHEV	0	(0%)	1'040	(2%)	-		-	
Roland Berger EV	-		-		9'000	(15%)	-	
Frost & Sullivan EV	42	(0%)	1'226	(2%)	-		-	
Citigroup Global PHEV	-	(0%)	-	(3-10%)	-	(8-70%)	-	
All cars sold (’000)*	48'860	(100%)	53'658	(100%)	58'928	(100%)	71'071	(100%)

1.7.3 The charging infrastructure

When the EV runs out of power there needs to be an infrastructure for repowering. Today there are two main ways of repowering; charging or swapping battery. Battery swapping takes about 3 minutes for repowering while charging requires more than 15 minutes from an empty to a full charge (Gartner & Wheelock 2010).

Chargers exist with different voltage and current specifications in both AC and DC. The original segmentation of charging was done in three levels. Level 1 charging was defined to be home charging at AC current 12A/120V. Level 2 charging was faster AC charging and level 3 charging corresponded to DC fast charging. Charging a 25kWh typical EV battery requires up to 15 hours with a level 1 charger while fast charging requires 10-30 minutes for charging[2] (Gartner & Wheelock 2010), see Table 4.

Table 4. Adapted from Table 2.2 Gartner & Wheelock (2010, p.9). See also California Air Resolutions board (2001-03-26).

Level	Voltage, V	Current, A	Maximum power, kW
1	120	12	1.44
2	208/240	32	6.7/7.7
3	480	400	192

ABB's DC fast charger is developed for the level 3 charging segment according to the Chademo (Charge and Move) standard. The Chademo standard is typically based on 80A/400V DC which comprises a power of 50kW and charges an average electrical vehicle to 80% within 30 minutes. The converter equipment for AC to DC at 50kW is heavy and therefore the Chademo standard supplies a DC current directly to the car's battery.[3] The protocol standardizes the power level and messaging taking place between charger and vehicle. The car acts as master and the charger as a slave. This design pattern implies that the charger is told by the car which maximum power level that should be supplied at a particular time (Chademo 2011).

Chademo originates from Japan where currently more than 570 compliant chargers have been installed (Chademo 2011). The standard was founded after a study that was made by the Japanese utility TEPCO. The study (Anegawa 2008-10-01; Aoki 2010-11-05) showed that cars on average were driven 203 km/month when no fast charging existed in Tokyo and that the average battery "state of charge" was higher than 50% of full capacity when cars got back to the office. After fast chargers were added in July 2008, average monthly mileage was 1472 km and cars tended to get back to office with average battery state of charge below 50%. Hence, knowing that fast charging capability exist makes drivers more relaxed and reduces the so called range anxiety which is a barrier that must be overcome for adoption of electrical vehicles (Chademo 2011).

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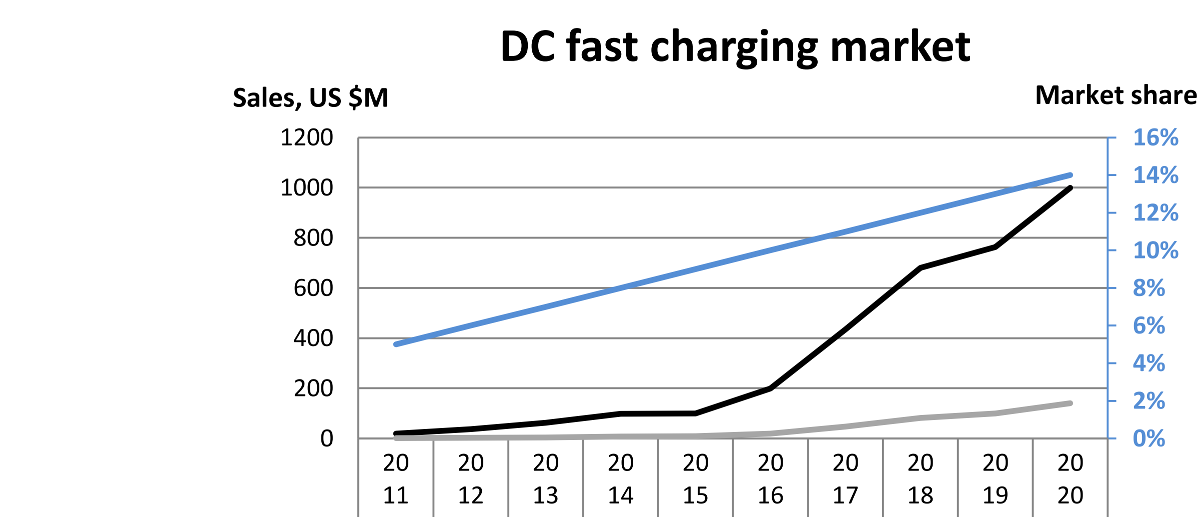
[2] $Theoretical\ charging\ time\ =\ Energy\ /\ Power$. Although charging at higher power levels take more time. Losses need to be added and for adding the last charge to the battery the current must be reduced in order to save the battery for optimal lifetime (Van den Bossche, 2010).

[3] For less technical readers; a battery gives DC as output and must be charged with a DC input. The conversion from AC is either made with equipment included in the car or in the earlier stage with a charger. The fast charger is nothing else than a big adapter, comparable to what is used for charging mobile phones or laptops.

Today the Chademo standard has more than 300 members and it is adopted by the Nissan Leaf, Subaru R1e and Mitsubishi i-MiEV which are the first electrical vehicles mass produced by the main auto companies. Concept cars from Toyota (EV), Volvo (C30), Citroen (C4), Peugeot (iON) and Protoscar are also supporting, or will support Chademo. However it is far from clear yet if Chademo is going to be adopted worldwide. China is developing a proprietary standard on 100 kW DC (BYD 2011-03-11). The German car manufacturers are looking at using the same connector (Mennekes) for all levels of charging delivering an AC current of up to 44kW.

To get a sense of how big the market for infrastructure in eMobility is, petrol stations can be studied. There were 117,908 petrol stations with revenues of $448b in USA in 2007 (U.S. Census Bureau 2009). These stations refuel 255.9m registered vehicles (137m cars) (Bureau of Transportation Statistics n.d.) which mean about 2000 vehicles per station. For long time, petrol vehicles will however outnumber EVs. This will require fewer charging stations for EVs than for petrol vehicles. However the growth of chargers is likely to be in parity with the growth of cars for the first years. Frost & Sullivan (2009) believe that after 2011 the number of chargers per car will drop below one and 2015 there will be two cars on one charger. The charging units this refers to is not only DC-fast chargers, but the number estimate includes slow chargers at level 1 and 2. ABB estimates are using 1 DC-fast charger per 100 electrical vehicles as a measure for estimating the fast charging market initially. The price of a DC-fast charging unit is initially around $50’000 but this will drop when the market takes off to about $20’000 per unit. Based on these assumptions (see appendix 3), Figure 8 has been drawn as one potential market development for DC-fast chargers in the next ten years. The figure only includes hardware sales and services added to the offering will expand the market for hardware suppliers. In 2020 the market size is $1b, which is small compared to total ABB revenues.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Market size ($M sales)	19	37,6	62,3	98,1	99,6	198,8	434,8	680,6	763,2	999,4
ABB revenues ($M)	0,95	2,25	4,36	7,84	8,96	19,8	47,82	81,67	99,21	139,9
Market share ABB	0,05	0,06	0,07	0,08	0,09	0,1	0,11	0,12	0,13	0,14

Figure 8. Total DC-fast charging sales worldwide projections. Based on assumptions in appendix 3 (author).

A major advantage with electricity is that the core network is already developed and the charging infrastructure will in many cases be easy to connect. Compared to repowering with petrol, charging electricity can be done whenever the car is not moving. Charging the car can hence be tied together with every parking place. For most of the cases when a car is used the driver will not go far, and the car will often be full when starting the trip. For many EV users there will therefore not be a need to visit fast charging stations regularly. When it is done a fast charging station will be used in the same way as a petrol station is today. 350Green is a company that aims to provide charging infrastructure in the US. The company stresses that it can be a one-to-one mapping between cheap home charging stations and parking. For fast charging, utilization of the charger is important and hence fast chargers should be built around areas where the parking space is only utilized for maximum 30 minutes (350Green 2011-03-15).

1.7.4 Battery swapping and repowering technologies

When studying DC fast charging it is interesting to also look at what competitive technologies that exist in the market, although this does not directly answer to the purpose of this thesis. Today there are three technologies for repowering batteries that are being commercialized; battery swapping, DC fast charging and AC charging. These usage and benefits of these are illustrated in Table 5. Inductive charging is a technology that also solves the repowering problem, but which today is further away from commercial implementation.

Table 5. Comparison of the three repowering methods (author).

	DC fast charging	AC slow charging	Battery swapping
Effective repowering time, T.	15-30 minutes	5-20 hours	3 minutes
Cost mass production	$20’000	$800	$500’000
Stations for $1m	50	1250	2
Full charged cars/day for $1M	1500-4000	1250-5000	800
Attractive case	Top-up 20->40% (40 km) takes 5 min.	Slow charger tied to parking	Full repowering on short time
Where?	Distributed network for quick top-ups.	Everywhere. A one-to-one mapping with parking	A few per city

Better Place is a key player in the eMobility market, which is mostly famous for battery swapping but that also supplies charging units. Better Place has together with the joint venture Nissan-Renault formed a business model where the customer leases battery, charging and swapping services. The customer will pay a subscription for using the services and borrowing a battery. The thought is that this will add up to a valid business model. First the car will be competitive in price to a petrol vehicle (since the customer does not pay for the batteries). Second, the subscription to repowering services will be priced competitive to what the customer today pays for petrol. However researchers question the viability of the business model since it requires many subscriptions to pay off the infrastructure. The investment in the swapping station facility alone is about $500’000 (Gartner & Wheelock 2010). Jobin’s et al. (2009) mean that if Better Place could reach 40’000 customers with 85 installed stations the investment will be break even if customers are charged with fees equivalent to a petrol price of $5 per gallon (today $3 per gallon).

The investment in battery swapping can be compared to a petrol station investment. With 4 pumps a station costs about 6M SEK to buy, build and install. This corresponds to $850’000 at an exchange rate of 7SEK/$ (appendix 4). A petrol station with four pumps has similar capacity to a battery swapping station in terms of cars per time unit to repower (one every two to three minutes). Since the cost of petrol is high, a comparably low gross margin is enough to get a good profit and cover overheads. For a swapping station the gross margin for selling electricity must be very large to cover investments and overheads. This is because the value of electricity that can be sold per time unit is low compared to petrol[4]. The customer of petrol does neither have an alternative source of buying petrol to compare prices with. This is however the case for the customer of electricity which implies that it is hard to motivate a high gross margin. A subscription model with other value adding services (such as owning and servicing the battery for the EV driver) might be the only viable commercial business model for battery swapping.

Better Place is at the moment rolling out infrastructure in Israel and Denmark. Apart from battery swapping, the aim is to build networks of 100 000 chargers in both countries (Gartner & Wheelock 2010). However, since the business model is capital intensive, Better Place aims at raising venture capital for building networks in each country (Garthwaite 2009-03-06).

Since charging to 90% will be done at home the network of swapping stations must be a lot sparser than for petrol stations. Battery swapping may seem like a superior technology for the EV user’s perspective for solving the range anxiety problem with fast repowering. It only takes three minutes to change battery and this is comparable to today’s system with petrol stations. However the infrastructure is costly and for the same investment of one swapping station ($500’000) one could build 25 DC-fast charging stations (assuming $20’000 per station). With a 15 minute service time these stations can serve five times more customers[5]. With this in mind, DC-Fast charging seems to have a performance/cost benefit for repowering system providers for some market segment. Table 5 compares three methods for repowering an electrical vehicle. One development that might be likely is that fast charging stations will have a similar spread as petrol stations while battery swapping will only exist in cities and densely populated areas.

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[4] The value of 1 fully charged battery is the value of 25kWh energy. This is about $1-2.
The value of a full tank of petrol (50 liter) is on the other hand around $50, which is many factors higher. Repowering a battery or a petrol tank takes about the same time.

[5] Using Little’s law where $= service\ time * service\ rate\ (customers\ per\ minute) \rightarrow Service\ rate = Queue\ /\ service\ time$. With $queue_{swap} = queue_{charge} \rightarrow$ ‘$Service\ Rate$’$_{charge}$/’$Service\ rate$’$_{swap} = 3/15$. But with 25 chargers the total rate is $3/15 \cdot 25 = 5$.

2 THEORY

In order to address the research purpose, theory is used. In this section the key frameworks that will be applied in the methodology, data presentation and analysis are presented.

2.1 SERVICE THEORY AND CLASSIFICATIONS – SERVICE IS A MEANS FOR DIFFERENTIATION

Services can be categorized in different ways when looking at an industrial goods producing company. One concept, the augmented product, looks at services as something that strengthens the core product. Levitt (1980) discusses the generic, expected and augmented product. A generic product is the steel of a steel producer or the loan from a bank. Two steel producers make essentially the same steel and two loans with the same interest rate are at their core the same. However, the customer expects more than a core product; delivery, support efforts and cost reducing new ideas are some examples posted by Levitt (1980). A product can only be sold once overall expectations are met, even if the core offer is the same. The augmented product in Levitt's (1980) definition is to offer customers value from something that they do not expect which makes the company stand out from competition. Grönroos (1987) has adopted Levitt's (1980) theory to a classification for services, although the content is basically the same. Facilitating services corresponds to the expected product that the customer buys. Supporting/enhancing services, on the other hand, correspond to what Levitt (1980) calls the augmented product, an offering that surprises and adds value to the customer.

In a global competitive market, such as for eMobility, it is of great importance to stand out and be differentiated. Augmenting and differentiating can be done by any means as long as it adds value to the customer in a cost efficient way for the supplier (Levitt 1980). In the 21th century, as described earlier, service has come to play a greater role in companies' offers.

Table 6. Frameworks for classifying service and product offerings. Services can be a means for companies to differentiate (author).

Augmented Product (Levitt 1980)	Augmented Service (Grönroos 1987)
• Core product • Expected product • Augmented product	• Core service • Facilitating services (needed for core to be provided) • Supporting /enhancing services (add value above the core)

For manufacturing companies in particular there are many different service classifications of which Nutek (2008) has a summary. Some of the classifications used in literature include *industrial services*, *solutions services*, *selling function*, *full service strategies*, *after market services*, *product support* and *product service*. Nutek's (2008) conclusion is that all these categories overlap.

A useful way of classifying services is to look at when the service is supplied and this is described by Grönroos (2007) to be a common approach in industry where companies use a life cycle approach to service the products.

According to Grönroos (2007) service management shifts the focus from product based value (focus on one time sales) to a total value view for the customer (value in use). This implies long term relationships and a shift from providing core products to providing products that totally solves customer problems. Tekes (2003) characterizes this transition with a continuum of responsibility (Figure 9). This ranges from the customer being completely responsible for a product after buying it, to the producing company instead serving as a solution provider owning the product and selling usage to the customer.

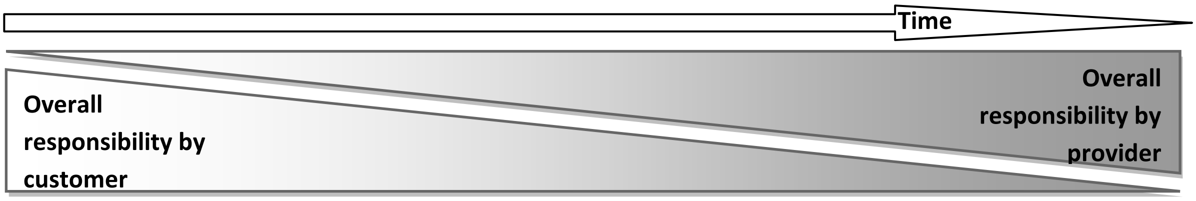


Figure 9. Framework of value transition showing the trend of shifting towards provider responsibility (Tekes 2003, p.9).

Olivia and Kallenberg (2003) describe a similar scale that starts from being a product supplier, supplying services only for the product to work, to at the other end taking over the end user's operation. This framework is similar to Figure 9 but has discrete categories, see Figure 10.

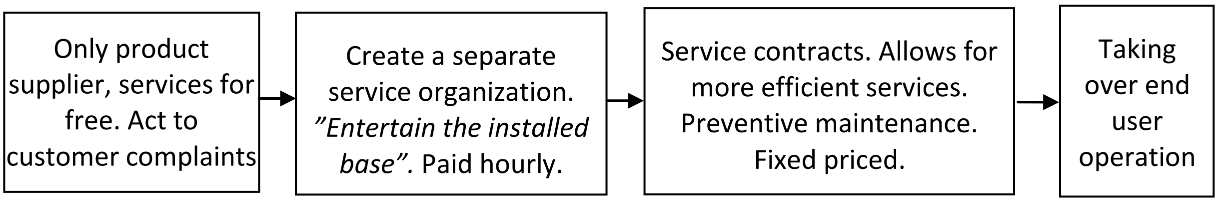


Figure 10. Interpretation of Olivia and Kallenberg (2003). The figure shows a service continuum, from a product supplier only to a full service organization who takes over end user operation (author).

Mathieu (2001) discusses two perspectives that can be taken on service, namely (i) services that support the product and (ii) services that support the clients and their actions. This is another way to look at the continuum Olivia and Kallenberg (2003) describe. Mathieu (2001) argues that only supplying services for the product can no longer be seen as a differentiating strategy and that companies have to start optimizing for the client's use of the product.

2.2 Developing service concepts

So what do academics say when it comes to developing service concepts? Table 7 presents an overview of some of the success factors associated with successful new service development.

Table 7. Success factors for efficient service development (summarized by author).

Success factor	References
Market oriented service development	(Nutek 2008), (Gebauer et al. 2006), (Tekes 2003)
Clearly defined development process	(Gebauer et al. 2006)
Cross functional idea generation	(Nutek 2008)
Concurrent product and service development	(Nutek 2008), (Tekes 2003)
Extend service offering	(Gebauer et al. 2006)
Separate service organization	(Gebauer et al. 2006)
Establish a service culture	(Gebauer et al. 2006), (Nutek 2008)
Close customer relationships	(Gebauer et al. 2006), (Nutek 2008)

First of all there is a consensus about that product and service development affect each other. In new product development, the product and service value proposition should be considered concurrently as a system (Nutek 2008, p.108). The result of new product development must be a product that is optimized from a service perspective as well as a product perspective. Having cross functional idea generation and clearly defined development process are two success factors directly related to the above discussion (Gebauer et al. 2006).

Among the success factors for service development Nutek (2008) also stresses meeting with customers as important when forming the service requirements (market oriented service development). Customers are a good source of information since they in the end will be buyers and users of the developed services (Nutek 2008).

Further, Gebauer et al. (2006) stress that that a success factor is to have a complete service offering with both product and customer related services. Product related services are those directly required to run the product while customer related services are more related to solving a customer problem while for example using the product and thereby adding extra value. This is similar to what is aforementioned about an augmented product and also in line with earlier service classifications.

A separate service organization should be put in place with profit responsibility and operations specialized on running services. There should be a clear service strategy for how the company intends to use service. This is in order to have clear directions in resource allocation (Gebauer et al. 2006).

Companies that establish a service culture are more likely to have high service revenues. Product manufacturers have a tendency to regard services as add-ons to the offer that is sometimes given away for free. This mentality does not favor high service revenues (Gebauer, Friedli & Fleisch 2006). A service culture is defined as being customer driven instead of product driven (Nutek 2008). Of course this success factor could not always be applied if contracts should be won, but in order to have a strategy where service and recurring revenue is a big part this also has to be understood by negotiators (Nutek 2008).

Close customer relationships are a final success factor that is mentioned. Relationships increase the knowledge about the customer which can be used to develop the offering. It is also a means to protect from competition since it increases customer loyalty (Nutek 2008; Gebauer et al. 2006).

2.2.1 Assessing customer needs

As stated above, one success factor for service development is to use the customer as a source of information. The importance of this has also been stressed in product development literature (see Wheelwright & Clark 1992). The customer is the central pillar in the total quality management which by many academics is promoted to be a best practice way of managing organizations (see Bergman & Klefsjö 2010). The importance of the customer is clear since he or she in the end will be providing the revenue streams.

But how are customers' best used in service development? Customers can be used in all stages of service development, from idea assessment to implementation, as an evaluator of the developed ideas and concepts (Bergman & Klefsjö 2010). However, according to Marin and Horne (1993), companies that use customers in all stages are not more successful than companies who use customers in a subset of the product development process stages. This means that customers should not be overused. According to Edvardsson and Olsson (1996) the customer can not only be used as an evaluator and entity for specifying requirements, also ideas can be retrieved from customers. Britan and Pedrosa (1998) argue that development should start by identifying what the customer needs and requires and combine these requirements together.

However, asking the customer what he wants is likely to not give all the possible service concept opportunities that are available. Osterwalder (2010) quotes Hendry Ford, founder of Ford Motor Company and father of mass production:

> ***"If I would have asked my customers what they wanted, they would have told me 'a faster horse'" (Hendry Ford, from Osterwalder 2010, p.129).***

Matzler et al. (1996) argue that for idea generation the attractive requirements, that will differentiate the company towards competitors, are hard for customers to imagine if being prompted directly. Attractive needs are implicit for the customer and likely to be omitted. There are essentially two ways to overcome this problem:

- **Ask the customer the right questions when interviewing**. The right question means that you should ask the customer about problems and not desires (Matzler et al. 1996, p.9). When you do this you will not limit yourself to particular solutions that the customer knows about; the design space is still open. On the other hand, as a researcher you will later have to put some effort in finding solutions to the problems. Matzler et al. (1996) presents the following questions as a guideline:
    a. Which associations does the customer make when using the product (or service)?

b. Which problems/defects/complaints does the customer associate with the use of the product (or service)?

c. Which criteria does the customer take into consideration when buying the product (or service)?

d. Which new features or services would better meet the expectations of the customer? What would the customer change in the product?

- **Use ethnography**, which means to observe customers who use the product. This is recommended by Alam (2006) in order to discover implicit needs.

A Kano survey is a good way to classify attributes into categories of importance. The survey can measure to which degree an attribute (a service or product idea) contributes to customer satisfaction if it exists, and also how dissatisfied a customer will be if the attribute is absent (Matzler et al. 1996, p.10). Depending on where an attribute is in this space, Kano made a classification which is depicted in Table 8.

Table 8. Kano requirements classification (author adopted from Matzler et al. 1996).

Requirement/attribute	Specification	
	If present	If not present
Attractive, (A)	Satisfaction	No impact
One dimensional, (O)	Satisfaction	Dissatisfaction
Must be, (M)	No impact	Dissatisfaction
Indifferent, (I)	No impact	No impact
Reverse, (R)	Dissatisfaction	No impact

This can also be depicted in a graph, see Figure 11.

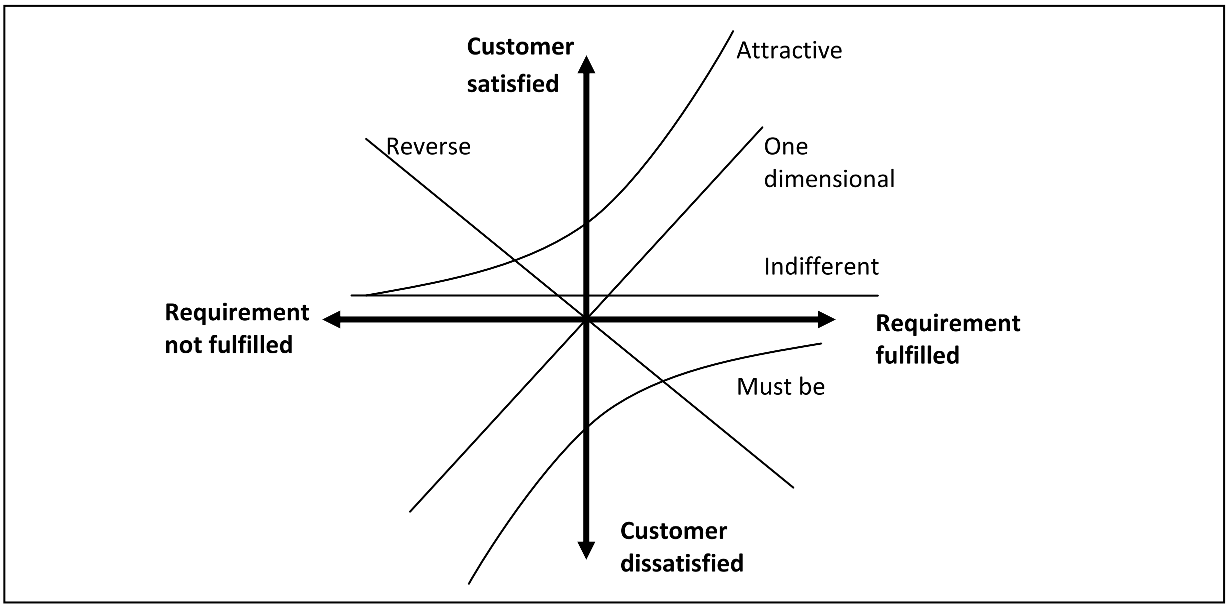


Figure 11. The Kano model for customer satisfaction (Matzler et al. 1996).

Must be requirements are those that a value proposition must have in order to even compete on the market. One-dimensional requirements could be omitted but most actors will include them with different quality in the offering. Attractive requirements are those that will make a company stand out from competitors if they are included in an offering. Finally, an indifferent attribute does not give any value to customers and should be omitted (Matzler et al. 1996). Customer preferences of attributes tend to change over time according to the rule:

$\boldsymbol{I} \rightarrow \boldsymbol{A} \rightarrow \boldsymbol{O} \rightarrow \boldsymbol{M}$ (Nilsson-Witell & Fundin 2005).

An attribute that today is indifferent might in a few years be attractive and when the market matures even more turn to one-dimensional or must be. By studying the customer maturity via a technology readiness index it is possible to determine where the customer preferences are on the scale (Nilsson-Witell & Fundin 2005).

It can be noted that the classification of attributes/requirements in the Kano model is similar to the levels of service that Levitt (1980) proposed. Hence, the Kano model is in line with the success factor presented earlier in this chapter. A product should be augmented if it should be successful in the market.

2.2.2 Measuring the internal perspective

A core competence is a skill that is unique and difficult to imitate. It differentiates a company from competition. According to Leonard-Barton (1992) there are four dimensions to core competence; (i) skills and knowledge base, (ii) technical systems, (iii) managerial systems and (iv) values and norms. If there is a match between all of these, the competence could be seen as core.

An interesting note is that a paradox exists between innovation (implying change from core competences) and the status quo (strategic fit with core competences) (Leonard-Barton 1992). A company should do what it is good at, but at the same time it must deviate from this in order to innovate and stay ahead of competition. Prahalad (1993) discusses the notion of the strategic intent to be the misfit between aspirations and current resources and processes for using them (core competences). In technology intensive businesses Leonard-Barton (1992) concludes that organizations have no other choice than continuously challenging old competences. Ibid further argues that organizational learning therefore is an important element to sustain competitive.

Irrespective of the paradox many authors have although found that aligning new offers with core competences tends to be correlated with success. Martin and Horne (1993) conclude that firms successful in new service development tend to align services better with the current business compared with unsuccessful firms. Similarly de Brentani and Cooper (1992) have found that a company’s ability to leverage resources, skills and experience contributes to development success.

According to Britan and Pedrosa (1998) an internal strategic assessment should determine how well the new product or service ideas fits the firm’s current offering and how it will impact operations. It is up to the organization to find criteria for how to determine if a competence could be considered core or not.

2.3 A FRAMEWORK FOR DESCRIBING A BUSINESS MODEL AND ITS COMPONENTS

The business model canvas (Figure 12) originates from Osterwalder's (2010) book "Business Model Generation". The canvas is a way to present business models, including products and services. It can be used as a tool for business model generation as well as illustration of existing business models. The business model canvas is used in the idea generation phase of this thesis where different customer business models in eMobility studied. This is done in order to understand needs and requirements of the customers.

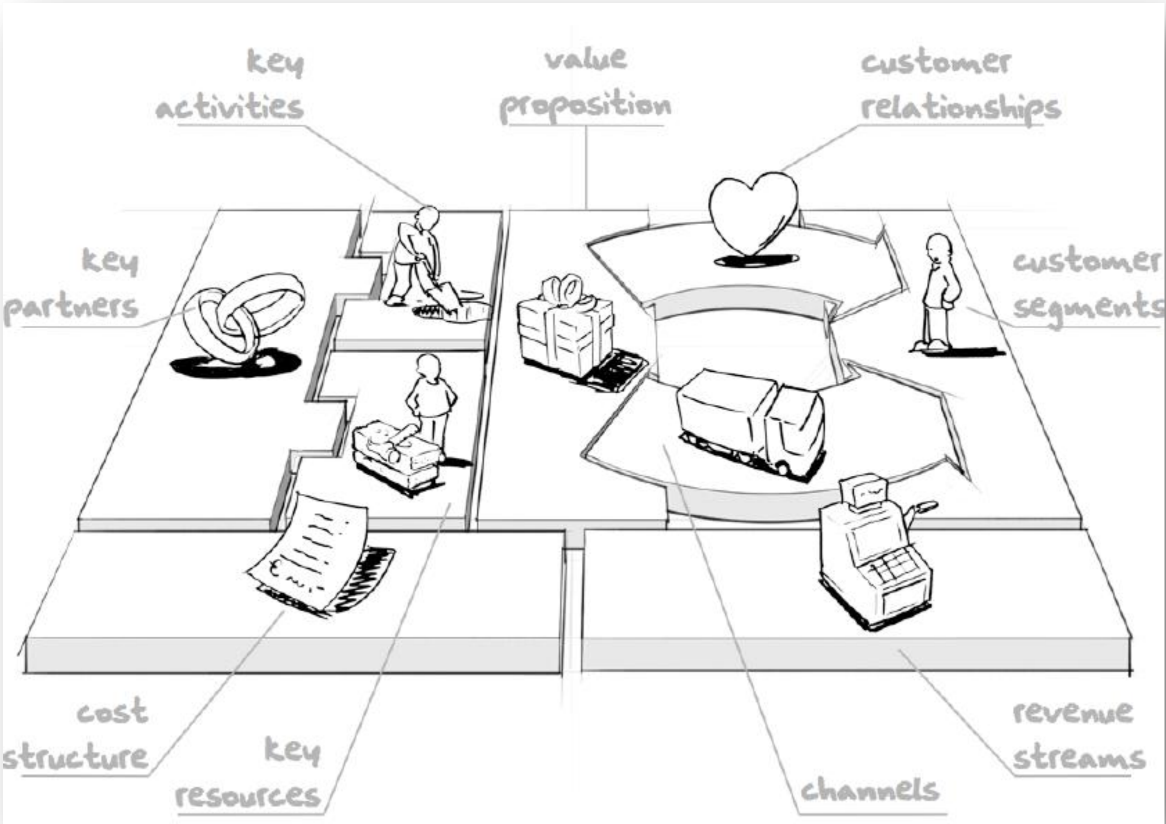


Figure 12. The business model canvas (Osterwalder 2010, p.18-19).

According to Osterwalder (2010) there are nine building blocks of a business model (Figure 12). The value proposition, which the business offers to customer segments, is central. The value proposition is delivered by distribution channels. Customers are contacted and acquired with different kinds of customer relationships or marketing channels. In the bottom right corner revenue streams are depicted. The right side is chosen since revenues are generated when products and services are sold to customers. On the left side of the canvas is the cost driving activities and resources that are needed to supply the value proposition. The activities and resources as such also make use of key partners supplying products or services to the business.

3 METHODOLOGY

This section presents how the study has been designed to answer the research questions. An assessment of validity and reliability of the methodology is also presented.

3.1 GENERAL RESEARCH DESIGN

The problem analysis section defined a process for addressing the purpose of the study and posted research questions that this study should address. In order to address these research questions and process stages, a few methods have been used which are presented in **Error! Reference source not found.** (in relation to the process of addressing the problem) and Table 9.

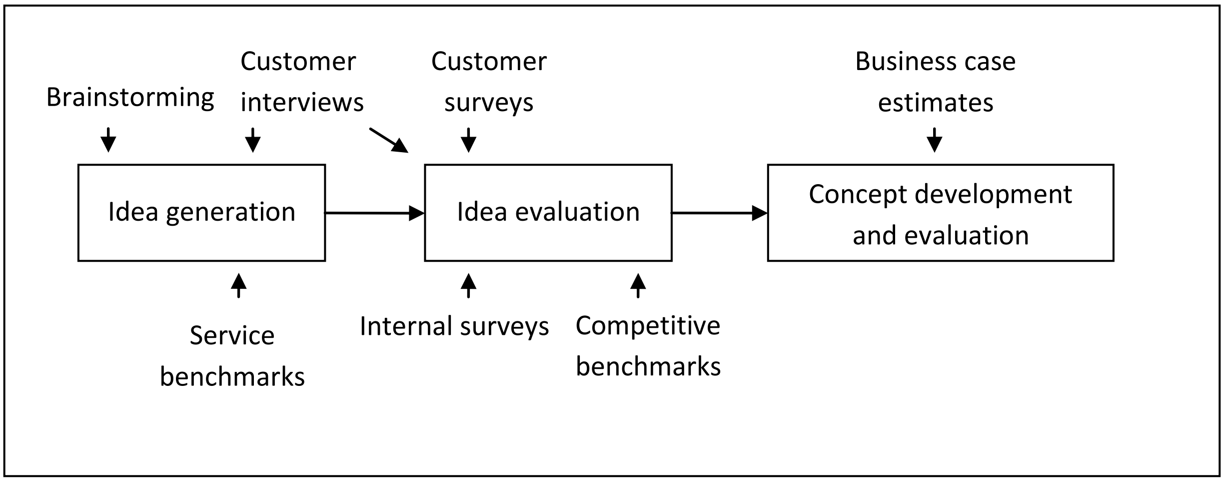


Figure 13. The framework for addressing the purpose with method stages (author).

The research methods used have been collection of primary empirical data, assessing secondary data sources through literature and using methods and tools to analyze the data in a good format.

Table 9. Detailed description of research methodology to address each process stage (author).

Stage \ Method	Primary data: Qualitative	Primary data: Quantitative	Secondary data	Methods and tools
Idea generation	- Brainstorm - Customer interview - Service Benchmarks			
Idea evaluation		- Customer survey and interviews - Internal survey	- Competitive benchmarks	- Kano Model
Concept development and evaluation	- Input of data from above	- Input of data from above	- Input of data from above	- Business case

3.2 Idea generation

During the idea generation stage, brainstorming was primarily used to come up with the ideas that later was evaluated. The idea generation phase also included customer interviews and service benchmarks. The customer interviews were used to assess the needs and requirements from customers, the latter which are used as input to idea evaluation and concept development. This also leaded to generation of new service ideas. Benchmarks were also primary used to get ideas and inspiration for different service strategies.

3.2.1 Brainstorming

Osterwalder (2010) presents a creativity method using the business model canvas as a starting point for the discussion. Together with the canvas the method makes use of Post-It notes and brainstorming to come up with valid business opportunities. As with all brainstorming session's quantity is the focus before quality. It is important not to give negative critique to other ideas, all ideas could potentially contribute in the end and analysis should not be done during idea generation. Encouraging wild ideas, being visual (paintings and descriptions) and letting one participants speak at a time are other norms Osterwalder (2010) recommends. Osterwalder (2010) also recommends not going too far off target and to have a facilitator to keep the session organized.

Figure 14. Ongoing brainstorming session with team 1 (author).

To generate ideas two brainstorming sessions were conducted. Participants were collected cross functionally from the service department as well as from product development (see appendix 5 for list of participants). In total six persons participated during the first session and four during the last. The duration of the sessions was on average 1.25 hours. In order to maximize the quality of ideas, participants were given material about the market and the customers two days in advance. Before the sessions started a short presentation was held to get participants in the mood for idea generation. A topic was set for the sessions to be "services and opportunities" and this was put on the wall. The first research question 1.1 was put as an instruction for generating ideas. Participants were given Post-It notes and pencils to write down ideas. As ideas were being invented the moderator (author) posted them on the wall.

In the first brainstorming session the ideas were not generated with an existing framework in mind for sorting them. This became a final question for the group to address. A two dimensional structure was decided by the group. In one of the dimensions ideas were structured according to when they occur in the life cycle. In the other dimension ideas were sorted according to who the customer is. This is in line with what the previous theory chapter described. After the session, the ideas were analyzed by the author and it was decided that a third dimension was logical to apply on the ideas. About half of the ideas were product related services that optimized the function of the product during different life cycle timeframes and another half was related to the customer's use of the product (action related). This categorization was presented earlier in chapter 2 and is in line with how service classification can be done. The final framework that was used to structure the service ideas is presented in Table 10. Appendix 8 gives the framework together with all service ideas.

Table 10. Framework used to structure service ideas (author based on theoretical classifications).

<table>
<tr><td rowspan="3">Product related</td><td colspan="4">Life cycle – When does the service occur?</td></tr>
<tr><td>Sales and pre</td><td>Project management</td><td>Operation</td><td>End of life</td></tr>
<tr><td>• Idea...
• …</td><td>• Idea...
• …</td><td>• Idea...
• …</td><td>• Idea...
• …</td></tr>
<tr><td rowspan="3">Action related</td><td colspan="4">Customer – towards who is the service?</td></tr>
<tr><td>Utility</td><td colspan="2">Owner or operator</td><td>EV driver</td></tr>
<tr><td>• Idea...
• …</td><td colspan="2">• Idea...
• …</td><td>• Idea...
• …</td></tr>
</table>

3.2.2 Customer interviews

As suggested in theory, customers should be used to get service ideas (research question 1.1). A few concerns had to be regarded when forming the interview questionnaire. First of all, theory suggests that customers cannot be asked directly of which services they need since this omits many potential ideas. Second, the amount of customers was limited since the market is immature and few actors have today thought of a business model in eMobility for DC fast charging.

The questionnaire was therefore set up using a funnel approach. This is recommended by for example Malhotra et al. (2008) as a good way of designing interviews. The instrument had five parts which is illustrated by the five levels in Figure 15.

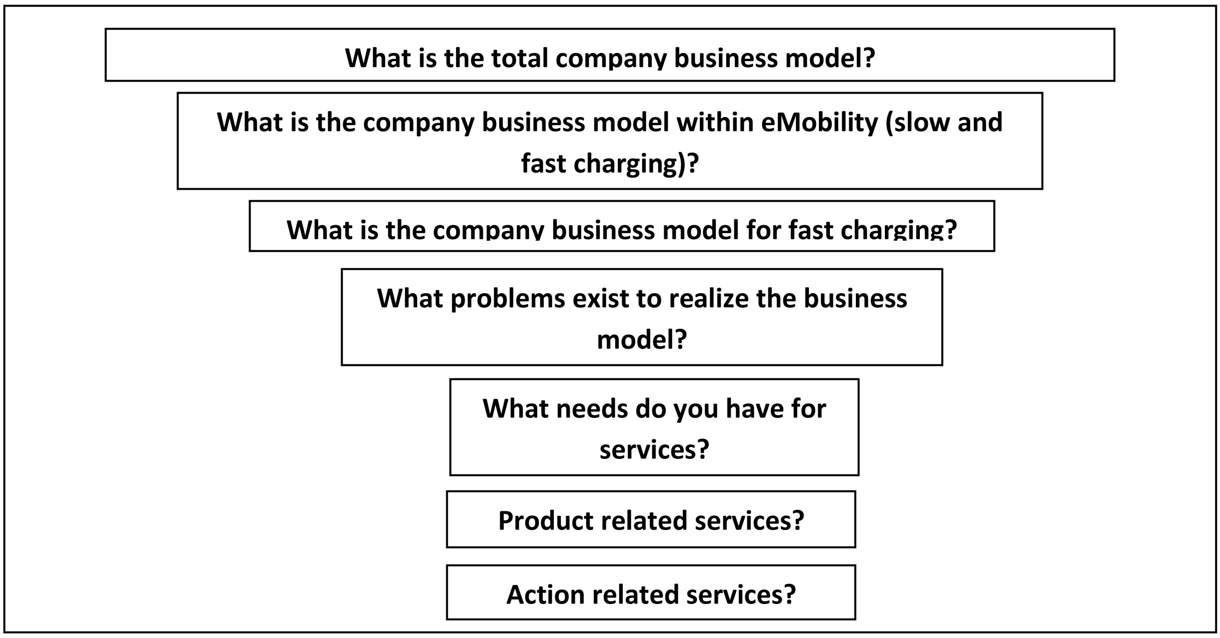


Figure 15. Framework for conducting customer interviews (author).

