IIIEE Theses 2016:27

A Ticket to Ride

The Market Potential for Electric Trucks in Urban Building and Construction

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Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, September 2016

THE INTERNATIONAL INSTITUTE FOR
INDUSTRIAL ENVIRONMENTAL ECONOMICS

"No on should be panicked. On the contrary, you should be eager."
-Luis Mundaca, on facing challenges

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ISSN 1401-9191

Acknowledgements

This thesis is the culmination of a process that started in June 2013, when I found out about the EMP programme and contacted Birgitta Olofsson to ask for more information. Since then I have received help and support from all over the world. I will do my best to thank as many people as possible here, starting with Birgitta and Beatrice Kogg for all your organisation and guidance this year. I also owe a big cheers to Nicholaus Arsenault and Lucas Playford, as well as the many other Canadian alumni who answered my countless questions while I was applying for the programme. And of course, thank you to the rest of the staff at the IIIEE who are excellent educators, fine people, and occasionally party animals.

Tusen tack to Carl Dalhammer and Christina Stenman Jörgensen for your fantastic work as my supervisors. Calle, thanks for your availability and targeted feedback. Your humour and focus kept me on track. Christina, thanks for all the time and effort you have devoted to helping me scope this thesis, get the data I needed, and providing feedback as well. And a mycket stort tack to everyone at Volvo who answered questions and provided inspiration, you made me very welcome in the Lindholmen offices and graciously provided your time and expertise.

Merci beaucoup to those at Renault who provided very helpful information. Et merci bien to my primary language instructors Amelia and Milan, your lessons were extremely valuable during this research.

A big thank you to all my survey respondents and interviewees, especially those who took up the challenge of answering a phone call from a strange Canadian student. Your participation in this research was crucial.

To everyone from each chapter of my life who has passed through Väpplingvägen this year, most notably Ms. Sophia Peppa, thank you for putting up with me. Ευχαριστώ.

To Batch 21, it has been a long, wild ride and we made it so much fun. Every one of you is inspiring in your own twisted monkey way. Thanks for making this year jättemycket bra.

To my family, thank you for every manner of support you have offered me: reading drafts, late-night phone calls, words of encouragement. I love you all, and once the sun is over the yardarm, I'll look forward to lighting fires with you again.

And finally, it would have been impossible to get through these years without some music. I would like to extend my most heartfelt thanks to T-Swift, for reminding me to just shake it off.

Abstract

The purpose of this thesis is to determine how electric vehicle trucks can meet the needs of customers in the urban building and construction sector. This sector contributes significantly to greenhouse gas (GHG) emissions, and also creates noise and other disturbances in urban environments. There are multiple benefits that come with electric trucks, which can address these issues if they are used for applications within cities. In order for electric trucks to be considered by customers, they must be matched properly with customer needs. Data was collected from customers through a series of expert interviews and a survey of truck drivers. Original Equipment Manufacturers, logistics experts, policy experts, and construction companies were among those interviewed to better understand the current industry situation. The data was organized into a Value Proposition canvas that showed both the customer issues and the subsequent solutions that can be created through the use of electric trucks. The major findings showed that customers are wary of electric trucks, but that they are aware that changing policies could make electric trucks a more competitive choice for their business. They expect that municipal legislation will become stricture in regard to environmental regulations. Furthermore, experts interviewed during this research agreed that environmental restrictions in cities will become stricter in the future, and electric trucks may eventually be a part of these regulations. Many pilot projects exist across Europe that can encourage the uptake of these trucks, including some very notable projects in Sweden. In order for these projects to have an impact, they must involve Original Equipment Manufacturers (OEMs), municipal governments, and truck customers. It will be crucial to educate customers about the electric truck technology, and also to assist them with initial financial risk in the near future.

Keywords: Electric trucks, Construction logistics, Value Proposition canvas.

Executive Summary

Problem Definition

The issues stemming from construction trucks in urban areas are numerous. Truck transportation is a main contributor to air pollution, which is one of the leading causes of cancer and other illnesses (WHO, 2013). In Sweden, building and construction is the dominant sector in the haulage industry (Sveriges Åkeriföretag, 2016), and heavy truck transportation made up 26% of GHG emissions from road transportation in Sweden in 2014 (Trafikverket, 2016, p. 12). The Swedish National Road and Transport Research Institute (VTI) estimate that heavy duty road traffic has socioeconomic costs of 3 billion SEK per year (VTI, 2008, p. 56). Electric trucks, however, are much quieter compared to their diesel countrerparts and can have no emissions, if powered with renewable electricity. Technological developments and economies of scale could make electric trucks more financially attractive in the future than they are now (Davis and Figliozzi, 2013).

Much research and attention has already been devoted to electric truck transportation for commercial distribution in cities, for example to grocery stores and retail shops. There are also pilot projects happening in some places in Sweden for electric construction machinery, such as cranes and cement mixers (Swerock, 2015; Cederstav, n.d.). There is very little research done, however, on the potential for electric trucks in urban building and construction.

This thesis is primarily a study in how different stakeholders in a given situation react to fundamental change. The stakeholders in question are truck drivers, truck owners, municipal and national policy makers, construction companies, and Original Equipment Manufacturers (OEMs) of trucks. The situation is urban construction and building transportation, meaning trucks carrying goods to and from construction sites that are located within cities. The fundamental change, lastly, is the electrification of those trucks: partially, as plug-in hybrid electric vehicles (PHEVs) or fully, as Battery Electric Vehicles (BEVs).

Research question and objective

The objective of this thesis is firstly to determine the existing needs of customers who purchase and drive trucks to and from urban construction and building projects, and then determine how electric trucks can meet those needs. The policy context is also analyzed to better understand the wider perspective in which this business case exists.

The following research questions are designed to achieve this objective.

RQ1: What are the major customer pains and gains for truck customers in the urban building and construction sector, and why?