First of all an introduction of the thesis, author, purpose of study, confidentiality and interview structure was held. Thereafter the overall business model of the customer's company was discussed with the goal to understand the nature of the businesses that potentially would move into buying or providing fast chargers. The third topic of the interview considered eMobility. Questions were asked to investigate the customer's potential business model in this segment. A business model is made up of nine parts (Osterwalder 2010). The focus of the interview was to define three of these parts (Figure 16).

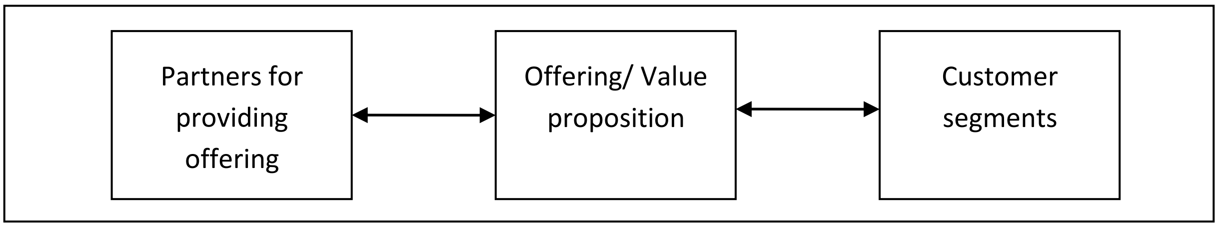


Figure 16. The three parts of a business model used in interviews to consider customer needs (simplification of Business model canvas Osterwalder 2010).

After the business model in eMobility (fast and slow charging total market for electrical vehicle infrastructure) was defined the fourth part of the instrument was to discuss the business model for fast charging in particular. This discussion was also held according the framework in Figure 16. However questions were also asked regarding potential monetary streams; how should the end customers pay for the service?

When the customer's business models had been defined for DC fast charging, questions were asked to define what needs and problems the customer would have to realize it. What partners would be required? What part of the offer should a partner deliver and what should be delivered in house? What are potential problems and where is there need for help?

With this discussion in mind, the customer's needs and problems had been defined. This answers research question 1.2. The customer was then asked to come up with potential service ideas (research question 1.1). Firstly the framework with product related services and customer action related services were presented and the customer was asked about services in all of these categories (Table 10). As time went by the customer was probed with ideas within this framework and as much feedback and input as possible were gathered. Figure 15 presents the structure of the interview.

The duration of the interviews was 30-60 minutes per customer. A semi structured approach was taken and the author tried to maximize space for the customer to elaborate in order to reveal as many ideas, problems and needs as possible. However the author made sure to direct the interview so that each topic was covered.

A transcript based analysis was made of all the interviews. The interviews were recorded and notes from the interviews were compiled into documents that were sent to each interviewee. Each interviewee was asked to correct any mistakes and to add information if needed. After compiling the data, an analysis was made to draw in conclusions about general needs and patterns. To illustrate these ideas quotes have been taken. After the analysis was completed the interviewees have been given the result. This is an important part to increase the validity of the results. For privacy reasons the full transcripts have not been enclosed in the report.

To conduct the study it was important to understand who the customer is. To begin with an internal segmentation was done based on the product that ABB would like to supply. ABB wants to position itself as a charging unit and assembly provider. This means that ABB wants to manufacture complete chargers as well as subassemblies for other manufacturers' chargers. This is depicted in Figure 17.

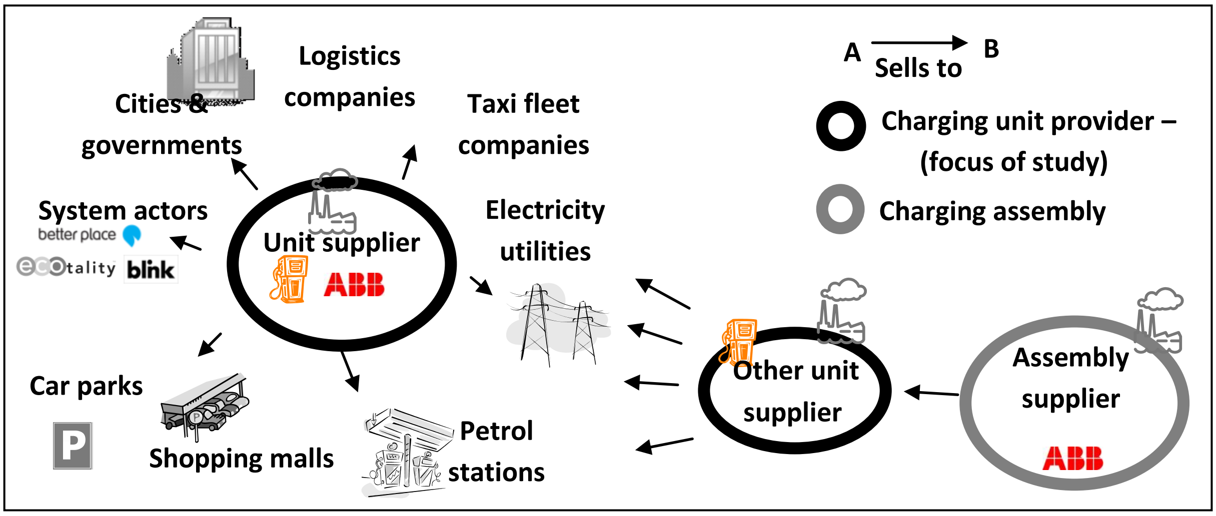


Figure 17. Segmentation of customers for ABB at both charger assembly and unit level (author).

As stated earlier in the delimitations this study is delimited from looking at other customers than those buying charging units. There were not enough customers of charging assemblies and those that were contacted did not want to participate for confidential reasons. The study therefore has focused on the charging unit customers and it is those customers that have been interviewed to investigate their value propositions and requirements within eMobility.

Potential companies buying charging units were found by brainstorming from the perspective of a car; who could potentially want to do a business around car charging? Fast chargers can be used by the public market. It does also have applications in a private market for actors that have fleets with cars which have a high utilization rate and need to be charged more often than during night or parking. This private segment includes taxi fleets, logistics/delivery organizations and car pools of electrical vehicles. To find potential customers in the public segment applications where cars are parked during 30 minutes were searched for. This is a time frame when a fast charge can be gained. The outcome of this public segment was actors like shopping malls, temporary car parks, petrol stations, utilities and cities who would potentially own one or many chargers and offer charging towards the EV drivers. The other group in the public segments includes actors that will potentially not own chargers but serve as middle men to offer full functioning charging networks. These are called "system actors" in Figure 17.

The customer interviews were not only used as a source for generating product ideas. The resources were also used for idea evaluation. Requirements, feedback and differences between customers were all assessed during the interviews.

3.2.3 Service benchmarks

Benchmarking was included in the study in order to find learning points that can be applied to service evaluation and development in eMobility (research question 1.3). Both internal and external sources were used which are presented in Table 11. The service benchmarks are different from the competitive benchmarks, which later will be explained, since they are made on companies which are not competing with ABB. Interviews were conducted with each service benchmark and a few major areas were examined:

- What does it take to be successful in the service area?
- Service ideas from a hardware supplier's perspective – what addresses customer needs best?
- Details about the benchmark's service offer – pricing and segmentation?
- How to organize for service delivery?

Table 11. Benchmarks for the study (author).

Company	Function interviewed	Why?
ABB Robotics	Head of Service ABB Robotics Sweden	Successful with service contracts
ABB Corporate Research Germany	Fleet management (another term for service contracts) research team	Get latest thoughts on service contracts applied to ABB
ABB LV Drives Finland	Service Development for solar inverters	Newly developed service for similar sized product
Ericsson Managed Services	Information Manager	Very successful servicing networks

ABB Robotics was chosen because the division has a reputation to derive the majority of its profit from services (Bergman & Klefsjö 2010). LV Drives in Finland was chosen because they offer a product, the solar inverter, with a similar price level and technical complexity (150kW and 500kW options) to a market with similar maturity as the DC fast charger. ABB Corporate research in Germany has developed concepts for fleet management (service contracts for taking over maintenance or operation) which was considered interesting by ABB.

Finally Ericsson was chosen as an external benchmark for several reasons. First of all mobile network infrastructure has similarities with charging infrastructure in the core characteristics of network equipment. Secondly Ericsson is a western company with a similar competitive situation as ABB. Thirdly Ericsson is a role model that has come further than ABB in the transition against becoming a complete solution provider for its customers (Table 12).

Table 12. Comparison of some key parameters of Ericsson and ABB (Ericsson 2011; Ericsson 2010; ABB 2010a; ABB 2010b; ABB 2010c).

	Ericsson (mobile networks)	ABB eMobility
Market shift	From fixed line to mobile	From petrol vehicle (PV) to electrical vehicle (EV)
Shift started	1980; 4.5b mobile subscriptions today	2010
Market risks	Slow adoption rate, device (car) prices, performance compared to previous solutions	
Characteristics	- Mobile device price higher than fixed - Mobile subscription price higher than fixed + Mobile performance better than fixed	- EV price higher than PV + EV cost/km lower than PV - EV performance worse than PV
Organization	Global structure with local offices close to customers	
Services part of sales	40%. Initially no service. Trend is that service share is increasing.	15.6% ABB in total
Service subscribers	370m network users. Global market.	None but potentially many. Global market.

3.3 IDEA EVALUATION

To evaluate the ideas and present decision support material for concept development, three methods were used; a customer survey, an internal survey and competitive benchmarks. The surveys were of quantitative nature and the competitive benchmarks qualitative based on secondary data.

3.3.1 Customer survey

In order to examine the customers' preferences for particular service concepts (research question 2.1) a Kano survey was conducted. The concept behind a Kano survey was previously described in the theory chapter. The survey is a useful way to get customer feedback in a consistent manor on different service attributes. The Kano survey was designed around the framework of ideas generated in the brainstorming session.

The same set of service ideas was used in all surveys. Even though potentially new ideas were gathered during the customer interviews these were not added to the survey since the same survey needed to be given to all customers for consistency. The ideas found during the customer interviews all fitted to some degree with the ideas from the internal brainstorming session. No service idea was therefore left out from evaluation. The total number of ideas that were surveyed amounted to 43. Of these, 26 were product related services over the product's life cycle, 10 action related service ideas towards the EV driver, 4 action related services towards the charging station owner and 3 action related services towards the utility.

A Kano questionnaire has a special structure. It consists of two questions per attribute. The first question asks how a customer would feel if an attribute/service idea is present (functional). The second question asks how the customer would feel if the attribute/service idea is not present (dysfunctional). Both questions are answered with a special categorical scale with five options (Matzler et al. 1996):

- I like it that way
- It must be that way
- I am neutral
- I can live with it that way
- I dislike it that way

Since the questionnaire had 43 attributes space needed to be taken into account as a long questionnaire decreases the response rate (Malhotra et al. 2008). It was therefore decided to use a table formatted questionnaire with the options as headings and the attributes as rows. The question (functional or dysfunctional) was the same for each table. This does not provide the same celerity as repeating the answer alternatives for each attribute; however the tradeoff is worthwhile to get responses to the survey. An example of how the questions were structured in provided in Table 13. To minimize bias due to misinterpretations the author made clear instructions to each participant about how the questionnaire should be filled in.

To decrease the likelihood of misunderstandings in filling in the questionnaire it was electronically distributed. Computer technology allows for instructions on each question as well as prohibiting the user from filling in multiple or no answer when just one answer per question is required (Malhotra et al. 2008). No questionnaire received was wrongly filled in.

Table 13. Example of a question in the Kano survey. The example depicts a functional attribute question table which could fit about 14 attributes to be measured per page. There is both a functional and dysfunctional question for each service idea (author).

	Functional dimension If ABB offers <service x> together with charging system hardware sales, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Sales	Sales and presentation services (i.e. for proving business case and charger technology)	○	○	○	○	○
	Question 2 under sales…	○	○	○	○	○
	….					

The digital questionnaire was produced in Microsoft Office Word and required the setting “macros enabled” to be completed. Some interviewees did not have the ability to use macros and in these cases the survey was printed and distributed via regular mail. The questionnaire can be found in appendix 6.

The target population and sampling procedure for the survey was the same as previously described for customer interviews (see section 3.1). Each interviewee was given a survey to complete. However the response rates of the surveys were smaller. In total 9 surveys were received back. Figure 18 depicts the distribution of answers for the survey and interviews broken down on the company’s original business model and the intended value proposition within eMobility. Customers intended to take more than one value proposition within eMobility and an assessment has been made on the relative percentage each value proposition has in each company. Hence the responses within eMobility value proposition do not add up to integer numbers (more on this in chapter 4 where the value propositions for the different companies are defined from the interview results).

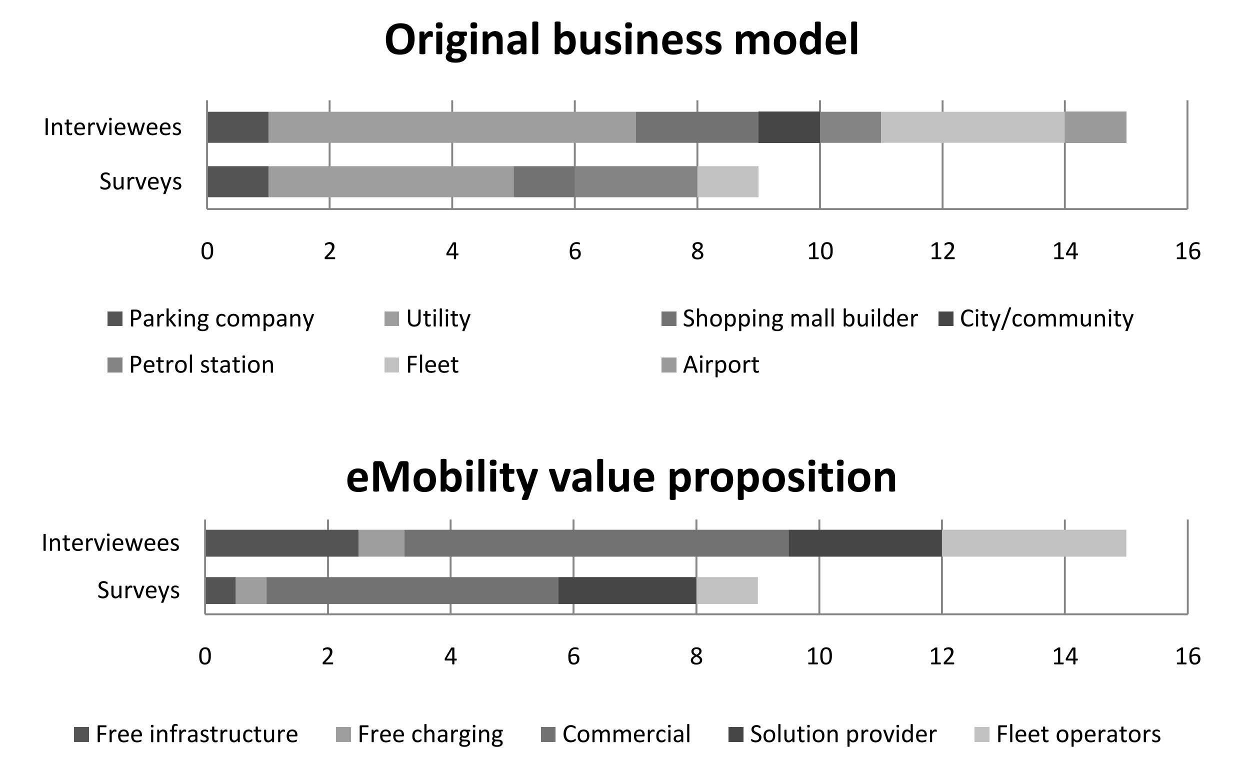


Figure 18. The distribution of answers with different main business models and value propositions within eMobility (author).

When data from each customer has been collected the functional and dysfunctional answers translate each attribute/service idea into one of the Kano categories. This is done according to Table 14. When attributes are translated a researcher should always be suspicious if questionable (Q) appears, it is unlikely that an interviewee gives this answer and it is normally due to a wrongly filled in questionnaire. No questionnaire had a questionable answer.

Table 14. Classification table for Kano attributes. The functional and dysfunctional questions give a classification by following row/column values. (Matzler & Hinterhuber 1998).

		Dysfunctional attribute/service idea				
		I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Functional attribute/service idea	I like it that way	Q	A	A	A	O
	It must be that way	R	I	I	I	M
	I am neutral	R	I	I	I	M
	I can live with it that way	R	I	I	I	M
	I dislike it that way	R	R	R	R	Q

Following this the data can be analyzed in several ways. Matzler and Hinterhuber (1998) suggest two of these. The first option is to count which category of attributes that has gotten the most answers. If two attributes end up with the same number of answers, the precedence rule is used where $M > O > A > I > R$. This method does not take the spread of answers into account. The second option for analysis gives a better way to distinguish between attributes that have a clear majority within one category and others that have a high spread of answers (maybe a case where the precedence rule is used). This option calculates a satisfaction (S) and dissatisfaction (DS) coefficient according to (Matzler & Hinterhuber 1998):

$$S = \frac{O+A}{M+O+A+I} \qquad DS = -\frac{M+O}{M+O+A+I}$$

Figure 19. Satisfaction and dissatisfaction indexes for the Kano model (Matzler & Hinterhuber 1998, p.33).

The indexes can be used to plot each attribute in a two dimensional space. The attributes in the space can then be interpreted like Table 15.

Table 15. Table to interpret the Satisfaction and dissatisfaction coefficients (Author).

		Dissatisfaction	
		< -0.5	≥ -0.5
Satisfaction	≥ 0.5	Attractive	One dimensional
	< 0.5	Indifferent	Must be

Another method for measuring how certain it is that a service idea can be classified into a category is to look at the spread of answers between categories. If the spread of answers is wide between categories the certainty of classification is less than if all answers have appeared in one category.

Table 16. Illustration of how the standard deviation of answers can be used to show how certain a classification of a service idea is (Author).

Examples	Data M	O	A	I	R	Classification (majority)	Total	σ_i	Certainty, σ_i / σ_{max}
Certain M categorization	7	1	0	0	0	M	8	3.0	85%
Uncertain M categorization	3	2	2	1	0	M	8	1.1	32%
Max	8	0	0	0	0	M	8	3.6	100%

An example is depicted in Table 16 where the standard deviation of the answers in different categories has been taken as a measure of their spread. It is important to note that the standard deviation of categorical data has no other statistical interpretation. By taking the standard deviation of the answers for each attribute/service idea and dividing by the maximum possible standard deviation a measure of certainty for each classification can be constructed (Table 16).

One of the research questions 2.2 asks how different customers value the services. An analysis of this was made based on the responses in each customer category. With between zero and three answers per segment it is likely that bias from random errors is large. Therefore a quantitative evaluation of the data has only been done dividing the customers in two main groups; utilities and Others. The reason for this split is that utilities have technical knowledge and often experience from servicing network equipment. The Others group consists of mostly commercial actors without technical knowledge or service resources. It is interesting to see if this maturity level of customers explains what service needs they have. As mentioned earlier, a qualitative evaluation from the interviews is made to explain all segments' needs.

Raharjo et al. (2009) and Raharjo (2010) use the Kano model as an input to quality function deployment (QFD). The attributes rated in the Kano survey are translated as design qualities into the QFD matrix. For doing that each attribute is assigned an importance weight. In Raharjo (2010) the importance weight is set based on the majority classification of that attribute according to Table 17.

Table 17. Attribute weight assignment scheme (Raharjo 2010).

Attribute classification	Weight
R	-0.1
I	0.1
A	0.2
O	0.3
M	0.4

In Raharjo et al. (2009) a suggestion is made that in cases where the classification is close between two categories (e.g. A or O) an average of the weight is taken (i.e. 0.25). This thesis goes one step further. Instead of just weighing the indexes that are tied for an average measure, the total distribution of answers has been considered. This gives a more valid priority number that also takes spread of answers into consideration. An attribute with only "must-be" answers will have a higher priority number than an attribute with half attractive and half one dimensional answers. The priority number is in this report defined as:

$$Priority = w_R \cdot R + w_I \cdot I + w_A \cdot A + w_O \cdot O + w_M \cdot M$$

Raharjo et al. (2009) suggest that weightings should be made to consider attractive attributes most important because they create the highest satisfaction level. In this thesis however the Table 17 ratings will be used. The must be requirements should be in place before even considering attractive attributes and for this reason the scale has been considered reasonable by the development team.

The priority index has been used for ranking the service ideas together with the other measures described in this section. In order to make comparisons between measures these have all been standardized in the data analysis according to a $N(0, 1)$ distribution (subtracting the data points' mean value and dividing by the standard deviation).

3.3.2 Internal survey

As previously discussed, an internal perspective is important when developing new products or services. Existing resources and skills should be utilized wisely; even though some new skills need to be developed for moving into new markets.

In order to measure the strategic fit and intent (research question 2.3 and 2.4) of each service idea a questionnaire was designed. DePiante-Henriksen and Jensen-Traynor (1999) argue that scoring is a good method to use since it does not require economical data that might not be available. Scoring models are also highly customizable for certain applications. A third advantage is that many criteria can be taken into account in the model (ibid). The criteria are weighted and a final decision support can be obtained based on the aggregated data from all criteria. One prerequisite is that the attributes that should be scored are independent which most (unfortunately not all) of the service ideas fulfill (ibid). This affects the internal validity of the study since some bias will occur. The findings have to be considered with this limitation in mind.

Bitman and Sharif (2008) have reviewed eight frameworks for scoring R&D projects. Based on this review they present a framework for developing a scoring model questionnaire. The framework could in short be described according to Figure 20. This process has been followed when designing the internal questionnaire.

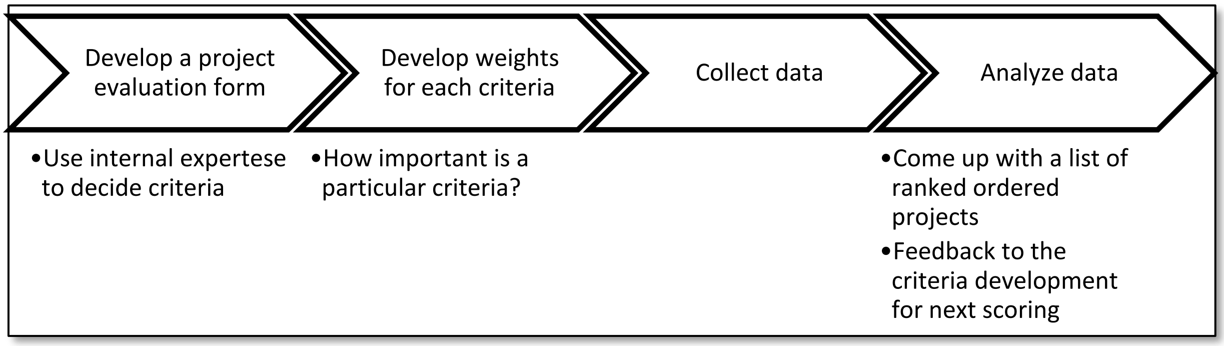


Figure 20. Simplified framework for developing a scoring model (Adapted from Bitman & Sharif 2008, p.271).

The criteria for measuring strategic fit were first developed by using internal expertise from the product and service organizations. This is suggested by Bitman and Sharif (2008). Within each criteria ibid suggest that descriptive values should be developed that can be put on a measuring scale. Table 18 shows the three criteria and corresponding scales that were used in the survey.

Table 18. Criteria and measuring scales for strategic fit. Each criterion was assessed for each of the service ideas to be able to compare the ideas on strategic fit (author).

Criterion for measuring strategic fit	Measuring scale
Competence – Fit with current organization (does ABB's competences and knowledge align with the service idea?).	1. No match 2. Bad match 3. Partly matching 4. Good match 5. Perfect match
Ease of offering (have infrastructure and resources for delivering service idea)	1. Through partner 2. Centrally from ABB 3. ATP/eMobility CH 4. Regional service 5. Global/local service
Ease of developing ("Making" hardware, resources, staff and/or processes)	1. Very hard 2. Hard 3. Moderate 4. Easy 5. Very easy

For the second step, to develop weights for each criterion, Bitman and Sharif (2008) suggest that internal expertise should be used to develop a "relative importance pair wise comparison matrix". An attempt to do this was made together with business development experts within ABB eMobility; however the comparison was hard and characterized by "it depends" statements. It was therefore decided to let the survey respondents decide about how to weigh each criterion. Table 19 depicts the question that was asked for each of the three criteria.

Table 19. Question for each criteria to decide their relative weight, see last part of questionnaire in appendix 7 (author).

Weighting question	Measuring scale
The important of <criterion> is? Where **<criterion>** is: • Competence – Fit with current organization • Ease of offering • Ease of developing	1. Very low 2. Low 3. Moderate 4. High 5. Very high

Research question 2.4 addressed what strategic intent is associated with the idea. To investigate this, a checkbox was added in the evaluation asking the respondent to choose "if the service is something ABB should be doing or not?" (Table 20). The employees should answer this after their opinion on what is best for ABB. The answers to this question were either yes or no. Yes were coded with 1 and no with 0. A total score for each service idea on strategic intent can then be constructed by averaging the total answers to this question. The index then has the following interpretation, "how many percent of the respondents believe that ABB should do the service". The higher number, the higher is the strategic intent.

Table 20. Criterion and measuring scale for strategic intent. The criterion has answer alternatives yes or no; these are assigned values 1 and 0 respectively for the quantitative analysis (author).

Criterion for measuring strategic intent	Measuring scale
Should the service be part of the offer?	1. Yes 0. No

An interesting point of analysis is to look at if the strategic intent and the strategic fit are correlated. That is, do ABB want to do what fits the company? The correlation analysis is made on the ranking numbers each service idea receives in strategic intent and fit.

Several ways of classifying services were previously discussed and in this context it is important to know where ABB would like to position on Olivia and Kallenberg's (2003) service continuum. This question was hence added to the questionnaire.

The target population for the data collection within the internal perspective was all ABB employees with knowledge about services and/or eMobility. To find respondents the organization chart for the business unit was studied together with the stakeholder group. 19 names were identified within the organization that could have sufficient knowledge to give relevant answers that were more than just unqualified guesses. The entire target population was hence sampled. The survey received ten responses which imply a response rate of 53 %. One reminder was sent out and the survey was distributed over e-mail.

In order to reduce the bias from insufficient market knowledge of the respondents an introduction was written to the survey. The introduction was a three page summary about the market (with estimated projections), customer segmentation and potential competition. To make sure that each dimension was answered according to what was intended; detailed descriptions of each criterion were given. The questionnaire was distributed in Microsoft Office Word format. A description of how to enable macros was given and in contrary to the customer survey no complaints were made about this procedure. In appendix 7 a copy of the internal questionnaire can be found in order to understand the structure of the questions. Since macros was used this again allowed to control for wrongly filled in answers. It also made the questionnaire more compact since a drop-down control could be used for each question with the five alternatives to answer.

Completed surveys were checked for omitted answers and potential errors of entering information. In total 43 of 1720 answers were omitted, most likely due to that respondents had problems assessing the answer. In the analysis of the service ideas with some omitted answers only the complete answers have been counted. Once data was received Bitman and Sharif's (2008) scoring method was used to analyze the results. For each service idea a strategic fit priority index was calculated according to:

$$\boldsymbol{Strategic\ fit\ priority_{service\ i}} = weight_{competence} \cdot mean(All\ answers\ to\ \{i, competence\}) + weight_{ease\ of\ offering} \cdot mean(All\ answers\ to\ \{i, ease\ of\ offering\}) + weight_{ease\ of\ developing} \cdot mean(All\ answers\ to\ \{i, ease\ of\ developing\}),$$

where $weight_j = mean(all\ answers\ for\ importance\ assessment\ of\ criteria\ j)$.

Each of the questions measurement scales were constructed so that the worst fit corresponded to 1 and best to 5. This meant that the higher priority, the better strategic fit. The priority scores obtained values in the range: $[0;\ 5 \cdot (w_{competence} + w_{ease\ of\ offering} + wease\ of\ developing]$.

In order to find a more understandable measure the priorities were standardized to a $N(0,1)$ distribution.

Similar to the customer survey the standard deviation of the priority for each service idea was calculated. Opposed to the customer survey, a higher standard deviation of answers to strategic fit must be interpreted as more uncertainty. Since the ratings were composed of products between criteria the standard deviation was calculated according to:

$$\boldsymbol{\sigma_{Ranking\ service\ i}} = stdev\{w_{competence,i} \cdot mean(competence_i) + w_{offering} \cdot mean(offering_i) + wdeveloping,\ i \cdot meandevelopingi =$$

$$[(w_{competence,i} \cdot mean(competence_i) + w_{offering} \cdot mean(offering_i) + w_{developing,i} \cdot mean(developing_i)] \cdot \sqrt{\frac{\sigma_{competence,i}{}^2}{mean(competence_i)^2} + \frac{\sigma_{offering,i}{}^2}{mean(offering_i)^2} + \frac{\sigma_{developing,i}{}^2}{mean(developing_i)^2}}$$

3.3.3 Combining customer needs and internal perspective

All the significant methods of strategy formulation include making prioritization between different options (Slack 1994). Slack (1994) describes an approach that compares the customers' perceived importance of an attribute with the internal performance. This method was first introduced by Martilla and James (1977). These authors had asked customers two questions; *"how important is this feature?"* and *"how did the company perform?"*. From these questions they extracted a matrix that compared attributes in the importance-performance space. Depending on where attributes exist in the space different strategic actions should be taken (Figure 21).

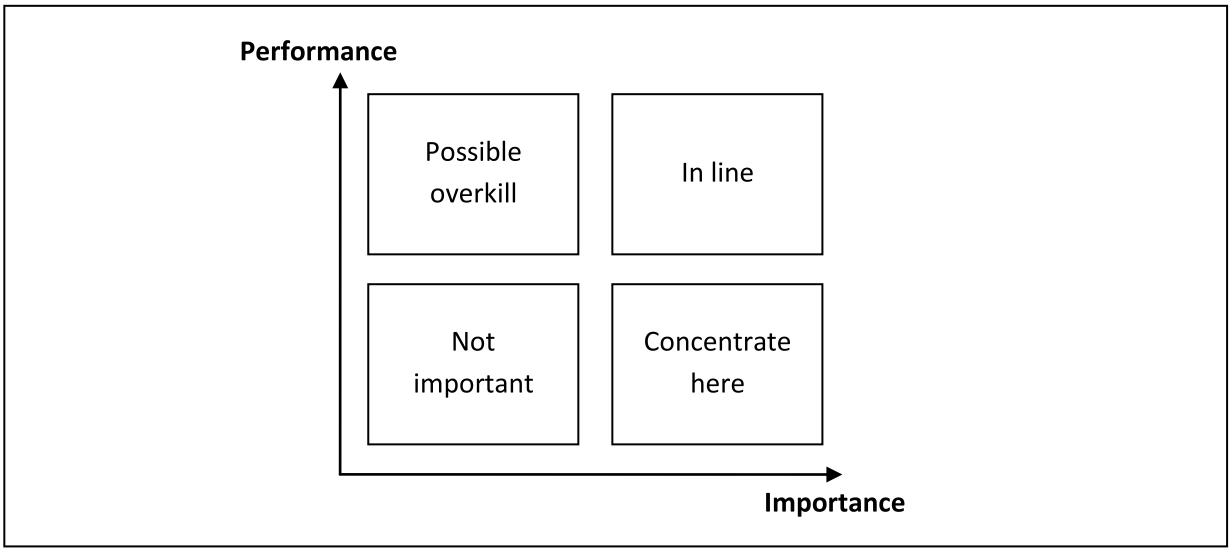


Figure 21. The original version of the importance performance matrix (Martilla & James 1977).

Slack (1993) states that it is common to make adoptions of the importance-performance matrix. In this thesis indexes have been derived for customer importance and internal performance/fit respectively. These dimensions are hence suited for an importance-performance analysis. Figure 22 depicts how the classification has been done based on the data. Both priority dimensions are standardized to a $N(0,1)$ distribution.

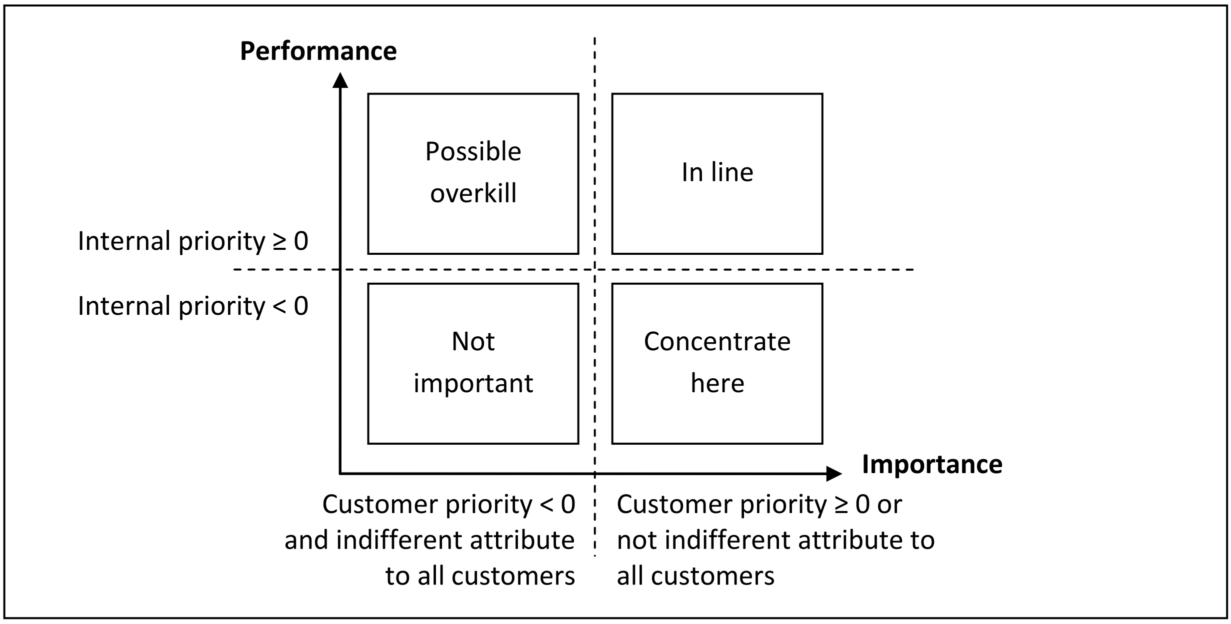


Figure 22. Illustrating how classification of attributes based on importance-performance has been done (author).

To classify a service idea the performance perspective is first constructed with the internal priority number, the limit as taken at standardized priority number 0. Everything above or equal to 0 has a good strategic fit/performance, everything below is weak. The limit in the importance perspective is at standardized customer priority 0 or based on the Kano attribute classification. If the attribute is indifferent to all customers and has a standardized priority less than 0 it will be on the less important side in the importance dimension. If this is not true it will be on the important side. The standardization makes the comparison relative. An absolute comparison cannot be used since it is not supported by the questionnaire scales used. However the categorization in the importance performance matrix is absolute; one attribute is either in one criterion or in another and it does not have to be equally many attributes for each criterion. This is a limitation of the analysis that has to be taken into account when conclusions are drawn. Since conclusions in the end have to prioritize between different options a relative assessment is sufficient.

An interesting question is whether the customer needs and internal perception of fit is correlated. A standard linear regression was made between the dimensions. An F-test made for the slope on the line (k-value) gives a level of significance for if there is a relationship between the variables or not. A correlation analysis also gives the R^2 value. There is no clear rule about what is a weak or strong correlation since the correlation scale is continuous. In this report a R^2 value above 0.5 is considered a strong correlation between two variables. A R^2 value below 0.5 (close to 0) on the other hand is an indication of a weak or uncorrelated relationship.

3.3.4 Competitive benchmarks

Martin and Horne (1993) have found that successful firms in service development tend to copy competitors less and focus more on customer needs and internal development. However to get a hint of what competitors are doing is important in an emerging market when developing new business models (see Osterwalder 2010). When a market emerges standards are being set for what customers want. Although the eMobility market still is immature many competitors are further ahead than ABB when it comes to technological sophistication and capabilities of delivering a mass produced product. Competitors can today supply chargers at a cost of $20’000 together with payment solutions, management systems, operational service contracts and entire network operation services. These features might become standard for customers and ABB must hence consider acquiring them quickly.

To measure what competitors are doing, a first thought from the author was to distribute a survey and interviewing them about their service offering. However this idea was quickly abandoned since it does not comply with competition law and since it is unlikely that competitors would co-operate and share information. The approach that has been taken is instead to study publicly available written material that is offered customers. This gives an assessment of competitors’ current offering but not on their strategic intent.

To find competitors an extensive list of the target population was found on the Chademo web page (www.chademo.com). The webpage presents a list of all suppliers that are compliant with the standard and that can supply chargers. If was found that many of those competitors are Japanese manufacturers with Japanese information material. This material has been hard to understand but Google translate (translate.google.com) has been used to read the material in English. This translation is not a one-to-one mapping between two languages and the findings might therefore have a higher likelihood of being biased by misinterpretations.

To assess a competitor's offer a framework was used. The framework (Table 21) is an adoption of Olivia and Kallenberg's (2003) classification of level of service delivery. This ranges form no service delivery to full operation of customer's product.

Table 21. Framework to assess competitors (author inspired by Olivia and Kallenberg's (2003) classification of level of service delivery).

HW	Product related service	Payment system	Owner and utility monitor system	Owner and utility control system	Product related operation	Operate end user interface
Can supply HW?	Can do product related services?	Has an integrated payment system?	Has a system for the owner/utility to draw statistics?	Has a system for remotely controlling features in the charger?	Makes sure hardware is working for owner. Ensure product availability.	Operates registration and complaints from EV driver.

As previously described the Japanese fast charging infrastructure is already well developed. In order to investigate what solutions that have formed for services in Japan, representatives from Chademo have been interviewed. An informal interview was held with a European Chademo representative at the Geneva motor show. A Japanese Chademo representative from the utility TEPCO has been asked questions over e-mail. Questions were asked on how the Japanese charging system works:

- How do you pay for charging?
- How does the business model around charging work in general?
- What services are being delivered from the charger apart from charging and payment?
- How is the charging network operated?

3.4 Concept development and evaluation

Service concepts have been defined from the many service ideas that have been evaluated. The concepts are as far as possible mutually exclusive and each concept covers one or many service ideas. The same framework was used as for defining the service concepts as was used in idea evaluation with the main ideas structured in action and product related services. The product related services was then structured according to the life cycle. The service ideas were grouped under one of the main concepts in this model so that each concept got one or many service ideas that related to it. This allowed evaluating the concept and to see to do what degree the concept should be offered.

The framework used to evaluate each concept, once the ideas were grouped into it, is depicted in Figure 23. This part of the study addresses research questions 3.1-3 for each service concept. The concept development stage is designed according to how a service concept should be defined including both a *what* and a *how* part. The evaluation phase of the concept is made only from a business case perspective. The business case evaluation is made with a simple cost/revenue framework.

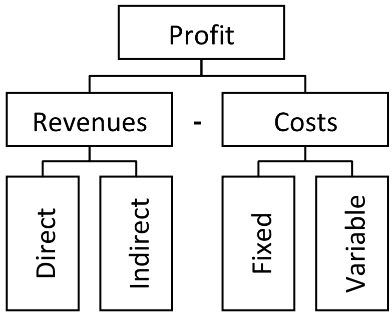
Development		Evaluation
What	**How**	**Business case**
A summary of what customers want, strategic fit, strategic intent and customer assessment lead up to an evaluation of what should be included in the service concept.	Define how this could be delivered at a high abstraction level. No detailed blueprints made. Aims to answer the question: How could/should the requirements (specified by *what*) be developed, implemented and/or delivered?	General framework used for reasoning: 

Figure 23. Framework for concept development and evaluation (author).

3.5 Reliability

A reliable study has a methodology that will give the same results if it is repeated (Kumar 2008). Many variables cannot be controlled and will differ between two occasions of data collection. However if the method is applied to a similar group of respondents in a similar context then similar results should be found (Cohen, Manion & Morrison 2007).

Cohen, Manion and Morrison (2007) distinguish between reliability in quantitative and qualitative research. Quantitative research should have stability, equivalence and internal consistency. Stability is tested by applying the same method again at a later occasion to a similar group. Equivalence is reached if a similar survey, with other wording of the questions, reaches the same results. Internal consistency means that if the sample is split in two homogenous groups the results should be similar. In qualitative research the strength is the depth and information that can be gathered only due to a specific situation that is hard to recreate (Cohen, Manion & Morrison 2007; Gliner & Morgan 2000).

The questionnaires that were given both to customers and internally have not been retested, checked for equivalence or internal consistency. One reason for this is that the number of target populations for both surveys are small which makes it hard to do repeated tests or waste half of the responses on splitting the group into two. Another reason is resource and time constraints. The respondents could potentially have been given two surveys measuring the same thing but doing this was assessed to be too time consuming and not add much extra value to the results.

The data analysis of the two surveys has high reliability. A spreadsheet has been made to which data from the surveys has been copied. Both data entry and formulas for evaluation have been checked twice. This does however not ensure that the analysis is reliable but since the results are reasonable it could be assumed that the calculations are correct.

Indications of reliability for a qualitative study can be drawn by assessing (Cohen, Manion & Morrison 2007, p.148):

- Stability – if the observations occurred in a different time frame, would the result be the same?
- Inter-rater reliability – would another researcher have drawn similar conclusions given the same observations and theoretical background?

Given the fact that the brainstorming session and interviews have been designed and acted according to questionnaires the data collection procedure can be repeated. Using the same participants and interviewees would most likely yield the same or similar answers. However it must be noted that idea generation and creativity to some extent is spontaneous and many ideas could potentially have been discovered only because a certain situation or discussion appeared. The interviews were semi structured around a framework of questions which makes it hard to recreate the same questions. Also if the interviewees and brainstorm participants would have been gathered today, a few months later, the participants have had time to learn more about the topic and may give other answers. The internal participants would also be biased by the findings the author has presented during his work.

The author believes that another researcher would have drawn similar conclusions from the data. Transcripts are available of the interviews and brainstorms from where conclusions can be drawn. These are available for internal assessment, so that anyone can go over the findings. Stakeholder meetings have been held continuously to discuss the findings in order to reach a common logical interpretation. The conclusions that have been made are further strengthened by using quotes from the original data.

3.6 Validity

A valid methodology measures exactly what the purpose claims should be measured (Kumar 2008). Validity can be split into internal and external validity. External validity "is the condition permitting the generalization or inference of the sample finding to the population from which the sample was selected" (Singh & Bajpai 2008, p.135). External validity hence has to do with how sampling is made and to what extent the findings from the sample could be generalized to a larger population. Internal validity on the other hand means how variables have been controlled during an experiment (Singh & Bajpai 2008).

The brainstorming and internal survey have a high external validity. A majority of the employees who could have knowledge in the field were present during the brainstorm and the internal survey had a reasonably high response-rate within the internal stakeholder group. There is no reason to believe that the 47% of non-respondents would have a different opinion than the respondents, however this has not been further investigated (which according to Malhotra et al. 2008 could be done to increase validity).

The goal of the customer interviews was to access needs and problems in different segments in order to find ideas for services. With this objective in mind the results from interviews are probably valid. The author got the feeling that interviewees with similar business models addressed the same problems and that an exhaustive list of ideas to a high degree was reached. If customer segments are homogenous (in this case representing the same type of customer) it has been found that a sample of 20-30 interviews or questionnaires are sufficient to find 90-95 % of all product (or service) features (Griffin & Hauser 1993). Since the study has made 15 interviews this confirms that most ideas should have been found if account also is taken to the two brainstorm sessions held internally for idea generation. The distribution of interviews in the different customer segments was good. It was easier to find participants/potential customers from utilities, since this most likely is the largest and most mature customer group. Hence this group also got most respondents.

The customer surveys for idea evaluation has on the other hand a low external validity. The intention for ABB is to enter a global market in eMobility. The sample of this study is mostly taken from Europe with a majority of participants in Sweden. The incentives for introducing eMobility are probably different all over the world. To exemplify the funding of the electricity grid, environmental issues, access capital and growth rate of EVs are parameters that differ among countries and that should have a large impact of implementation of DC fast chargers. The customer survey for evaluating service ideas can therefore not be claimed to have high validity for the worldwide customer target population. Another reason for the low validity is that the survey only represents a small portion of the customer segments. As Figure 18 depicts a very low representation of answers within the free infrastructure, free charging, fleet and sell chargers value proposition. Both of the free value propositions could be assumed to have very different priorities and needs than the commercial actors and the solution provides. This has been seen when interviewing with the city of Amsterdam and it is also seen on the outcome in London and Portugal where the contract winner has taken a high responsibility for network operation.

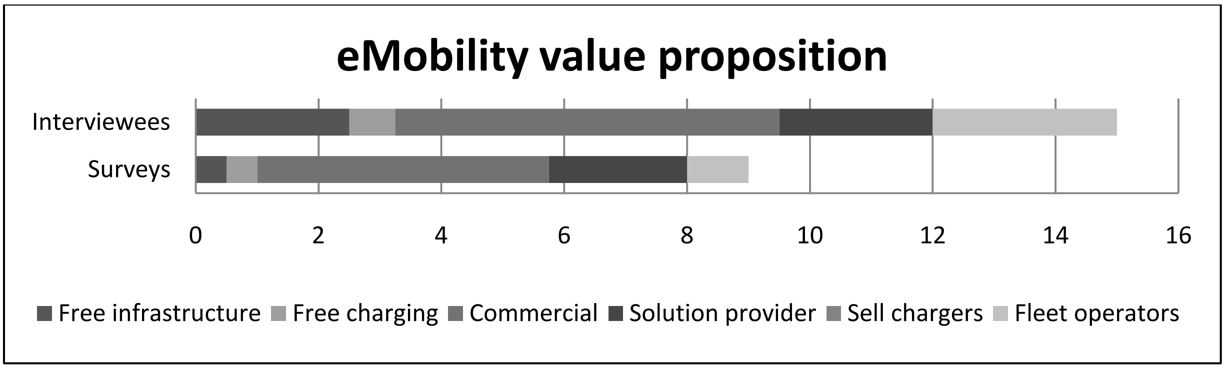


Figure 18. The distribution of answers with different Main business models and value proposition within eMobility (author).

For this reason the survey only illustrates some parts of the whole truth. The “sell chargers” value proposition has not been represented at all in either interviews or the survey. The reasons for this are that the author has not been given access to the customers in this segment, that the response rate is low and that the target population of companies in this segment is small. Given this the study cannot with customer data fulfill its purpose of looking at charging assembly customers.

Qualitative research is suitable when an in-depth understanding of a topic is sought (Malhotra et al. 2008). This in-depth understanding has been collected by the researcher and this is of value when evaluation is done. The value of this cannot be disregarded in concept evaluation, even though it is not measured in validity terms.

Internal validity has been increased by cross checking the results with customers after a draft of the report was written. Notes from the interviews have been given to participants for commenting, changing misunderstandings and adding information that might have been left out. The results from the survey and interviews have also been shared with participants. This has increased both the validity of the results as well as ensured that customers have given consent of the information to be published. For confidentiality reasons it was in correspondence with the customers decided that company names should not be published in the report.

4 IDEA GENERATION

In this section, service ideas from the brainstorming activity, customer interviews and service benchmarking studies are presented.

4.1 INTERNAL BRAINSTORMING RESULT

The ideas that were found during brainstorming are found in Table 22. This table answers research question 1.l, to find which service ideas that exist for the DC fast charging product. The IDs are used to keep track of the services when they are used in charts and data presentation. They are structured according to the order they were evaluated in the two questionnaires. These ideas are used for evaluation and input throughout the study. Appendix 8 lists the service ideas in the way they first were evaluated using the framework described in the methodology section.

Table 22. Service ideas from brainstorming sessions (author).

Class		Id	Service
Product lifecycle related services	Sales and pre	1	Sales and presentation services
		2	Consulting network design
		3	Consulting unit sizing
		4	Consulting location analysis
		5	Consulting cost of connection minimization
	Project man.	6	Installation
		7	Location specific adoptions (civil engineering)
		8	Commissioning
		9	Balance of plant
	Service during the product's operational life	10	Maintenance training
		11	Operating training
		12	Documentation
		13	Network operation
		14	Hardware upgrade, replacement or reconditioning
		15	Software updates
		16	Spare part field service
		17	Repair field service
		18	Troubleshooting field service (maybe by using remote control)
		19	Preventative (scheduled) maintenance
		20	Predictive maintenance (using remote)
		21	System optimization consulting during operation
	EOL	22	End of life recycling
		23	End of life buy and re-selling
		24	Service contracts with different levels of service
		25	Financial services (i.e. renting or payment options)
		26	Warranty

IDs 24 to 26 were not considered in any group when the survey was constructed. However, after in the concept development stage these services were grouped into services during the product's operational life. Also ID 9 and 14 changed categories for the final concept recommendation.

…Table 22. Service ideas from brainstorming sessions (author).

Class		Id	Service
Action related services	EV driver	27	Smart payment service (subscription, cash or credit)
		28	Reward system for charging at your stations
		29	Open payment standard (supported by all chargers)
		30	Wi-Fi services to smart phones in the area
		31	Media distribution/sales capability (app or movie store)
		32	Car maintenance (software updates to cars)
		33	Statistics/information (battery, how often, where, prices)
		34	Unit availability (where is the next charger?)
		35	Remote charging control (user can be away and see status on phone)
		36	Openly accessible stats API for app development
	Owner	37	Remote control of display content
		38	Remote system for advertising on display
		39	Operational statistics raw data
		40	Processed statistics in a interesting and useful format
	Utility	41	A smart grid service for selling, buying and storing power
		42	Operational statistics
		43	Pre and post grid analysis

4.2 Customer interviews[6]

As previously described, customers have been interviewed in many different segments. The general business models of customers are utilities, shopping mall builders, parking companies, cities, petrol stations and different fleets. When interviewing these customers a few generic value propositions for eMobility have been found. These are listed in Table 23 split on the interviewee companies. The interviewed companies were investigating multiple value propositions and the degree of strategic intent within each has been assessed using pie slices. For each customer all slices add up to a full pie. As an example utility 1 mostly intends to have a commercial value proposition (assessed to ¾ of the strategic intent), putting fast chargers on the streets and collect the revenue. To ¼ of the strategic intent utility 1 could also see itself being a solution provider, reselling fast chargers to others.

This section describes each of these value propositions. Answers will be given to research questions 1.2 and 2.2 on customer requirements differences between customer segments. This will help to provide further answers to research question 1.1 for finding service ideas.

[6] The information in this chapter is taken from customer interviews if no reference is given. Transcripts are available from each interview (however not part of the appendix) and the information has been cross checked with each interviewee to increase reliability.

Table 23. Generic customer value propositions in eMobility split on interviewees. The fulfillment of each value proposition is assessed with pie slices; ranging from a full black circle (100% strategic intent) to a quarter of a black circle (25% strategic intent). Each company's strategic intent adds up to 100%. Two interviews/ questionnaires were conducted/given to the petrol station (author).

Type of eMobility/fast charging value proposition	City 1	State owned utility 1	State owned utility 2	Shopping mall bulder 1	Shopping mall bulder 2	Petrol station	Airport (Arlanda)	Parking company	Utility 1	Utility 2	Utility 3	Utility 4	Fleet rental company	Taxi company	Car pool company
Free infrastructure – Give charging infrastructure away for the benefit of inhabitants.	●	●	◑												
Free charging – Give away charging to attract business.				◑	◔										
Commercial – Provide and <u>own</u> infrastructure and take a subscription or a cost per charge for others usage.			◑	◑	◕	●	●	●	◕	◑	◔				
Solution provider – Sell a complete solution with charger, action and product related services. No ownership.									◔	◑	◕	●			
Fleet – Taxi, delivery and car pool companies.													●	●	●

4.2.1 Free infrastructure and free charging

In practice nothing is free of charge. However, there are a few examples of value propositions where the network or the entire charging fee is not debited to the EV driver directly (Table 24). The infrastructure can be covered by tax, hidden on energy bills for the entire population or used to attract business. According to Gartner and Wheelock (2010 Q2) the initial investments in fast charging are likely to be from governments and communities to a majority.

Table 24. Business model for free infrastructure value proposition used in cities, communities or countries. A partner runs the system and the "city" takes the investment (Business model Framework adapted from Osterwalder 2010).

Partners	Value proposition/offer	Customers
Hardware and management/payment system supplier administrating everything.	City or country providing free infrastructure	All EV drivers in a country or city. Utilities selling electricity can also be customers.

Costs (-$)	Revenues ($)
Hardware and installation paid by city. Recurring cost for operation taken by partner.	Customer fee for electricity and premium. Premium covers commercial partner's costs.

Amsterdam and the state owned utility 1 have decided on giving away charging infrastructure for free to end EV drivers. In Ireland state owned utility 1 will build charging infrastructure, which can be used by energy producers to sell electricity to EV drivers. The infrastructure is paid for by the Irish population via the network fee, which is part of every electricity bill. In Amsterdam the infrastructure is put in place for environmental benefits to air quality and to encourage driving electrical cars.

In both Amsterdam and Ireland the network is free for the EV driver but charging from the network will in the long run not be (although Amsterdam initially has set up a model where parking and charging is free until April 2012 to stimulate EV buyers). In Amsterdam fast charging will cost 4€ per 30 minutes fast charge. This fee will be collected by the company who are responsible for operating and maintaining the infrastructure and interacting with end EV drivers. In Ireland the electricity producers and dealers will put different tariffs to compete about customers. Tariffs will be based on the type of charging and when charging is done on the day. For both Ireland and Amsterdam the management system will consist of RFID cards that are used for customer identification and billing. In the Irish case the RFID works as a prepaid card that can be charged with money from different providers that the user selects when buying credit over the internet or via shops/small stores. The system is open for all vendors of electricity. In Amsterdam the system will be operated by RWE (German utility and competitor) who will sell electricity and collect revenues to cover for the operation. Opposed to Ireland, the system in Amsterdam is closed to RWE, which alone will supply the electricity.

In the shopping mall sector Shopping mall builder 1 and Shopping mall builder 2 see an opportunity of adding chargers when building shopping malls to make them more attractive. The chargers would potentially give away charging for free (see Table 25 for assessment of this value proposition).

"The electrical car might change the current trend of moving shopping malls back to city centers. When cars are becoming green there is no large ecological incentive to reduce shopping malls outside city centers. At shopping malls outside city centers I can see a need for chargers, slow and fast, to attract customers to business. Our vision is to build Sweden's most attractive shopping centers." – Shopping mall builder 2

Shopping mall builder 1 sees a business model for shops giving charging away for free. Charging is tied to a loyalty program and shopping at a store. By entering the shop, the customer is more likely to buy existing products. That will pay the small costs of supplying the customer with electricity.

The free infrastructure or charging value propositions have in general high needs for partners. In Amsterdam the city sought for one supplier who could deliver chargers and take care of operations towards the EV drivers. To just interface with one supplier was important for the city. RWE is today taking this role, buying chargers from a hardware supplyer and operating the network. In London Siemens has taken the same role. Siemens provide a system for operating the network and handling the payment and identification over RFID (Source

London n.d.). In Ireland both suppliers for hardware and IT systems will be asked for in the tender for 30 fast charging stations over the country:

> ***Q) If a hardware supplier could deliver a full solution with IT system, would that be attractive?***
>
> ***"Yes. Definitely. Currently we plan to let an IT consultant do the IT system but if it is included with hardware that would be attractive. However the system needs to be able to work with different charger manufacturer's hardware." – State owned utility 1***

When it comes to product related services the companies with free value propositions had two different levels of requirements. These requirements correlated well with the capabilities of the customer. A utility has knowledge and resources to service network equipment. State owned utility 1 could potentially see maintenance as an in-house activity and expressed that they also intend to do installation. The feeling from the interview was, however, that this not yet was decided. Buying service contracts of availability for a fixed yearly price was discussed in the interview and this was also potentially attractive depending on price and value.

Table 25. Business model for free charging value proposition used at shopping malls to attract business (Business model Framework adapted from Osterwalder 2010).

Partners	Value proposition/offer	Customers
Hardware, payment system, install and maintain chargers.	Free charging	All customers to the shopping mall
Costs (-$)	**Revenues ($)**	
For hardware and services	Indirect revenues via additional customer to shop	

Amsterdam would definitely not do any product related services. Amsterdam wanted this to be part of the overall contract with the one supplier who takes care of the offer towards customers. Here a full service contract had been set up with RWE. After installation and all the fixed cost were paid at one occasion the city has been leasing the fast chargers from RWE. Every year the city and RWE negotiate a "fee per charge" that RWE can apply to the EV driver. Through the revenues from sales, RWE finances the operation and lease of the charging stations. RWE is a good example of the *solution provider* value proposition that later will be presented.

> ***"This model suits us because the supplier is still responsible for the equipment. This gives us the ability to get the latest updates every year in a market that changes rapidly. The leasing contract is a win-win solution for us and RWE."***
> ***–Amsterdam***

For the companies that potentially want to provide free charging as a value proposition the importance of partners was also big. Both Shopping mall builder 1 and Shopping mall builder 2 expressed that they would like to tie charging to their customer loyalty programs. The customer loyalty card was expressed as one potential solution.

For product related services both Shopping mall builder 1 and 2 expressed a need of services all over the life cycle. Installation, network design and maintenance were addressed by both actors. Service contracts were also interesting and leasing chargers was seen as something attractive. Shopping mall builder 1 expressed that they do not have the technical capabilities to assess what maintenance that is needed on a charging system and leaving that risk to the supplier was discussed during the interview as an attractive option. However price and the business case was of course an important issue. Shopping mall builder 2 stressed that the lease fee has to be compared with the price of borrowing money from a bank.

Smart grid solutions of building battery storage, chargers and local production (solar or wind) together was an idea that was brought up by both shopping malls builders. The idea was attractive from a marketing perspective of the facilities, as well as from power supply perspective. Shopping mall builder 2 consumes 300 GWh of energy every year in its properties which implies a cost that can be reduced. Shopping mall builder 1 has made tests with smart grid generation at a few properties. Erikslund in Västerås, is one example were the roof is covered with $200m^2$ of solar cells delivering 35kW (0.2GWh/year) on average. This is about 2% of the usage of the store but the power is sufficient to run a DC fast charger at 50kW through battery storage.

The biggest problem that was put forward by Shopping mall builder 1 and 2 for implementing charging was power supply to the stores. At an existing store Shopping mall builder 1 typically has 6-7 cables high voltage inlets. Each cable is 250A/400V so the total power is around 600kW. This is typically used at peak consumption and to add a fast charger requires an extra 50kW or another inlet cable. This is a large investment apart from the charger and something that hinders investing in fast chargers for all existing facilities.

Advertising and additional action related services, such as selling washer liquid, was not attractive for this segment. At shopping malls advertising is done with large paper posters. Washer liquid can be bought inside the shopping malls.

London and Portugal are two free value proposition actors who have not been interviewed. However a general understanding about the projects have been gained through public accessible information, speaking to representatives at Geneva Motor Show and in London's case by talking to the local ABB representative. In London and Portugal RFID systems have been/will be put in place. In London a subscription model is used while in Portugal the EV driver pay per charge. The city and community have in both cases made the infrastructure investment. The direct fees cover network operation. What seems to have been important when a fast charger supplier has been selected in London is to provide solutions for the customer. This can be seen from the following quote.

> ***"David,***
>
> ***We applied for two pilot projects in 2010, one for Transport for London, the other for the North East England. I spent many hours filling in web prequalify data but we failed to prequalify because they wanted:***
>
> ***a) Product available ...we could not supply quaintly required in the time scale requested***
>
> ***b) Business System to trial for customer charging and the business infrastructure ...I suggested we should talk to Oyster card, used as a non contact ticketing and charging system through London***
>
> ***c) Contracting to install, service and maintain the assets.***
>
> ***Our score was about 30% ...so we did not prequalify and lost out. It seems we are not ready for this yet so I have put on the backburner until we have the above sorted."***
>
> ***Graham Barlow, 2011-03-18, e-mail***
> ***ABB Ltd., Power Electronics, UK,***

4.2.2 Commercial value proposition

Utilities, parking companies, shopping mall builders and petrol stations could all see some kind of commercial value proposition offering fast charging towards EV drivers. However, the uncertainty of companies within this segment was greater than for the free segments. This is a major point that has to be taken into consideration by ABB. Many actors expressed that fast charging has a negative net present value and a too high investment. This implies that many actors are passively waiting for the market to develop, investing for goodwill reasons or for reducing range anxiety. This interview finding is in line with the prediction made by Gartner and Wheelock (2010 Q2, p.4) who states that:

> ***"…sales (of DC fast chargers) to commercial entities, such as retailers, will be limited initially due to lack of a clear revenue model."***

The commercial value proposition (Table 26) is characterized by control of fast chargers. The chargers are placed in the public domain and EV drivers can choose to use them in exchange for money. Two revenue models have been suggested; a *subscription model* with a yearly/monthly fee or a *fee per full charge* (10-30 minutes charging) *model*. Electricity costs are about $1-2 for a full 25kWh charge and a premium of $2-3 will be taken for providing the fast charging service. This high gross margin premium could, as discussed earlier, be hard to justify since the customer has a cheaper alternative at home. However, the value of speed and convenience might be high and a couple of dollars for this service might not be too expensive for most EV drivers.

Table 26. Business model for value proposition commercial (Framework adapted from Osterwalder 2010).

Partners	Value proposition/offer	Customers
Hardware. Different requirements for payment system, management system, life cycle services.	Own or lease a fast charger and make publicly accessible. Charge others for using it.	Public EV drivers.

Costs (-$)	Revenues ($)
For hardware and services.	Fee per charge (i.e. $5/30min) or subscription (i.e. $200/year).

Control does often imply that chargers are owned by the company, but actors with this value proposition were also open to leasing alternatives. Often companies with a commercial value proposition wanted to stand behind the value proposition with their brand and organization. If a charger is owned or controlled by a company it should also be branded with the company logo.

The need for partners in the commercial value propositions varied between the companies except for the basic hardware requirement. Utilities had very little need for product related services since they have an organization capable of installing and maintaining electrical equipment. The petrol station and the parking company, on the other hand, expressed a greater need for help with product related services.

For action related services and features the companies have in general similar needs; the stations should be manageable and provide capability to make payments. The companies have different maturity levels and requirements of having these solutions provided from the manufacturer or just enabled by hardware for them to build in-house. In general the commercial value proposition segment expressed a strong need of always finding the most cost efficient and competitive alternative:

> ***"We will put installation and maintenance on the market; either it is our internal organization, the hardware manufacturer or an external actor who will get the contract."***
> ***- Utility 1, 2 & 3***

4.2.3 Solution provider

A solution provider's value proposition (Table 27) takes a role between the hardware actor selling fast chargers and the commercial or free value propositions. This is depicted in Figure 24. This is an assessment of all the value propositions described in section 4.2 along the value chain for fast charging.

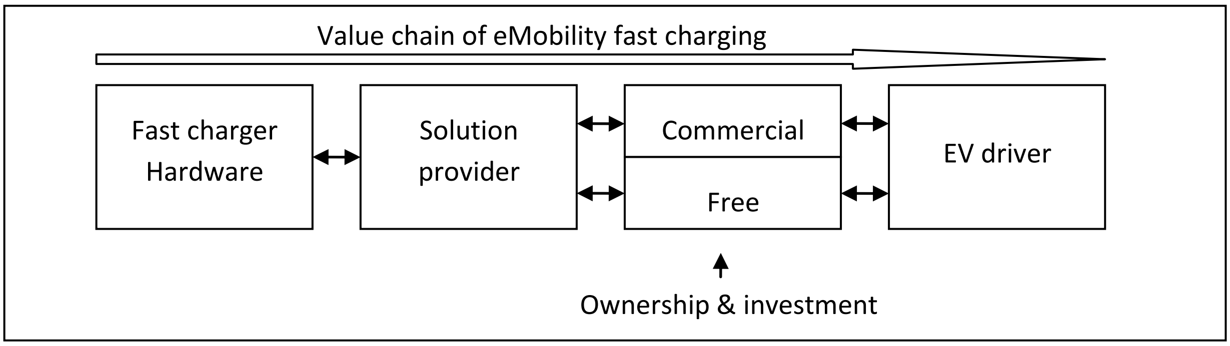


Figure 24. Figure depicting different value propositions in the fast charging market (author).

What is important in this value proposition is that ownership of the fast charger typically not resides on the solution provider's balance sheet. The free or commercial actor invests in the charger. Taking this role typically reduces the commercial risk of bearing an investment. However, the technical risk and requirements of development is higher. German RWE is an example of a solution provider for the free value proposition of Amsterdam. The company takes care of customer management and also guarantees hardware availability. A similar role is taken by Siemens in London. In other countries, such as Portugal, solutions are provided by a consortium of companies. Eleven companies have in total done technology development, charging installation, network operation and customer management (Mobie.e.– *Partners* n.d.).

Table 27. Business model for value proposition "solution provider" (Adapted from Osterwalder 2010).

Partners	Value proposition/offer	Customers
Typically buys hardware. Typically in-house development of SW & services.	Sell eMobility and fast charging solution for the owner of the fast charger.	Potential infrastructure owners (commercial or free value propositions)

Costs (-$)	Revenues ($)
Development, management and service organization. Competence from suppliers or fixed in-house.	Lump sum for installation and HW. Recurring through service contracts for maintenance and customer management.

Since the solution providers often do not own chargers they could be seen as competitors to ABB. What makes them potential customers are that the typically do not have in-house production of DC fast chargers. RWE has bought fast chargers from Epyon for the installation in Amsterdam and Siemens have today not demonstrated a DC fast charger. However it is likely that they soon will have an in-house alternative since they present this in marketing material (see Siemens n.d.). A company can hence take multiple roles in the value chain and ABB might as well need to move more into the solution provider space in order to sell towards the free and commercial value propositions. However, actors in the commercial value proposition might also move down the value chain and interact directly with hardware suppliers.

Of the utilities that were interviewed, utility 1, 2, 3 and 4; all want to be solution providers. However the extent of this varies. Utility 1 would for example want to do solutions for the private segment. For the most part, however, they also want to develop a commercial value proposition towards EV drivers.

> ***"We think that the private segment for taxis and fleets will take off first and we will be there with solutions." – Utility 1***

The Dutch utility 4 does not want to own any chargers at all and they position as a solution provider. The same is true for utility 3, which believes that fast charging could only be profitable together with other businesses and extended offerings (selling coffee or having a shop next to the charger for example). Hence utility 3 aims to provide solutions for the commercial segment of shop owners that have other business as well. Utility 3 could also potentially own fast chargers and share revenues together with the commercial actor who has a nearby shop. This is in line with the value proposition ECOtality is adopting for its network in USA (see chapter 5.4.5). The thought is to let small commercial actors take the hardware investment and then share revenues with them in exchange for servicing and operating the network.

Utility 2 is the Swedish utility that might have come furthest in eMobility. The company has four legacy fast chargers from the nineties and is today experimenting with Chademo charging and ultra fast charging (250kW). The company has not formed a clear value proposition for fast charging yet but would like to provide solutions for commercial actors as well as putting up own controlled chargers.

The requirements for partners are similar to the commercial segment. For product related services the solution providers as well plan to choose either internal or external providers depending on that is most cost efficient. However many solution providers are in general utilities that have high capabilities. For installation, utilities are often by law the only companies who are allowed to work with high voltage equipment, which further reduces the need for help. Utility 4 however expressed installation to be a natural service that the hardware supplier should take care of.

For action related services or features there is however a smaller need for help compared to the commercial segment. The solution providers themselves have to develop a core competence in some area and often this is done within a management and payment systems. RWE and Siemens have done this as well as utility 2. The Others are likely to do something similar. However, not all of them have done this to date. Utility 1 and 3, for example, includes a payment system as an example of an area where help is needed and where it could be attractive to have solutions from a supplier such as ABB.

4.2.4 Fleet

The fleet segment is characterized by having transport as the central part in its value proposition (Table 28). When electrical vehicles enter the market many believe that this will be the segment that adopts them first (e.g. utility 1 expressed this). One reason for this is that the fleet segment drives a lot and hence reaches breakeven faster for when investment in an EV is better than in a petrol vehicle ($Break\ even, km = Extra\ investment\ for\ EV\ compared\ to\ petrol\ vehicle, \$)/(Saving\ per\ distance, \$/km$).

Table 28. Business model for value proposition "fleet" (adapted from Osterwalder 2010).

Partners	**Value proposition/offer**	**Customers**
To deliver charge to the EVs	Provide transport of people or goods using EVs	People who travel, send mail/post or rent cars

Costs (-$)	**Revenues ($)**
Charger hardware, energy and maintenance are part of total cost.	Revenues from transporting fees, not from chargers. Potentially benefits from using electrical green cars.

One hypothesis was that fleet companies would plan to buy their own private charger to use on their fleet and that this charger would not require identification, payment or networking since charging is done privately within the relatively small fleet. This hypothesis has not been strongly supported by the three interviewed companies. The taxi company could potentially own a charger on their yard if the investment would pay off. Back in the days, they had a diesel pump since this was profitable to have in-house. Today a combustion engine car can drive one working session without refilling gas (500 km average distance per taxi for 8 hours work shift). A hinder for owning a fast charger is that it is very hard to know where a taxi is going to be when it needs to refill. It is unlikely that the taxi will be at the office. Hence the taxi segment is not a likely fast charger customer. The taxi company is now testing an EV (Mitsubishi i-MiEV) in their fleet. The car will be stationed around Arlanda Airport were Swedavia (the Airport owner) will set up a dedicated taxi fast charger. Only taxi companies will use the charger. However this charger will serve many taxi companies and for this reason a system for identification is needed. Swedavia will in the end have a commercial value proposition towards the taxi companies that will have to pay for using the charger. Arlanda Airport is today the largest taxi market in Sweden. Swedavia has a business model for taxis where they provide customers in exchange for a fee that the taxi companies pay for picking up customers at the airport.

The car pool company provides a fleet of vehicles for a large city/community area. All municipal organizations have to rent cars through the company and the goals for green cars are very highly set. The car pool company believes that there must be around 20 fast chargers in the community (with around 1 million inhabitants) to solve the range anxiety problem. However they do not plan to have fast chargers dedicated to their fleet.

> ***"Our customers will charge on the publicly available infrastructure that is planned in the community" – The car pool company***

The fleet rental company is a startup company that rent out electrical vehicles to public and private customers in Sweden, Norway and Denmark. The public customers subscribe to the service monthly and pay an hourly fee every time they use the car. There is no kilometer based fee or insurance cost, which often exists in rental companies for petrol vehicles. One hypothesis was that the fleet rental company would prioritize having a high utilization of their vehicles and that fast charging would provide a good way to improve the business case. However having a car available for the customer is more important than full utilization.

Keeping the current availability/utilization is done with slow AC charging 16A/230V/3.7kW. Cars run on average 40 km per day which is within their range. Their CEO however put forward that fast charging would be interesting if the price is right.

The fleet rental company is the only fleet company interviewed that potentially would be interested in owning fast chargers. The company has a fleet management system that is integrated in their cars. From this system the company can monitor where the cars are, if they are being used and what battery capacity that still remains. The rental customer books cars through the system. The customers enter how far they plan to go and for how long the car will be reserved. The system makes sure a car can be picked up and that enough charge exists to drive the required distance. A potential fast charger sold to the fleet rental company would hence not require an advanced payment or identification system. However, they put forward that the charger should be able to heat the car cabinet when it is cold and be used for smart grid services. For life cycles services the fleet rental company could potentially need expertise in installing and maintaining the charger.

4.3 SERVICE BENCHMARKING

This section addresses research question number 1.3 in idea generation; what service ideas and success factors for service can be found from service benchmarks?

4.3.1 Key success factors in network services[7]

Ericsson Managed Services is a company within Ericsson that performs operation and field service of base stations and operation of entire networks. This is the big bulk of work in managed services, but Ericsson Managed Services also does planning, design, building, rollout (installation, commissioning and training) and support of networks. Ericsson Managed Services would like to be seen as the competence for operating networks.

> ***"Ericsson should be seen as the 'man in the van' to network owners who do not need to acquire competence to operate networks." – Elin Aldén, Ericsson Managed Services***

Ericsson has separated the organizations for hardware sales and network operation. Ericsson Managed Services has no requirement to recommend Ericsson equipment to be installed when upgrades need to be done. The customer buys hardware separately and Ericsson's network operation service only recommends what type of equipment to buy, not the vendor. This way of organizing service and product has been put forward as a key success factor in literature and it could be something for ABB to follow. ABB does not necessarily require an own product in order to build a service organization, this could be done independently. Splitting the service organization also implies that service is sold on its own and not given away for

[7] The section is from a phone interview 2011-02-23 with Elin Aldén, Informer at Ericsson Managed Services.

free with the product. Both the service and product organizations then compete on the same terms with others, which is an important factor for gaining trust. When service contracts are being written; trust, openness and tangibility are important to let the customer see the value of the contract.

In the mobile network service industry, standards enable Ericsson to service a network from any vendor following a particular standard (CDMA or 3G). Agreements between the different hardware providers enable spare parts to any service supplier.

> ***"We operate all kinds of network. It does not matter what the technology is. We buy the competence. Economics of scale is the important thing. No magical recipe, we service as everyone else, but we are big. In service, utilization of staff is a key success factor." – Elin Aldén, Ericsson Managed Services***

A typical setup of a service contract from Ericsson Managed Services is to utilize key performance indicators with the customer who should be followed for a fixed yearly price. Incentives are built into the contract for Ericsson to take a share of the cost savings that could be achieved by the customer. Normally, cost savings are in the range of 10-15%.

> ***"There is no need to have five parallel networks in a country being serviced by different organizations when they can be serviced by one at a lower cost." – Elin Aldén, Ericsson Managed Services***

Outside of the service contract, Ericsson typically can supply different consulting services. One example is on how the network best should be strengthened with new equipment in order to achieve certain performance targets.

To reach the goals of the service contract, Ericsson typically demands their "toolkit" to be used by the customer. This toolkit involves software that is installed into the network for Ericsson to use in monitoring its status. If this is not done, Ericsson cannot use its normal processes and benefit from scale that can be reached in service centers. Normally, these tools have to be paid for by the customer with a lump sum in the beginning of the service contract. Doing this creates a lock-in for the customer to use Ericsson when the next service contract is to be signed after the current has expired.

The most recent trend is to set key performance indicators and service level agreements from a customer perspective and not from a product perspective. Coverage and speed are two examples of requirements that are related to the end customer; the number of nodes that are active is on the other hand a product related measurement (the network of nodes is the product). Many nodes could be down and customers could still get a good coverage and speed. Hence it is more relevant to use customer related measurements. If these (such as coverage) cannot be fulfilled with the existing equipment, Ericsson recommends what should be done to solve the problem with upgrades. If this way of reasoning is applied to the fast charger it does not count how often servicing has been done; the total uptime is more important. Another measure would be to minimize how many customers that have seen that the charger is broken which might be correlated with a total service goodwill measure.

L.M. Ericsson stared as a repair shop for telephones. The service culture was early part of the company. When the mobile network market opened up, hardware was naturally becoming the most important business. After over 100 years of building mobile networks, the coverage in the world is today rather good and the importance of services is increasing. The managed service business model started 15 years ago when a customer, who had been part of a training activity on his new network, asked Ericsson to not hand over the operation of the network. Ericsson was already managing the network during the training course and made it so well that the customer wanted Ericsson to continue. Ericsson benefits from having superior knowledge in technology and a global service organization that can be leveraged to do network service and operation cost efficiently. Today, it is very hard for a hardware organization to differentiate without services. Everything is standardized and good margins are therefore hard to achieve for pure hardware.

Ericsson has 45’000 service employees where 10’000 are part of global service centers and 35’000 local representatives on site. The service organization is structured according to competence and, as for ABB, according to product/business unit. If a certain customer or product requires a competence, this is collected from a competence area. This way of organizing eliminates the fight over competences from different business units within the company. This fight and lack of cooperation is a big problem within ABB and the current drive from management is to solve this and become “one ABB”.

4.3.2 Models for service contracts[8]

Ericsson is one example of a successful organization in the service industry. The company is at the very end of Olivia and Kallenberg’s (2003) continuum of classifying the level of service offering in an organization. ABB has a similar setup at ABB Robotics where the service department also has taken over end user operation. In some manufacturing cells, ABB Robotics has service level agreements based on providing a predefined output with the customer’s robots. ABB Robotics also has focus on contracts for maintaining robots and “protect your investment to a fixed cost”. For other customers, to who this is not attractive, reactive service options also exist to repair equipment that has been broken. This is charged for by the hour. In ABB Robotics’ market, downtime is very costly for customers which is one reason that has led many customers to buy service contracts to prevent faults from occurring instead of being surprised and repair when they occur.

Similar to Ericsson, ABB Robotics has a global service organization spread over more than 50 countries. This is according to Isaksson a success factor for efficient service delivery. Each local office makes close customer contacts after every sale. To execute on the service

[8] This section is based on telephone interviews with Brith Isaksson, Head of Service ABB Robotics Sweden, 2011-02-11; Luigi Malinverno, Service development Solar Inverters ABB Finland, 2011-02-18 and Christian Stich, ABB Corporate Research Germany, 2011-02-17.

delivery, the local country has support from a global service centre that can be used for remote maintenance and support activities.

Just as for robots, solar inverters are a crucial component for the customer's facility to work (according to Malinverno maybe the most critical). ABB LV Drives Solar Inverters has developed a special maintenance program called drive care. This is offered together with ABB LV Drives' normal service programs consisting of installation, commissioning, training and spare parts. The drive care program has essentially three service levels which are depicted in Table 29 to be technical support, preventative care and complete care. A response time guarantee option is available as an add-on to any of the service levels.

Table 29. Complete care concepts (ABB 2011b).

Service	Technical support	Preventative care	Complete care
Telephone support	X		
Preventive care planning		X	X
Components for preventive care		X	X
Labor for preventive care		X	X
Travel cost preventive care		X	X
Spare parts for repair			X
Labor for repair			X
Travel cost for repair			X
Pricing	Free or $/occasion	2-5% of HW cost/year	7-12% of HW cost/year

The pricing is based on the costs of using ABB service labor and the scheme of maintenance that are suitable for the inverter product. The maintenance scheme implies spare part costs and labor hours. The scheme has been derived from mean time between failure data of components that make up the product. Components that need maintenance includes air filters, pumps, cooling fans, electrolytic capacitors and the electronic board. Malinverno recommends looking at similar data for the DC fast charger components. An organization servicing similar equipment is the best benchmark; asking the manufacturer is likely to give answers that their equipment never breaks. ABB LV Drives has specialists in 60 countries with slightly different capabilities for doing service. When a service package is set up the local constraints need to be taken into account.

Stich at ABB Corporate Research Germany has also looked into the area of service contracts. The belief is that service contracts are the best ways to reach ABB's target of increasing service revenues from $5b to $15b by 2015.