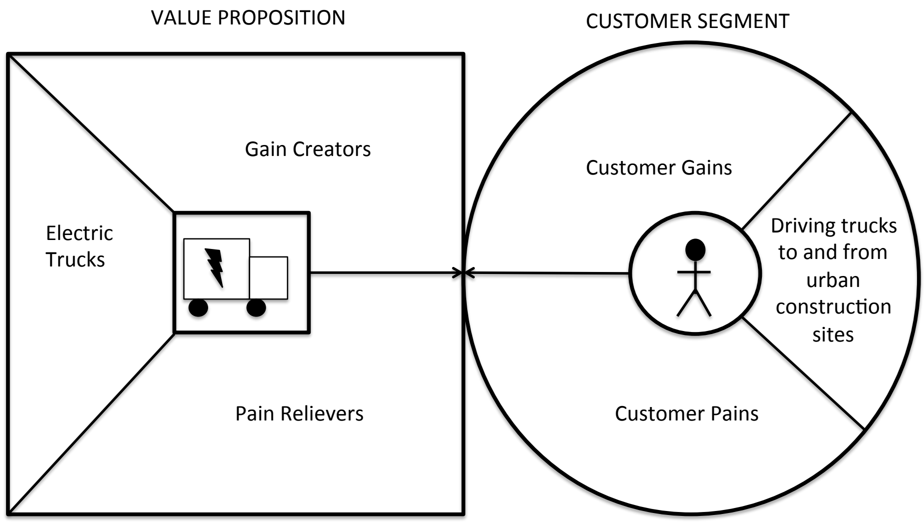
RQ2: What gain creators and pain relievers can OEMs offer customers through a Value Proposition that includes electric trucks?

RQ3: How can government policies encourage the electrification of trucks used in urban construction?

Framework: Value Proposition canvas

A solid business case is important when introducing a new project into the market, and the customer perspective is an important part of any business case. In order to better understand the customer perspective a diagram called the Value Proposition (VP) canvas is used. The VP canvas is illustrated in Figure 1. Osterwalder et al.'s *Value Proposition Design* was particularly helpful for designing interview and survey questions to identify what Osterwalder refers to as customer 'pains' and 'gains'. Pains are defined by Osterwalder et. al. as "bad outcomes, risks, and obstacles related to customer jobs" and gains as "outcomes customers want to achieve or the concrete benefits they are seeking" (2014, p. 9). Gain creators, which "describe how your products and services create customer gains", and pain relievers, which "describe how your products and services relieve customer pains", (2014, p. 8), are the intended research outcome of this thesis.

Figure 1. The Value Proposition canvas



*Adapted from (Osterwalder et al., 2014, pp. 36-37)

Logic and Methods

The decisions to purchase or lease trucks can be heavily affected by the position of the person making the decision, the regulatory environment in which they work, and the norms in their industry. This research attempts to identify those actors through literature review and expert interviews, in order to understand how they affect the purchasing decisions of truck customers. This methodology is mainly inductive research, based on the initial idea that electric trucks could be used for urban construction and building projects 5-10 years from now.

The methods used to carry out this research included a literature review, 20 interviews with experts from construction, logistics, government, and truck drivers, and a survey that had a 25% response rate (or 20 responses). Further interviews are also cited in some parts of the thesis, although these act more as supplementary information and were not subjected to the same analysis as the original 20 expert interviews.

The interviews were grouped based on the questions that were asked to interviewees, and for the first groups qualitative content analysis was used to determine codes and track them. For the second group, Drivers, directive content analysis was used based on the existing knowledge that price was a very important decision-making factor, and other contributing factors needed to be determined. The empirical survey response data was analysed to see how many respondents chose certain answers regarding openness, or lack thereof, to electric trucks.

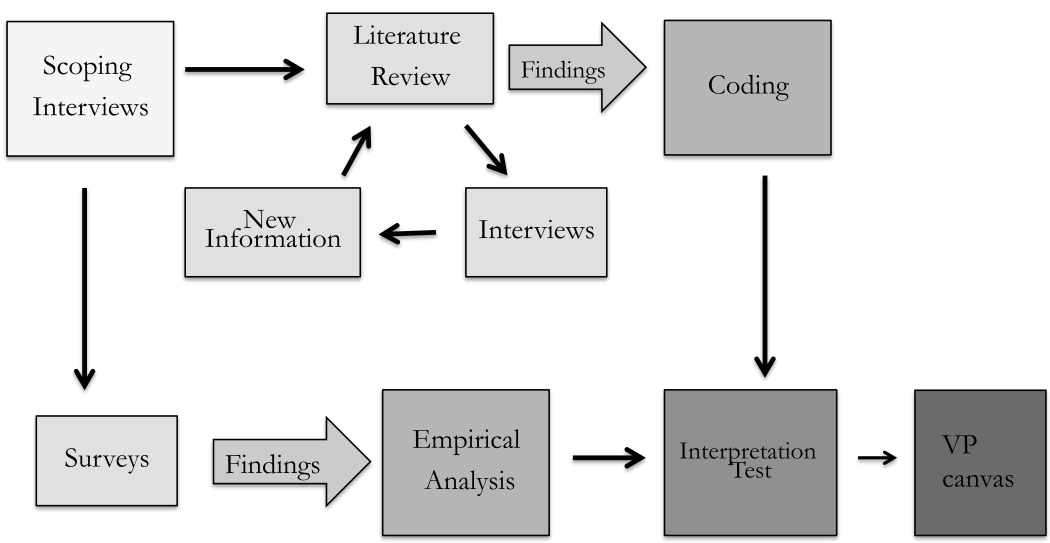
Finally, an interpretation test was done on the interview and survey data from truck drivers and construction companies to place their individual responses within the larger group norm. This interpretation test helped to recommend optimal pain relievers and gain creators by taking into account the importance of individual and group perspectives. An abbreviated version of the interpretation test is shown below.

Figure 2. Customer Response Interpretation Test

Customer	Doxastic (Individual)	Normative (Group)	Secondary interpretation (Researcher)	Final
Drivers	Uncertainty towards electric trucks.	The industry is conservative, and drivers consult each other during the buying process.	More information and support needed from OEMs and municipalities.	Better marketing and service contracts that train drivers and assuage fears.
Construction Companies	Very interested in environmental goals.	Small margins, maximum payloads and tight schedules.	Construction companies worry about financial and operational risk.	Government programs can mitigate risk and spread awareness.

Although these steps are listed chronologically above, they were in fact part of a more cyclical research process that is illustrated in Figure 3.

Figure 3. Research Methods Process



Pains, Gains, and Drivers: Answering the Research Questions

The pains that stood out during the interviews, supported by the survey data and literature review, were: tight margins, the price of fuel, change, fuel theft, the risk of accidents, and stricter environmental regulations in cities. The gains that customers would like to experience were steady profits, safe conditions, and adaptation to changing conditions. These gains imply awareness from customers that regulations and standards are constantly changing, and it is important for them to stay updated on these. This is interesting because it goes against the general fear of new, untested technology that was very explicitly stated in the interviews and illustrated here in the pains. The difference seems to be that when there is no choice, companies will make the changes because they feel they have to.

Policy Context

The interviews brought up the point that once customers have used technology, they are much more likely to trust that technology (Log3, 2016). Thus they may be more open to purchasing or leasing it. OEMs can help with the communication regarding the new technology, explaining not only how it works but also the best financing options and services that make the transition easier. Municipalities can incentivize the uptake of new technology by implementing Low Emissions Zones or other regulations that call for low-emissions and low-noise vehicles.