> ***"The challenge is to link customers to ABB over a life cycle and not just at the sale occasion. One way of doing this is through life cycle service contracts. The business model for the customer is to minimize risk and guarantee uptime in the most efficient way. Some customers know nothing about technology and here is an opportunity. ABB's offer could be to guarantee uptime to 99% and operate the product."***
> ***- Christian Stich, ABB Corporate Research Germany***

The customer benefits from service contracts guaranteeing performance includes[9]:

- **Reduced life cycle costs** – A well maintained product will have a longer working life cycle with fewer break downs.
- **Predicted life cycle costs** – A service contract with a fixed yearly payment will insure the customer from unexpected events.
- **Removed peaks in cash flow –** Unexpected events require available cash flow to cover repairs and damages. A service contract transfers the risk for handling these events from the customer to the supplier.
- **Less requirements of specialized technical knowledge** –The customers can focus on their core business, which might be unrelated to servicing the product in question.

During the interview with Stich, a discussion was also held on what can be done for customers, such as utilities, which have technical knowledge to service the hardware in-house. One option is to create training certificates that must be taken by all service staff who works on the product for warranties to be valid. Another option is to have certain areas where only ABB people are allowed to do service. This strategy might however be hard to sell to a customer with a proprietary service organization that is likely to screen suppliers on this criterion.

4.3.3 Refurbishment, repair or buy & re-sell[10]

ABB Robotics has a program for refurbishing, repairing or buy and resell robots. The company has 41 front end units that interact with the customers to solve their problem. In the backend there are spare part centers in China, Japan and in Sweden. In Mexico and Czech Republic there are factories that additionally can do repairs and refurbishment. Refurbishment implies that a customer can send a worn (but working) product to these centers to get it back in shape again. Repair means that the product (or a part of it) is fixed after being damaged. The customers can also sell or give their product to ABB who refurbish it and sells it to customers at a second hand market. After the robot has left the process it is "as good as new", which implies that a one year warranty period is given. It takes between two and three weeks to refurbish a product. The strength of letting ABB do the refurbishment and repairs is that

[9] Christian Stich, ABB Corporate Research Germany, 2011-02-17.
[10] ABB (2010d) and ABB (2011d)

ABB can use original parts and have the full knowledge to service the product in the way it should. The refurbishment process consists of 152 inspection points where parts are cleaned, changed or re-painted. Oil change is also done.

4.3.4 A possible solution for management and payment systems[11]

ABB Corporate research in Västerås, Sweden, made a project to create a communication system together with an AC charger. The system used a computer that was equipped with a local database and a RFID reader for user identification. The computer and the charger communicated over Ethernet. The charger in turn was equipped with a smart meter which also had IO functionality. With this, data could be sent about a current charging process and the charger could be controlled to stop or continue. The service could identify users locally but to get the full system functionality it was integrated with Nokia-Siemens Networks' system. This system has features towards the end customer to register and pay for using the network.

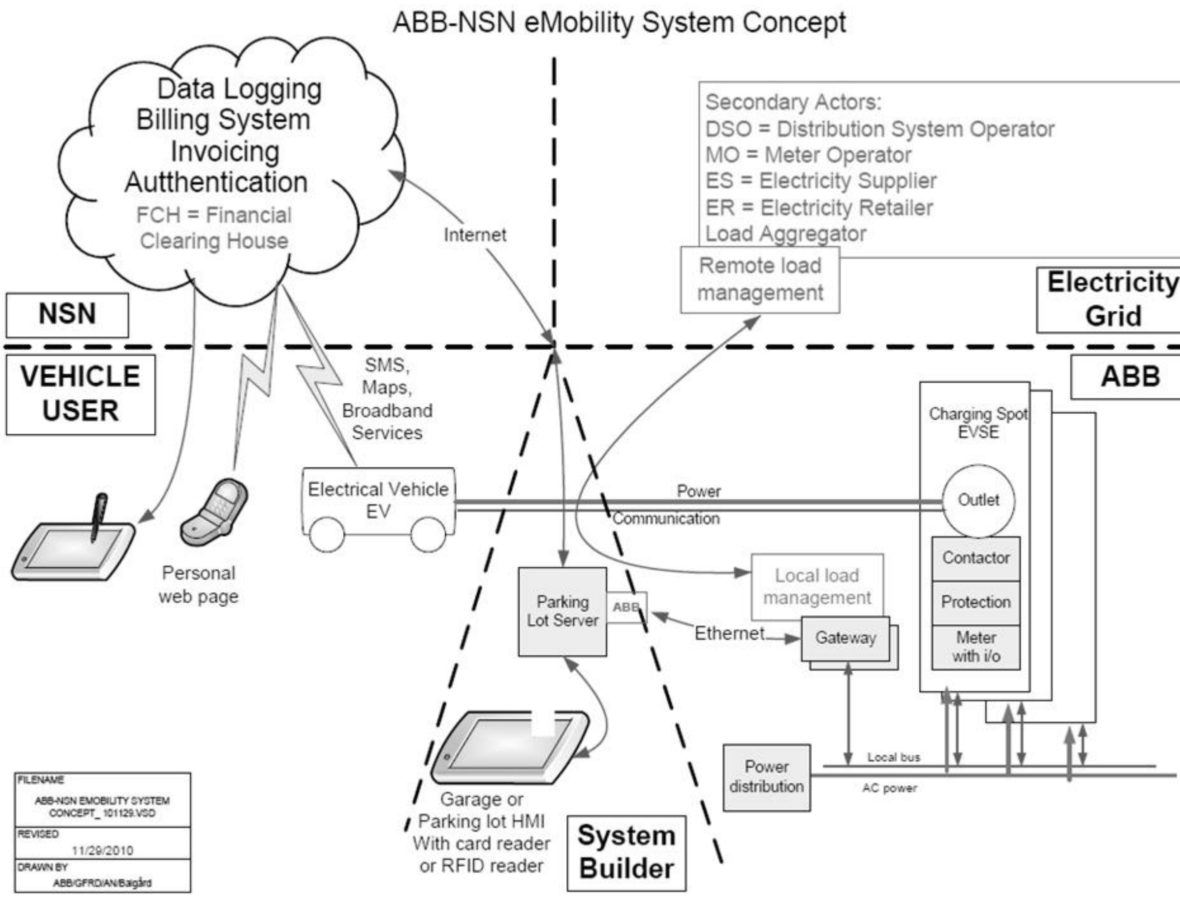


Figure 25. Figure illustrating the integration with the NSN service and its integration with an ABB AC charger (ABB CRC Sweden, internal document).

[11] Interview with Pier Blomkvist, ABB CRC Västerås Sweden, 2011-04-05, about integration of chargers in Nokia-Siemens Network's systems.

Blomkvist expressed that this project did not require much time and it was interesting to test how the system works. To build a similar integration for the DC fast charger would be an easy task. According to Blomkvist it would require approximately one man working one month to get an API for the charger from which data could be read, billing rates set and identification to work. Blomkvist thinks that ABB should not be a bank doing financial services. Doing integration towards a third party, such in the test project that was undertaken, should according to Blomkvist be the best strategic fit for ABB.

4.4 SUMMARY OF CHAPTER 4

This chapter has presented the results from internal brainstorming activities, customer interviews and several benchmark interviews. All these activities have had one purpose in common; to serve as a foundation for idea generation. The idea evaluation (chapter 5) started already in parallel to idea generation and was based on the framework presented in Table 22. This framework, consisting of the 43 service ideas, is hence brought to the next chapter and further through the report. The findings from the interviews are used when concepts finally are developed in chapter 6. The interview results are used together with the quantitative evaluation data from the next section to define the *what* part of the each service concept.

Table 30 presents a summary of the different needs that was brought up during the interviews from different actors. The ideas coincide with what was found during the brainstorming session (Table 22) and what has been included in the evaluation survey sent to customers. Together, this provides the answer to research questions 1.1 and 1.2. However, some ideas and the format of them are additional from what was included in the survey. These will however be taken into account in concept development.

Table 30. Summary of needs addressed during customer interviews and an assessment of how many of the interviewees that shared the need (the demand) (author).

Product related	Demand
Updates and upgrades	**High**
Emergency repairs and troubleshoot Installation Help commercial actors to build business case Scheduled maintenance Remote maintenance Service contracts – availability/insurance and risk transfer. Leasing – with availability and updates Rebranding of charger End of life service – recycling or reselling	**Moderate**

…Table 30. Summary of needs addressed during customer interviews and an assessment of how many of the interviewees that shared the need (the demand) (author).

Action related	Demand
Payment system - RFID or magnet card (tied to customer relationship management) - VISA payment – but questionable - No payment on charger, circuit breaker in store. - Via mobile phone (SMS or app). - Open standard	**High**
Monitor or management system - Control price (tariff) - Manage customer registration, charging RFID cards - Remotely (by owner) control if charge can be done or not and to what level - Control screen content (advertising) - Call centre service and total operation solution - See statistics of usage - Control the heater in the car	**Moderate**
Consulting and sales of smart grid solutions	**Moderate**
Towards customer - Where is closest charger and is it occupied? - Control charging remotely with phone	**Low**

Features such as controlling the heater in the car and the ability to change price tariffs have for example not been evaluated in the survey. A more detailed assessment of the companies can be made based on the interviews. In general, the different value propositions and needs from these are important for the understanding of customers.

Table 31 assesses the interviewees requirements in a two dimensional space spanned by product life cycle related services on one axis and action related services/features on the other. This both address research question 2.2 since this asks for differences between customer segments. In this space, utilities in general require less product related services due to their already existing knowledge and in house servicing capability. Depending on the companies' efforts in eMobility, different requirements are placed on the action related dimension as well.

Table 31. Assessment of the different interviewed customers in a service space spanned by action related services/product features and product related services over the life cycle (author).

Action services / **Product life cycle**	**Charger**	**Network-enabled charger**	**Complete solution**
Few services (less labor intense)	State owned utility 2	Utility 1, 2, 3 and 4, State owned utility 1	
Many services (service contracts, more labor intense)	Shopping mall builder 1, The fleet rental company	Shopping mall builder 2, The petrol station	Amsterdam, Ireland, Portugal, London, The parking company

The assessment in Table 31 shows that cities and some commercial actors are probably keener to buy a working solution for payment and management together with outsourcing most of the product related services. This has been seen in developments in cities and countries. This segment is already starting to take off and the solution providing actors in eMobility are providing offers that fit here. There are however many companies that do not want a complete working solution and there are possibilities of many different combinations of offers.

Further on, service benchmark findings in this chapter lie as a foundation for further concept development in chapter 6. The findings are summarized in Table 32. This provides a short answer to research question 1.3 of what ideas service benchmarks could give for designing service concepts for this project. The internal interview findings related to service contracts are used as an input to design the service concept for operational life time services. The Nokia Siemens Networks benchmark is used as input for the action related service concepts.

Table 32. Summary of key learning points for service benchmarks (author).

FROM ERICSSON

- **Scale** is important to reach utilization of the service organization. Utilization drives profit and competitive advantage.
- Services are important for **differentiation** of a hardware supplier. A network service organization can be run independently of producing hardware but knowledge synergies are an important reason for having both businesses under the same company.
- **The service offering is developing over time** for the hardware producer to take on more risk.
- A **global service organization is beneficial** to be close to customers and tie important relationships for service agreements.

FROM INTERNAL BENCHMARKS

- If the client has operations with high output value per time unit, having hardware suppliers guaranteeing uptime is important.
- Three levels of contracts are normally used within ABB for operational services; technical support (customer risk), preventative care (shared risk) and complete care (ABB risk).
- Service contracts are done by many ABB companies and can provide win-win for customers and ABB. There are four reasons for customer to buy service contracts including; reduced and predicted life cycle costs, removed peaks in cash flow and lower requirements of technical specific knowledge. Pricing is done in relation to total hardware costs per year and is derived from mean time between failure data of product components.
- Refurbishment and buy & re-sell are done within ABB Robotics and the main reason for choosing ABB is guaranteed quality due to OEM parts and correct refurbishment process.
- Building an API for charger communication requires approximately one man month of work. Building solutions with the API is more cumbersome. Solutions are very important for selling to the “free infrastructure” value proposition.

5 IDEA EVALUATION

In this section results from the customer and internal surveys will be presented as well as competitive benchmarks.

5.1 CUSTOMER SURVEY

Table 33 shows the evaluated customer ideas providing an answer to research question 2.1, i.e. what the customer feedback was on service ideas. Hardware upgrades, replacement, reconditioning, spare part field service, documentation, warrantee and operating training receive the higher priority numbers. That is, many customers think that these are services that must exist for them to buy from ABB. ABB must hence have them to be in the service business. On the bottom of the list can network operation and different action related services such as car maintenance be found. This result can be explained by the information from interviews. Customers do in general not want action related services that are far from the core business of ABB. The low evaluation of network operation can be explained by the fact that no free value proposition respondent exist in the survey sample. The city of Amsterdam and other cities did not complete the survey. It is likely that those actors would have preferred network operation since it has been a must be attribute for selling chargers to them.

Table 33. Service ideas ranked according to priority. Most important is hardware upgrades, replacement, reconditioning and spare part field service (author).

Service idea	R	I	A	O	M	Other	Utility	Total	Standardized priority (←)	Rank
Hardware upgrade, replacement or reconditioning	0	1	0	2	6	M	M	M	1.93	1
Spare part field service	0	1	0	2	6	M	M	M	1.93	2
Documentation	0	1	1	3	4	O	M	M	1.46	3
Warranty	0	2	0	2	5	M	M	M	1.46	4
Operating training	0	1	1	4	3	O	M	O	1.30	5
Software updates	0	2	0	3	4	O	M	M	1.30	6
Troubleshooting field service	0	1	2	2	4	M	M	M	1.30	7
Open payment standard	0	2	1	1	5	M	M	M	1.30	8
Maintenance training	0	1	3	1	4	A	M	M	1.15	9
Repair field service	0	2	1	2	4	M	M	M	1.15	10
Operational statistics raw data	0	2	1	3	3	O	M	M	0.99	11
Sales services	0	2	2	2	3	M	I	M	0.84	12
Operational statistics	0	2	2	3	2	O	A	O	0.68	13

…Table 33. Service ideas ranked according to priority. Most important is hardware upgrades, replacement, reconditioning and spare part field service (author).

Service idea	R	I	A	O	M	Other	Utility	Total	Standardized priority (↓)	Rank
Unit availability (where is the next charger?)	0	1	5	3	0	A	O	A	0.22	14
User remote charging control	0	0	7	2	0	A	A	A	0.22	15
Processed statistics	0	2	3	4	0	O	O	O	0.22	16
Balance of plant	0	3	4	0	2	A	A	A	0.06	17
End of life recycling	0	4	2	1	2	I	M	I	0.06	18
System optimization consulting during operation	0	2	4	3	0	O	A	A	0.06	19
Service contracts with different levels of service	0	2	5	1	1	A	A	A	0.06	20
Smart payment service (subscription, cash or credit)	1	3	0	3	2	M	O	O	0.06	21
Commissioning	0	4	2	2	1	I	M	I	-0.09	22
Consulting unit sizing	0	4	3	1	1	I	A	I	-0.25	23
End of life re buy and reselling	0	2	6	1	0	A	A	A	-0.25	24
Consulting network design	0	4	2	3	0	O	A	I	-0.25	25
Consulting cost of connection minimization	1	1	4	3	0	A	O	A	-0.25	26
Remote control of display content	0	6	0	2	1	I	I	I	-0.40	27
Remote system for advertising	0	6	1	1	1	I	I	I	-0.56	28
Installation	1	2	5	1	0	A	A	A	-0.72	29
Preventative (scheduled) maintenance	1	3	3	2	0	A	I	A	-0.72	30
Pre and post grid analysis	0	5	3	1	0	I	A	I	-0.72	31
Openly accessible stats API	2	1	3	3	0	A	O	O	-0.72	32
Wi-Fi services to smart phones in the area	0	5	4	0	0	I	A	I	-0.87	33
Media distribution/sales	0	5	4	0	0	A	I	I	-0.87	34
Consulting location analysis	1	4	3	1	0	A	I	I	-1.03	35
Smart grid service storing power	0	6	3	0	0	I	A	I	-1.03	36
Statistics/information to end user	1	2	4	1	0	A	A	A	-1.03	37
Location specific adoptions (civil engineering)	1	4	4	0	0	I	A	A	-1.18	38
Predictive maintenance (using remote)	1	4	4	0	0	A	A	A	-1.18	39
Financial services	1	5	2	1	0	A	I	I	-1.18	40
Reward system for charging at your stations	0	7	2	0	0	I	I	I	-1.18	41
Car maintenance (software updates to cars)	2	4	2	1	0	A	I	I	-1.49	42
Network operation	3	3	2	1	0	R	I	I	-1.80	43

The classification of attributes can be depicted with the satisfaction and dissatisfaction scores. Figure 26 shows this evaluation. Figure 26 also groups the service ideas into their total classification as either must be, one dimensional, attractive or indifferent. Reward system for charging and remote control of the display are examples of ideas that are most indifferent with this way of analyzing. Network operation and the different consulting services are on the border line to be attractive.

The most attractive service is “user remote charging control”, where the user can log in to the charger and see status whole for example being away drinking coffee. The strongest must be service is to have hardware upgrades, replacements and reconditioning. Field service, documentation and warrantee are also very important to have.

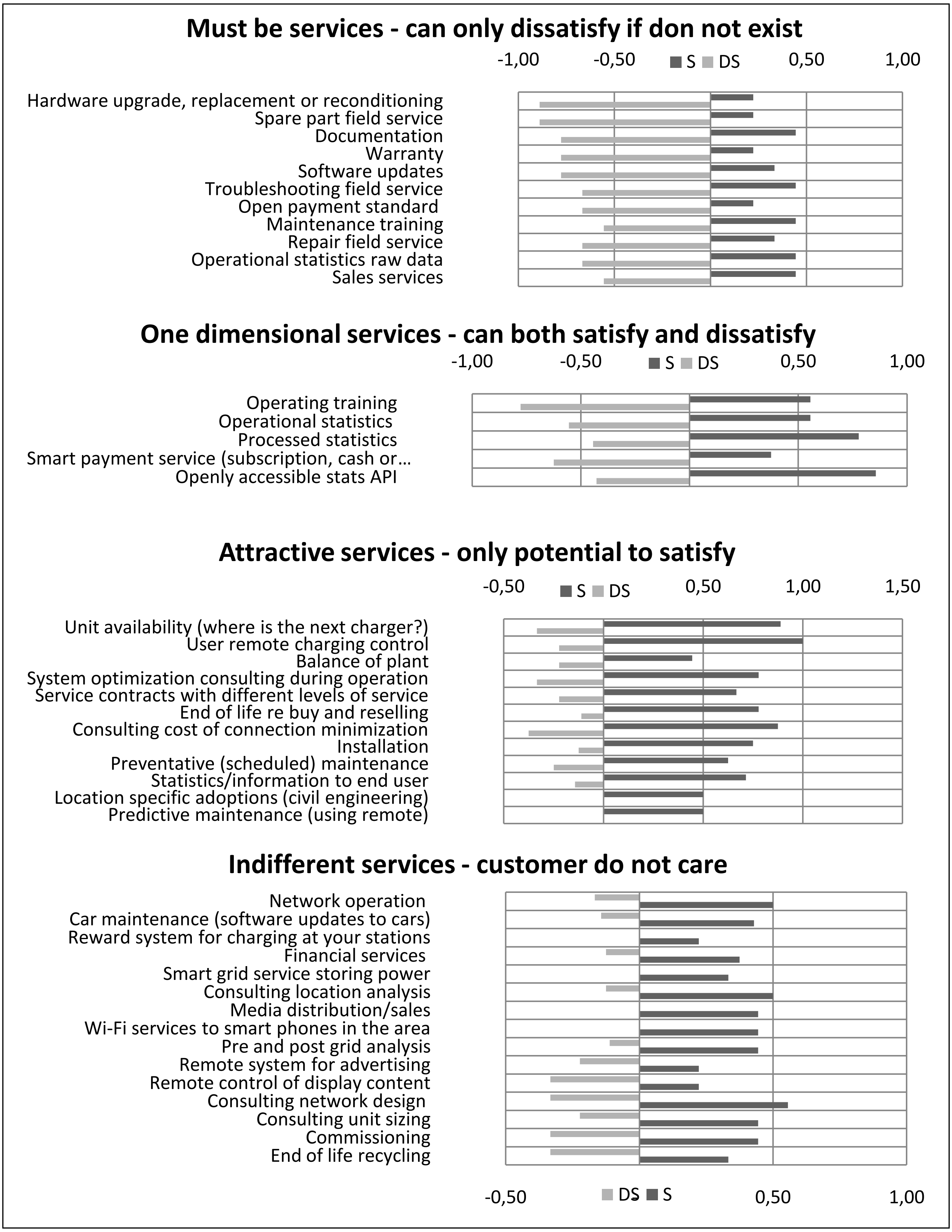


Figure 26.Service ideas categorized according to their type when evaluated by the nine respondents (author).

Figure 27 shows the certainty of different classifications together with priority. High certainty means that most answers lie in the same category; low certainty implies a spread.

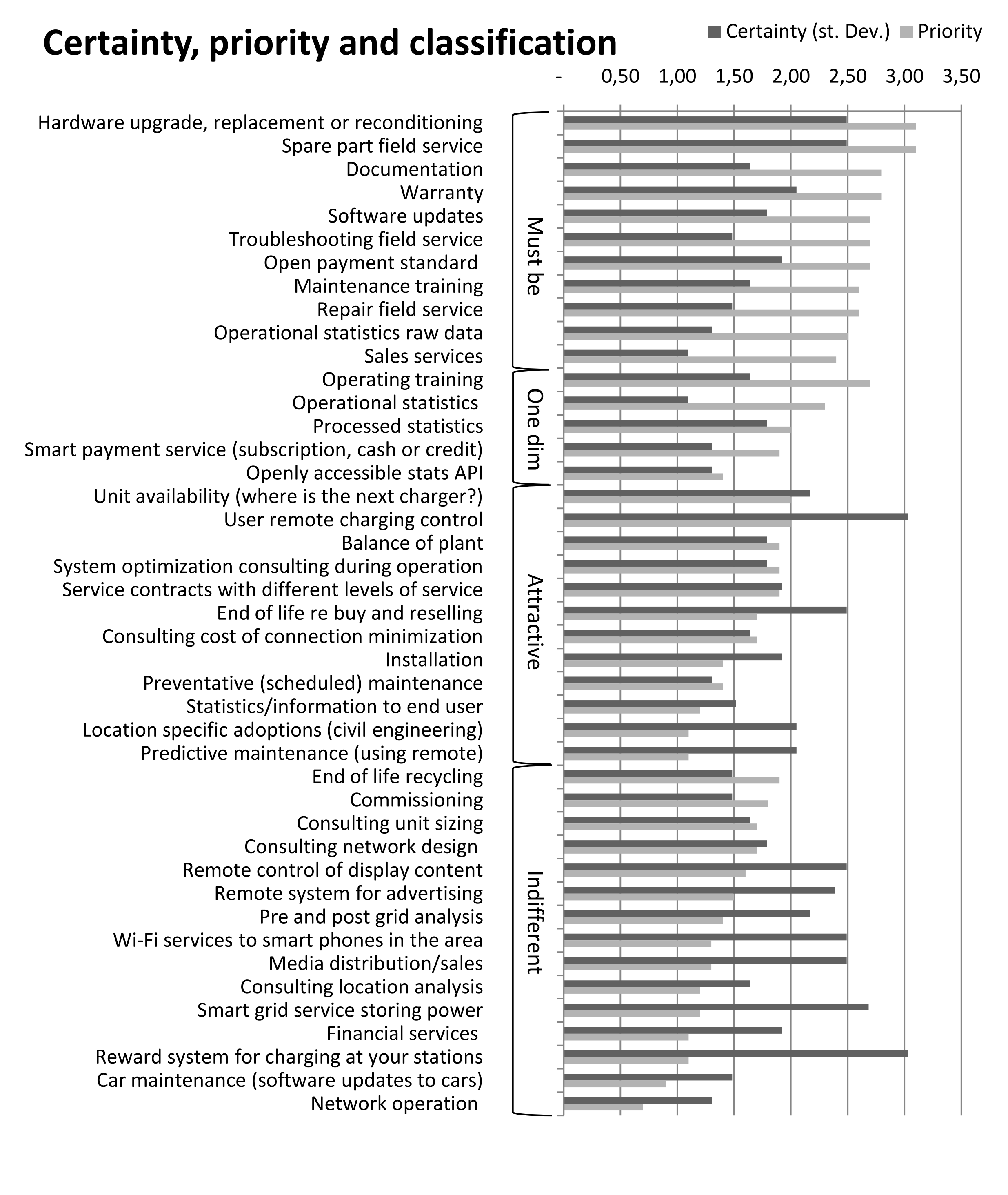


Figure 27. A high certainty means that many answers are in the same category. Service ideas with high priority and certainty could be assumed to be worth much to customers. Spare parts and hardware upgrades are examples of these services ideas. Reward system for charging at your stations is with a high certainty a service idea that is indifferent to customers. Hardware upgrades, replacements and reconditioning has a high certainty to be a must be service (author).

5.1.1 Differences between customers

One research question was to understand if different customer segments have different needs of services (RQ 2.2). With the low number of survey respondents in mind it is impossible to do a fair break down of differences between all six potential value propositions in eMobility. This segmentation would have been the most interesting to look at since it reflects the customer type within DC fast charging best. The qualitative assessment in the previous chapter gives the best picture of what different customers put high value on. To make some kind of quantitative judgment of different customer requirements, the surveys were split based on the type of original business model the customers have. The survey respondents are grouped in *utilities* and *Others*. Others include the petrol station (two survey answers), the shopping mall, the parking company and the fleet company. These companies have different value propositions within eMobility but mostly their value proposition is commercial. For utilities the value proposition is also commercial or solution provider.

Table 34. Table showing ***$Prio_{utility}$-$Prio_{others}$*** *sorted descending. Prio is the standardized priority numbers for each service idea which has been calculated for both customer groups. Looking at differences in priority numbers shows what service ideas that differ most between the segments.* ***$Prio_{utility}$-$Prio_{others}$*** *gives a measure that if positive means that utilities value the idea more than Others and if negative the opposite holds true (author).*

Utility prioritization versus other commercial respondents	Total	Utility	Other	$Prio_{utility}$ - $Prio_{others}$
Openly accessible stats API	O	O	A	1.7
Software updates	M	M	O	1.5
End of life recycling	I	M	I	1.2
Pre and post grid analysis	I	A	I	1.1
Commissioning	I	M	I	1.0
Predictive maintenance (using remote)	A	A	A	1.0
Consulting unit sizing	I	A	I	0.7
Maintenance training	M	M	A	0.7
Smart grid service storing power	I	A	I	0.6
Documentation	M	M	O	0.6
Warranty	M	M	M	0.6
Preventative (scheduled) maintenance	A	I	A	0.6
Network operation	I	I	R	0.5
Operational statistics raw data	M	M	O	0.4
Reward system for charging at your stations	I	I	I	0.4
Open payment standard	M	M	M	0.4
Operating training	O	M	O	0.4
Unit availability (where is the next charger?)	A	O	A	0.3
Processed statistics	O	O	O	0.3
Wi-Fi services to smart phones in the area	I	A	I	0.3
Hardware upgrade, replacement or reconditioning	M	M	M	0.2
Balance of plant	A	A	A	0.1
Operational statistics	O	A	O	-0.1

…Table 34. Table showing $Prio_{utility}$-$Prio_{others}$ sorted descending. Prio is the standardized priority numbers for each service idea which has been calculated for both customer groups. Looking at differences in priority numbers shows what service ideas that differ most between the segments. $Prio_{utility}$-$Prio_{others}$ gives a measure that if positive means that utilities value the idea more than Others and if negative the opposite holds true (author).

Utility prioritization versus other commercial respondents	Total	Utility	Other	$Prio_{utility}$ - $Prio_{others}$
Location specific adoptions (civil engineering)	A	A	I	-0.2
Media distribution/sales	I	I	A	-0.3
Remote system for advertising	I	I	I	-0.3
Spare part field service	M	M	M	-0.3
End of life re buy and reselling	A	A	A	-0.4
System optimization consulting during operation	A	A	O	-0.5
Smart payment service (subscription, cash or credit)	O	O	M	-0.5
Statistics/information to end user	A	A	A	-0.5
Remote control of display content	I	I	I	-0.7
Car maintenance (software updates to cars)	I	I	A	-0.7
User remote charging control	A	A	A	-0.8
Consulting network design	I	A	O	-1.0
Repair field service	M	M	M	-1.0
Service contracts with different levels of service	A	A	A	-1.1
Consulting location analysis	I	I	A	-1.1
Installation	A	A	A	-1.2
Financial services	I	I	A	-1.3
Troubleshooting field service	M	M	M	-1.3
Sales services	M	I	M	-1.5
Consulting cost of connection minimization	A	O	A	-1.6

The standardized prioritization index for each group is used to study differences. Looking at the difference $Prio_{utility} - Prio_{others}$ and sorting the service ideas, a list is given where the top and bottom items have services with different priorities between the groups. Table 34 shows this sorted list where the top of the list has higher priority of utilities and the bottom higher priority for the Others group. Some interesting conclusions can be drawn from Table 34:

- Utilities care less than Others about field services, maintenance (with the exception of predictive maintenance), installation and life cycle services that include labor. This could be explained by the fact that utilities have more knowledge about electrical equipment and usually an internal service organization for their network. On the other hand, utilities are more attracted by training of different kinds; both for maintenance and for network operation.
- Utilities care less than Others about different consulting services such as cost of connection minimization, network design and location analysis. The utilities could be assumed to have higher maturity in electrical knowledge and hence the consulting services are less attractive.
- Utilities worry more about commissioning than Others (must be versus indifferent). This is a somewhat strange result. One possible explanation is that utilities understand

what commissioning is, since this is something they normally do when buying power equipment. Commissioning is the activity that transfers responsibility of the equipment from the supplier to the customer. The supplier makes sure that the equipment works and is tuned according to specification. This is sometimes a weekly long activity that ABB sends engineers to perform on larger products. The Others (non utilities) are not used to this and this might be a rationale for why they are indifferent towards it.

- Having an openly accessible API from the charger that can be used by the public for developing applications (apps) is something that is one dimensional for the utilities. The utilities, who plan on building a charging network, might think that it is a good idea that the network is as user friendly and accessible as possible. On the other hand, the Others thinks that this feature is reverse; that is something that will only dissatisfy if it exists. This striking difference is important to take into account when offering the product to these different actors.
- Utilities care more about software updates than Others.

5.2 Internal survey

This section presents the results of the internal survey. Two research questions are being addressed:

RESEARCH QUESTIONS
Internal
RQ 2.3. What strategic fit does each of the service ideas have?
RQ 2.4. What strategic intent does ABB have for each of the service ideas?

The answers to the research questions follow directly in Table 35 where both the results of strategic intent and strategic fit are listed. Network operation, car maintenance and remote control of display are service idea examples that have a bad strategic fit. Particularly interesting is that most action related services (product features) have a comparably low strategic fit internally. The traditional ABB services have a high fit as well as high strategic intent. Field service, preventative maintenance, spare parts, training and commissioning are the top five.

Table 35. Result of internal survey, sorted on strategic fit (author).

Rank	Service idea	Strategic intent	Strategic fit (↓)
1	Preventative (scheduled) maintenance	100%	46.5
2	Repair field service	100%	45.1
3	Spare part field service	100%	44.7
4	Maintenance training	90%	43.2
5	Commissioning	90%	42.6
6	Consulting cost of connection minimization	80%	41.6
7	Installation	50%	40.5

…Table 35. Result of internal survey, sorted on strategic fit (author).

Rank	Service idea	Strategic intent	Strategic fit (↓)
8	Service contracts with different levels of service	80%	39.8
9	Consulting location analysis	90%	39.6
10	Documentation	80%	39.4
11	Sales services	100%	39.2
12	Warranty	100%	39.0
13	Balance of plant	70%	38.6
14	Consulting unit sizing	100%	37.6
15	Troubleshooting field service	90%	37.3
16	Operating training	70%	37.3
17	Hardware upgrade, replacement or reconditioning	90%	36.6
18	End of life recycling	50%	35.7
19	Consulting network design	90%	35.5
20	Software updates	80%	34.0
21	Pre and post grid analysis	70%	33.7
22	Location specific adoptions (civil engineering)	10%	33.7
23	Operational statistics	70%	33.3
24	Predictive maintenance (using remote)	70%	33.3
25	System optimization consulting during operation	40%	32.7
26	Smart grid service storing power	60%	31.3
27	Wi-Fi services to smart phones in the area	20%	31.0
28	Operational statistics raw data	50%	30.9
29	End of life re buy and reselling	30%	29.5
30	Financial services	40%	28.8
31	Processed statistics	60%	28.5
32	Open payment standard	60%	26.3
33	Smart payment service (subscription, cash or credit)	50%	26.0
34	User remote charging control	60%	24.9
35	Unit availability (where is the next charger?)	60%	23.6
36	Statistics/information to end user	40%	22.0
37	Media distribution/sales	30%	21.5
38	Network operation	10%	21.4
39	Openly accessible stats API	20%	20.4
40	Remote system for advertising	30%	20.2
41	Reward system for charging at your stations	10%	19.6
42	Car maintenance (software updates to cars)	10%	19.3
43	Remote control of display content	10%	19.2

The services in Table 35 are sorted on strategic fit (not standardized). It can be noted that the strategic fit seems to be related to the strategic intent. In the top of the table are both high scores on intent and fit; in the bottom of the table the opposite is true. Looking at a correlation plot between strategic fit and intent (Figure 28), it shows a R^2 value of 0.67 meaning that there is a high correlation between the two dimensions. The interpretation of this is that ABB wants to offer the service ideas the company thinks should be done in the future.

A question was also raised on where ABB should be on the service continuum. The result (Figure 29) was that most respondents (70%) thought that ABB should take some customer risk (i.e. do service contracts) but not take over all end user operation.

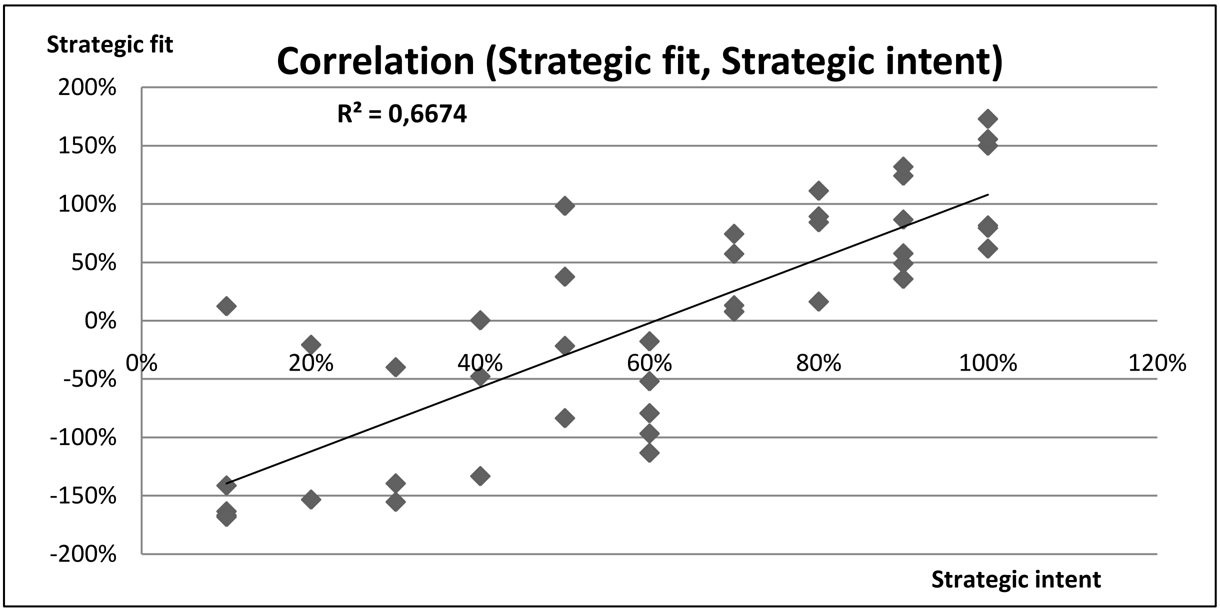


Figure 28. Strategic fit and strategic intent seem to be rater correlated. This means that ABB wants to do essentially the same services as the organization believes has a strategic fit. $R^2 > 0.5$ is a sign of strong correlation.

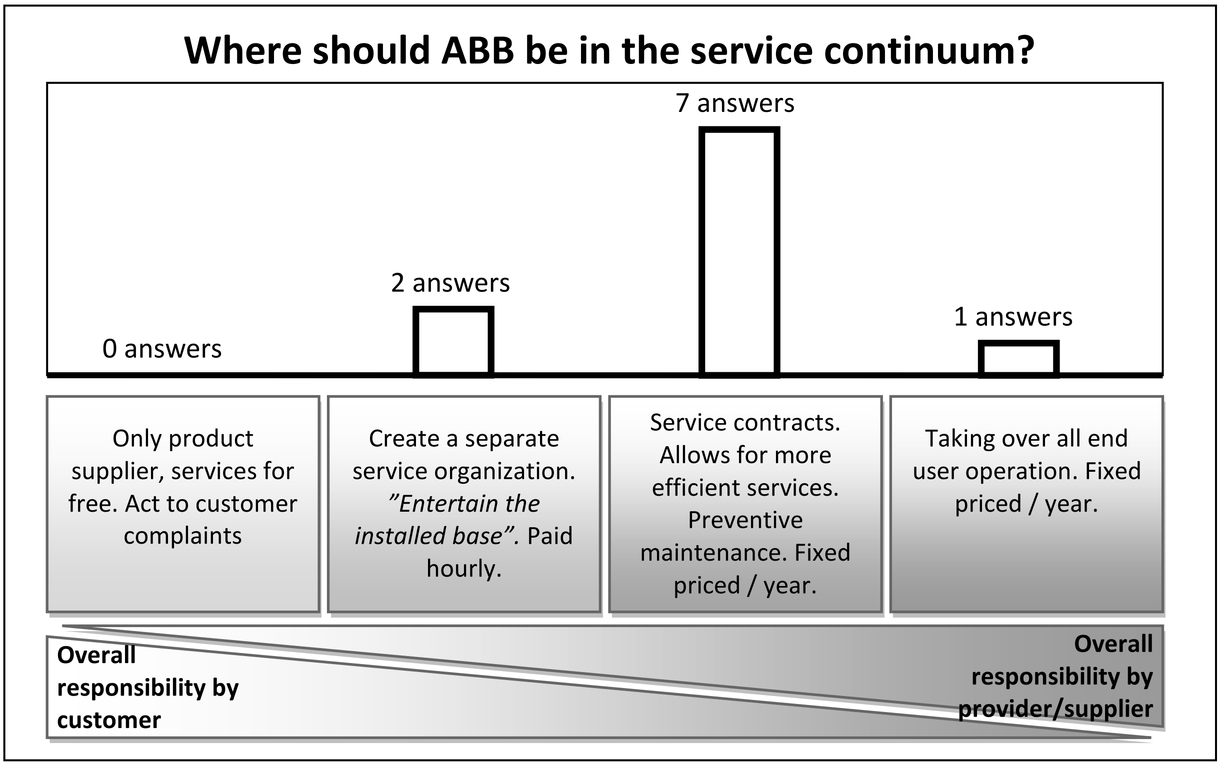


Figure 29. Question to the internal organization on where ABB should position on the service continuum (see model from Olivia & Kallenberg 2003).

Two open ended questions were also posted in the questionnaire. The questions involved to comment on the importance of product and action related services respectively. The answers that were gathered are summarized in Table 36.

Table 36. Voices from the survey (author).

COMMENTS ON IMPORTANCE OF PRODUCT RELATED SERVIES

- Important to offer complete care packages for customers who are not interested or capable of doing product related services. Some customers will require this.
- ABB should offer standard packages under the life cycle; this is a “winning formula”. ABB cannot afford to tailor solutions for every customer.
- Product related services mean a differentiation potential from charging unit only suppliers.
- Product related services offer access to attractive high margin potentially recurring revenues.

COMMENTS ON IMPORTANCE OF ACTION RELATED SERVIES/FEATURES

- Fast charging alone is too narrow to compete with; the offer has to be widened. The full solution package has to be one of the standard packages in ABB’s offering.
- There is a significant risk involved.
- Not ABB’s core business.
- Most of the parts like payment solutions are just mandatory. Customers will require it.

Figure 30 presents an assessment of how similar respondents answered of answers for strategic fit. The standard deviation in this case is low when respondents agree on the answer and high when there is a higher uncertainty. Preventative maintenance is the service idea with the highest strategic fit and it also received a high certainty ranking. Interesting is that the uncertainty is relatively high for network operation meaning that it is some disagreement whether ABB should be in that business or not. This is in line with the findings in Table 36. Some believe it is a high risk to do action related service; others mean that it is a way of differentiating.

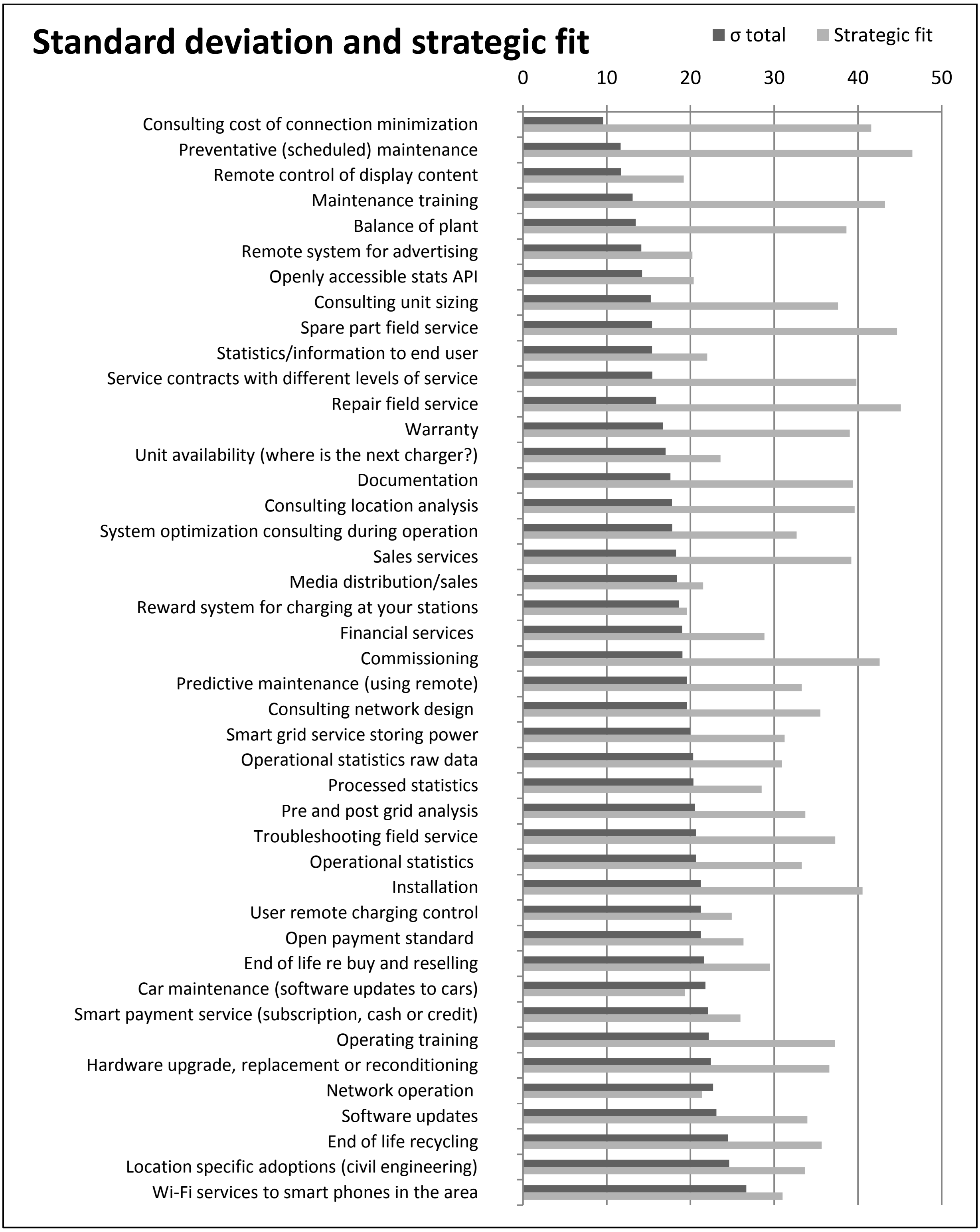


Figure 30. A low standard deviation here means a high certainty of the answers. Preventative maintenance and spare part service are examples of service ideas with both a high strategic fit and level of agreement with the respondents. Network operation has high standard deviation (low certainty) and a low ranking. There is no correlation between strategic fit and standard deviation (R^2=0.03). A similar analysis with strategic intent was done showing similar results (author).

5.3 COMBINING CUSTOMER NEEDS AND INTERNAL PERSPECTIVE

This section addresses the following research question:

Customer compared to internal
RQ 2.5. How does ABB's perception of strategic fit align with customer value?

This might be the most interesting evaluation in this report since it has direct strategic implications. Figure 31 depicts a plot of strategic fit (internal survey) and customer value (external survey). The plot is the key to answering the research question of this section. Some services are highly valued by both customers and internal ABB. These are labeled "in line" services. Other service ideas are important for customers but have not been prioritized by internal ABB; those services have a negative gap and are therefore a focus area to concentrate on. Not important are those services that neither customers nor ABB care about. Finally, a gap exists when ABB focuses too much on a service that customers are indifferent towards. These services are potential overkills where ABB can reduce focus.

One important note must be made. The analysis is made on the total set of answers. As previously shown, utilities and Others had differences in their evaluation. This implies that some unimportant services anyway can be important to focus on. When the final recommendations are done it is for this reason wise to not only stare at this one evaluation; all possible data should be used.

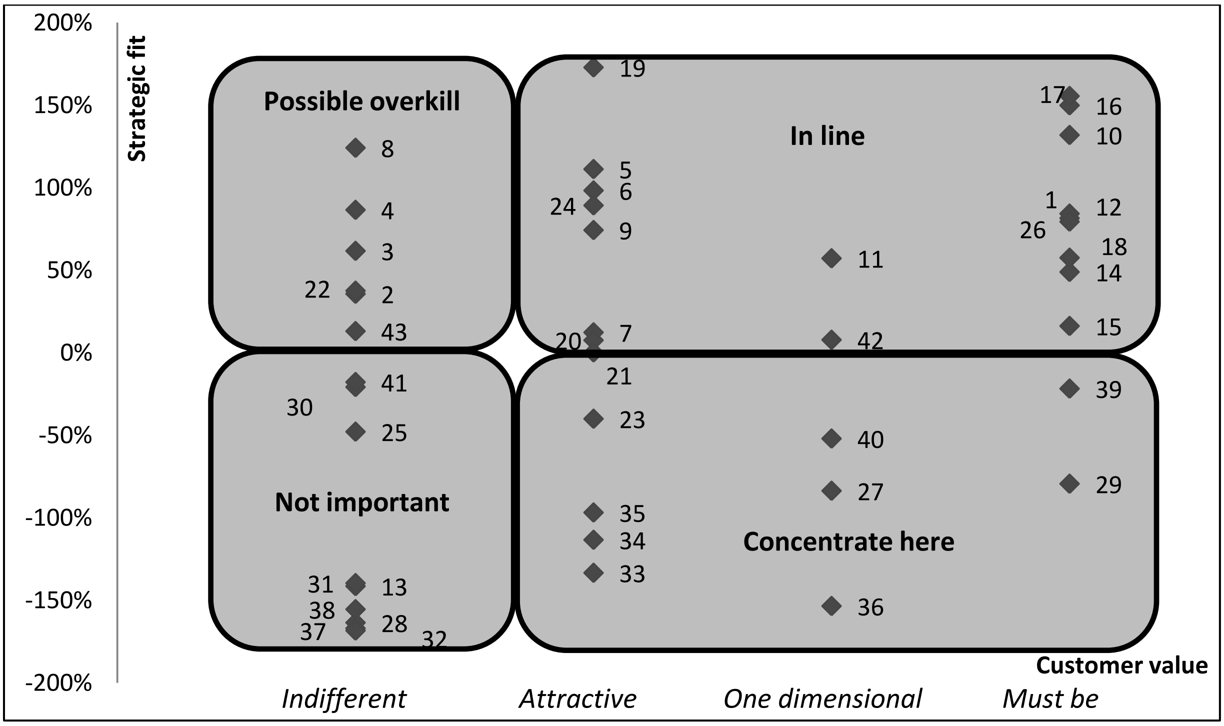


Figure 31. A plot with strategic fit and customer value for the service ideas. The service idea is represented by its ID, since the total label is too long (author).

Table 37 takes the services from Figure 31 and plots them with their full label. Spare parts, training, sales services and field service are services valued by customers and internal ABB.

A payment system as well as possibilities to see statistics is where ABB needs to put more focus. ABB has too much focus on consulting services.

Table 37. The importance-performance matrix applied to the service ideas. Importance is represented by the customer dimension (M, O, A is important, R and I unimportant). Performance is represented by standardized internal survey rating (author).

	Importance	
Performance	**Possible overkill**	**In line**
	• Commissioning • Consulting location analysis, unit sizing, network design, pre and post grid analysis • End of life recycling	• Repair & spare part field service • Maintenance & operating training • Sales service & documentation • Troubleshooting field service • Preventative (scheduled) maintenance • HW upgrades, replacement or reconditioning, SW updates • Consulting: cost of connection minimization • Operation statistics (for utility) • Service contracts, warranty • Civil engineering, installation • Predictive maintenance (remote)
	Not important	**Concentrate here**
	• Reward system for charging • Car maintenance and SW updates • Remote control of display and remote advertising • Media distribution & sales (app store) • Network operation • Financial services • Smart grid store, sell, buy energy	• Payment solution (cash, payment, RFID). Open standard. • Statistics for owner • Openly accessible API for app development • User services: remote charging control, charger location, statistics of charging • Consulting: system optimization during operation • End of life re-buy and resell

A correlation evaluation between the customer priority and the strategic fit of the service ideas has been made. The dimensions are weakly correlated ($R^2 < 0.5$). This is an interesting finding implying that ABB does not focus on the right areas. Figure 32 shows a correlation plot between the total customer segment and the internal strategic fit.

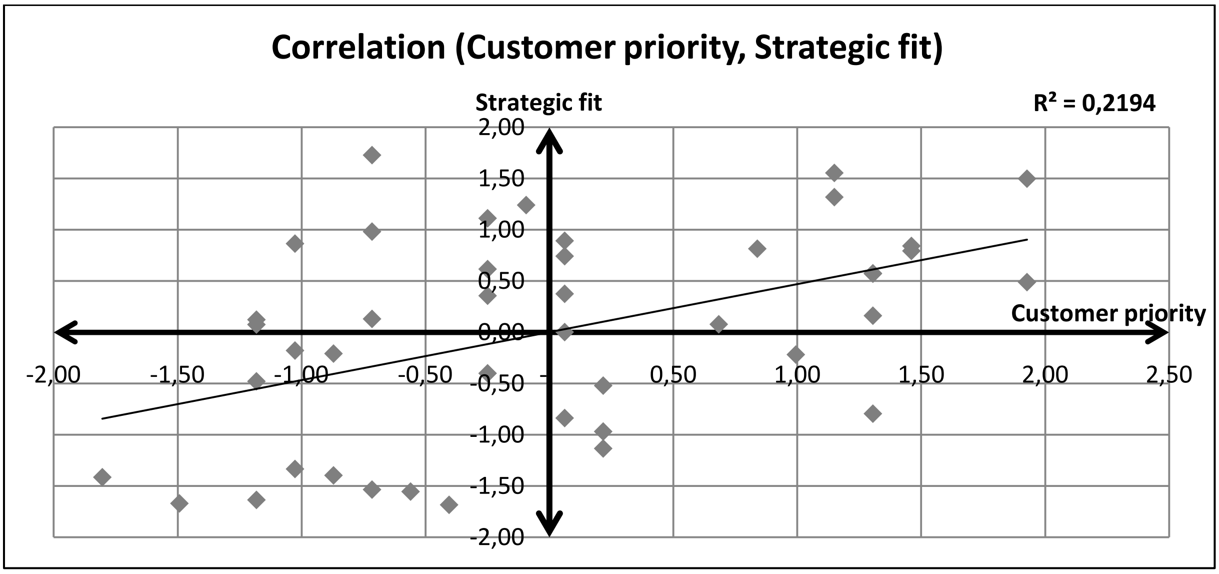


Figure 32. Plot of correlation between customer priority and internal rating. The indexes are standardized to N(0, 1). The plot shows a weak correlation ($R^2 < 0.5$) (author).

A correlation analysis was made for the two different customer dimensions to see if there are differences between customers. The results are presented in Table 38. Interesting is that none of the customer dimensions have a strong correlation with the internal strategic fit. Another interesting finding is that the correlation between the customer groups “utilities” and “others” is weak ($R^2 < 0.5$). This means that there is a difference between how these customers value the service ideas.

Table 38. Correlation between the different dimensions. None of the three customer dimensions have a strong correlation with the internal rating (everyone is $R^2 < 0.5$) (author).

R^2	Total customers	Priority Utility	Priority Others	Strategic fit
Total customers	1.00	0.86	0.77	0.22
Priority Utility	-	1.00	0.41	0.16
Priority Others	-	-	1.00	0.21
Strategic fit	-	-	-	1.00

A regression analysis (Table 39-41) was run between the three customer dimensions and strategic fit. All three regressions show a significant relationship. However, this only means that a relationship exists and not how strong it is or what it is explained by.

Table 39. ANOVA of regression between priority customers and strategic fit. The result shows that the two dimensions explain each other with a significance < 0.05 (author).

Priority customers total, strategic fit	***df***	***SS***	***MS***	***F***	***Significance F***
Regression	1	9.21	9.21	11.80	**0.001367**
Residual	42	32.78	0.78		
Total	43	42			

Table 40. ANOVA of regression between priority customers (utility segment) and strategic fit. The result shows that the two dimensions explain each other with a significance < 0.05 (author).

Priority customers utilities, strategic fit	df	SS	MS	F	Significance F
Regression	1	6.63	6.63	7.88	**0.007626**
Residual	42	35.37	0.84		
Total	43	42.00			

Table 41. ANOVA of regression between priority customers (Other segment) and strategic fit. The result shows that the two dimensions explain each other with a significance < 0.05 (author).

Priority customers Others, strategic fit	df	SS	MS	F	Significance F
Regression	1	8.87	8.87	11.23	**0.001735**
Residual	42	33.17	0.79		
Total	43	42.04			

5.4 Competitors[12]

Table 42 provides an assessment of competitors and their maturity over the service continuum. The competitors that have been assessed are only a subset of all companies that offer something in the fast charging/eMobility domain. The competitors are both startup companies and traditional power product competitors. Startup companies have emerged from two directions:

- Started developing fast charger hardware and are gradually moving into more advanced networked solutions (e.g. Aker Wade and Epyon).
- Started taking a network operative role buying hardware from others (e.g. Coulomb Technologies, ECOtality and Better Place).

In general many companies can today, as opposed to ABB, take orders and deliver working mass produced fast chargers. Epyon, SGTE and Aker Wade are examples of hardware producers in Europe and USA. In Japan; Takaoka, Hasetech and Takasago are examples of similar producers with proven installations. However few competitors have the capability to satisfy customers on both a solution and a hardware level. A description is made of each competitor below and after this some conclusions are drawn. Research question 2.6 is addressing what services competitors are offering. This is addressed directly in Table 42.

[12] The information in this section comes from publicly available sources (company web pages) and Chademo information material. A list of material for each company is available in appendix 9. Appendix 10 gives another evaluation of the maturity of different competitors.

Table 42. Assessments of competitors' maturity over continuum from pure product to pure service offering (author).

$^{\alpha}$ Siemens cannot deliver today but will deliver in-house in future. ECOtality has in-house assembly but possibly parts form ABB.

$^{\beta}$ Companies have API and possibility to integrate payment systems.

$^{\gamma}$ Has most likely a system but uses it internally to control the charger for the owner.

		Takaoka	Hasetech	Takasago	Siemens	RWE	Epyon	Coulomb	Better Place	ECOtality	SGTE	Aker Wade
HW	Can supply HW	X	X	X	/$^{\alpha}$		X			/$^{\alpha}$	X	X
Product related service	Can do product related services (install, maintain etc.)	X	X	X	X	X	X	X	X	X	X	X
Payment system	Has an integrated payment system?	X	X		X	X	/$^{\beta}$	X	X	X	X	/$^{\beta}$
Owner and utility monitor system	Has a system for the owner/utility to draw statistics?				X	X	X	X	X	X	X	X
Owner and utility control system	Has a system for remotely controlling features in the charger?				X	X	X	X$^{\gamma}$		X$^{\gamma}$		
Product related operation	Makes sure hardware is working for owner. Ensure product availability. (Service contract with supplier taking risk for owner).				X	X	X	X	X	X	X	
Operate end user interface	Operates registration and complaints from EV driver.				X	X		X	X	X		

5.4.1 Japan (Takaoka, Hasetech and Takasago)

The Japanese charging infrastructure is the world's most developed with more than 500 installed DC fast chargers. Most of these chargers have been installed for non-profit reasons (public offices) or for fleets of electrical vehicles (utilities) to reduce range anxiety (Tepco 2010-11-24).

Table 43 and other discussions held with Chademo representatives' hint that chargers at these installations have been produced by Japanese manufacturers. These competitors might also have helped with installation. Operation and maintenance of chargers are according to above organized by each charger's owner on an ad hoc basis which does not exclude the possibility of the hardware company helping to some degree.

Table 43. E-mail conversation with Mr. Tomokazu Takita from Tokyo Electric Power Company / CHAdeMO (2011-03-23).

"How do you pay for charging in Japan?

Most of DC fast chargers provide free charging service at this stage in Japan. Some charger owners charge around JPY500/charge ($6.2) and it is paid by cash or similar simple method. There is no Identification/Billing system using smart grid/meter.

How does the business model around charging work in general?

Today the chargers are in general free to use or with some ad hoc commercial business model. There are however exceptions. Nissan provides charging service for its membership customers. It costs JPY1500/month ($18.5) and customers can get free fast charging and so on. Chademo is establishing a business model for those charging owners that are not part of a subscription network. This business model will bring all chargers together in an association to which members subscribe.

What services are being delivered from the charger apart from charging and payment (i.e. action related services or features)?

There is no significant service in addition to charging from DC fast charger.

How is the charging network being operated?

At this stage, the owner, e.g. the utility, gas station, government or auto dealer, owns and operates the network by itself."

Payment systems and other action related features/services are not used in existing installations. The hardware could be assumed to just support fast charging and have no network capability, although the trend is that business models are developing to include subscription models that require billing systems. More advanced co-operations and subscription business models are also forming in order to increase profitability.

5.4.2 Siemens

German Siemens is one of ABB's major competitors in most business units for power products and it is currently pursuing a development effort for eMobility. Siemens's offer ranges from slow to fast charging and apart from just manufacturing hardware Siemens also has software solutions for "individual handling and central control" (Siemens n.d.). Siemens is behind the Source London project where it will deliver solutions for both fast and slow charging including managing the interface towards EV drivers (Source London n.d.).

Siemens offers feature both action and product related services/features. Siemens (n.d.) presents the following:

- Solutions for monitoring and remote control of charging hardware

- Infrastructure maintenance solutions
- Energy and load management solutions (smart grid integration)
- Back-office ERP, CRM, billing solutions
- Portal and service desk solutions
- Security, identity and access management
- Battery asset management
- Vehicle integration and charging interaction
- Fleet management
- Ecosystem and business case simulation

No information has been found on how Siemens can help with installation, upgrades or different levels of consulting. Since Siemens is doing all these services on its normal products range it could be assumed that it also have the capability within eMobility. This is also reasonable to believe since it offers packages to handle a customer’s complete operations.

To date the author has no knowledge of whether Siemens takes orders or not. Siemens is still not listed as a Chademo compliant partner although it claims to be able to deliver fast chargers (Siemens n.d.). It is likely that a fast charger soon is presented since the company has an agreement with London where this is included and also uses the product in marketing.

5.4.3 RWE[13]

RWE is the biggest utility in Germany, second biggest in the Netherlands and third biggest in UK (2009). The company has revenues of €48b (2009), 70’000 employees and 16 million customers. Table 44 presents RWE’s current service offer. The company states that “all of the services are subject to standard service level agreements (SLAs), i.e. binding definitions of the service quality” (RWE n.d. a).

As found in interviews with Amsterdam, RWE does full operation and customer management of charging networks. The company claims that its equipment is smart grid enabled for vehicle to grid operation and that it has a system for grid friendly load management charging (RWE n.d. b).

RWE has today no proprietary production of DC fast chargers. The highest output supplied from its chargers are 44 kW AC. However the company has integrated DC fast chargers from Epyon in their systems for the city of Amsterdam.

[13] Information taken from interview with RWE trade fair representative at Geneva Motor Show 2011, marketing material from Geneva Motor show 2011 and RWE (n.d. a).

Table 44. The service offering from RWE presented at Geneva motor show 2011 (author).

Service group	Service
Hardware	• Shipping • Extended warranty period (24 months) • Decal (rebranding)
Technical training	• Technical training on installation, maintenance and repairs (final maintenance can be done through partners).
Installation and commissioning	• Choice of location • Grid access management • Installation & commissioning
Operation	• Control centre • Helpdesk • Authentication • General inspection, maintenance and repairs • Technology updates • Electricity supply • Metering point management and operation • E-roaming
Software	• Customized authentication applications • Customized software from operation of helpdesk • Control centre software

5.4.4 Epyon

Epyon is a startup company with five years experience developing and supplying DC fast chargers (Epyon n.d. a). Apart from supplying hardware Epyon offers installation, maintenance, updates and support for all European countries through in-house or partnering organizations. Similar to RWE, Epyon also offers different service level agreement contracts with customers to ensure performance (Epyon n.d. b). The company has extensive knowledge in how charging best is optimized to take care of batteries. The company claims to have a big database with performance data of charging which might have some consulting value. Epyon does not seem to offer consulting services to optimize location of chargers or do civil engineering.

Epyon has a service centre called Epyon Power Routing that provides “support, software updates and upgrades, remote maintenance, servicing and monitoring of Terra chargers” (Epyon. n.d. c). This IT service centre can together with the maintenance personnel ensure that a network is operating. If the customer (charging station owner) does not want to have Epyon operating the network an off-the-shelf tool called Galaxy MySite allows accessing statistics and configuring operational parameters of the chargers. A set of APIs further enables the customer to build interfaces for billing, fleet management systems or smart grids (Epyon n.d. b).

No material found is indicating that Epyon intends extending their offer to also take care of the interface towards EV drivers. Epyon is not handling end user (EV driver) registrations, billing and complaints but enables the customer (charging station owner) to perform that activity. This is different from what RWE and Siemens are offering but it is for example in line with ABB's strategy.

5.4.5 Coulomb Technologies, ECOtality and Better Place

Coulomb Technologies, ECOtality and Better Place are US based startup companies with similar strategies. They all want to take a role as infrastructure operator for different investors (typical solution providers). Without owning the infrastructure, they plan to provide systems for handling the end user (EV driver) interface providing registration, identification and payment models (fee based or typically subscriptions). Also part of the model is to provide services for maintaining and operating the chargers for the owner. Revenues are shared with the owner of the charging stations.

On a hardware level the companies are sourcing products from hardware suppliers. SGTE and Aker Wade are supplying to Coulomb Technologies and Better Place. ABB is working together with ECOtality and is the company's preferred supplier of power electronics. ECOtality however does assembly in-house.

5.4.6 SGTE[14]

SGTE is a French power conversion specialist (AC↔DC) that has supplied fast charging since 1995. The company had a product ready for the electrical vehicle hype that took place during the 90s. SGTE is together, with Epyon, probably Europe's most mature supplier of fast chargers with internal manufacturing and design. The product related service offering includes consulting pre-studies, design, installation, commissioning and maintenance. Products can also be rebranded.[14] SGTE has supplied chargers to Nissan (during trade such as Geneva Motor Show 2011 charging is done on SGTE fast chargers), Tepco (as only non Japanese manufacturer), Better Place, Coulomb Technologies and Total Belgium (petrol station).

SGTE has little information of its action related service capabilities. However its brochure tells that remote communication management systems exist and that the chargers are pre-equipped for payment. In an interview with Chademo[15], it was found that SGTE has supplied chargers with RFID payment systems. SGTE also integrated a management system with the charger for the petrol station Total Belgium. The custom developed system should comply with the DOMS-standard for remote management of petrol station prices.

Although SGTE does not have official material about action related service packages it is evident that they are capable of finding solutions to the customers' requirements in this area. In relation to Siemens and RWE, there is no indication that SGTE intends to operate the

[14] SGTE Power. (n.d.). *Universal DC Quick Charger for EVs.* Marketing Material Supplied at Geneva Motor Show 2011.

[15] Elie Bougourd (2011-03-11) at Geneva Motor Show

chargers for the owner. SGTE neither provides operative staff for managing end user (EV drivers) registrations or billing.

5.4.7 Aker Wade

Aker Wade is a startup company from year 2000 with facilities in Charlottesville, USA. Aker Wade supplies fast charging systems for electrical vehicles (Aker Wade n.d.). Initially, the company was founded to supply chargers for the electrical car effort during the 90s. However GM together with all other car manufacturers closed their development programs (Aker Wade 2009). In year 2009, Aker Wade had more than 8000 installations of DC fast chargers over the world (Aker Wade 2009). These chargers are mainly industrial installations for trucks and trolleys in distribution centers and manufacturing facilities.

It is uncertain what Aker Wade is offering in the product related service area. Probably similar service can be provided as for the industrial chargers but what this service offer is has not been found. Action related services and features include networking capability and a software to monitor and manage power levels and see statistics.

It is clear that Aker Wade does not want to operate the end customer (EV driver) interface or the network of chargers towards the owner. However, from the vision within fast charging and supply agreement to Better Place, it is evident that the charging equipment is capable of these services on either a hardware or full solution level.

5.4.8 Conclusion of competitive benchmarks

There are few companies which manufacturer DC fast chargers and supply the entire span of action and product related services. Siemens seems to be taking the most complete role in the value chain with in house production, product related services, EV driver interfaces (operation) and management solutions towards the hardware owners and utilities. However, today Siemens is still not Chademo members so it is hard to assess if the company can deliver and how much of the offer that is just strategies on paper.

Apart from Siemens, there are two typical competitors. The category is hardware suppliers that are moving toward becoming solution providers. SGTE, Epyon and Aker Wade are three good examples of companies where Epyon might have come furthest since it offers services for operation. Yet, none of these companies have taken the step to interface directly with the end infrastructure user, the EV driver. It might be likely that these competitors also chose to not move into this domain. The second category is companies such as RWE, ECOtality, Better Place and Coulomb Technologies. These actors do not, with some exceptions, produce their own fast chargers but have chosen to compete by managing the end EV driver interface for charging owners. Due to this, these actors could potentially be customers of ABB hardware.

6 CONCEPT DEVELOPMENT AND EVALUATION

Based on the above evaluation of different service ideas this section presents six service concepts. The six concepts follow from clustering the service ideas with a common denominator together. For each concept; what, how and a business case is presented under separated topics. This answers the research questions (3.1-3) for concept development and evaluation.

6.1 DEFINING THE SERVICE CONCEPTS

The service ideas have been evaluated based on customer preferences, internal fit and competitive benchmarks. Doing this, the ideas have been independently assessed. However when the ideas were generated they got structured according to a framework that was presented in Table 10 (reproduced below). Ideas were sorted in a category during the life cycle (product related ideas) or related to what the customer can do around the product (action related ideas). The same structure of ideas is still valid when moving on to defining mutually exclusive concepts.

Reproduced Table 10. Framework used to structure service ideas (author based on theoretical classifications).

	Life cycle – When does the service occur?			
Product related	Sales and pre	Project management	Operation	End of life
	• Idea... • …	• Idea... • …	• Idea... • …	• Idea... • …
	Customer – towards who is the service?			
Action related	Utility	Owner or operator	EV driver	
	• Idea... • …	• Idea... • …	• Idea... • …	

These concepts have been created using theory of categorizing services, the framework in Table 10 and the author's judgment. What is important is that all concepts are mutually exclusive. The service concepts differ among each other since they are executed during different points in time. They also use different operational procedures. The service concepts are:

- **Action related services** – All service ideas related to what the EV driver, charging station owner or utility can do with the product.
- **Sales service** – Selling and promoting the product.
- **Consulting services** – These services are outside the framework in Table 10 but still mutually exclusive from the other concepts. It therefore makes sense to address them individually.
- **Project management services** – Services related to preparing the location and installing the product.
- **Services during the product's operational life** – Different maintenance alternatives.
- **End of life services** – Services related to refurbishing or taking care of a worn fast charger.

6.2 Action related services

6.2.1 What

The action related service ideas are summarized in Table 45. The importance-performance classification varies a lot between the ideas. In general, the wild or costly ideas have been less prioritized by customers or internal ABB. For example, it is not important to be able to advertise via a screen on the charger or control the display content remotely. Focus should be on ideas tied to core features and services of the product.

Table 45. Summary of evaluation measures for service ideas within action related services (author).

Service idea	Utility	Others	Total	Customer ranking	$Prio_{utility}$ - $Prio_{others}$	Internal ranking	Importance - performance	Competition	Strategic intent
Open payment standard	M	M	M	8	0.4	32	Concentrate here	High	60%
Operational statistics raw data owner	M	O	M	11	0.4	28	Concentrate here	Mod	50%
Operational statistics utilities	A	O	O	13	-0.1	23	Concentrate here	Mod	70%
Processed statistics owner	O	O	O	16	0.3	31	Concentrate here	Mod	60%
User remote charging control	A	A	A	15	-0.8	34	Concentrate here	Mod	60%
Smart payment service	O	M	O	21	-0.5	33	Concentrate here	High	50%
Unit availability for EV driver	O	A	A	14	0.3	35	Concentrate here	High	60%
Openly accessible stats API for developers	O	A	O	32	1.7	39	Concentrate here / not important	Mod	20%
Remote control of display content (owner)	I	I	I	27	-0.7	43	Not important	Mod	10%
Remote system for advertising	I	I	I	28	-0.3	40	Not important	Mod	30%
Wi-Fi service from charger (EV driver)	A	I	I	33	0.3	27	Not important	High	20%
Media distribution/App-store in charger (EV driver)	I	A	I	34	-0.3	37	Not important	High	30%
Smart grid service storing power	A	I	I	36	0.6	26	Not important	Low	60%
Reward system for charging	I	I	I	41	0.4	41	Not important	Low	10%
Statistics for EV driver (display in on charger)	A	A	A	37	-0.5	36	Not important	High	40%
Car maintenance (software update to cars)	I	A	I	42	-0.7	42	Not important	Low	10%
Average (majority rule for classification)	**A**	**A**	**I**	**26**	**0.03**	**34**	**Concentrate here/not important**	**Mod**	**40%**

Interesting to note is that there is no service which is in-line between customers and internal ABB. Either ABB internally has too little focus on a service idea (classified "concentrate here") or ABB and customers share the evaluation that the service is unimportant (classified "not important").

According to the data, the fast charger should have a payment system and the capability for different users to get statistics and data from the charger. A system for remotely controlling the charger is not important. However, a smart grid service is attractive by the utilities and in the interviews it came forward as a potential need. Also the idea where the user remotely can see and control the charge on a smart phone is attractive with a high certainty index. ABB's customers believe that this will be a useful feature for their end customers, the EV drivers. Hence some kind of controlling functionality in the charger might be needed in the long run.

In the interviews it was found that customer segments required different levels of smartness in their chargers. It could therefore be wise to develop chargers with more or less features to target these customers. Table 46 depicts three different options of charging solutions ranging from a plain charger to a complete solution. The complete solution enabled option does not imply that the charger is operated by ABB; network operation is classified as a "possible overkill" service. The complete solution enabled charger allows for a network operator to start working directly with the system without having to put time and resources on developing system software. Although ABB does not want to operate charging systems, it is wise to enable operation in a convenient way for the customer.

An openly accessible API for app developers was the idea that generated the most different answers between utilities and the Other group. Utilities think it is a good attribute that could distinguish ABB from other suppliers, while the Other segment sees it as an indifferent attribute. A network enabled charger hence needs the option to either have highly secure or open data.

Table 46. Different offers of DC fast chargers (author based on the product classification ABB is using).

Charger	Network-enabled charger	Complete solution enabled
Log feature storing faults and operation data locally. Only charging provided. Customer uses other mechanism for identification, billing and statistics. This is most likely a local solution tidied to a shop with staff.	Charger running Ethernet. The network layer device is included in the hardware to work with the customer's internet options, maybe via GPRS. The product contains a computer and provides an API. The API can be used to read data for setting up a billing and identification system. It can also be used to build a management system or to access statistics. The API also allows for building a system to register new users to the system. The customer provides its own server for the data. An RFID or other card reader exists in the hardware.	ABB does not only provide the hardware for management and billing but also the software. ABB has a web based solution that hosts the data from the customers' chargers. The customer uses the system for managing the chargers and billing. The system is also set up so that customers can register to the charging network.

6.2.2 How

It would be convenient if early moving customers would prefer a simple charger without many features and that laggards would go for complete solution enabled chargers. This would enable development to take place incrementally. However there are indications (from interviews and literature earlier presented) that customers, who require full solutions, are the early adopters. Cities and countries (i.e. Portugal, London and Amsterdam) are examples of this. Commercial value propositions, that require less sophisticated solutions, are further away from full scale implementation. It is reasonable to believe that cities, communities and countries will be the biggest investors in fast charging. Being early to sell products to these customers can be a good way to build customer relationships. This stresses the importance of speeding up development in order to be competitive.

To develop a more sophisticated charging solution according to the specified needs there are a few options. Either the system can be developed in-house, bought from a supplier, developed via a partnership or acquired from buying a company which already has a similar solution developed. These alternatives have advantages and disadvantages (Table 47).

Table 47. Pros and cons of different strategies for developing a more sophisticated charging solution (author).

	In house	Supplier	Joint venture	Acquisition
Time	Depend on resources	Slow	Fast	Fast
Control scope & features	High	High	Moderate	Low

To tell anything about costs or revenues is hard. However, the shorter the time to acquire the right product capability, the higher market share can be assumed.

ABB is currently considering supply and acquisition strategies. For the acquisition strategy, it is important to find a company with the right portfolio to a price that is reasonable. The price must reflect the gain in sales, goodwill and customer relationships that will come from having a product on the market today; compared to if it is developed in-house. This increase in revenue must be discounted with a risk factor and costs for integrating the company in the ABB organization. The cost savings from in house development also need to be part of the equation. Table 48 gives a summary of what is important to consider when setting the price for an acquisition. Since the time gap is not so big until ABB has developed an own solution it might be hard to find a company to a low enough price.

Table 48. What to think about when acquiring a company to bridge the development gap (author).

Find a company where:
• The product portfolio has synergies with what ABB lacks in offer.   • $Price \leq ABB\ valuation =$ $= \begin{pmatrix} Extra\ chargers\ during\ gap\ time * Profit\ per\ charger \\ + Development\ cost\ savings \\ + Customer\ relationships,\ service\ profits\ and\ extra\ future\ profits \\ + technology\ (IP) and\ other\ synergies \\ - Company\ integration\ costs \end{pmatrix} * risk\ factor,$ where $risk\ factor < 1$.   • $Price \geq Company's\ owners\ valuation$. The company's owners can for example value the company based on (Stanzl, 2009):   ○ How much the company is worth in the books   ○ How high return the owners want on investment   ○ How big the discounted future market value is   ○ How much comparable companies have been bought for in a similar situation

In appendix 3 an estimate of how the fast charging market can develop in the world from 2011 is presented. The total number of chargers is expected to 1320 in the world by 2012. By acquiring one of the market leaders in fast charging, ABB might be able to sell 20% of these chargers (264). If a 20% profit margin can be achieved on the sales and the price is $20'000 per charger the profit due to extra charger sales is $1.1m. Table 49 further calculates the maximum price that ABB should pay for an acquisition. The numbers in the table are not real; they are rough assumptions that just illustrate the methodology. However, it is reasonable to assume that a price should be in the area of $12.1m. So is there a company out there with a cost optimized product that can be sold tomorrow to this price? Most likely a higher investment is required to reach this maturity and company owners will have hard to align with ABB at a price level that is acceptable to both parties.

Table 49. An assessment of what ABB should be willing to pay for an acquisition of a company with a DC fast charger available today (author).

Item	
$Extra\ chargers\ during\ time\ saved * Profit\ per\ charger$ $= 264 * 20'000\ (price\ per\ charger) * 0.2\ (profit\ margin)$	+ $1.1m
$Development\ cost\ savings = 60\ man\ years = 60 * \$100'000$	+ $6.0m
$Customer\ relationships, service\ profits\ and\ extra\ future\ profits$	+ $1.0m
$Technology\ (IP)\ and\ other\ synergies$	+ $5.0m
$Company\ itegration\ costs$	- $1.0m
TOTAL (risk factor = 1)	$12.1m

The joint venture strategy has many benefits if the right partner can be found. One alternative would be to do something together with ECOtality, where ABB already has invested $10m. ABB could bring manufacturing and chargers to the table and ECOtality could provide the system functionality. However this deal has not been made and it might be hard to find a similar partner who is willing to do a joint venture. So, what is a good plan for developing a more sophisticated charger in-house? Table 50 presents a prioritized list that can be followed step-by-step to develop a more sophisticated charger in-house or through managing a supplier.

Table 50. A list of process steps that can be followed to develop a more sophisticated charger in-house (author).

Prio	Process	Features achieved	Type
1	Design hardware to include RFID reader, a smart I/O Ethernet enabled controller	Enables software to run correctly. A charger should have these hardware options in order to qualify for most of the projects.	Charger
2	Implement server data storage (charger logs data to server) and develop an API to interface with the server	Statistics from the enabled (charger use API to store data in DB, API can be used to access statistics from DB). User registration enabled. Reading charger availability status enabled (the charging log file with status changes are reported to DB).	Network-enabled charger
3	Implement API in charger to interface with the charger directly	Billing or identification system enabled (API can be used to use RFID scanner, lookup user in DB, start and stop the charging). Monitoring and controlling charge via smart-phone or PC enabled (SSL connection with charger possible) Charger can respond to commands to start and stop charging. Smart grid functionality enabled.	Network-enabled charger
4	Establish an ABB eMobility server	The server can be used to store data and to host web/mainframe based interfaces towards EV drivers and charging management. The customer can choose to use ABB's server fort its hosting or someone else's. Set up the charger to report its statistics to the server. Different data can be stored. Status changes in availability, energy usage, etc. Data is stored both for the customer and EV driver to access. The server can also be used to store different data for ABB on status for different components. This data can be used for predictive maintenance.	Complete solution enabled
5	Build a flexible payment and identification system	The system uses the customer's server (maybe hosted by ABB) to store user information. Information is stored about the user which is tied to the id of the EV driver's RFID card. Information includes billing details, amount of money on the card and the status of the EV driver's subscription. Depending on which payment model the customer uses the system uses the relevant information to bill the customer. If the customer has a prepaid card the amount on the card will be updated in the database. If a subscription	Complete solution enabled

		or a monthly billing model is used for payment nothing needs to be updated in the database. A RFID card with memory can also be used to store the card balance locally on the card.	
5…	Build a management system for the identification of users and handling of payments server.com/EV-driver server.com/admin server.com/retail *(server.com could be eMobility.abb.com or customer.com)*	The payment system needs to have an interface for that can be used for registering user information and for charging the identification cards with money. This interface could be web based. The users can register an account and via one line payment transfer money to their card. A management end of the system needs to exist at the same time. When a customer registers he must be sent a physical card and identity. The system operator must have a way to know when to send out the cards or the monthly bills if a subscription or monthly-billing payment system is used. This management system could also be part of the web based portal (admin page). A retail interface could also be implemented. A login to this can be given to shops and retailers. They use the system to top up prepaid cards.	Complete solution enabled

5…

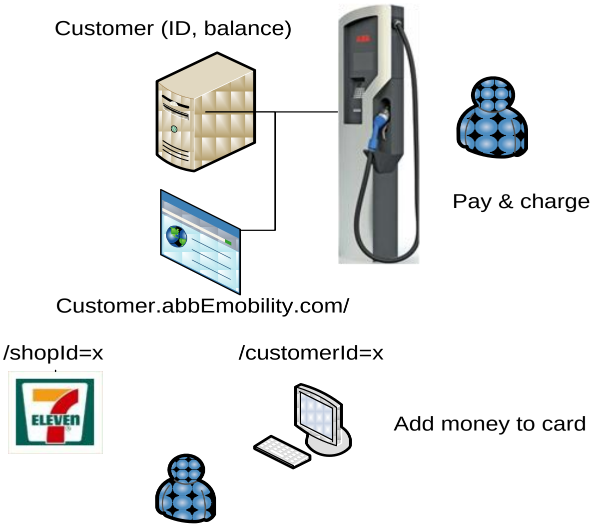


Figure 33. Illustration of item 5 (author).