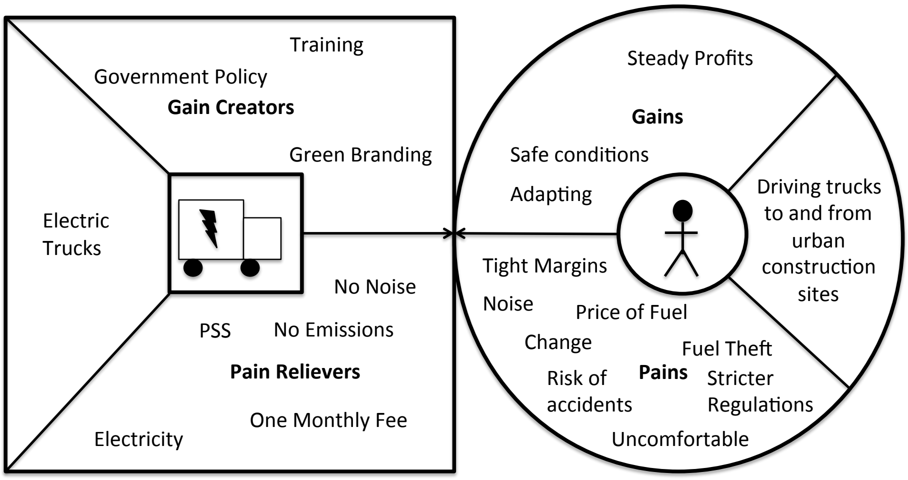
There are many different projects that exist in Europe already to pilot electric trucks in cities, and these can be increasingly leveraged to help customers adapt to the new technology and its benefits. For example, construction companies and OEMs could partner with local governments to create programs where smaller companies can test electric trucks without having to take the financial risk of purchasing or leasing.

Gain Creators and Pain Relievers

The gain creators that can be offered include pilot projects or other temporary training programs that give customers information and allow them to establish trust regarding the new technology. Customers who are willing to lease or purchase the trucks can also have the option of green branding, which could include low-emissions advertising on the trucks as well as wider company branding. Finally, government programs can be leveraged to help with initial financing so that there is enough demand and OEMs are financially able to produce electric trucks.

The pain relievers that can be offered through the value proposition of electric trucks start with Product Service System (PSS) leasing contracts that allow for monthly set costs with the price of elecitricty included. This addresses tight margins and the price of fuel, and also mitigates the risk of fuel theft. The vehicles could be silent and zero-emissions, therefore classified for any Low Emission Zone, and would be able to operate at night or in sensitive areas, thus relieving the pain of stricter regulations. As part of a PSS lease plan, OEMs could offer telematics systems and training to help with safer driving – many companies do this already, but the service could be re-marketed and adjusted as necessary for electric trucks.

Figure 4. Final VP Canvas
*Adapted from (Osterwalder et al., 2014, pp. 36-37)



Conclusions

In conclusion, this thesis determined that electric trucks can offer many gain creators to customers in urban building and construction sites, but there are many challenges before customers will think seriously about purchasing or even leasing a BEV. First, the pricing issue must be tackled either through government incentives or leasing service contracts. Second, existing efforts to shift towards electromobility in construction must be supported, through public funding or municipal regulations that make tenders more competitive for companies with electric vehicles. Finally and most importantly, clear communication from OEMs, government, and construction company executives is needed to demonstrate the safe, efficient benefits of electric trucks, and dispel unwarranted fears.

This project uncovered many areas that would benefit from future research, including but not limited to: the different specific applications of BEV trucks in CCCs, how larger companies can support the uptake of new technology by taking some of the financial risk and allowing their sub-contractors or members to test the new technology, and how local governments can benefit from EU or other funding to create public/private partnerships that pilot new technology which can meet new emissions standards in cities.

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Abbreviations

ATR – Advanced Technology and Research

BEV – Battery Electric Vehicle

BM canvas – Business Model canvas

bn – billion

COP – Council of Parties

EFV – Electric Freight Vehicle

EMP – Environmental Management and Policy

EUR – Euros

EV – Electric Vehicle

FREVUE – Freight Electric Vehicles in Urban Europe

GHG – Greenhouse Gas

HEV – Hybrid Electric Vehicle

IEA – International Energy Agency

IIIEE – International Institute for Industrial Environmental Economics

LBC – Lastbilcentral

LEZ – Low Emission Zone

OEM – Original Equipment Manufacturer

PHEV – Plug-in Hybrid Electric Vehicle

SED – Strategic Environmental Development

SEK – Swedish crowns

Transportstyrelsen – Swedish Transport Agency

Trafikverket – Swedish Transport Administration[1]

TfL – Transport for London

ULEZ – Ultra Low Emission Zone

UNFCCC – United Nations Framework Convention on Climate Change

UTS – Urban Transportation Solutions

Volvo GTT – Volvo Group Truck Technology

VP canvas – Value Proposition canvas

VTI - Swedish National Road and Transport Research Institute

[1] In order to avoid confusion between the Swedish Transport Agency and the Swedish Transport Administration, both will be referred to by their Swedish names.

1 Introduction

1.1 Background

"In today's economy, the key ingredients in success and survival are adaptability and the capacity to learn and change"(Allen, 2001, p. 149). This thesis is primarily a study in how different stakeholders in a given situation react to fundamental change. The stakeholders in question are truck drivers, truck owners, municipal and national policy makers, construction companies, and various actors involved in urban building and construction logistics. The situation is urban construction and building transportation, meaning heavy-duty trucks carrying goods to and from construction sites that are located within cities. The fundamental change, lastly, is the electrification of those trucks: partially, as plug-in hybrid electric vehicles (PHEVs) or fully, as Battery Electric Vehicles (BEVs).

This research mainly focuses on the potential for BEVs, but both are discussed throughout the document depending on the customer situation. The thesis does not suggest that this change is inevitable, nor does it assume that electrification is the most financially or environmentally sustainable solution for the urban construction and building segment to adapt its transport system to changing industry standards and norms. This thesis does, however, make a thorough study of the different ways that electric trucks can meet the needs of those who purchase and drive trucks for use in urban construction and building.

Alexander Osterwalder's Value Proposition (VP) canvas is used here to identify the different needs of the customer segment, so that original equipment manufacturers (OEMs) such as Volvo can better understand how to meet the needs of their customers using technology they have developed. As Osterwalder and Pigneur point out, soliciting customer opinions can create entirely new pathways for business development (2010, p. 128). It can also confirm what is already thought to be the norm, and can even hinder progress – automobile pioneer Henry Ford famously said that if he had asked customers what they wanted, they would have asked for a faster horse (ibid, p. 129).

Today, customers do not just want the horse. They may want a truck that has maximum uptime, or one that comes with a service contract, or even one that can be driven during off-peak hours, with immaculate exterior design. They might want branding that shows how sustainable, or reliable, or down-to-earth their company is. But similarly to Ford's customers, they want it for a reasonable price. This is the reason that many of the questions and interviews for this thesis focussed on a time horizon of 5-10 years. Many of the different emissions targets or fleet percentage targets that are cited reference 2030 or later as the deadline (IEAb, 2016; Stockholm Stad, 2014; Khan 2014).

The first electric truck that was developed by Volvo was in the 1990's (Volvo Group Global, 1997). It was a Hybrid Electric Vehicle (HEV), meaning that the battery was charged through regenerative power from the brakes, and the vehicle could not be plugged into a power source. More than 20 years later, the company has sold many HEV trucks, but they remain a very small percentage of total sales. PHEV trucks have been piloted in some places, but are not being sold yet. BEV trucks are even further behind either of these, and part of the reason for the slow takeoff is the initial purchase price. An electric truck, be it HEV, PHEV, or BEV, is still much more than that of its diesel counterpart. Until this initial purchase price is lowered, electric trucks will continue to have a difficult time competing in the market (Davis and Figliozzi, 2012).

1.2 Research Gap

Much research and attention has already been devoted to truck transportation for commercial distribution in cities, for example to grocery stores and retail shops. There are also demonstration projects in different European cities that are studying the potential for electric vehicles at a smaller scale, such as vans less than 3.5 tonnes making deliveries, or street cleaning machines (Nesterova and Quak, 2015). Construction projects, however, are very prevalent in most major cities today, and for this thesis Stockholm and London will be looked at in more detail because of the logistics programs that they have created for construction projects specifically.

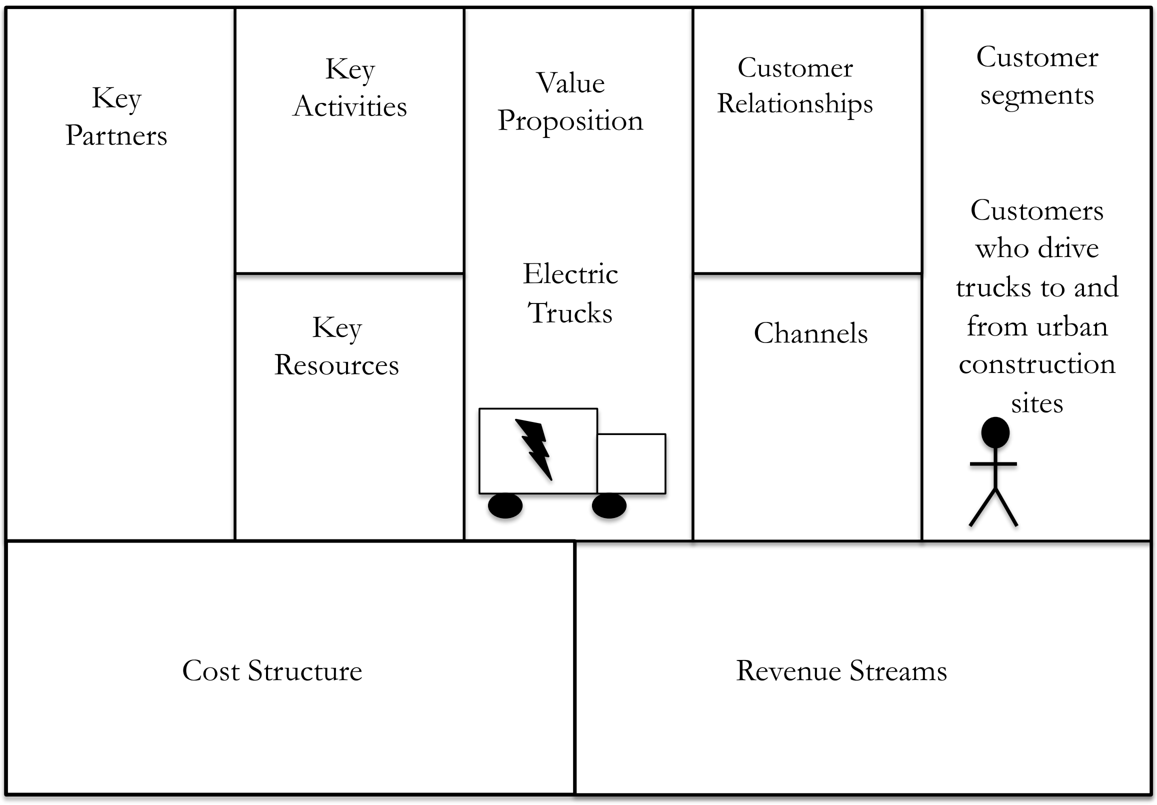
The urban building and construction customer segment could represent a good opportunity for electrification: trucks driving well known short routes, in urban areas where noise and local emissions are especially unwelcome. The issues stemming from construction trucks in urban areas are numerous. Truck transportation is a main contributor to air pollution, which is one of the leading causes of cancer and other illnesses (WHO, 2013). In London, transportation from heavy and light duty trucks contributed significantly to overall nitrogen oxide and particulate matter emissions in 2010 (Transport for London, 2014). In Sweden, building and construction is the dominant sector in the haulage industry, with the transport of sand, stone and gravel taking up a larger portion of transportation (Sveriges Åkeriföretag, 2016). Heavy truck transportation made up 26% of GHG emissions from road transportation in Sweden in 2014 (Trafikverket, 2016, p. 12), and the Swedish National Road and Transport Research Institute (VTI) estimate that heavy duty road traffic has socioeconomic costs of 3 billion SEK per year (VTI, 2008, p. 56).

1.3 The Business Model Canvas and Value Proposition Canvas

The Business Model (BM) canvas visually displays the various parts of any given business. It allows employees to map out the different financial and information flows to better understand how those affect their organisation, and its revenues. The BM canvas acts as a tool, in this sense, to help employees study all the different aspects of their organisation, and pinpoint the places were changes can be made, both to help increase revenues, but also to communicate better with shareholders, increase customer satisfaction, or do a myriad of other specific actions that will allow the company to perform better over the long term.