6	Build a management system for statistics	The EV driver can access the system via the web to see statistics about how often charging is done, where, what the battery limit has been. Also the balance on the RFID card can be read. For the owner of system statistics can be read of a web page. Interesting facts are utilization spitted on different charging locations.	Complete solution enabled
7	Build an app for the EV driver to monitor and control charging from smart phone	An app can be developed that the EV driver can log in to. The app asks the central server if an active charge is going on between the user id and a charging station. If so is the case the IP of this active station is sent to the phone. The phone uses this to establish a SSL-connection with the charger. The connection is used to monitor the status of the charge and potentially to	Complete solution enabled

		tell the charger to stop or start charging.	
8	Develop the charging station interface	The charging station should use the data from the charging network which is stored in the central server. The interface could be used by the EV drivers to look at their personal account details on statistics and account balance. They could also see where other chargers tied to the network are located.	Complete solution enabled
9	Build a management system for charger control and smart grid integration	Smart grid functionality could include starting and stopping the fast charger remotely. It also includes integrating smart generation, storage and consumption. A system could be designed to integrate a DC fast charger with battery storage, solar and wind generation.	Complete solution enabled

Work can be done concurrently on API, complete solution software and product hardware by defining clear interfaces in development. Developing an API for retrieving data from the charger and storing in a database is a rather easy task to do as soon as the hardware is in place. During the interview with ABB corporate research it was stated that developing a stats and a billing API would take one man month of work, which is not much. This development corresponds to some of the scope of point 2 and 3 in Table 50. Going for a complete solution enabled charger will require more time and effort.

6.2.3 Business case

The action related service ideas are not traditional services for ABB. Most of the ideas are related to product hardware or software. The features could be expected to directly increase the product value leading to increased sales. The ideas were however included in the study since they were of interest to examine. The action related services are also by definition services, although ABB is structured so that they are handled by the product development organization. So, how could potentially a service concept earn recurring revenue of the ideas? Table 51 summarizes the service concepts that can be designed from the action related services ideas.

One use of action related service concepts is to collect data from the chargers when they operate. Data can be used to gain consulting knowledge. It could also be used to do predictive maintenance looking on how components age through for example heat sensors. Both these services were however not very attractive by the survey or interview respondents, predictive maintenance were not popular.

Another way to earn revenues from the action related ideas could be to sell consulting services for doing optimizations or adoptions of the product for the customer. If the customer wants a complete solution enabled charger then ABB can use its main system and customize it for the customer’s business. Customizing IT systems such as SAP is a big global business. The reason for this is that it is uncommon that the customer has internal knowledge or resources for doing the customization. Hence there is an opportunity for a consultant company to also do these adoptions for fast chargers.

Table 51. Examples of some services with recurring revenue that can be designed from the action related service ideas (author).

Action related service concept	Description	Revenues
Gather product data	Gather knowledge from the network enabled products by making them send operation information. Sell predictive maintenance and consulting.	Hard to realize the concept and hard to make customers pay for it.
Licensing	Provide complete solution enabling software and software updates	Life time or monthly
Hosting	Provide a server for customer data and applications	Hosting fee. Low margins.
Network operation	Operate the interface towards EV drivers and make sure that the product is working (maintain and repair).	Take part of the fees for EV drivers to use network. High margins.
Training	Training can be sold for network operation. It can also be sold for system integrators (using APIs).	Onetime fee

Software licenses are generally of two kinds; either open or proprietary. When the software is proprietary it is not given away for free and the ownership resides on the publisher. Open software can generally be used and modified under certain restrictions. Utilities have expressed that an openly accessible API might be attractive. However, this does not necessarily mean that the source code for the API must be open, just that it can be used freely. If ABB develops a network enabled charger with an API or a solution enabled charging system (billing and management) it is room to license this to network operators. Since customers are interested in receiving software updates, this must be included in the license. A license could have expiry time and using this essentially two revenue options exist. ABB could either provide a monthly or a lifetime license. The monthly license is less costly but needs to be renewed continuously. The lifetime license is paid once and the customers only changes software when a major version is released with a quality that they are willing to pay for.

Revenues can also be gained through hosting customer data on ABB servers. This is delimited from running network operation (i.e. being the party that uses the management system and makes sure everything is working). Hosting data is however a commodity service with high competition and tough security requirements. This leaves little room for ABB revenues.

If ABB wants to earn good recurring profit on action related services it is required that certain responsibility is taken for network operation. Major investment projects in cities/countries are from customers that have no resources for network operation but much money to spend. This is however a step that the company is not willing to take. One reason for this is that ABB does not want to deal with B2C activity. Taking the role as network operator does however not necessarily imply much extra work than maintenance and field service which ABB wants to do. Much of the activities are easy to outsource to suppliers once the complete solution enabled software has been developed. Table 52 depicts the main actions that need to be taken to develop a network operation service. An internal team is required to manage the project towards the customer and this team can also be used to manage the EV driver interaction by setting up partnerships or outsourcing agreements. Finding win-win solutions with partners should not be hard for the activities below; giving the partner part of the revenues for each sale/transaction is one option that is used for public transport systems.

Table 52. Action related activities needed to do network operation for a customer (city, community or country). The product related activities to maintain and field service the products are not included since ABB already aim to be doing them. The table illustrates that it is not much extra effort required to set up a complete operation once software is in place to run the operation (author).

Activity	Action
EV driver registration	Use web based software and partner with Seven Eleven or/and other local shops. Set up a system where local shops can sell RFID cards. A third party logistics centre can handle sending RFID cards to customers who register online.
EV driver help desk	Outsource call center to for example India.
EV driver retention and marketing	Partner with the customer that the system is operated for.
Adding money to the RFID card	Use a web based management software or partners (shops).
Manage system towards owner	The internal ABB project management team can monitor statistics from the system and provide reports from this to the owner. Just like Ericsson Managed Services recommendations can be given for upgrades in the network based on operational data (utilization in certain busy areas etc).

To do network operation is can be profitable since it adds much value to the customer. In Amsterdam, for example, a model has been set up where the solution provider RWE has sold chargers to the city and operates these on behalf of the city. All revenues from the chargers go to RWE to cover the operation. Amsterdam city benefits from having a company which takes cares of transitioning to a cleaner city. The only investment made is in the charging infrastructure which is put in place for the sake of the public. RWE, on the other hand, covers the cost for their chargers and has a good chance to earn high service margins on the network operation.

6.3 Sales service

6.3.1 What

Some customers find it hard to understand what a fast charger can do, why the ABB charger is the best or how a good business can be built around a fast charger. The sales service has especially been important in the Others segment, utilities are indifferent (Table 53). One reason for this might be that utilities are more mature than Others. Utilities have thought more about their business cases in eMobility and hence need less sales services. In total the sales presentation service is classified as an in line service, the customer and internal ABB prioritize it equally. All respondents to the internal survey also agree that sales service is in line with ABB's strategic intent. Competitors could also assume to provide this service for customers who are interested in buying chargers.

Table 53. Summary of the different evaluations made of sales and presentation services (author).

Service idea	Utility	Others	Total	Customer rank	$Prio_{utility}$ - $Prio_{others}$	Internal rank	Importance - performance	Competition	Strategic intent
Sales and presentation service	I	M	M	12	-1.5	11	In line	High	100%

6.3.2 How

To meet the customers need ABB should provide sales services. This can be done at several levels depending on how much interaction a customer requires (Table 54). Mature or small customers might only ask for a tender that supplies pricing and product information. This document can be supplied online or through ABB's local sales organization and will not imply substantial costs.

Another category that is important is companies that plan to install a substantial amount of chargers. They should be given a more sophisticated sales service. With these customers, ABB should leverage its local sales organization and build customer relationships. The product centre in Switzerland could provide expert knowledge and support with the tender.

Table 54. Differentiating sales service towards different customers (author).

Customer \ Project size	Big	Small
Mature	- Customer relationship. - Information material (price, product specification).	- Information material (price, product specification).
Immature	- Customer relationship. - Extended information material (business case examples).	- Extended information material (business case examples).

Customer relationship marketing is a school for how sales should be conducted nowadays. Relationship marketing uses trust between two parties to fulfill promises on both ends (Sheth & Parvatiyar 1995). An immature customer has a lot to learn from a hardware supplier with technical knowledge such as ABB. Relationship marketers believe that building trust, sharing information and helping each other interdependently have higher synergies than pushing for the lowest possible price using competition (Sheth & Parvatiyar 1995). ABB has strong relationships with suppliers' utilities all over the world delivering quality products. Many interviewees put forward ABB to be a well known brand and reliable supplier. The trust from these relationships can be utilized for eMobility since customers know that ABB will deliver good products. Emphasizing size and reliability is a key advantage for ABB.

6.3.3 Business case

The business case of sales service activities is good. Table 55 depicts an assessment of the two *how* parts of the service concept; customer relationships and information material. Both these services are something that customers in most markets expect to get for free. It is up to the suppliers to provide sales information if they wish to sell products. Sales services however impacts revenues indirect. Without a sales service the customers will buy from someone else or not at all.

Table 55. Profit evaluation for sales and presentation services (author).

	Costs		Revenues	
Service concept	**Fixed**	**Variable**	**Direct**	**Indirect**
Customer relationships	No	Yes	No, free	Yes
Information material (online or printed)	Yes	No	No, free	Yes

The cost of providing sales services depends on the extent of the offer. Creating sales material is a fixed cost which can range from a few dollars per leaflet to a complete marketing kit prepared by a professional design firm. Competitors such as RWE are spending substantial amounts on television advertisements in Germany. However most competitors have a simple leaflet and are present at trade fairs. This is also in line with what ABB is doing at the moment, which might be an appropriate level for marketing.

When it comes to building customer relationships this cost is more variable. It is about dedicating sales people to interact and be available for the customers. This part of the sales service offer is a major ABB strength towards most competitors. ABB is present in 90 countries all over the world and have a very good capability to meet the vast majority of customers. A challenge is however to assist the local sales organization towards the customers. To do this an internal information package should be developed that can be supplied to internal ABB offices.

6.4 CONSULTING SERVICES

6.4.1 What

Consulting services are useful when the customer has less knowledge than ABB and where ABB's knowledge can help the customer to create value. During the brainstorming activity six different consulting service ideas were generated which have been evaluated (Table 56). These ideas were mainly based on what could be done with ABB's competence around the fast charger.

The evaluation showed that customers found unit sizing confusing; the certainty is low and answers are spreading. This is indeed true, how can you sell a consultant service for sizing a unit that does only have one size today (according to the 50kW DC Chademo standard)? This service was directed towards customers ABB intend to sell charging assemblies to. This segment has not answered the survey. It could however be assumed that a consulting service in this area would be needed if the product range widens in the future. This service could however be hard to charge the customer for; it must be seen as something that is included with a sales service.

Table 56. Summary of the different evaluations made of consulting services (author).
**** Balance of plant is put together with commissioning in the project management service concept.***
***** System optimization consulting during operation is recommended as something that could be sold together with a service contract to the customer during the products operational lifetime (including for example cleaning and updating software).***

Service idea	Utility	Others	Total	Customer rank	$Prio_{utility}$ - $Prio_{others}$	Internal rank	Importance - performance	Competition	Strategic intent
Consulting unit sizing	A	I	I	23	0.7	14	Possible overkill	High	100%
Consulting network design	A	O	I	25	-1.0	19	Possible overkill / in line	Low	90%
Consulting cost of connection minimization	O	A	A	26	-1.6	6	In line	High	80%
Consulting location analysis	I	A	I	35	-1.1	9	Possible overkill	Low	90%
Balance of plant*	A	A	A	17	0.1	13	In line	Low	70%
System optimization consulting during operation**	A	O	A	19	-0.5	25	Concentrate here	Low	40%
Pre and post grid analysis	A	I	I	31	1.1	21	Possible overkill / not important	Low	70%
Average (majority rule for classification)	**A**	**O**	**O**	**25**	**-0.33**	**15**	**Possible overkill**	**Low**	**77%**

Location analysis is a consulting service that has been classified as a “possible overkill”, since it is indifferent to both customer categories. The internal ranking of the service is however high. At the moment ABB is working on projects to build a program for optimizing locations of chargers for electrical buses. There are logical reasons for location analysis to be indifferent to the surveyed customers. The utilities most likely want to decide the location themselves. They have the most information about the grid and are likely to want to put chargers where the grid can cope best. The segment of Others only has certain locations where their stores, parking lots or petrol stations are. With respect to this it is not much for a consultant to analyze. One customer segment that is likely to be very attracted by a location optimization service is cities or communities. They have access to all locations and are likely to be willing to get the best balance for all interests (convenience for EV drivers and for the grid owner). Cities such as Amsterdam could benefit from an independent study of good charging locations. In the interview with Amsterdam the location was brought up as an important issue for the fast charging project. The solution that was being implemented was to build fast chargers along the cities ring road. This might be a good approach when it comes to availability, convenience and grid coverage but having an independent actor look at the problem does seem better than an ad-hoc solution.

The network design consulting service idea is related to the location analysis but the scope is broader. It can also include deciding where AC charge points should be installed, how many to cover a certain availability, what extra grid-components are required to support the charging networks etc. If ABB should take a role of consulting on charging locations it might as well be better to include a wider network study which is attractive for more customers and can be assumed to be easier to charge for.

The cost of connection minimization service is less attractive for utilities than in the Others segment. Actually this service idea has the largest difference in customer priority index between the segments (-1.6). Utilities know where their network is weak and where it is easiest to connect chargers without buying other grid equipment while the Others segment needs help. Although this is a segment that ABB thinks the strategic fit is high (rank 6 internally), it is probably more likely that this service is supplied from a utility. Today you can actually already get information from utilities about costs to connect equipment with certain power levels in certain areas.[16]

The balance of plant and system optimization during operation is actually very similar concepts. Balance of plant is another word for tweaking settings before a product is taken into operation while system optimization during operation concerns the same thing but after the product is taken into operation. These services are both something that customers require and that ABB should do. Customers want their equipment to run as efficiently as possible and look as good as possible. This consultation service is however closely related to commissioning, maintenance, upgrades and replacement, which later will be presented as concepts.

To summarize, the only consulting services that there is a need for ABB to do, that not are tied to other service concepts and that could be charged for are network design and location analysis.

6.4.2 How

ABB has a long history within electrical engineering and extensive knowledge beyond just charging technology. ABB does power networks, systems and grid studies. A profitable business model within ABB is to sell equipment that strengthens the power quality. One customer example is aluminum smelters, which have an unstable consumption that causes harmonic overtones in the network. Penalties from utilities apply on smelters if they impact

[16] Network fees in Sweden is about $10’000 for 50kW per year. See: http://eon.se/templates/Eon2TextPage.aspx?id=48593&epslanguage=SV

the power quality in the grid. ABB's equipment removes this penalty and the savings this implies justifies the customer's investment.

There is no doubt that the competence exists within ABB that is attractive and useful for DC fast charging customers. It is however not that simple to free this competence to use for eMobility customers. The Power System engineers are organized in another division than Discrete Automation and Motion. With this functional organization every division bears its own costs and ABB Power Systems would not give away their engineers for projects that do not show on their yearly result.

In Ericsson, the organization is made based on competence and an engineer could work towards any customer without restrictions. This might be an organizational structure that could be efficient in ABB but it requires a major change in the company that is unlikely to happen. To implement consulting services with today's organizational structure, ABB eMobility either has to employ and develop internal competence for network studies or buy consultant hours from ABB Power Systems (or someone else with the competence). The best option might be to partner with someone that has power system knowledge. ABB eMobility is working closely with customers and if they see a need for doing a network study for a city or customer related to fast charger installations, they can help ABB Power Systems to bring in this business opportunity. For mediating between customer and consultants, eMobility sales could have a good business opportunity with low risk.

To staff up internally implies a large internal risk to have competence idle, especially since the customers do not show very high demand for network studies. It might be possible to create a market for consulting studies by going to customers and marketing the service. However a safer option is to grow organically when the demand arises.

6.4.3 Business case

Consulting studies are services that are excluded from the core offering. Since they solve other problems for the customers and add extra value they can be charged for and generate direct revenues. When competition is low, knowledgeable consultants are valuable and potentially a source for high margins. Doing a consulting study for a client might be a good way to build customer relationships and will generate indirect revenues through sales. However the effect of this is probably low. The costs for a consulting service are either variable or fixed depending on if it is bought from another ABB company or acquired in-house. Table 57 presents an assessment of consulting service profits.

Table 57. Business case for a consulting service.

	Costs		Revenues		
Service concept	**Fixed**	**Variable**	**Direct**	**Indirect**	**Profit**
Consulting study	Yes / No	Yes / No	Yes	Probably low	Potentially high

6.5 Project management services

6.5.1 What

Project management activities have not been very highly valued by customers. The average customer priority of 27 is far below the internal priority (12) of this service concept area (Table 58).

Table 58. Assessment of project management service ideas (author).

Service idea	Total	Utility	Others	Customer rank	$Prio_{utility}$ - $Prio_{others}$	Internal rank	Importance - performance	Competition	Strategic intent
Installation	A	A	A	29	-1.2	7	In line/ Possible overkill	High	50%
Commissioning	I	M	I	22	1.0	5	Possible overkill/ In line	High	90%
Balance of plant	A	A	A	17	0.1	13	In line	Low	70%
Location specific adoptions (civil engineering)	A	A	I	38	-0.2	22	Possible overkill/ not important	High	10%
Average (majority rule for classification)	**A**	**A**	**I**	**27**	**-0.08**	**12**	**Possible overkill**	**High**	**55%**

Location specific adoptions (civil engineering) are an activity that should not be undertaken. ABB is not a construction firm and the customer sees this as well. The activity is a "possible overkill" in the importance-performance classification.

Both commissioning and installation are on the border line of being "in line" or "possible overkill". Concerning installation, it is an attractive attribute for all customers, however the overall ranking is low and the strategic intent. Frankly speaking, installing the fast charger on its socket and connecting its power supply is an easy task. Installation is hence not an activity that has to be done by an ABB engineer. If the customer has internal labor or wants to employ someone else to do the installation that should be a straight forward task. When it comes to commissioning, customers have in total been indifferent. The difference between utilities and the Others group is big. One reason for this could be that the Others segment does not know what commissioning is, since they are not used to buying power systems. The normal procedure when installing ABB equipment is to have an ABB engineer participating in the installation, making sure it is done correctly and running tests on the final installation. Customers might demand that commissioning should be a straight forward activity. The product should work when it is switched on. Still, even if the process is well defined and simple, it is important to have a hand over phase when responsibility of the product transfers from ABB to the customer. The product could have been damaged during transportation or installation and when dealing with high voltage products, security is important. Most competitors offer some kind of installation or commissioning service. There is also big competition in the construction part of project management from construction companies and electricians. A hand over phase/commissioning is therefore a required activity but it might be hard to charge high margin prices.

Balance of plant was a consultant service idea that was ranked high among customers. If ABB could add some value during the commissioning that the customers cannot do themselves, this might be a reason to charge the customer a premium price. If is however questionable if this is possible since there is not much to tweak and balance after installing the fast charger; either the grid is strong enough to support the charger or it is not. Fixing a weak grid is about adding other components to the grid and it is not much that can be tweaked and balanced from the fast charger. If the fast charger is part of a smart grid with local production and storage there might however be certain control equipment that needs to be modified at site which can add value for the customer. There is also another possibility, related to the service concept of services during the product's operational life, to do a training session with local service engineers during the commissioning. This will add value and be possible to charge for.

6.5.2 How

Requirements should be put on how the socket should be constructed for the fast charger and that the converter can be placed in a shielded and safe environment. As a service, ABB could give advice based on experience from how other installations have been done before. This can be part of success cases used in marketing material.

For commissioning and installation, the author recommends ABB to offer a service. An engineer is sent to site to meet the customer, hand over documents and startup the equipment. When the product matures this activity could most likely be done locally by an ABB representative. The commissioning and installation process should be as standardized as possible. A manual should be written with a step wise approach to installation and commissioning. If something falls out of the pattern, the commissioning engineer could contact an engineer at the global office for help with troubleshooting.

In certain countries (e.g. Sweden) it is only the network owner (utility) which is allowed to install equipment on the medium or high voltage grid. In this case, the utility can do the installation but a commissioning activity needs to take place where both the customer and ABB approve that the installation has been done correctly.

6.5.3 Business case

Table 59 presents an assessment of the business cases for installation and commissioning. Installation is an activity that requires labor. If this is done by ABB, it is reasonable that the customer is billed for it. If commissioning could be charged for is a harder question to address. When ABB has a service contract with the customer where ABB takes the risk, commissioning should be included in the contract. It is ABB which gains from knowing that the equipment is installed correctly since the company is obliged to maintain the equipment and handle the damages if it breaks. This is also the case when the customer takes the risk of operating and maintaining the equipment if there is a warrantee period given. If a warranty does not exist and the customer directly is responsible over the equipment there is in general no reason for ABB to do commissioning apart from goodwill. In this case the customer might be interested in a commissioning activity where an ABB responsible person switches on the equipment and takes the responsibility for checking that the installation has been done correctly. This risk could be worth paying for but most customers might demand that it is included in the product price. The direct revenues of commissioning therefore depend on the situation and so does also the indirect revenues (or cost savings). If ABB has a service contract taking the product risk, it is good to minimize the number of occasions where the product breaks due to a faulty installation. In this case commissioning will minimize the costs of replacement due to breakdown at startup.

Table 59. Assessment of business case for installation and commissioning (author).

	Costs		Revenues		
Service concept	**Fixed**	**Variable**	**Direct**	**Indirect**	**Profit**
Commissioning	No	Yes – labor	Maybe	Maybe	Low
Installation	No	Yes – labor	Yes	No	Low

6.6 Services during the product's operational life

6.6.1 What

By compiling the data on the different service ideas a good view can be given on customer needs for maintenance and services related to product operation (Table 60).

The service ideas have a R^2 of 0.49 between the internal and external perspective. This is a high value compared to the overall correlation of service ideas between internal and external perspectives ($R^2_{total} = 0.22$); however, it is not a strong correlation. There is in particular one misfit (preventative maintenance) that accounts for the low correlation scores. Internally, this is ranked highest, but the customer rank is only 19.

Interesting to note is also that services further to the right of Olivia and Kallenberg's (2003) service continuum are less attractive. Network operation is one such example as well as preventative and predictive maintenance. Receiving updates, spare parts, training and other services where the supplier takes less responsibility (i.e. to the left of Olivia and Kallenberg's (2003) service continuum) of the product is more in line. One reason for this is that customers are scared of all services that will add to the recurring costs of the product. Since the commercial business case of DC fast chargers is week, it is important to be lean with costs.

Service contracts is a service idea that is in line and an activity that should be done. This possibility includes a large responsibility from the supplier to guarantee a risk free operation for the customer. Hardware upgrades is the service that customers value the most. ABB could easily deliver equipment for ultra fast charging or an upgraded version of the Chademo standard. However, the best way to solve this is to sell a new product to the customer or change the interior of the charger (either on site or in production).

Table 60. Summary of idea evaluation for services during operation (author).

Service idea	Utility	Others	Total	Customer rank	$Prio_{utility}$ - $Prio_{others}$	Internal rank	Importance - performance	Competition	Strategic intent
Preventative (scheduled) maintenance	I	A	A	19	0.6	1	In line	High	100%
Repair field service	M	M	M	10	-1.0	2	In line	High	100%
Spare part field service	M	M	M	2	-0.3	3	In line	High	100%
Maintenance training	M	A	M	9	0.7	4	In line	High	90%
Warranty	M	M	M	4	0.6	12	In line	High	100%
Service contracts with different service levels	A	A	A		-1.1	8	In line	High	80%
Documentation	M	O	M	3	0.6	10	In line	High	80%
Trouble shooting fields service (maybe using remote control/monitoring)	M	M	M	7	-1.3	15	In line	Med	90%
Operating training	M	O	O	5	0.4	16	In line	High	70%
Hardware upgrade, replacement or reconditioning	M	M	M	1	0.2	17	In line	High	90%
Software updates	M	O	M	6	1.5	20	In line	High	80%
System optimization consulting during operation	A	O	A	19	-0.5	25	Concentrate here	Low	40%
Predictive maintenance (using remote)	A	A	A	39	1.0	24	Concentrate here /not important	Med	70%
Financial services	I	A	I	40	-1.3	30	Not important	Med	40%
Network operation	I	R	I	43	0.5	38	Not important	High	10%
Average (majority rule for classification)	**M**	**M**	**M**	**14**	**0.08**	**14**	**In line**	**High**	**79%**

6.6.2 How

ABB's Hermes 1 fast charger is the current version that and used in prototype installations. Hermes 1 is based on the PCS100 product. The PCS100 has a maintenance sheet which recommends actions to guarantee the most optimal operation. Environmental conditions, pollution level and usage are heavily correlated with the lifetime of components. During continuous operation at 40°C (which is normal for the PCS 100) the components are stressed. Electrolytic capacitors, switch mode power supply, film capacitors on filters and fans all need to be regularly replaced to guarantee fault free operation during the product life time of 20 years.

The chief engineer has been consulted about how the mean time to failure pattern will look for Hermes 2. Since Hermes 2 will not be continuously operated, the component wear/aging effect is lower. The only components that will need regular replacement are the fans. Apart from this, the equipment should be regularly cleaned and especially the filters should be vacuumed on a yearly basis.

The PCS 100 is an industrial product that is locked up securely inside a factory. It has low customer exposure. This is different from the DC fast charger that will be exposed to the public. This makes it subject to potential vandalism and wear from customers. Since the fast charger can be placed outside, weather is also a factor impacting the product quality. In Denmark, a DC fast charger prototype is installed in central Copenhagen next to a gas station and a car rental company. Right next to the installation, an AC charging station is full of graffiti (Figure 34). The DC fast charger has a robust aluminum/steel exterior. The power cable, connector and touch screen are however all vulnerable to damage, theft or customer wear and tear (Figure 35). The power converter and power electronics are placed in a separate locker which is shielded from vandalism and does not have any parts that the customer interacts with.

Figure 34. AC Slow Chargers installed 20 meters from the DC fast charger in Copenhagen (no security cameras for protection) (author).

Figure 35. The DC Fast Charging prototype installation in Copenhagen. The picture also shows the components that are subject to wear and tear (author).

The fast charger will be a quality product, which is likely not to break that often by itself. The design life of all components exceed the 20 year product life time. Exceptions are the fans and the power module which might need replacement after five respectively fifteen years. Preventative maintenance is limited to changing fans and making sure the equipment is clean. The main impact on the availability of the product is more likely to be due to malfunction imposed by damaged user interface components (cable, plug, protective glass or display). Wear and tear to these components can be controlled by changing them upon inspection. However, if something is damaged by vandalism or an accident this cannot be tackled by planning. Hence, there are two types of services related to operation; one is a reactive field service/trouble shooting and one is a regular preventive maintenance.

Since there are different needs on maintenance and operation related services between customers (found during interviews) it is wise to develop different packages to cater these needs. This has been done by the benchmarked ABB companies. It has also been put forward by survey respondent inside ABB. The reason addressed is that the fast charger is a volume product and ABB cannot afford to treat each customer individually.

Table 61. Service models for operation related services.

Item	Customer risk	Shared risk	ABB risk
Commissioning	Excluded	Included	Included
Training	Included	Excluded	Excluded
Maintenance spare parts	Excluded	Included	Included
Maintenance travel costs	Excluded	Included	Included
Maintenance labor cost	Excluded	Included	Included
Product optimization service (Software upgrades, cleaning etc.)	Excluded	Included	Included
Field service spare parts	Excluded	Excluded	Included
Field service labor	Excluded	Excluded	Included
Field service travel cost	Excluded	Excluded	Included
Fault detection service	Excluded	Excluded	Included
Documentation	Included	Included	Included
Hardware upgrades	Excluded	Excluded	Excluded
Pricing	Per occasion	Per year / per occasion	Per year

Table 61 depicts three suggested models for operation related services. The “customer risk” option is aimed towards those customers who have their own service organization in a related field that could maintain the fast chargers. It involves a higher risk for the customers but could potentially imply lower costs. The third model, “ABB risk”, puts all the risk of equipment failure on ABB. It means a low risk for the customer and a predictable recurring cost. The equipment will here be maintained in the most optimal way and the customer does not need to educate in-house staff. The second model of operational services is a shared risk model between the customer and ABB. The customers do not need to keep their own staff for maintenance; this will be handled by ABB. However, if something breaks (maybe due to vandalism) the customer will have to pay. This option is good if the customer could take risk but do not want to bother educating, employing or buying staff. Vandalism risks are tied to the operative environment (not product related). A DC Fast Charging customer typically already has other assets exposed to the public and could have insurance to cover events. Therefore, when making a shared risk alternative, it makes sense to keep these risks on the customer and let ABB deal with insurance towards product related risks. With the shared risk service model, the customers can chose to either use their own service department or call ABB to deliver field service when something is damaged on the product. If ABB's field service department is used the customer is charged hourly per occasion.

Huiskonen (2001) believes that the handling of spare part services should be differentiated depending on the characteristics of the spare part. Ibid presents a model (Figure 36) for looking at how spare part characteristics affect the logistic system design.

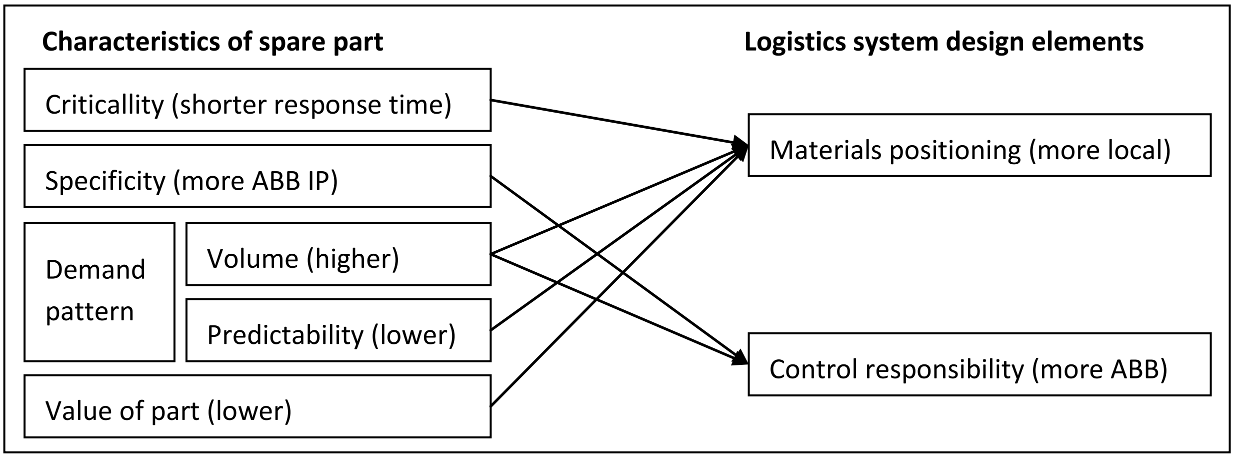


Figure 36. Model depicting the design elements for a spare part system which depend on the spare part characteristics. The arrows from "characteristics of spare part" to "logistic system design" show what characteristic that impact which logistic system element (adapted from Huiskonen 2001, p.129).

The criticality dimension on a spare part is high if the spare part needs immediate replacement and medium to low if some time is acceptable for supplying the part. The specificity of a part aims at if it is standard or user-specified (Huiskonen 2001). ABB uses a classification for this with three levels; either the part is ABB intellectual property, modified for a customer or standard/common goods. Demand pattern has two dimensions; volume (high or low) and predictability of failure (totally random or predictable). Finally, the value of a part is either high or low (Huiskonen 2001).

The logistic system design strategies differ for all combinations of spare part characteristics and also based on the customer's preferences. Table 62 uses the framework to assess each of the spare part components and where they should be stored. Since all components need to be replaced on a week or faster, producing the spare part to order is not applicable. Either a central, regional or local inventory is required.

Table 62. Assessment of the different spare parts; where they should be placed and if ABB should control them.
**** Depend on number of fast chargers installed. This volume/scale impact will be further assessed later in this chapter.***
L = local
G = global

Spare part component	Criticality	Specificity	Volume*	Predictability	Value of part	Control	Position
Fans	High (24h)^{L}	Standard	1 per 5 years $^{L/G}$	Predictable ^{G}	Low ^{L}	-	Local/ Global
Power module	High (24h)^{L}	ABB IP	1 per 15 years ^{G}	Predictable ^{G}	High^{G}	ABB	Global
Display	High (24h)^{L}	Modified	1 per 5 years $^{L/G}$	Random ^{L}	High^{G}	ABB	Local
Protective glass	Med (1w)^{G}	Standard	1 per year^{L}	Random ^{L}	Low ^{L}	-	Local
Plug & cable	High (24h)^{L}	Standard	1 per year^{L}	Random ^{L}	Medium^{G}	-	Local

The power module and display are the only components that ABB should control the sales over (that are not standard). These should be supplied from an ABB warehouse. The criticality of both components is high, which calls for local storage. However the power module has a predictive failure pattern which implies that scheduled maintenance can be done and parts sent from a global storage. The fans have less value and are changed more frequently than the power module. They should hence be stored more locally. Still the fans have a predictable failure time so global storage is not an excluded option since scheduled maintenance can be used and the part only sent to site when it is needed for this. With the same kind of reasoning the storage for protective glass, plug and cable are comparably more local than the other spare parts (however due to different factors). The analysis of all the different components is however highly dependent on the volume which in turn follows the number of fast chargers installed in the country and for the client. In the end, a policy decision has to be made on whether a component should be stored locally or globally and who should control the inventory.

Another factor that should be discussed is how maintenance should be done. Different viewpoints have been put forward by ABB engineers. The thermal interface is a specific material consisting of oil and heat conductive material. The material is often in form of a paste which is applied to the surface of the power module and the heat sink to increase the contact area (and the cooling) at nano-level. Due to pump-out, bleed-out, run-out and dry-out mechanisms the paste often disappears after 5-10 years. This is according to McLaughlin[17] the reason for the power module to fail after 10-15 years, the thermal interface between the heat sink and power module should be changed before it is worn. Apart from this a few electrolytic

[17] Interview Steven McLaughlin ABB. Design and Engineering. Steven is responsible for environmental directives. Turgi, 2011-05-09.

capacitors on the power module board also need replacement due to dry-out after 10-15 years. Changing the whole power module is however a recommended action since it takes shorter time at customer site. The old power module can be brought back to factory for refurbishment and then used for 15 more years (see chapter 6.7). According to McLaughlin the fans also need replacement since they get worn. It is important to place the fans to blow cold air on the heat sink and not the opposite (such hot air from the heat sink). This extends the lifetime of them. Another big problem is that the heat sink often gets dirty from all the coolant air. This needs to be cleaned when the fans are replaced.

Components can also fail well before their expected MTBF time. A high likelihood of failure exists in the early phases if the component follows a bath-tube curve (which often is assumed). Something could have been broken during production or delivery which is only detected once the product is in operation. To take care of this, a central stocking of all spare parts is important in order to quickly solve a problem that might be discovered during commissioning. A failure happened with the connector after commissioning of the test project in Denmark and this was fixed by supply of a spare part from the global supply.

To do maintenance, the possibility to get in contact with global ABB eMobility for expert advice is valuable. This approach has been taken during a pilot project when a fault has occurred. The local service person described the fault message and supplied the log files from the charger (if the charger is not network enabled when this can be read directly). This enabled the eMobility engineers to figure out which actions to take by studying the lab unit, electrical schemas and making software updates. If ABB is not responsible for the field service the company can set up a service hotline to take care of events that the customer's internal service organization cannot handle itself.

Availability levels were discussed during the interviews. It was put forward that it is important that the fast charger is not malfunctioning for a too long time. This might give the fast charger a bad reputation among EV drivers. The models in Table 61 can all be delivered with different availability levels. The availability depends on if spare parts are stocked in the country, globally in Switzerland or not at all. It also depends on if local labor can do the job or if engineers must be sent from Switzerland, however the delivery time of spare parts is assumed to be the bottle neck (take more time than having available labor).

In Amsterdam, the availability of the fast charger was set to 99%. This means a maximum of three days per year. With this scheme, spare parts have to be stocked close to the fast charger or shipped with air. Having local labor is also important. The local labor does not necessarily have to be in-house. A supplier can be used to do the service. With a service contract where the risks are on ABB, a supplier can still be used for the delivery. Table 64 depicts the resulting worst case availability if each component is stocked locally or globally. The 99% availability level is reached if all components are stored locally or if the random failure components are stored locally and the predictive failure components stored globally.

Table 63. Possible ways to provide spare parts and labor with different implications for availability. 5 days (120h) is assumed for a global and 24 hours for a local spare part delivery. Each component has a MTBF which provides a number of occasions the charger is down per year (1/MTBF). This number multiplied with the delivery time for local or global storage gives an expected yearly downtime for delivery of one component. If the different components fail at different occasions the worst case expected downtime can be calculated by summing the expected yearly downtime of each component (author).

	MTBF, years	Break per year	Downtime per year	Downtime per year	Downtime per year
Fans	5	0.20	24 (global)	24 (global)	4.8 (local)
Power module	15	0.07	8 (global)	8 (global)	1.6 (local)
Display	5	0.20	24 (global)	4.8 (local)	4.8 (local)
Protective glass	1	1.00	120 (global)	24 (local)	24 (local)
Plug (connector) & cable	1	1.00	120 (global)	24 (local)	24 (local)
Total worst case downtime (h)			**296**	**84.8**	**59.2**
Availability			**96.62%**	**99.03%**	**99.32%**

The necessity of high availability depends on two factors; (i) how much revenue is lost when the product is not operating and (ii) what goodwill losses for eMobility and the total charging service are made when the customers see malfunctioning chargers? The revenue losses from one fast charger add up to a maximum of $150/day. [18] This is a small amount compared to what a 24h field service costs to maintain. The goodwill losses depend heavily on individual customer perceptions. It also depends on how dense the network of chargers is. If the network is so dense that the customer has many options to charge from, the availability requirement on each charger can be lower. If two adjacent chargers break down independently their total availability is $1-(1-p)^2$. To exemplify, if each charger has 80% availability, the two chargers together will have 96% availability in total. Amsterdam clearly had high requirements for availability of each individual charger and hence valued losses of goodwill high. However state owned utility 1 expressed that it will not have so high availability requirements due to the above two reasons (i and ii).