Figure 5. The Business Model Canvas

*Adapted from (Osterwalder et al, 2014, p. xvii)



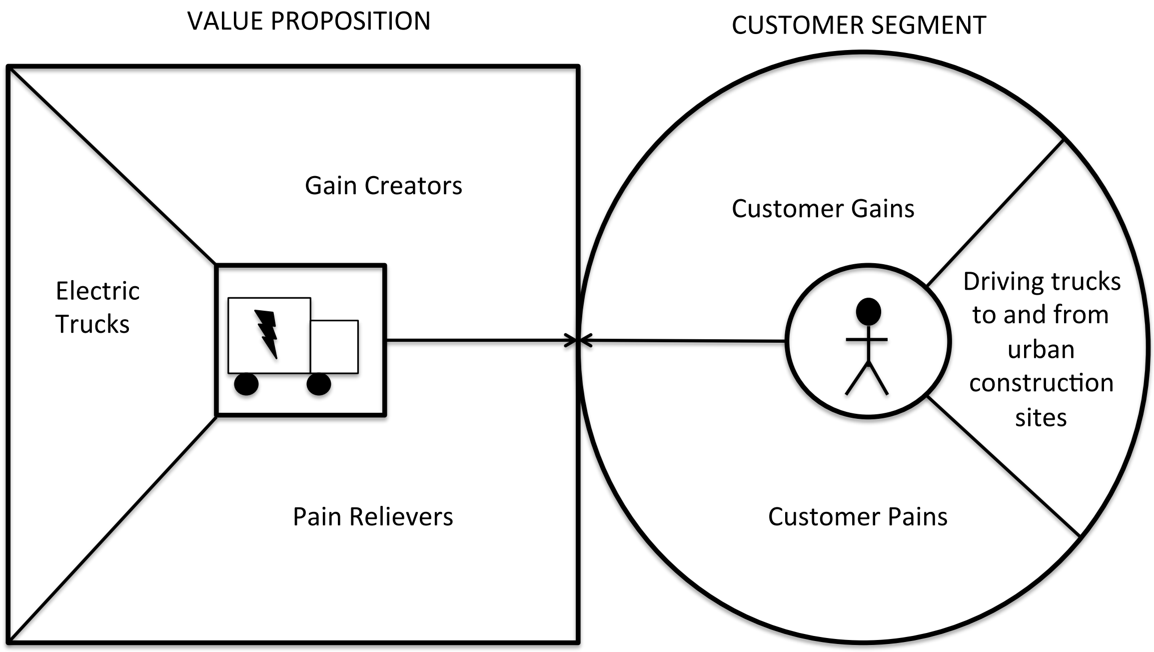
Within the BM canvas there are two sections that address customer relations: the Value Proposition, and the Customer Segment. The Value Proposition is comprised of the products and services that the company offers which create value for their customers. The Customer Segment is the group that the company is targeting with this value proposition. Together the Value Proposition and Customer Segment create another tool, the Value Proposition (VP) canvas.

This thesis will attempt to better understand the business case for electric trucks from the customer perspective. The Value Proposition approach was particularly helpful for designing interview and survey questions to identify what are known as customer 'pains' and 'gains'. Pains are defined by Osterwalder et al. as "bad outcomes, risks, and obstacles related to customer jobs" and gains as "outcomes customers want to achieve or the concrete benefits they are seeking" (2014, p. 9). Gain creators, which "describe how your products and services create customer gains", and pain relievers, which "describe how your products and services relieve customer pains", (2014, p. 8), are the intended research outcome of this thesis.

The VP canvas allows the company to focus specifically on their customers, identify customer needs, and then assess how their value proposition can provide customers with products and services that meet those needs. In an ideal situation, the VP canvas might also act as a tool to create 'gains' that customers cannot currently imagine, to create niche value proposition offerings that competitors either did not think of, or are unable to offer. This tool, if used efficiently, should allow companies to understand their customers well enough to offer 'gain creators' and 'pain relievers' that are part of the value proposition that customers may need in the future.

Figure 6. The Value Proposition canvas

*Adapted from (Osterwalder et al., 2014, pp. 36-37)



1.3.1 The Connection between Sustainability and Good Business

This thesis is written as part of the Environmental Management and Policy (EMP) programme at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University. The IIIEE's mission is to promote sustainable solutions, and one of the methods to do this is by "exploring visions and scenarios for a sustainable future" (IIIEE, 2016). One of the underlying tenets of the IIIEE is that often, sustainable solutions are good for both the revenues of companies, and the environment. In the case of urban construction, many of these connections exist: if trucks create zero emissions, they can enter into environmental zones or other sensitive areas to deliver goods. If the trucks are quiet because they have an electric rather than diesel drivetrain, they can make deliveries at night, and help to reduce congestion and associated emissions during peak hours. Both of these options also make these trucks more flexible, and thus more competitive, than their diesel counterparts. But due to the increase in initial purchase price, and the change in technology, OEMs need to also create products that meet the real pains and gains of their customers.

These 'pain relievers' and 'gain creators' make up the business case for electric trucks in urban building and construction, meeting both the objective and the research questions of this thesis. A part of this business case also addresses the government policies that encourage electric truck use, and the thesis will also mention a couple of applications that could be an opportunity for electrification.

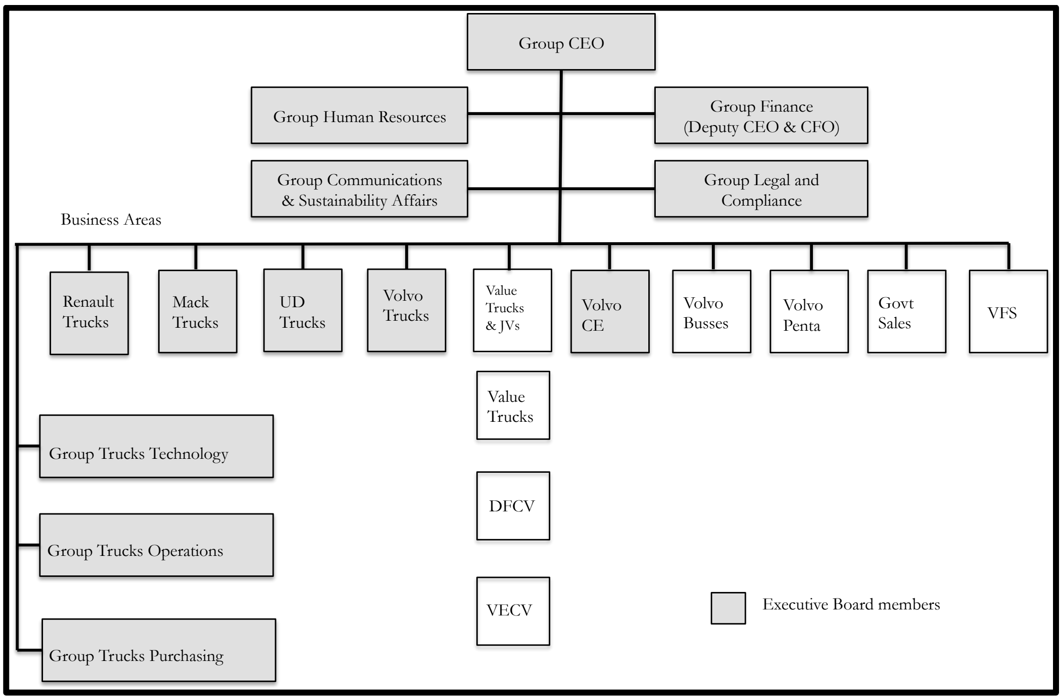
1.4 Volvo Group Trucks Technology: A thesis partner