As put forward by Ericsson Managed Services, services are not necessarily tied to hardware from a particular vendor. Ericsson services equipment from multiple manufacturers. The reason for this is that the software and hardware is reasonably standardized according to certain protocols. ABB could potentially do the same thing within eMobility. Each charger follows Chademo and has similar designs. Similar to Ericsson Managed Services, spare part agreements can be done with vendors from all types of hardware when service contracts are made. Doing this however loses the benefits from good spare part margins. Scale is however an important factor for profitability as well and it could make sense to mix some high margin contracts on equipment sold by ABB with maintenance on other suppliers equipment in order to reach high utilization of service engineers.

[18] Best case business case with 50% utilization: $12hours/day * \frac{60\frac{min}{hour}}{20\frac{min}{charge}} * \frac{\$4}{charge} = \$144/day$

One strategy is to lock the customer in with certain technology and spare parts. However this strategy is not wise since customers explicitly want hardware from different vendors to work together (state owned utility 2). Ericsson neither uses lock-in strategies for its hardware. The products are standardized according to the same protocols (software). The hardware and software departments should be separate and ABB hardware should be sold because it is better than competing options (success factor for service). Service and hardware departments could however draw synergies of customer relationships. Customer relationships tied during sales can be passed over to the service department. Relationships built during a service period can be leveraged when new products and upgrades are needed.

6.6.3 Business case

In order to make business cases for getting more insight of when it is reasonable to have the customer or internal ABB to take operational risks some assumptions first need to be made. These two extremes are looked at and the shared risk alternative could be assumed to have an application somewhere between the extreme cases. An analysis of the business cases could be made incredibly complex. For example, graph theory can be used to find optimal inventory locations. Table 64 depicts the assumptions that have been made for this analysis. Two factors that are not taken into account are differences in travel distance and cost of labor depending on where in the world the customer exists.

Table 64. Assumptions underlying the business case for service contracts.

Assumptions	
Hardware price	$20'000
Service labor cost	$200/hour
Average service person travel cost	$300/travel
Inventory keeping rate	15%
Order handling cost	$20/order
Customer maintenance training	$5'000/occasion
Customer maintenance training lifetime	10 years
Product life time	20 years
Installed base WW	10'000

Further on, an assessment of the DC fast charger components has earlier been made. In Table 64 the costs are included together with MTBF, specificity (part type), gross margin (example figures) and external price to the customer (costs plus gross margin). The power module is the only part that is not bought from a supplier (ABB IP) and hence has a high gross margin. The fan, protective glass, plug and cable are all standard components which customers will buy from other suppliers if the margin is too high. The display includes ABB software and could be seen as something in between a standard component and pure ABB goods. The result of this assessment is that if ABB sell spare parts for the product it is not reasonable to assume a gross margin larger than 44% on all components sold during a year to one charger. It is also interesting to note that $636 (60%) of the total yearly value of spare part sales ($1’070) comes from components that ABB does not add any value to in production.

Table 65. Assessment of the different components in the fast charger that will need maintenance or reactive field services. Internal ABB products have a higher gross margin assessed compared to goods bought from suppliers. Scale effects will still make it feasible to redistribute common supply components (author).

Component	MTBF, *years*	TTR, h	TTR, h/year	Spare part cost	Specificity	Gross margin	Price to customer	Cost, *$/year*	Price to customer*$/year*
Fans	5	2	0.40	$50	Common	20%	$60	$10	$12
Power module	15	2	0.13	$800	ABB IP	170%	$2'184	$53	$146
Display	5	1	0.20	$800	Modified	80%	$1'440	$160	$288
Protective glass	1	0.25	0.25	$20	Common	20%	$24	$20	$24
Plug & cable	1	0.25	0.25	$500	Common	20%	$600	$500	$600
Average			**1.23**	**$2'170**			**$4'308**	**$743**	**$1'070 (44%)**

The first step of the analysis for choosing between the customer or ABB risk models is to understand the customer risk model. With this model as a base case, it can be investigated when it is profitable for both ABB and the customer to choose a service contract where ABB takes the product risk.

Table 66 shows the yearly sales of spare parts form ABB to the customer and ABB’s corresponding revenues. It also shows the costs for the customers to service their fast chargers. The costs have both a fixed and a variable part. How large the fixed part (investment) is for the customer will determine when a service contract with ABB makes more sense than investing in an in-house service organization. The total variable costs add up to $1’686 per year and charger for the customer (including spare parts, travel and labor).

Fixed costs for the customer include investment in education for service labor, software updates, spare part inventory handling (the customer needs to stock spare parts locally or pay for ABB to do that in order to have an availability guaranteed over 99%) and other fixed costs in tools and equipment. Depending on how many internal resources the customer has, different fixed costs apply. A customer without service organization (such as petrol stations, shopping mall builders and cities) needs to invest in for example tools and service trucks. With 10 years depreciation the yearly cost of acquiring this is estimated to $5’000.

Table 67 and Table 68 present a break even analysis between a service contract when ABB takes the risk and a set up where the customer takes the full risk. Table 67 is for a mature customer (such as a utility), which has lower fixed costs than a more immature customer (petrol station, city, shopping mall owner or fleet operator) (Table 68). A service contract will always cost less for ABB to deliver than the customer. A customer will be willing to pay the same (or just below) for a service contract as it would for in-house supply costs. The difference between the willingness to pay makes up the gross margin for a potential service contract.

Table 66. An assessment of a service model where the customer takes the risk. ABB has a 44% profit margin on spare part sales. The customer buys spare parts and does the labor internally. The total yearly cost to service a charger is $1'686 per charger. This corresponds to 8% of the HW investment. In additional different fixed costs apply to the customer which impacts the total cost for operating the charger.
**** The cost should not be amortized but taken as a fixed cost. However this has still been put as a yearly cost to simplify calculations.***
***** For a customer who do not have an established service organization.***

Customer risk	$ per year and charger
ABB	
Spare part cost	$743
Spare part price to customer	$1'070
Profit per charger and year (gross margin)	$326 **(44%)**
Customer cost per charger	
Spare part cost	$1'070
Labor cost	$247
Travel cost	$370
Total cost (% of $20'000 in HW cost)	$1'686 **(8%)**
Customer fixed costs	**Per year**
Training assuming that one training session at $5'000 lasts for 10 years.*	$500
Software upgrades	$500
Spare part inventory capital and handling costs	Varies with IB
Tools, service vehicle and other costs (10 year depreciation)**	$5'000

Table 67. A break even analysis between the customer and ABB risk models for a mature customer. At five fast chargers the margin for ABB is the same as when only providing spare parts.
****The fixed costs include training ($500/year), SW updates ($500/year) and inventory keeping costs. Inventory keeping costs depend on the number of units that need to be stocked, the stock keeping rate and the material handlings costs: The more units, the more spare parts that need to be handled and stocked. Table 69 depicts the inventory costs for an internal ABB inventory with an installed base of 10'000 units. The same calculation method was applied to figure out inventory costs for customers with different number of chargers by varying the installed base number. The spare part cost was put to the ABB retail price.***

Number of chargers	Customer fixed costs*	Total costs customer (willingness to pay)	Service contract cost for ABB	Service contract gross earning	Service contract margin	% of HW cost
0	$1'000	$1'000	$0	$1'000	Inf	Inf
1	$1'067	$2'753	$1'360	$1'393	102%	14%
3	$1'201	$6'260	$4'080	$2'180	53%	10%
5	$1'335	$9'766	$6'800	$2'966	44%	10%
10	$1'669	$18'532	$13'600	$4'932	36%	9%

Table 68. A break even analysis between the customer and ABB risk models for an immature customer. At 25 fast chargers the margin for ABB is the same as when only providing spare parts.
The fixed costs include training ($500/year), SW updates ($500/year), depreciation of service equipment ($5000/year) and inventory keeping costs. Inventory keeping costs depend on the number of units that need to be stocked, the stock keeping rate and the material handlings costs: The more units, the more spare parts that need to be handled and stocked. Table 69 depicts the inventory costs for an internal ABB inventory with an installed base of 10'000 units. The same calculation method was applied to figure out inventory costs for customers with different number of chargers by varying the installed base number. The spare part cost was put to the ABB retail price.

Number of chargers	Customer fixed costs	Total costs customer	Service contract cost for ABB	Service contract gross earning	Service contract margin	% of HW cost
0	$6'000	$6'000	$0	$6'000	Inf	Inf
1	$6'067	$7'753	$1'360	$6'393	470%	39%
3	$6'201	$11'260	$4'080	$7'180	176%	19%
5	$6'335	$14'766	$6'800	$7'966	117%	15%
10	$6'669	$23'532	$13'600	$9'932	73%	12%
25	$7'673	$49'830	$34'000	$15'830	47%	10%
50	$9'346	$93'659	$68'000	$25'659	38%	9%
150	$16'037	$268'977	$204'000	$64'977	32%	9%
250	$22'729	$444'296	$340'000	$104'296	31%	9%
1000	$72'760	$1'759'027	$1'360'000	$399'027	29%	9%

For a mature customer, the result shows that at five installed fast chargers ABB has 44% gross margin on the contract which is equal to the margin for only selling spare parts. According to this analysis ABB should not offer service contracts to mature customers with more than five installed fast chargers. Similarly, when the customer is immature, service should not be done for the customer when the number of chargers is more than 25. ABB should also make sure that service contracts are priced above 10% of hardware costs.

There are certain limitations to the analysis made above. First of all, not enough data has been acquired of actual costs of labor and inventory costs. Secondly, the analysis does not take scale effects into account. When servicing many products the utilization of the service staff increases and according to the service benchmark studies this is a key success factor for profitable service delivery. Scale also decreases spare part handling costs per unit. This has however not been accounted for in the analysis. Scale impacts the utilization of the service staff but not the actual service time per unit. Therefore, the analysis above is rather valid. However, if the service staff cannot be used for other tasks when not working with fast chargers this cost has to be included in the fixed cost calculations. This implies that the break even limit for those customers (most likely immature without other equipment) will rise to several hundred chargers (assuming salary for service staff >$50'000 in Europe).

When ABB launches the service concepts a true calculation should be done for each region in the world by each local office with the correct labor costs and travel costs. Also an estimate of the customers investment needs should be done. Based on this, a win-win case can be constructed where the customer and ABB benefit from an ABB risk service contract below a certain amount of fast chargers. The same methodology as above can be used. Interesting to note is that the average time to repair a charger per year is 1.23 hours (Table 67). This means that a service person can repair a few chargers every day (maybe field service repairs in the morning and scheduled maintenance in the evening). In total the same service person can serve a country's fast charging network if it is smaller than 500 chargers. Table 67 and 68 further indicate that the customers willingness to pay for a service contract tend to go towards 9% of hardware costs when the number of fast chargers increases. This limit only takes cost into account. If ABB could have a comparably higher performance of its service the customer might be willing to accept a service contract at 10 or 11% of HW costs. Such performance could be reached by incorporating predicative maintenance in the offering. ABB's product knowledge can also be leveraged in the service contract to guarantee better support if something breaks. ABB can have a troubleshooting service which can be activated via a telephone number (if someone discovers a fault) or, if the charging station is networked, faults can be reported directly when they occur. The charger log can for example continuously be sent to a server which triggers field service or trouble shooting if a fault occurs. With immediate fault reports the failure could be repaired before the first customer even has seen that the charger is out of order. A trouble shooting or field service can also be set up with cascading. To begin with the error starts with the most local service unit. It they cannot solve the problem they send it upstream to eMobility service which in turn can contact R&D if they neither can deal with the problem.

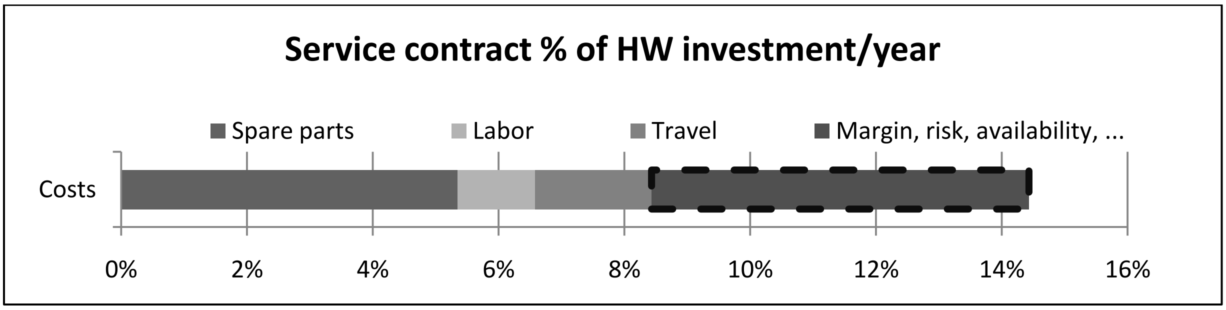


Figure 37. An assessment of the costs of spare parts and maintenance. ABB margin of 44% is included in the sales of spare parts. The dashed line area shows the room for margin, risk premium and availability guarantees. This area is subject to negotiation (author).

Figure 37 depicts the yearly costs of a service contract as a percentage of hardware investment. The dashed line shows room for value creation and negotiations.

The total spare part business for DC fast charging is worth $10.7M per year when the installed base amounts to 10 000 DC fast chargers. This is estimated to happen within 5-10 years (see Table 69). This number is derived from Table 69 which has used economic order quantity to decide the order point and from this derived the average inventory assuming a certain security inventory. The assumptions are stated in the table text. Interesting to note is that the business for quite few spare parts is substantial if the projected volume of 10'000 fast chargers can be reached.

Table 69. The spare part business with an installed base of 10 000 DC fast chargers. Assumptions: Security inventory 20 days
Lead time 40 days
Inventory keeping rate, R 15%
Unit cost, C Depends on the unit
Annual demand, D_{year} Depends on the unit
Order handling cost, S $15
Economic order quantity, $Q^* = \sqrt{2DS/RC}$

	MTBF, years	D_{year}	Q*	Cost	Predictive	Order point	Average inventory	Inventory costs	Sales
Fans	5	2000	103	$50	Yes	329	219	$41'644	$120'000
Power module	15	667	15	$800	Yes	110	73	$22'100	$1'456'000
Display	5	2000	26	$800	No	329	219	$66'301	$2'880'000
Protective glass	1	10000	365	$20	No	1644	1096	$203'288	$240'000
Plug & cable	1	10000	73	$500	No	1644	1096	$282'192	$6'000'000

As presented above, an ABB risk service contract profitability for the customer depends heavily on how much investments the customer need to do for acquiring in house skills. As discussed earlier, lock in strategies can be used to create higher fixed cost for the customer if deciding to do service independently of ABB. Training certificates is one way to put cost barriers for the customers to service on their own. The hardware then needs to be serviced by an educated engineer in order to have valid warrantees. One could also build software that only can be updated by ABB engineers. Log files and data for maintenance could be tied to fixed cost barriers.

ABB needs to be innovative in finding ways to raise the required investment for the customer. However it is important that all these ways are justified and add value. ABB could also change the difference between the ABB risk service contract and customer risk option by giving away incentives for free when the customer chooses the service contract. Table 70 provides a list of possible strategies within these two dimensions.

Grönroos (2007) discusses the characteristics of services. One characteristic is that it is to a large degree only the visible part of the service process that matters in the customers mind. A service is to a large extent intangible and the implications of what Grönroos (2007) states is that it is the tangible outcome of the service that matters. This might explain why customers value field service and software updates high in comparison to predictive maintenance or even service contracts. In order to ensure that the customer is satisfied with a service contract where ABB takes the product failures risk, it must be evident that ABB is adding value for the customer and not just receiving a high margin for nothing. Since services are famous for high margins this makes customers suspicious.

All options in Table 70 are ways to make the service contract benefits more tangible in comparison to the option where the customers take the risk their self. Availability guarantees is one way to make service contracts tangible ensuring the customer about a certain outcome that exceeds what the customer might be able to do in-house. Another way to achieve tangibility is to provide the customer with continuous reports about the status of the equipment, what has been serviced, how long the service time was and/or how the current availability is for the year. If the contract turns out very favorable to ABB and few repairs has been made after the period, is can be good to have some guaranteed amount of maintenance made per charger and year. If the pool of maintenance is not used during the period it is then used for preventive maintenance, upgrading or refurbishing after the period. The service contract can also be continuously adapted to a level that suits the customer's risks and environment.

Table 70. A table of different strategies for ABB to increase margin of service contracts. Either increase the cost for customers to do service in-house or increase the benefits of choosing ABB as a supplier for service (author).

Rise investment requirement for customer to do service internally	Increase the number of features the customer gets with a ABB service contract compared to internal service
Lock-in strategies • Special tools needed to make service • Special software needed to make service Training • Require certificate for maintenance labor to be approved serving (warranty issues) Increase the cost of components • ABB produced components such as the power module should be priced as high as possible. Investing in an inventory will then be costly	Better availability • Use predictive maintenance • Use components that can detect when they are broken and tell the service department Better product • Include software updates for free with the contract • System optimization service Customer relationships Guarantee short response time • E.g. within 24 hours. Have a guaranteed pool of maintenance over the year. Could be used for: • Field service if something breaks • Scheduled maintenance for components that needs replacement due to age (e.g. fans) • Preventive maintenance – if maintenance pool remains after period, use it to refurbish the equipment The value of a service contract is additionally to give the customers a reliable operation and reduce their risk.

There are other reasons to not stare blindly at margins and costs when looking at a service contract. In 80% of the cases with a service contract, customers buy something more apart from just the service.[19] Meeting with the customer when the service is being done also builds relationship for future sales of products and services. Another justification for service contracts from the customer's viewpoint is insurance against failure. Letting ABB take the product risk ensures a more predictive business model.

[19] Tanja Vainio. Head of ABB ATPS. Stakeholder meeting 2011-04-26.

6.7 End of life services

6.7.1 What

End of life services exist for taking care of products that the customers no longer want or can use. A product might have served for its operational lifetime of 20 years or for some reason became outdated. In a few years the fast charging standards might change so that the hardware becomes obsolete. During the interviews many customers expressed concerns about the hardware at end of life. Utility 2 has still old fast chargers from the electrical car hype ten years ago that have been left at their installation sites. If an end of life solution can be created the author believes that many customers will find a large value in this.

Table 71. Evaluation of service ideas related to end of product life (author).

Service idea	Utility	Others	Total	Customer rank	$Prio_{utility}$ - $Prio_{others}$	Internal rank	Importance - performance	Competition	Strategic intent
Hardware upgrade, replacement or reconditioning/refurbished	M	M	M	1	0.2	17	In line	High	90%
Recycling	M	I	I	18	1.2	18	In line	Low	50%
Buy and re-sell	A	A	A	24	-0.4	29	Concentrate here/ Not important	Low	30%
Average (majority rule for classification)	**M**	**A**	**A**	**14**	**0.33**	**21**	**In line**	**Med**	**60%**

The quantitative evaluation in Table 71 shows that recycling is more valued than a re-selling/refurbishing service. However this difference is probably unimportant. What is likely to be of value to the customer is to get rid of the product if he does not want or cannot use it any more. Another option is that the product is upgraded, replaced or refurbished. This was ranked as the most important service from customers. This service idea was part of the evaluation of operational life services. However, since it is not part of one of the service contract options this is a service that should be considered separately. Refurbishment could be seen as a service for those customers who has not chosen to have a service contract with ABB and where maintenance has not been done properly.

To summarize, depending on what the customer wants and how far the product is in the life cycle, there is a few options for a product (Table 72). The options have two things in common. First, they require the product to be sent to a factory for some kind of operations. Second, the services have a business concept with clear direct revenues.

Table 72. A few options for end of life services (author).

	HW upgrade	Refurbish	Buy and re-sell	Recycle
Why?	Technology outdated / new technology exists	Product is worn / product should be rebranded	Customer does not want product	Product at EOL, cannot be used further
Ownership	Same	Same	New	-

6.7.2 How

With the previously described needs in mind, ABB could offer a service similar to ABB Robotics refurbishment and buy & re-sell service. A service centre could be built somewhere in the world, preferably in a low labor cost country with a well connected logistics system. Similar to ABB Robotics, a standard process can be set up where each fast charger goes through a program. First, an inspection is done where needs are assessed. Then, repair, refurbish and updating are done according to a defined schedule. Finally, the product is adapted according to the customer's needs. Maybe it is re-painted or re-branded (see Figure 38).

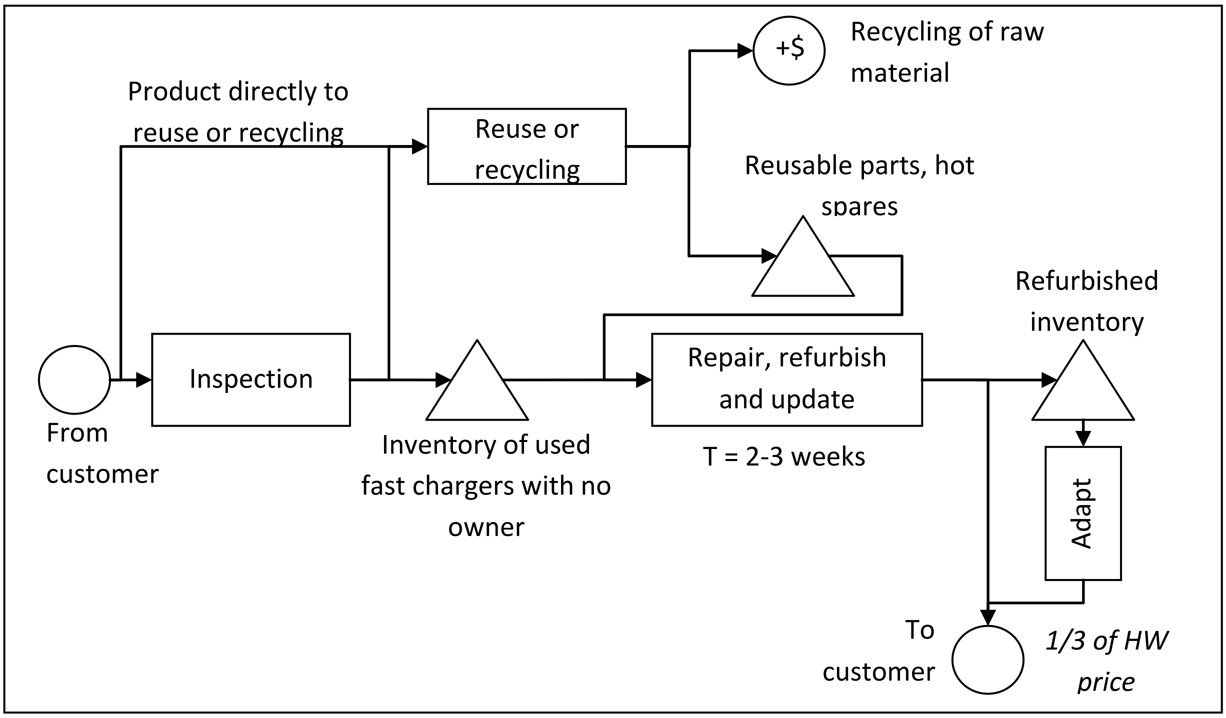


Figure 38. Process for a factory that handles refurbishment, repairs and buy and re-sell of a fast charger (author).

It is important that the freight cost to this centre is low. According to Mclaughlin[17], ABB could charge about one third of the new hardware cost for a refurbishment that gives a product back to the customer with full warrantees (good as new product). This means that revenues are roughly $7000 for a refurbishment. Customers also can not have a too long delay with their fast charger out of operation. A lead time over two weeks is probably not acceptable for a relatively high price of one third of the HW investment. One way to solve this is to use so called “hot spares”. This means that key components that need maintenance and refurbishment are changed on site to new or previously refurbished components (premium or standard refurbishment). The old components are brought back to the refurbishment factory to be cleaned, maintained and potentially upgraded. After the refurbishment, the same warrantee as for new products is given. Since the customer roughly pays one third of the initial HW price (depending on type of refurbishment) a warrantee is a necessary incentive. Keeping the product on site for refurbishing has the benefit that a long lead time is allowed for refurbishment of the components. Another benefit is that transportation costs of the components (or assemblies) that need refurbishment are lower than sending the whole unit. Mclaughlin[17] has never experienced that a customers have complained to not get their particular components back after refurbishment. The customer is only concerned about that the product works and trusts ABB that the hot spare part is as good as the old spare part that was exchanged. ABB also guarantees this by giving a warrantee which is a good receipt for building trust.

To buy a customer’s charger and resell it could most likely be priced higher than doing a refurbishment for a customer. This is since the new customer buying the second hand charger will receive a whole new unit.

Recycling can also be included in this process. Components that are fresh can be taken care of and used for repairs of other products. In ABB Robotics, the customer can chose between using new or used original parts when repairing and this can be done also for the fast charger. Parts that are not possible to refurbish should be recycled. The parts to recycle are sent to a junkyard customer who is willing to pay the highest price.

By 2020, the chargers sold today might start to create a demand for refurbishing and gradually also for recycling. ABB have, time to prepare for the business by building operations. Already today, it is worth thinking about designing for recycling. Design for recycling is defined as constructing the product with two goals in mind; do not use hazardous or toxic materials in the design and discourage non-recyclable materials or production techniques that make a product non recyclable (Institute of Scrap Recycling Industries, 2005).

There are certain regulations that have to be followed by electronic equipment for consumers. RoHS (Restriction of Hazardous Substances Directive) and WEEE (Waste Electrical and Electronic Equipment Directive) have become EU law. RoHS limits the use of certain materials, such as led, mercury and cadmium. Either the materials are prohibited or they are allowed to a percentage of the total product weight. The WEEE directive dictates that manufacturers are mandated to take care of their products and recycle them when they have reached end of life. Only certain categories of companies have to consider the directive today (WEEE Register Society n.d.). Industrial equipment is so far not under the law until 2020 but due to lobbying this date might be put earlier.[17] All ABB’s products that are being developed today supports these directives including the DC fast charger Hermes 2.[17] By the time when recycling will be done of the fast chargers, it is very likely that ABB will be obliged to take care of it.[17] Today, most electronic manufacturers (that are under the RoHS and WEEE already) have free programs for returning/recycling their old products[17]. Apple and Dell are two examples of this. This can be set up as well by ABB and used in marketing. Since the product contains many kilos of valuable metals the business could potentially be profitable if the labor requirements to extract those metals are low. Mclaughlin[17] stated that ABB's products are goldmines for junkyards. He believed that there definitely is money to make in recycling. The hard part is the PCB (printed circuit board) that contains many small components of different materials. Today, there exist recycles that are willing to pay for these boards[20] and that extracts all the valuable metals. The board is first grinded to a fine powder and then different separation techniques are used (e.g. magnetism, centrifuge and shaking tables).[17] According to Mclaughlin[17] ABB should organize a pickup service for those customers who are concerned about how to get rid of old fast chargers. ABB can then sell the chargers to junkyards. Most ABB customers realize the value of the products that have reached end of life and do recycling contracts with junkyards themselves without help from the supplier.[17] This might however not be the case for all eMobility customers who have expressed a need for the service.

6.7.3 Business case

There is one reason to why refurbishing products for customers and a second hand market can have a good business case. The business case for new products is tough and there is a high focus on reducing costs. Therefore it should be a demand for cheaper alternatives for commercial actors who would like to be part in the eMobility business. For companies buying new fast chargers there is also a demand for having someone who takes care of the chargers when they are old. This creates a push from the supply side so that second hand chargers should be accessible to buy for a good price or receive for free in exchange for removing it.

A second hand charger could potentially be sold to 70% of a new chargers price ($14'000) after refurbishing (with the same warrantee guarantees as a new charger). If the charger can be transported from site and refurbished to a price below this than the activity should be done. Table 73 shows an assessment of the profit for the different services within this concept.

Table 73. Assessment of business case for mid or end of life services (author).

	Costs		Revenues	
Service concept	**Fixed**	**Variable**	**Direct**	**Indirect**
Refurbish or upgrade	Factory	Comportments, labor, transport and warrantees	1/3 of HW –> $7'000	Yes, attractive by customers so should be used in marketing
Buy, refurbish and re-sell	Factory	Take care of unit, components, labor	$10'000-14'000	No
Recycling	No	Transport costs	Yes, $400 material	Yes

[20] See BW Recycling. (n.d.). *Scrap PCB disposal & recycling services.* (Online). Accessed from: http://www.webuyics.com/scrap-pcb.htm. Accessed: 2011-05-10.

See also members of Institute of Scrap Recycling Industries organization, ISRI.

Refurbishing and upgrading chargers is also an activity that should have a good business case. To have the activity will for sure generate indirect revenues. It is also reasonable that direct revenues can be taken since there is a clear value that the customer is paying for. Since it is only ABB that has the full knowledge of manufacturing and servicing the product, there is a big competitive advantage in doing refurbishing/upgrades. Hence the margin should be high for this activity.

7 CONCLUSION AND DISCUSSION

The purpose of the thesis is to develop a set of service concepts for ABB's DC fast charger product. The concepts should combined make up ABB's total service offering. The process started off with generating service ideas. The ideas were structured according to an adapted life cycle framework. Evaluation was then done individually of each idea using different perspectives. In the previous chapter the ideas were put together under a framework that resulted in clearly defined service concepts. Within each of these concepts, *what* should be offered was recommended based on the evaluation of the ideas related to the concept. The result of the thesis is summarized in Table 74. All of the concepts are important to a certain degree; however in consulting and project management only certain sub-concepts are recommended (i.e. not all of the evaluated service ideas).

Table 74. A summary of the service concepts presented in chapter 6 (author).

Service concept	Conclusions
Action related services	- Focus on management and payment system. - Providing a solution is the key to address the early market.
Sales service	- Provide a sales service using relationship marketing and information material. - Differentiate the service depending on customer maturity and scale of project.
Consulting services	- Provide network and location studies. - Grow organically to acquire competence.
Project management services	- Provide installation and commissioning services. Try to get direct revenues but do not expect it. Make sure to develop a straight forward process that is easy to execute by local ABB service labor.
Services during the product's operational life	- Provide at least two different kinds of service alternatives with different levels of risk for the customer and ABB. It makes sense to provide the service for the customer if few chargers are installed and if the customer is less mature. - Spare part gross margin is around 44% and it is hard to make it higher. Do not expect to sell availability but work with the advantage of being a product supplier to add value.
End of life services	- Provide recycling, refurbishing and a buy and re-sell service when the market starts to mature. The service is likely to be profitable. - Common to this concept is that a service operation centre is needed to do refurbishing and inventory management. Use the fact that the product follows WEEE and RoHS in marketing.

Looking at these service concepts, it is interesting to discuss what total value services have over the product life cycle. Initially, in the introduction, it is stated that services are good sources of revenue and have high margins. It is also described that ABB's (and many other western industrial companies') strategy is to increase the service offering since this is one way to build a sustainable future business model not only based on new sales. So how does this relate to the service strategy of this thesis; are the criteria of profitability and high revenues fulfilled? For profitability, there are certain services that have a good business case. However, the main service for the fast charger, i.e. maintenance and services during operational life might be hard to sell with high margins to all customers. The reason for this is that the specificity (ABB in-house produced and IP products) is low for the charger and that reactive maintenance services have the largest proportion of maintenance. Apart from this, profit could most likely be made on refurbishment and end of life services but this is hard to assess since the activity is still far ahead in the future.

Revenues can on the other hand be estimated with the figures derived in the report. Looking at one individual charger, the yearly maintenance (including labor) accounts for $2’000 or 10% of hardware investment. With a discount rate of 10%, the value over 20 years maintenance is $17’000 per charger. If the customer chooses to have ABB doing maintenance, the revenue business case is similar. ABB moreover sells spare parts for $1’000 per year and charger. This equals $8’500 over 20 years. Refurbishing, training and software upgrades might add on to these revenues giving a total revenue per charger of $39’481 for the 20 year period. See Figure 40 for a breakdown chart of the estimations. This example is simplified and depends on the contract structure for maintenance, how much maintenance the charger needs, how long the life time is for the customer and if refurbishing is made. However, it gives a hint that maintenance is a very important revenue source in this highly competitive market.

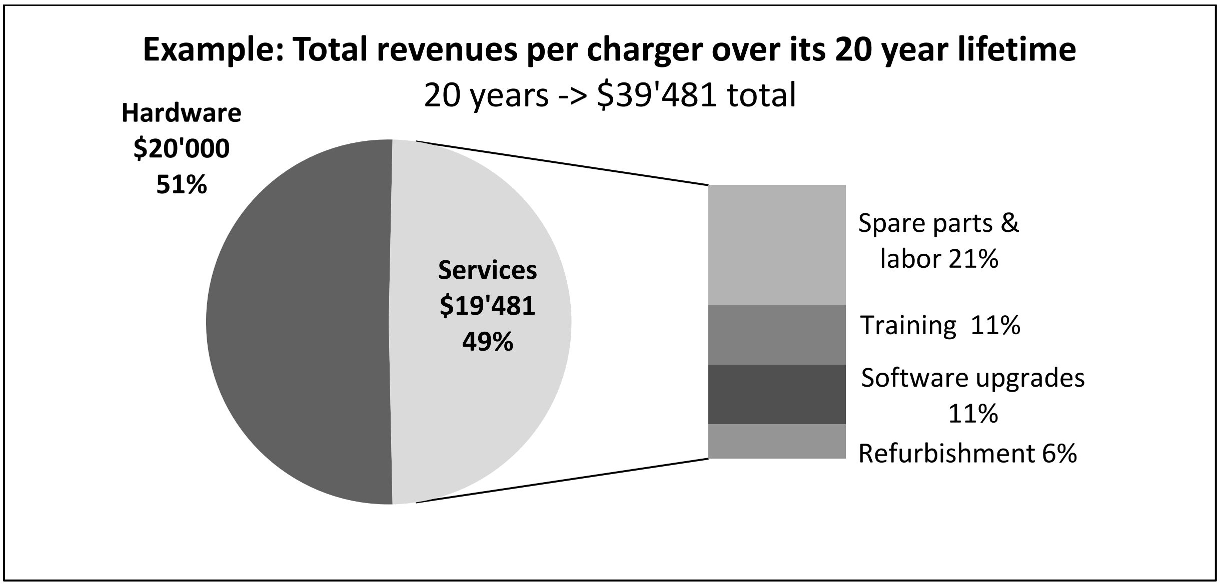


Figure 39. Estimates of total revenues for a DC fast charger with 20 years lifetime and a discount rate of 10% (which reflects the risk and other possibilities to invest).

This thesis has made an attempt to develop services for ABB’s total DC fast charging market given the constraints in resources and market access. No survey data has been collected from customers in the assembly segment or customers from cities with “free” value propositions. This is unfortunate since these segments are likely to have different needs than the main survey base of utilities and commercial value propositions. An assessment of how the cities with the free value proposition behave has however been done from interviews and secondary data. This suggests that cities, countries and communities with the free value proposition tend to have higher requirements on both product related services and action related services/features. Since we are seeing that cities, communities and countries are the first to invest in eMobility infrastructure (due to difficulties of finding profitable commercial business models) this implies interesting characteristics to the market. For normal products such as cars or phones there is normally a development where a simple product is released first and as the market matures more features are added. For eMobility, and especially for DC fast charging, the opposite is however true. The reason for this is that the early investors (cities, communities and countries) require full solutions and larger supplier responsibility than later investors (commercial actors such as utilities). An illustration of the eMobility dynamics has been made in Figure 40. This dynamic poses requirements on product development and the business. Taking larger responsibility for the customer implies major risks. To sustain in eMobility, ABB must speed up development and/or find partnerships to be able to offer early customers full solutions. If this is not done, competitors will continue to run ahead.

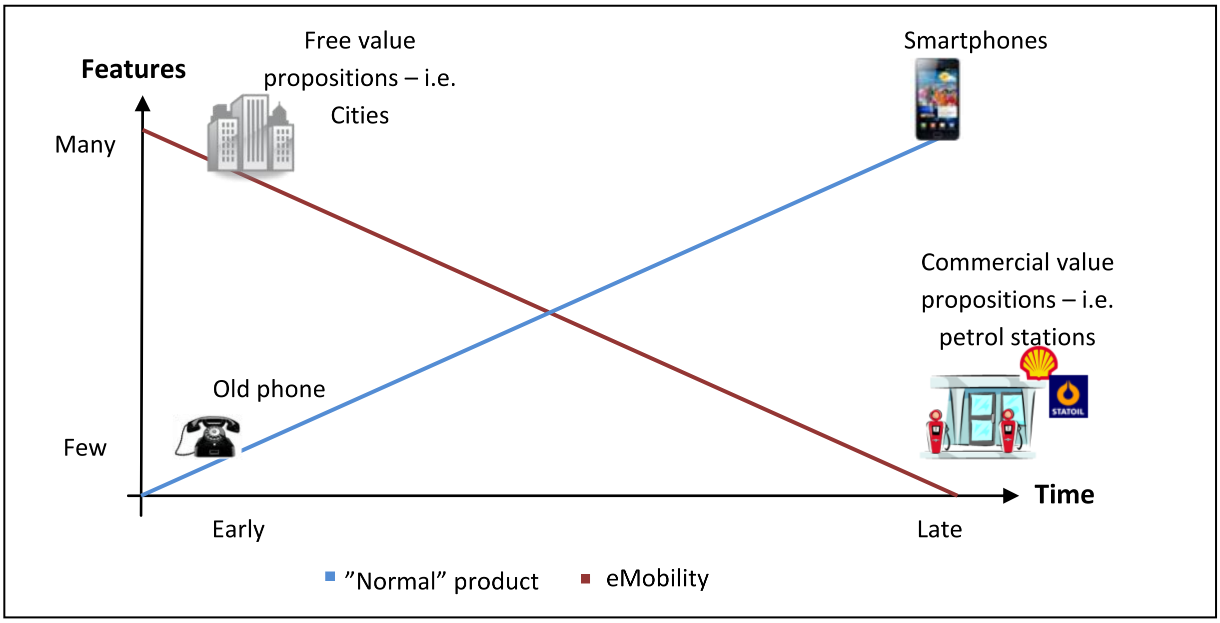


Figure 40. Illustration of eMobility market dynamics compared to traditional (i.e. telephone) market. eMobility has a requirement of many features (full solutions) already very early in development. This implies larger risks but maybe also larger gains (author).

For the second segment of customers that has not been part of the study (customers that buy assemblies) some qualified guesses could also be made. Most likely the services these customers demand will be a subset of what the customers for the full charging unit demand. Commissioning is for example not applicable to this customer. End of life services are also taken care of by this customer for the total product. It is unlikely that ABB will tie any service contract with the end user. However, executing the part of the customer's service contract which has to do with the assembly might be a business. If the power module is sold as an assembly to a customer then this might be subject to servicing according to the same maintenance scheme as for ABB's charging unit. Consulting services are however an exception of a service concept not covered by the charging unit service concepts. Charging assembly customers might be interested in a consulting service for how to design the entire unit in an efficient way.

In total, the author believes that the study took a good approach to service development in this project. Cooperation with customers has been done closely by listening to their plans and subsequent product requirements for eMobility. Although many of the interviewed customers to this day have not bought fast chargers and see this in a ten year perspective, their input is still valuable for development. Many of the customers were commercial actors with the key concern of finding profitable business models that could be a foundation for investments in DC fast chargers. Finding profitable business models relies heavily on how fast and when customers start to adopt electrical vehicle technology. As written in the introduction, it is no doubt that the transition will come and that fast charging has a role to play in the future infrastructure for eMobility.

This report gives a valuable contribution to research in the service area for eMobility infrastructure to date. As far as the author knows, no study has been made in this area before. The studies of product development are also mostly focused on market projections. The market is however constantly evolving. As discussed in the theory chapter customer perceptions develop over time. Attributes that are indifferent to customers tend to get attractive when they are profitable. Attractive attributes turn into must be attributes that the customer cannot be without. One example of such a development that might be expected is for remote monitoring and controlling tied to unit servicing. Many of Other segment found this a potential overkill if they bought a fast charger today. In ten years however this might be required in order for the customers (or suppliers) maintenance organization to work efficiently.

Future research in this field and ABB could benefit from longitudinally studying how the market develops its requirements. It would also be interesting to look at a broader sample in other regions of the world. Suppliers of fast chargers should make sure to use their customers as a resource in service and product development. Send them surveys, let them be involved and show them that their requests get priority and help to create great products and services.