This thesis research is jointly performed between Lund University and Volvo Group Trucks Technology (Volvo GTT). The position was originally posted by Volvo GTT, and the subject matter builds on a project done by IIIEE students with the same company in early 2016. This first project, which was part of the Strategic Environmental Development (SED) course at the IIIEE, focussed more on the overall business case for electric trucks in Sweden, and the idea of a "Zero Contract" that would ensure customers an electric vehicle with zero emissions, but also zero cost impact and range anxiety. This Zero Contract was looked at as part of a product service system (PSS), where the customers would lease the truck, and Volvo would pay for the electricity to charge the truck. Customers would not pay more in intitial purchase price since they would be leasing the vehicle, and the monthly costs could be reduced since the price of diesel fuel would be removed. Volvo could profit from the arrangement by offering services that other companies cannot, such as maintenance for electric trucks, charging stations, fleet management and communication between vehicles, and in the far future even things like 'truck pooling', where customers could sign out trucks as they do today with car-sharing companies.

Volvo Group's aim for this thesis was to build on the work that had already been done in the SED project. The difference is that this thesis will on the business case specifically, and have more communication with the customers. There are two other master thesis projects going on in parallel: one regarding charging infrastructure and one regarding batteries for electric trucks.

Volvo Group is a large organisation that comprises many different parts, including brands in France, the US, and Asia. As can be seen from Figure 7, it also comprises Volvo Bus, Volvo Construction Equipment, and Volvo Financial Services (VFS), which helps customers finance their vehicles. Within Volvo Trucks there are three divisions, and this thesis work is housed within Volvo GTT, and within that the Urban Transportation Solutions section of the Advanced Technology and Research department. Actors from all different parts of Volvo Group, however, have helped with both the scoping and the research in this thesis.

Figure 7. Volvo Group Organisation Chart as of March 1, 2016.



*Adapted from (Volvo Group, 2015, p. 181)

1.5 Time Scale

In terms of time horizons, many sources cite long-term goals. The IEA *Nordic Energy Technology Perspectives 2016* report looks as far ahead as 2050 when predicted the percentages of medium-sized truck stock (2016). Roland Berger, a consulting company, was commissioned by a coalition including BMW, Daimler, Honda, NEOT/St1, Neste, OMV, Shell, Toyota and Volkswagen. Their 2016 report *Integrated Fuels and Vehciles Roadmap to 2030 and Beyond* looks at 2030 in regards to time horizon, predicting that 5% of trucks will be HEV, BEV or PHEV by that time (van der Slot et al., 2016). Åkerinäringen, the Swedish Haulers Association, mentions in their latest factsheet that 38% of trucks in Sweden in 2030 will still be conventional diesel, given that the lifetime of a truck is 15 years and a phase-out period is needed (Sveriges Åkeriföretag, 2016, p. 14).

1.6 Scope

As is mentioned above, the scope of this research is limited to trucks that drive in and out of construction sites within cities. The research focuses on trucks between 7.5 to 64 tonnes because that is the maximum weight allowed for trucks in Sweden (Åkerinäringen, 2014), and examples are taken from trucks of different sizes within this broad range. Many such examples are chosen because of their suitibility for electrification, such as those carrying cement mixers or cranes. This is noted in the text. There are many different models and types of trucks that are examined, and in order to gain a thorough understanding of the construction segment no one truck could be chosen as the main example when creating interview guides and surveys. In the findings, however, different types of trucks are looked at to suggest what could be optimal for electrification.

This thesis project is in partnership with Volvo Group Trucks, who are headquartered in Sweden. Thus the Swedish context is examined and analysed in detail, but the scope was expanded to the city of London and also other countries which had interesting examples of construction routes or logistics systems that lent well to construction. These expansions in scope were based on findings from expert interviews and literature review.

1.7 Research Objectives

1.7.1 Aim

The aim of this thesis is firstly to determine the existing pains and gains of customers who purchase and drive trucks to and from urban construction and building projects, and then determine how electric trucks can meet those pains and gains with pain relievers and gain creators. Finally, the different political drivers, which are related to the business case but may be external to OEMs such as Volvo, are briefly analyzed to better understand the wider perspective in which this business case exists.

1.7.2 Research Questions

The following research questions are designed to achieve this aim.

RQ1: What are the major customer pains and gains for truck customers in the urban building and construction sector, and why?

RQ2: What gain creators and pain relievers can OEMs offer customers through a Value Proposition that includes electric trucks?

RQ3: How can government policies encourage the electrification of trucks used in urban construction?

1.8 Disposition

Chapter 1: Introduction

This chapter provides a contextual background regarding the emissions and other sustainability issues that electric trucks can address. It also introduces Volvo Group, the urban building and construction customer segment, and the VP Canvas.

Chapter 2: Research Design

This chapter explains the logic behind the research design, as well as the limiting factors and the ethics of this project. The methodology and methods are laid out in as much detail as possible to show the reader how the research was designed to best meet the research objective and answer the research questions.

Chapter 3: Literature Review

This chapter looks at many different concepts and themes that fit into this research in order to elaborate on the background information on the industry segment and policies. This chapter also highlights existing conditions in some government projects that are optimal for electric trucks.

Chapter 4: Findings

This chapter presents the findings from the interviews and surveys. Much of the data is displayed in graphs and charts to illustrate the frequency of certain responses. The themes that emerged from the surveys are also introduced in this section.

Chapter 5: Discussion

This chapter applies information from the findings to argue how certain factors can affect the business case for electric trucks in urban building and construction.

Chapter 6: Analysis

This chapter analyses the discussion section to pull out the gain creators and pain relievers that go into the final VP canvas for electric trucks in urban building and construction. It also notes the policy context that could potentially encourage the uptake of electric trucks.

Chapter 7: Reflections and Conclusions

This section reflects on the research design and process, and states the final conclusions of the thesis.

2 Research Design

2.1 Ethics

The ethical considerations of this research require the researcher to state that Volvo Group Trucks has funded the research, and Volvo employees, including a designated supervisor, have been given the chance to influence the analysis of the data to some extent, primarily through scoping interviews and literature contributions. However, the researcher had the final say on all decisions, and followed the academic instrutions from the IIIEE regarding the scope of the research, the research gap, the analysis and conclusion.

Regarding the subjects of this research, all interviewees are kept anonymous save for their professional association. For example, experts from the Construction industry are listed in the bibliography as "Con1", "Con2", etc. The survey was done anonymously at the construction company Cliffton AB, no names were written on any of the survey papers.

Many different diagrams, most notable the VP canvas, are used throughout this thesis, and they are always attributed to the original author. Any confidential data from Volvo was stored solely on the researcher's computer and external hard drive. All interviewees and thesis respondents were notified beforehand that their responses would be part of thesis research at Lund University, in partnership with Volvo Group Trucks. Whenever an interview was recorded, the interviewee was asked for permission first.

2.2 Limitations

The limitations of this research include time period, languages, and data collection methods. In terms of the time period, the thesis was scheduled to be researched and written between May and September 2016, which is a short time period of four months to complete an in-depth analysis of one industry's customers. This was complicated by the Swedish cultural norm of *industrin semester,* or industry holiday period, which generally takes place for 6-8 weeks between the end of June and the beginning of August. Luckily, many interviewees were still available during this time, and some were even kind enough to perform interviews during their holidays. However, it was still very difficult to find specific primary data during this time, especially regarding government policies and programmes.

The researcher does not speak a high enough level of Swedish to perform data collection, so there was considerable help offered from the designated Volvo supervisor and others to translate Swedish interviews and surveys. This language barrier would have been extremely limiting otherwise, as it became clear during the research that some interviewees and all of the survey respondents preferred to speak Swedish. The researcher does speak French, and so interviews with French native speakers were performed in French and translated by the researcher. In both cases, giving the interviewees the ability to speak and fill out surveys in their native langauges enriched the quality of the interviews, by allowing the interviewees to provide data in the most specific, detailed manner possible.

Finally, the method of collecting interviews was at times a limitation, due to a general resistance to telephone surveys. Approximately 25 phone calls were made to different construction companies and truck drivers, and only two agreed to an interview (this disclудes many other phone calls that were made to OEMs, logistics companies, government authorities, academics, and other interviewees). In some cases companies were very helpful and contacted drivers to suggest that they take part in an interview, but this required asking employees to take the time to make phone calls on behalf of the researcher. In the future, this type of research would benefit from focus groups with companies, or information sessions in person where the researcher could sign up drivers or other employees who might be willing to do an interview.

2.3 Methodology

2.3.1 Inductive Basis

This methodology is mainly inductive research, which is based on the initial idea that electric trucks could be used for urban construction and building projects in 5-10 years from now. The initial assumptions made here include that the price of diesel will continue to rise because of increasing demand, and the price of electric truck batteries will fall because of technological developments and economies of scale. According to these assumptions, electric trucks will be more financially attractive in the future than they are now (Davis and Figliozzi, 2013).

The decisions to purchase or lease trucks are not always made based on the same set of criteria. Rather, the decisions can be heavily affected by the position of the person making the decision, the regulatory environment in which they work, and the norms in their industry. Again, this makes for research that is inductive in nature, because the initial assumptions lead to more and more actors who perspectives must be considered. This research attempts to identify those actors through literature review and expert interviews, in order to understand how they affect the purchasing decisions of truck owners. The policy context was also important to consider as part of the research, as regulations limit what trucks can be driven where, and therefore what trucks are optimal for owners to procure.

The VP canvas suits this research well, because it allows the researcher to map all the different parts of the value proposition and customer segment to best understand how electric trucks can fit into the urban building and construction segment. The VP canvas and other research methods will be described in more detail in the Methods section below.

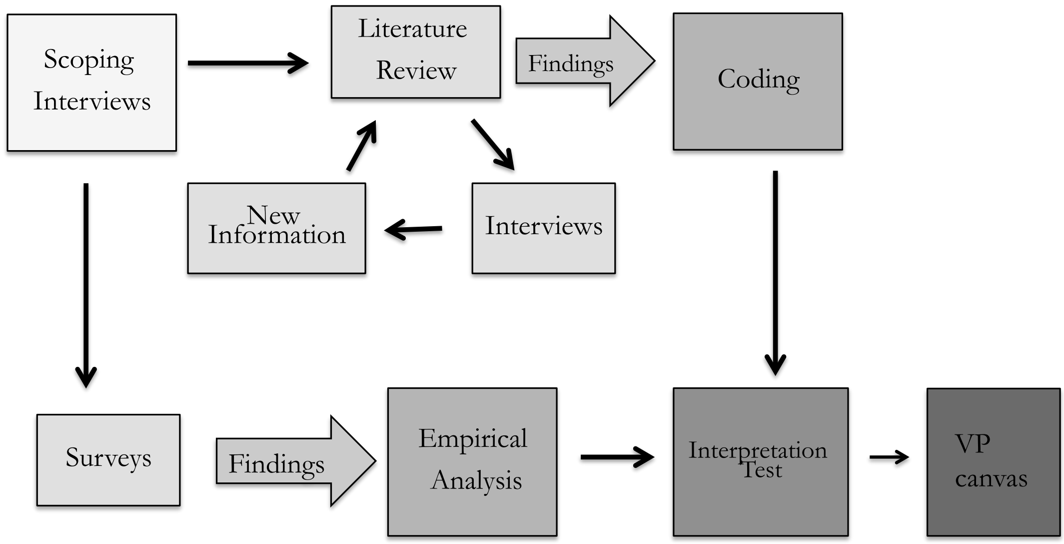
2.4 Methods

2.4.1 The Research Process

The methods used for this research include a literature review, 20 structured interviews, and a survey that received 20 reponses (representing a response rate of 25%). The researcher also performed supplementary interviews at the very end of the thesis period, and prior to the start of the thesis period, including some interviews from the SED project. When the interviews were originally part of a different project, the interviewees were contacted for their permission to use the same information for this research.

The topic was fairly new to the researcher, and so the nature of the research was cyclical: for example, the literature review took place on an ongoing basis and the interviews were conducted over almost the entire course of the thesis period. As new information came to light through the interviews and the surveys, it was included in the literature review. This is illustrated in Figure 8.

Figure 8. The Research Process



2.4.2 Step 1: Literature Review

This thesis focusses on a few different topics that are integral to the thesis: business models, construction logistics, government policies aimed at changes in transportation, and information provided by OEMs (such as survey and interview results, conference papers, and other studies). Early in the research process the interviews yielded more information on these topics in the form of articles and reports. These resources were screened for relevance and legitimacy; documents that were focused on electric trucks and that came from reputable sources, such as the International Energy Agency (IEA) or other well-known organisations were selected for the literature review.