At a higher level of aggregation, this study has shown how service development can be done in a systematical way. Mixing qualitative and quantitative research is a good way to get rich information, both broad and in-depth, that can be used to make informed decisions. Introducing new services involves high risks since they normally involve employing staff. Making sure that the services introduced have a valid market is therefore of high value. The next step in the service development process for ABB is to construct process maps for how to execute the suggested services in detail.

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FIGURES

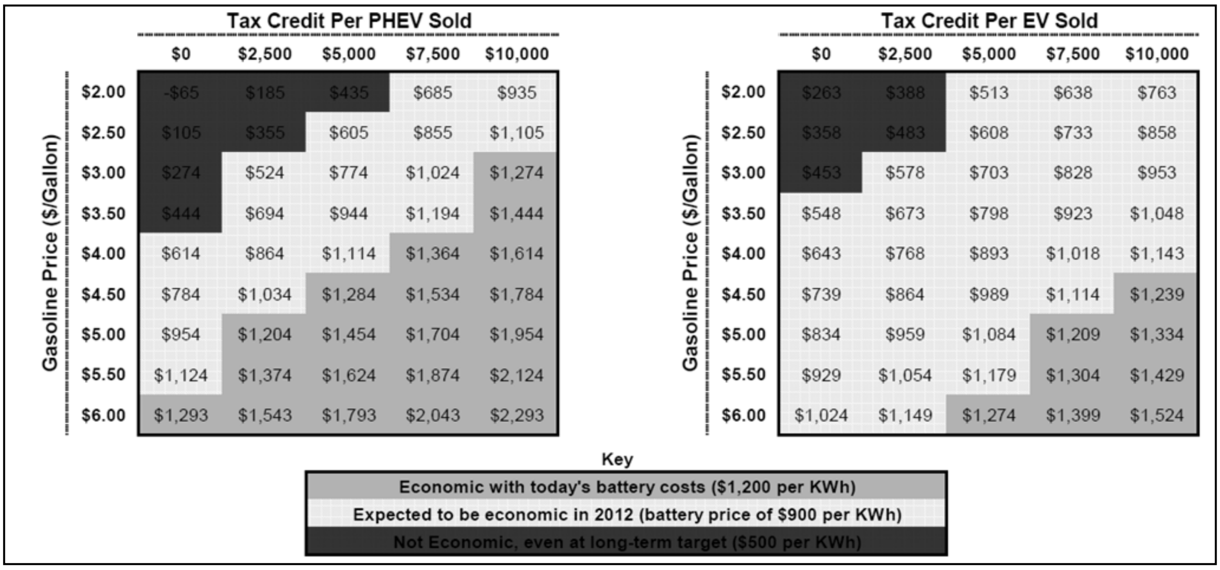
TABLES

APPENDIX 1. LIST OF EVS

Table 75. List of electrical vehicles. Energie Schweiz. (2011). eMobile Ecocars 2011*. (Marketing Material). pp.14-15.*

Make	Model	Seats	Power, kW	Max speed, km/h	Battery type	Rang, km	Consumption, kWh/100km	Price, CHF
ALKE	XT	2	12	60	Led	195		42 900
ALKE	ATX49	2	6	30	Led	70-90		27 800
GOUPIL	G3-1	2	12	30	Led	100	16	31 700
Citroën	C-Zero	4	49	130	Li-Ion	150	13.5	45 990
Fiat / Microvett	Fiorino	2	26-60	70-115	Li-Ion	70-140	Nn	55 800
Fiat / Microvett	Ducato	2-3	60	90	Li-Ion	70-140	Nn	127 000
Ivolt ag	Citroen EC1	4	38	120	Li-Ion	120	15	On request
Kamoo	Twingo Elektra	2-4	30	120	NaCl+Ni	145	16	39 980
Kamoo	500 Elektra	4	30	110	NaCl+Ni	120	16	61 480
Kamoo	500-220i	4	63	130	Li-Ion	200	12	64 780
Kamoo	500-220c	4	63	130	Li-Ion	200	12	67 780
Kamoo	Fiorino	2	63	130	Li-Ion	160	15	65 480
Mitsubishi	i-MiEV	4	49	130	Li-Ion	150	13.5	45 950
Nissan	LEAF	5	80	144	Li-Ion	160	Nn	49 950
Peugeot	iOn	4	49	130	Li-Ion	150	Nn	45 990
Piaggio	Porter	2	10.5	55	Led	90	15-18	35 000
Renault	Kangoo	2	44	130	Li-Ion	160		31 200
Renault	Fluence	5	70	135	Li-Ion	160		34 500
Tesla	Roadster	2	215	200	Li-Ion	393	10.8	138 300

APPENDIX 2. BREAK EVEN CALCULATIONS FOR EV BUYERS



Tax Credit Per PHEV Sold

Gasoline Price ($/Gallon)	$0	$2,500	$5,000	$7,500	$10,000
$2.00	-$65	$185	$435	$685	$935
$2.50	$105	$355	$605	$855	$1,105
$3.00	$274	$524	$774	$1,024	$1,274
$3.50	$444	$694	$944	$1,194	$1,444
$4.00	$614	$864	$1,114	$1,364	$1,614
$4.50	$784	$1,034	$1,284	$1,534	$1,784
$5.00	$954	$1,204	$1,454	$1,704	$1,954
$5.50	$1,124	$1,374	$1,624	$1,874	$2,124
$6.00	$1,293	$1,543	$1,793	$2,043	$2,293

Tax Credit Per EV Sold

Gasoline Price ($/Gallon)	$0	$2,500	$5,000	$7,500	$10,000
$2.00	$263	$388	$513	$638	$763
$2.50	$358	$483	$608	$733	$858
$3.00	$453	$578	$703	$828	$953
$3.50	$548	$673	$798	$923	$1,048
$4.00	$643	$768	$893	$1,018	$1,143
$4.50	$739	$864	$989	$1,114	$1,239
$5.00	$834	$959	$1,084	$1,209	$1,334
$5.50	$929	$1,054	$1,179	$1,304	$1,429
$6.00	$1,024	$1,149	$1,274	$1,399	$1,524

Key
Economic with today's battery costs ($1,200 per KWh)
Expected to be economic in 2012 (battery price of $900 per KWh)
Not Economic, even at long-term target ($500 per KWh)

Figure 41. The chart depicts what the battery price per kWh must be in order for an investment to break even (unknown exactly how it has been defined in their calculations) given a certain gasoline price and tax credit/subside (Jobin et al. 2009, p.19).

APPENDIX 3. PROJECTION FOR FAST CHARGING MARKET HARDWARE SALES

Table 76. DC-Fast charging sales. EV sales numbers are based on Credit Suisse market estimates. Charger price is based on estimates of scale economics and effect of competition (author).

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EVs sold ('000)	38	94	178	327	498	994	2174	3403	3816	4997
Charging units sold	380	940	1780	3270	4980	9940	21740	34030	38160	49970
DC fast charger price ($k)	50	40	35	30	20	20	20	20	20	20
Market size ($M sales)	19	37.6	62.3	98.1	99.6	198.8	434.8	680.6	763.2	999.4
Market share ABB	0.05	0.06	0.07	0.08	0.09	0.1	0.11	0.12	0.13	0.14
ABB revenues ($M)	0.95	2.25	4.36	7.84	8.96	19.8	47.82	81.67	99.21	139.91

APPENDIX 4. COST OF BUILDING A PETROL STATION

Table 77. Assessment of costs for a petrol station (including installation) (Interview with Petrol station 1, 2011).

Activity	Cost
Civil engineering (groundwork)	2’400’000 SEK
Roof over pumps	1’400’000 SEK
4 Meters and pumps	1’000’000 SEK
2 tanks	500’000 SEK
Propellant work	700’000 SEK
Others	150’000 SEK
Total	**6’150’000 SEK**

APPENDIX 5. BRAINSTORM PARTICIPANTS

	Name	Position
9/2-2011	Nick Butcher	Product manager eMobility
	Cal Lankton	Manager Business Development eMobility
	Fredrik Lidén	Product manager Service products
	Michael Locher	Head of operation Service Excitation systems
	Simon Felsenstein	ISI Smart Grids ABB Corporate
11/2-2011	Micha Gilomen	Manager R&D DC fast charger
	Christian Morf	Project Manager eMobility Infrastructure
	Mark Knechtle	R&D DC fast charger
	Benjamin Bastian	Service Development ATPS

Appendix 6. Kano survey for potential/existing ABB customers

Kano survey on service concepts for ABB DC Fast Charging

Answer the following questions as a potential buyer of ABB fast charging equipment. The questionnaire is of a special kind (called a Kano questionnaire). It will ask you two questions for each service to measure dysfunctional and functional quality. The questions are:

Functional	If ABB offer <service x> together with charging system hardware sales, how would you feel?
Dysfunctional	If ABB does **not offer** <service x> together with charging system hardware sales, how would you feel?

The questions will be answered by one of five alternatives;

- I like it that way
- It must be that way
- I am neutral
- I can live with it that way
- I dislike it that way

Please answer these questions as good as you can for each service. This will be of help for us when evaluating the service concepts later.

Demographics

Name (optional)	
Position	
Organization	
Company nation	

PRODUCT AND LIFE CYCLE RELATED SERVICES – FUNCTIONAL

	Functional dimension If ABB offer <service x> together with charging system hardware sales, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Sales	Sales and presentation services (i.e. for proving business case and charger technology)	○	○	○	○	○
Consulting	Network design (complete sizing, specification, optimization of a charging unit network)	○	○	○	○	○
	Unit sizing (with for specific grid requirements)	○	○	○	○	○
	Location analysis (does the grid cope with fast chargers, how many?, where is the best place to put them)	○	○	○	○	○
	Cost of connection minimization	○	○	○	○	○
Project management	Installation	○	○	○	○	○
	Location specific adoptions (civil engineering)	○	○	○	○	○
	Commissioning	○	○	○	○	○
	Balance of plant (optimization of a running charging facility)	○	○	○	○	○
Training	For maintaining charging station	○	○	○	○	○
	For operating charging network equipment	○	○	○	○	○
	Documentation	○	○	○	○	○
Operation	Network operation (running the network of charging stations)	○	○	○	○	○

	Functional dimension If ABB offer <service x> together with charging system hardware sales, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Replacement, reconditioning updates and upgrades	Hardware update (for new vehicle connections and to meet new charging levels)	○	○	○	○	○
	Software (for new standards, new features)	○	○	○	○	○
Field service	Spare parts	○	○	○	○	○
	Repair service	○	○	○	○	○
	Troubleshooting service (using remote control and monitoring, investigate fault remotely)	○	○	○	○	○
Maintenance	Preventative (scheduled maintenance)	○	○	○	○	○
	Predictive (using remote monitoring to for see when components are worn)	○	○	○	○	○
Consulting	System optimization (using the system the best way when it is operating)	○	○	○	○	○
End of life	Recycling	○	○	○	○	○
	Re-buy and re-sell (complete units or parts)	○	○	○	○	○
Non life cycle related	Service contacts (= service packages with a certain service level and including different levels of maintenance, remote control, operation and/or training. Also operational guarantees/availability)	○	○	○	○	○
	Financial services (i.e. renting charging station or payment options)	○	○	○	○	○
	Warranty (i.e. five years)	○	○	○	○	○

PRODUCT AND LIFE CYCLE RELATED SERVICES – DYSFUNCTIONAL

	Dysfunctional dimension If ABB **does not** offer <service x> together with charging system hardware sales, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Sales	Sales and presentation services (i.e. for proving business case and charger technology)	○	○	○	○	○
Consulting	Network design (complete sizing, specification, optimization of a charging unit network)	○	○	○	○	○
	Unit sizing (with for specific grid requirements)	○	○	○	○	○
	Location analysis (does the grid cope with fast chargers, how many?, where is the best place to put them)	○	○	○	○	○
	Cost of connection minimization	○	○	○	○	○
Project management	Installation	○	○	○	○	○
	Location specific adoptions (civil engineering)	○	○	○	○	○
	Commissioning	○	○	○	○	○
	Balance of plant (optimization of a running charging facility)	○	○	○	○	○
Training	For maintaining charging station	○	○	○	○	○
	For operating charging network equipment	○	○	○	○	○
	Documentation	○	○	○	○	○
Operation	Network operation (running the network of charging stations)	○	○	○	○	○

	<u>Dysfunctional dimension</u> If ABB **<u>does not</u>** offer <service x> together with charging system hardware sales, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Replacement, reconditioning updates and upgrades	<u>Hardware update</u> (for new vehicle connections and to meet new charging levels)	○	○	○	○	○
	<u>Software</u> (for new standards, new features)	○	○	○	○	○
Field service	<u>Spare parts</u>	○	○	○	○	○
	<u>Repair service</u>	○	○	○	○	○
	<u>Troubleshooting service</u> (using remote control and monitoring, investigate fault remotely)	○	○	○	○	○
Maintenance	<u>Preventative (scheduled maintenance)</u>	○	○	○	○	○
	<u>Predictive</u> (using remote monitoring to foresee when components are worn)	○	○	○	○	○
Consulting	<u>System optimization</u> (using the system the best way when it is operating)	○	○	○	○	○
End of life	<u>Recycling</u>	○	○	○	○	○
	<u>Re-buy and re-sell</u> (complete units or parts)	○	○	○	○	○
Non life cycle related	<u>Service contacts</u> (= service packages with a certain service level and including different levels of maintenance, remote control, operation and/or training. Also operational guarantees/availability)	○	○	○	○	○
	<u>Financial services</u> (i.e. renting charging station or payment options)	○	○	○	○	○
	<u>Warranty</u> (i.e. five years)	○	○	○	○	○

ACTION/USAGE RELATED SERVICES

This category of services is defined as services that the product should be able to deliver.

End customer related services

	Functional dimension If the DC fast chargers is capable of delivering <service x>, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Payment services	Smart payment service (different payment options, cash, credit card and/or subscription)	○	○	○	○	○
	Reward system (capable of setting up a service for rewarding for charging within your network of charging stations)	○	○	○	○	○
	Open standard (that can be supported by all cars and chargers)	○	○	○	○	○
Software	WiFi services (wireless network to computers and smart phones in the area)	○	○	○	○	○
	Media distribution/sales capability (had an app store service system that can be used for selling media, movies and applications)	○	○	○	○	○
	Car maintenance (system that could be used to deliver software updates to electrical cars)	○	○	○	○	○
Applications in charger /smart phone	Statistics/info (presented to user on battery condition, how often charging is done, where, to what prices etc)	○	○	○	○	○
	Unit availability (where is the next charger service)	○	○	○	○	○
	Remote charging control (for the user who can be away from the car when it is charging and monitor/control charge via smart phone)	○	○	○	○	○
	Openly accessible API (charging statics etc that can be used by app developers).	○	○	○	○	○

	Dysfunctional dimension If the DC fast chargers is **not** capable of delivering <service x>, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Payment services	Smart payment service (different payment options, cash, credit card and/or subscription)					
	Reward system (capable of setting up a service for rewarding for charging within your network of charging stations)					
	Open standard (that can be supported by all cars and chargers)					
Software	WiFi services (wireless network to computers and smart phones in the area)					
	Media distribution/sales capability (had an app store service system that can be used for selling media, movies and applications)					
	Car maintenance (system that could be used to deliver software updates to electrical cars)					
Applications in charger /smart phone	Statistics/info (presented to user on battery condition, how often charging is done, where, to what prices etc)					
	Unit availability (where is the next charger service)					
	Remote charging control (for the user who can be away from the car when it is charging and monitor/control charge via smart phone)					
	Openly accessible API (charging statics etc that can be used by app developers).					

Services related to you, as charging system owner

	Functional dimension If the DC fast chargers is capable of delivering <service x> to its owner (you), how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Remote services	Control content delivery for display (advertising, spreading information)					
	Advertising capability (system for managing digital signage, location based advertising)					
Operation statistics	Raw data					
	Processed statistics (power usage, how many cars, revenue per charger)					

	Dysfunctional dimension If the DC fast chargers is **not** capable of delivering <service x> to its owner (you), how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Remote services	Control content delivery for display (advertising, spreading information)					
	Advertising capability (system for managing digital signage, location based advertising)					
Operation statistics	Raw data					
	Processed statistics (power usage, how many cars, revenue per charger)					

Services towards a utility

	<u>Functional dimension</u> If the DC fast chargers is capable of delivering <service x>, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Smart grid	<u>A service for buying, selling and storing power</u>					
Operation statistics	<u>Data and statistics</u>					
Grid analysis	<u>Pre and post installation</u>					

	<u>Dysfunctional dimension</u> If the DC fast chargers is **<u>not</u>** capable of delivering <service x>, how would you feel?	I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
Smart grid	<u>A service for buying, selling and storing power</u>					
Operation statistics	<u>Data and statistics</u>					
Grid analysis	<u>Pre and post installation</u>					

Comments

Anything to add? How was the survey? Any service you are missing?

Thank you for participating!

APPENDIX 7. INTERNAL QUESTIONNAIRE

Dear ABB employee,

I am doing a project for the DC fast charging product that ABB is developing for electrical vehicles. The task is to evaluate which service concepts ABB should offer together with the hardware of the fast charger.

A few service ideas have been identified that potentially could be offered to customers. These concepts will be evaluated from four perspectives; customer perception, monetary value, competitive advantage and **strategic fit**. Strategic fit will be measured by ABB's internal perspective; and this is where you come in.

PURPOSE

The purpose of this questionnaire is to get a better view of which services that has a strategic fit with ABB. For each service I would like to measure three dimensions.

- Fit with current organization (ABB competence/knowledge alignment – measured by an estimate if ABB has competence to deliver the service)
- Ease of offering (infrastructure and resources for delivery – measured by at which organizational level the resources and capabilities exists)
- Ease of developing (in terms of hardware adoptions, resources, staff and processes – measured from very easy to very hard)

The assessment is relative between all the different services and subjective to what you think. The goal is to be able to relate different services to each other and see which has the best or worst performance in **strategic fit**. This will be used as an input when further developing the full service concepts for ABB.

Questions? Please call +41788332232 questionnaire service hotline and I will assist you.

Once the survey is completed, please save and send it back to david.gustafsson@ch.abb.com.

Sincerely,

David Gustafsson

DEMOGRAPHICS

Name (optional)	
Position	
ABB department	

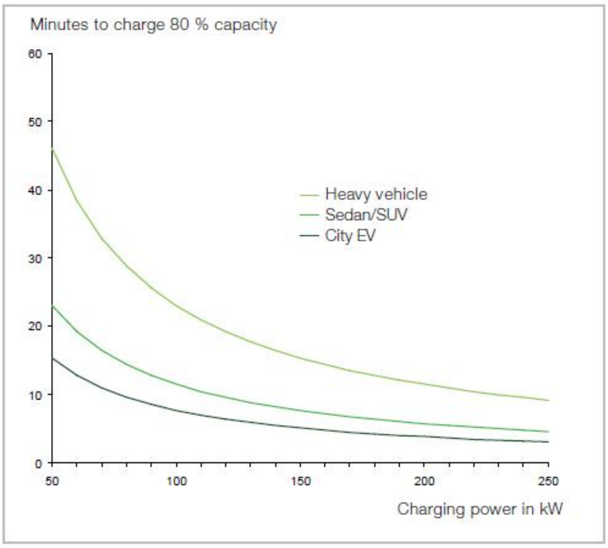
FAQ

WHAT IS OFFERED IN TERMS OF HARDWARE?

A fast charger provides a solution for the so called "range anxiety problem". When an EV owner gets into his car he need to be sure that he will get back to his house where the car is charged over night. 10% of the charging is estimated to be on public fast charging locations where the driver can fill his/her battery. Charging times varies between 10 to 60 minutes depending on battery and power.

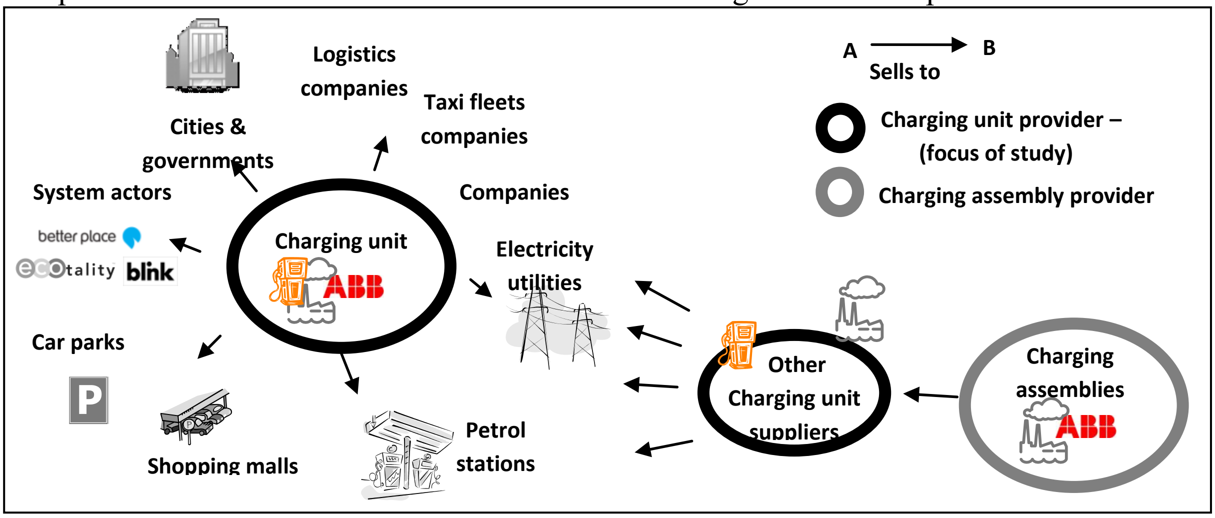
	Power Category		
	50 kW	100 kW	200 kW
Grid supply requirement*)	3 phase AC 380 - 480 V**) approx. 80 A/phase at 400 V	3 phase AC 380 - 480 V**) approx. 160 A/phase at 400 V	3 phase AC 380 - 480 V**) approx. 320 A/phase at 400 V
DC voltage range	50 - 600 Vdc	50 - 600 Vdc	50 - 600 Vdc
DC current range	approx. 125 A max	approx. 250 A max	approx. 500 A max

*) can be reduced with local energy storage
**) by customer request



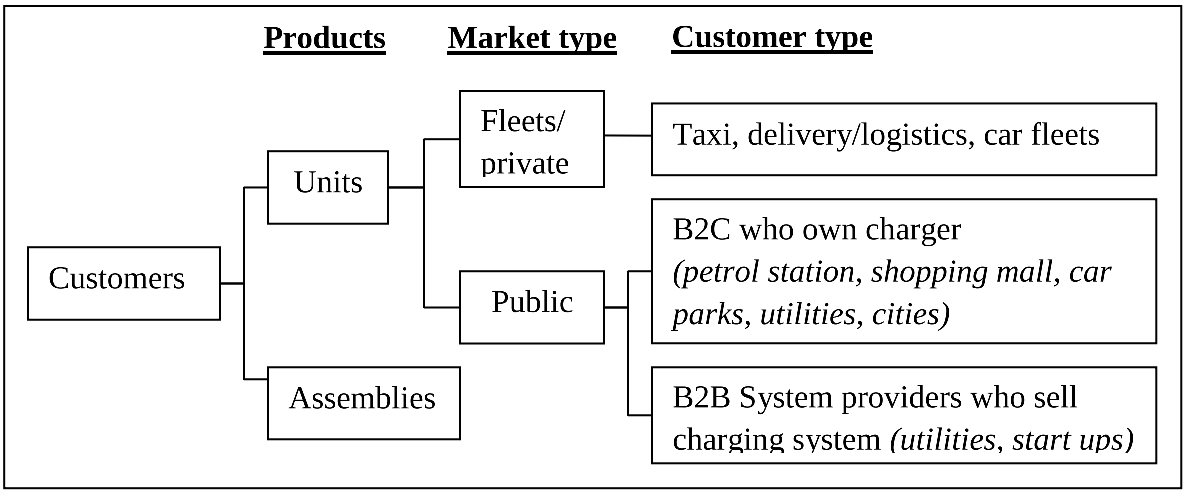
WHO IS THE CUSTOMER?

Slow charging is thought to be a service that is adding on to parking places and homes where the user can top up his battery. Fast charging on the other hand is provided for the charging service as such. To begin with an internal segmentation has been done based on the product that ABB would like to supply. ABB wants to position as a charging unit and assembly provider. This means that ABB wants to manufacture a complete chargers as well as components subassemblies for other manufacturers' chargers. This is depicted below.



The segmentation based on product type has further been broken down into sub-segments based on the market. Fast chargers can be used by the public market to charge cars for normal people. It does also have applications in a private market for actors that have fleets with cars which have a high utilization rate and needs to be charged more often than during night or parking. This private segment includes taxi fleets, logistics/delivery organizations and car pools of electrical vehicles.

To find potential customers in the public segment we imagined applications where cars are parked during 30 minutes. This is a time frame when a fast charge can be gained. The outcome of this public segment was actors like shopping malls, temporary car parks, petrol stations, utilities and cities who would potentially own one or many chargers and offer charging towards the EV drivers. The other group in the public segments includes actors that will potentially not own chargers but serve as middle men to offer full functioning charging networks.



MEASUREMENT SCALE

The dimensions will be measured with a Likert-scale from 1 to 5.

- Fit with current organization (does ABB's competences and knowledge align with the service idea?).
    6. no match
    7. bad match
    8. partly matching
    9. good match
    10. perfect match
- Ease of offering (has infrastructure and resources for delivering service idea)
    6. Through partner
    7. Centrally from ABB
    8. ATP/eMobility CH
    9. Regional service
    10. Global/local service
- Ease of developing ("Making" hardware, resources, staff and/or processes)
    6. Very hard
    7. Hard
    8. Moderate
    9. Easy
    10. very easy

ENABLING MACROS

This questionnaire requires that macros are enabled.

In Word 2003 this is done by:

tools->macros->security. Or selected when the document is opened.

In Word 2007 macros are enabled by:

Click the **Microsoft Office Button**, and then click **Word Options**.

Click Trust Center, click Trust Center Settings, and then click Macro Settings.

PRODUCT AND LIFE CYCLE RELATED SERVICES

	Please answer each of the criteria with a number from 1 to 5 according to the measurement definition on page 4.	Fit with current organization (ABB competence/knowledge alignment)	Ease of offering (infrastructure and resources for delivery)	Ease of developing (making hardware, resources, staff and processes)	Should be part of offer?
Sales	Sales and presentation services (i.e. for proving business case and charger technology)				☑
Consulting	Network design (complete sizing, specification, optimization of a charging unit network)				☑
	Unit sizing (with for specific grid requirements)				☑
	Location analysis (does the grid cope with fast chargers, how many?, where is the best place to put them)				☑
	Cost of connection minimization				☑
Project management	Installation				☑
	Location specific adoptions (civil engineering)				☑
	Commissioning				☑
	Balance of plant (optimization of a running charging facility)				☑
Training	For maintaining charging station				☑
	For operating charging network equipment				☑
	Documentation				☑

	Please answer each of the criteria with a number from 1 to 5 according to the measurement definition on page 4.	Fit with current organization (ABB competence/knowledge	Ease of offering (infrastructure and resources for delivery)	Ease of developing (making hardware, resources, staff and processes)	Should be part of offer?
Operation	Network operation (running the network of charging stations)				☑
Replacement, reconditioning updates and upgrades	Hardware update (for new vehicle connections and to meet new charging levels)				☑
	Software (for new standards, new features)				
Field service	Spare parts				☑
	Repair service				☑
	Troubleshooting service (using remote control and monitoring, investigate fault remotely)				☑
Maintenance	Preventative (scheduled maintenance)				☑
	Predictive (using remote monitoring to foresee when components are worn)				☑
Consulting	System optimization (using the system the best way when it is operating)				☑
End of life	Recycling				☑
	Re-buy and re-sell (complete units or parts)				☑
Non life cycle related	Service contacts (packages with a certain service level and including maintenance, remote control, operation and/or training. Also operational guarantees/availability)				☑
	Financial services (i.e. renting charging station or payment options)				☑
	Warranty (i.e. five years)				☑

ACTION/USAGE RELATED SERVICES OF FEATURES

TOWARDS THE END CUSTOMER DRIVING ELECTRICAL VEHICLES

	Please answer each of the criteria with a number from 1 to 5 according to the measurement definition on page 4.	Fit with current organization (ABB competence/knowledge	Ease of offering (infrastructure and resources for delivery)	Ease of developing (making hardware, resources, staff and processes)	Should be part of offer?
Payment services	Smart payment service (different payment options, cash, credit card and/or subscription)				☑
	Reward system (capable of setting up a service for rewarding for charging within your network of charging stations)				☑
	Open standard (that can be supported by all cars and chargers)				☑
Software	WiFi services (wireless network to computers and smart phones in the area)				☑
	Media distribution/sales capability (had an app store service system that can be used for selling media, movies and applications)				☑
	Car maintenance (system that could be used to deliver software updates to electrical cars)				☑
Applications in charger /smart phone	Statistics/info (presented to user on battery condition, how often charging is done, where, to what prices etc)				☑
	Unit availability (where is the next charger service)				☑
	Remote charging control (for the user who can be away from the car when it is charging and monitor/control charge via smart phone)				☑
	Openly accessible API (charging statics etc that can be used by app developers).				☑

Services related to as charging system owner

	Please answer each of the criteria with a number from 1 to 5 according to the measurement definition on page 4.	Fit with current organization (ABB competence/knowledge alignment)	Ease of offering (infrastructure and resources for delivery)	Ease of developing (making hardware, resources, staff and processes)	Should be part of offer?
Remote services	Control content delivery for display (advertising, spreading information)				☑
	Advertising capability (system for managing digital signage, location based advertising)				☑
Operation statistics	Raw data				☑
	Processed statistics (power usage, how many cars, revenue per charger)				☑

	Services towards a utility	Fit with current organization (ABB competence/knowledge alignment)	Ease of offering (infrastructure and resources for delivery)	Ease of developing (making hardware, resources, staff and processes)	Should be part of offer?
Smart grid	A service for buying, selling and storing power				☑
Operation statistics	Data and statistics				☑
Grid analysis	Pre and post installation				☑

The first three questions give the weight for each of the three dimensions

ADDITIONAL QUESTIONS

The importance of "Fit with current organization (ABB competence/knowledge alignment)" is:

○ Very low ○ Low ○ Moderate ○ High ○ Very high

The importance of "Ease of offering (infrastructure and resources for delivery – measured by the organizational level of resources and capabilities)" is:

○ Very low ○ Low ○ Moderate ○ High ○ Very high

The importance of "Ease of developing (hardware, resources, staff and processes – measured by man hours)" is:

○ Very low ○ Low ○ Moderate ○ High ○ Very high

Where should ABB be on the service continuum?

Only product supplier, services for free. Act to customer	→	Separate service organization. Paid hourly for repairs.	→	Service contracts. Preventive maintenance. Fixed priced/time period.	→	Taking over end user operation
○		○		○		○

How important is it to be able to offer a full life cycle service package (i.e. project management, maintenance and/or service contracts etc.) to optimize product functionality?

○ Indifferent ○ Attractive ○ One dimensional / differentiating ○ Must be

Why?

How important is it to be able to offer a full solution package apart from pure fast charging (i.e. system for payment, remote management and/or advertising capability etc.)?

○ Indifferent ○ Attractive ○ One dimensional / differentiating ○ Must be

Why?

COMMENTS ON ABOVE

Anything to add? How was the survey? Any service you are missing?

Thank you for participating! You can e-mail this survey to david.gustafsson@ch.abb.com or submit a printed version to David (eMobility office, floor one, Gusti 1, behind the staircase).

APPENDIX 8. LIST OF SERVICE IDEAS FOR EVALUATION

Table 78. Product related service ideas tied to life cycle and not. The life cycle ideas are also split into customer type (author).

<table>
<tr><th>LC Stage / Product</th><th>Pre sales & sales</th><th>Operation</th><th>Post, end of life</th></tr>
<tr><td>Charging unit</td><td>• <u>Sales activity and offering</u> (proving business case)
• <u>Consulting</u> (network design, grid analysis on aggregated level, sizing, requirement specification, location analysis, optimization of charger, cost of connection minimization, energy buffer offering)
• <u>Project management</u> (installing, commissioning, balance of plant, site specific adoptions)</td><td>• <u>Training</u> (product and system level, documentation)
• <u>Operation of charger stations/network</u>
• <u>Replacements, reconditioning, updates and upgrades</u> (software and hardware to new standards, cars and power, software controlling effect but product is over dimensioned - sell lock up)
• <u>Field service, troubleshooting and repairs</u> (spare parts with different service levels)
• <u>Maintenance</u> (Service contracts, preventative, predictive, scheduled)
• <u>Remote services</u> (predict and act to faults, remote controlling)
• <u>Consulting</u> (system optimization, e-Balance of plant)</td><td>• <u>Recycling</u>
• <u>Re-buy and re-sell</u> (parts, assemblies and units)</td></tr>
<tr><td>Charging assembly</td><td>• <u>Front end sales</u>
• <u>Consulting</u> (including Component selection, Design optimization)
• <u>Kits</u> (solutions for OEM)</td><td>• <u>Subset of above</u> (including training, unit optimization, maintenance and support)</td><td></td></tr>
<tr><td colspan="4">All life cycle stages but product related</td></tr>
<tr><td colspan="4">• <u>Service Contracts</u> (different scope in terms of risk sharing, cost structure, response time, physical closeness and service level)
• <u>Financial services</u> (finance plans)
• <u>Warranty</u> (X month guaranteed operation with full replacements)
• <u>Franchise</u> (offer complete package, easy to rebrand and earn revenue for a small actor, sell the hardware and a service contract)
• <u>Installed base tracking system</u>
• <u>Self service</u> (using a W&M system)</td></tr>
</table>

Table 79. Action related service ideas. These services are tied to what the customer wants to do with the product. They are categorized by customer type (author).

End customer services – supported by charging unit system	**Charging unit owner/operator**	**Utility provider**
<u>Payment services</u> • Smart system for handling cash • Reward system for charging within specific network • Based on open standard. No card needed, charger recognizes car and bill at the end of month **<u>Auxiliary services</u>** • Selling stuff – coffee, snacks **<u>Software services</u>** • W-lan connection for computers and smart-phones • Car maintenance (electrical system and battery status assessment. Updates to software) • Sales or distribution of media and entertainment (apps, movies, music) **<u>Applications (apps) – in charger display and web based.</u>** • Stats for the EV user, where charged? When? Price? • Unit availability: Where is the next charger? • Remote control of charging (away from the car and see status of ongoing charge on smart phone). • API that can be openly accessible	**<u>Remote services</u>** • Control content delivery for display (advertising) • Advertising capability (digital signage, digital out of home advertising, location based advertising capabilities) **<u>Operation statistics</u>** • Raw data • Processed statistics (power usage, how many cars, which chargers are profitable?)	**<u>Smart grid</u>** • Buying/selling power • Car park and rental • Provide technology and software to enable smart grid utilization of network. • Remote control of the charging unit and aggregated charging unit network. **<u>Grid analysis pre installation and after installation</u>** • How has charger impacted? • How will charger impact? **<u>Operation statistics</u>** • Raw data • Processed statistics (power usage)

APPENDIX 9. SOURCES FOR COMPETITIVE DATA

Epyon	http://www.epyonpower.com/Charginginfrastructure/Connection_standards.aspx
AeroVironment	http://evsolutions.avinc.com/services/installer_network/ http://evsolutions.avinc.com/products/public_charging/#public_charging_b
Eaton	http://www.eaton.com/Electrical/USA/ProductsandServices/Services/index.htm
Takaoka	http://www.takaoka.co.jp/product/ev/faq.html http://www.takaoka-eng.co.jp/english/maintenance.html
Takasago	http://www.takasago-ss.co.jp/products/power_electronics/sp/tqvc/index.html
Nittetsu Elex	http://www.ns-elex.co.jp/en/
Hasetec	http://www.hasetec.co.jp/batterycharger/product.html
Siemens	http://www.energy.siemens.com/hq/en/power-distribution/e-car.htm http://www.siemens.com/innovation/en/highlights/energy/update_03/charging-electric-vehicles.htm
SGTE	http://www.sgte-power.com/documentation/sgte-dc-evqc01.pdf http://www.sgte-power.com/mapage1/index-en.html
EFACEC	http://www.efacec.pt/PresentationLayer/efacec_press_01.aspx?tipo=&area=1&idioma=2&id=299
ECOtality/Blink	http://blinknetwork.com/media/kit/The%20Blink%20Network.pdf http://www.blinknetwork.com/commercial/dc-fast-charger.php
Aker Wade	http://akerwade.indigofiles.com/AWU-FleetManagement.pdf http://www.akerwade.com/v.php?pg=71
Coulomb Technologies	http://www.coulombtech.com/blog/tag/aker-wade/ http://www.coulombtech.com/products-charging-stations.php
RWE	http://www.rweMobility.com/web/cms/en/236726/rwemobility/ http://www.eafturkey.com/assets/Uploads/JENS_MEYER.pdf
Schneider Electric	http://www.greencarcongress.com/2010/07/evse-20100728.html http://www.schneider-electric.com/sites/corporate/en/products-services/product-launch/electric-vehicle/offer-presentation.page

APPENDIX 10. LIST OF COMPETITORS AND CLASSIFICATION

		Product related	Action related		
	Type	**Life cycle**	**To end customer**	**To owner/ operator**	**To utility**
Epyon	Startup.	Yes, not grid consulting	Yes, wide offer	Yes, stats. Ads?	Capable
Eaton	Power & industrial automation	Yes, service & engineers	No, but has network	Stats, no ad possibility	No
SGTE	Power products	Yes, some extent	No	No	No
AeroVironment	20 year old startup, truck and EV	Yes, but maintenance?	Usage stats & location	Stats	No
Aker Wade	10 years in forklift industry	Yes, maintenance = ?	Capable, up to buyer	Stats & capability	Capable
Coulomb Tech	Operate charging system	Yes, sourcing & remote	Yes	Yes, they operate	Yes
Better Place	Operate repowering system	?, probably through sourcing	Yes	Yes, they operate	Yes
ECOtality	Operate charging system	Yes	Yes, wide offer	Yes, they operate	Yes
Takaoka	Japanese manufacturer	Probably	Payment	No?	No?
Hasetec	Japanese manufacturer	Probably	Payment	No?	No?
Takasago	Japanese manufacturer	Probably	Payment?	No?	No?
Siemens	German manufacturer	Probably	Payment	Management system	Yes
RWE	German utility	Yes	Yes, billing at least	Yes, some features	Yes

Service Concepts for DC Fast Charging

DAVID GUSTAFSSON

Service development is often an ad-hoc process within companies that follows when a product already is launched. At ABB ATPS, Switzerland, management wanted to take a proactive approach to developing services for the DC fast charging product for electrical cars (the so called eMobility market). The purpose of this project has been to identify and evaluate different ideas for services around the DC fast charger and finally post recommendations for which service concepts that should be undertaken by ABB.

The thesis has made internal brainstorms, customer interviews and service industry benchmarks to find ideas for services and inspiration for service evaluation. To evaluate those ideas surveys were distributed to both customers (a Kano survey) and internal ABB. This enabled studying market requirements, internal strategic fit, internal strategic intent and the alignment between customer requirements and strategic fit. In total fifteen interviews and nine surveys were collected from customers and ten from internal ABB.

The study has found that customers are mostly keen on simple services with a clear value add. It has also been found that more technically immature customers, such as cities, have higher requirements for solutions compared to for example utilities. Six general concepts were finally developed from the service idea evaluation:

- *Sales service*
- *Consulting*
- *Commissioning*
- *Services during the products operational life*
- *End of life services*
- *Action related services*

In the report these services are presented together with their evaluation data, an analysis of how the concepts can be performed and estimations of their respective business cases.

Looking for a young talented business developer and entrepreneur?

Find my CV at www.davidgustafsson.com or follow me at www.techonomics.se.

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