2.4.3 Step 2: Interviews

The interviews, as well as input from supervisors, helped to add to this pool of material. 20 interviews were done with OEM employees, academic experts in logistics, municipal authorities in Sweden and England, construction companies, and truck drivers. As mentioned above, the 20 interviews were also supplemented by more informal discussions, and interviews from a previous project with electric trucks (thus the bibliography lists more than 20 'personal communication' entries). The coding and resulting themes were used to inform some of the questions in these supplementary interviews. In the case of supplementary interviews that took place prior to the thesis, when the interviewees were contacted for permission to use their information, the themes and codes acted as a guide for the researcher to explain this thesis project, and verify that the information was relevant.

Interviews with Volvo and Renault employees were especially helpful at the scoping stage, as they provided insight on what studies had been priotized by the OEMs in the past, so that this research was building on that work rather than repeating it. Unfortunately, due to confidentiality restrictions, the results of all these studies cannot be given in this public document, but they are referenced when possible.

The interviews were carried out in Swedish, French, and English. They were partially transcribed when it was necessary to find quotations or other specific information. When interviews were conducted in French, the interviews were translated by the researcher, with clarification from interviewees if necessary. When interviews were conducted in Swedish, they were carried out by Christina Stenman Jörgensen, the supervisor at Volvo, using pre-written questions that were developed by the researcher with input from Ms. Stenman Jörgensen. The Swedish interviews were translated and transcribed by Ms. Stenman Jörgensen.

2.4.4 Step 3: Surveys

The surveys, due mainly to time constraints, were more linear: they were handed out and collected in late June and the month of July exclusively, in order to allow for sufficient time to analyse the data and make any necessary translations. The surveys were originally written in English, and then translated into Swedish. As can be seen in Appendix 1, the surveys are comprised of questions that can be analysed easily in any language, so long as the researcher knows the questions, as is the case here. Where translation was needed, responses have been translated into English from Swedish. It should also be noted that the surveys went through many different drafts during the research process in order to collect relevant information without requiring a significant time commitment from respondents

2.4.5 Step 4: Interview Coding

Themes were identified from all the interviews using qualitative content analsysis, which is "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns." (Hseih and Shannon, 2005, p. 1278). This method was selected because there was enough information in the literature and corporate reports to create interview guides and potential categories, but it was not literature that was directly related to the exact subject of this thesis, which is the pains and gains that truck owners feel and how electric trucks can meet those. Therefore it was necessary to read through the interview transcripts and look at the language to identify patterns.

First Set: Everything, divided into groups

The interviews were broken into three groups based on the interviewee's expertise, and the interviews guides that were created for them: Construction, Logistics, and OEMs; Policy; and Drivers. The first group, construction, consists of 12 interviews with OEM employees, construction company executives, and construction or urban logistics experts. The second group, Policy, includes four interviews from professionals who work for municipalities, transport authorities, or national associations that create policy or otherwise govern transportation and construction policy (specialists in construction where interviewed whenever possible). The third group, Drivers, consists of four truck drivers, some of whom are owners, who drive trucks regularly and work within urban building and construction. The groups were divided up to present the findings because the questions that they were asked were slightly different depending on their grouping, and thus it was was logical to first compare the data within the groups to understand what the most salient points were, and then to put this data together in the discussion section. The discussion section looks at all the themes, and compares the perspectives from different individuals and groups.

Drivers Compared to themselves and each other

The truck driver interviews were analysed again using directive content analysis, which is antother type of of qualitative content analysis that is used when there is an existing concept, but it needs to be extended or further verified (Hseih and Shannon, 2005). In this case, the concept is that price is the most important factor for drivers, but there are other factors as well that can help to face the risks of higher prices.

2.4.6 Step 5: Survey Data Analysis

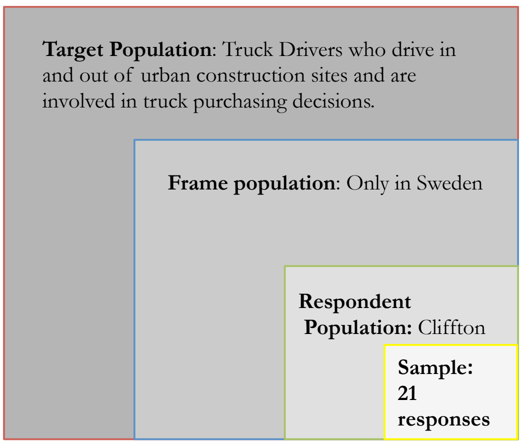
Survey Sample

Originally the target population, defined by Biemer and Christ as "the population to be studied in the survey and for which the basic inferences from the survey will be made" (p. 319, 2007), was meant to be truck owners who also drive their trucks, and make the purchasing decisions when it is time to replace trucks. These people would therefore be very influential regarding the uptake of, or lack thereof, BEVs. These owners must also drive trucks in and out of urban construction sites, rather than only in mines or other non-urban conditions.

There were different samples considered for the survey, as seen in Figure 9. During the first iterations of the survey, the researcher had originally hoped to be able to circulate it in France, Canada, and England, but the contacts there were unable to find sample groups. The next sub-set of population group after the target population is the frame population, which refers to the group within the target population that are considered to be possible to survey. In this case the frame population was limited to truck owners in Sweden, and expanded to include employees who drive trucks, but do not own them, since those employees could still have useful insights into the different influences on purchasing decisions.

The final two sub-sets of the survey population as described by Biemer and Christ are the respondent population and the sample population (2007). The respondent population was originally the truck owners and drivers at three separate Swedish companies, but one company was unable to disseminate the survey due to a lack of resources, so in the end the survey was distributed at Clifton AB and Malmo LBC, which represent the respondent population. However, there were no responses from Malmo LBC, so they were removed from the respondent population. That leaves Clifton AB, which has approximately 200 drivers, and 21 filled in the survey (one response had to be removed because it was from a long haul driver, not a construction driver). These 21 represent the sample population.

Figure 9. Survey Sample
*Adapted from (Beimer and Christ, 2007, p. 319)



Survey Weight and Analysis

The survey will not be subjected to any weighting because the sample is not large enough to represent the population accurately. However, the responses are still interesting and provide important background information for the analysis of the interviews. In order to break down the survey data and use it to inform the interview analysis, the questions were analysed individually.

2.4.7 Step 6: Interpretation Test for themes

Data was subjected to an interpretation test created by the researcher, using information from Christine Bellamy and Perri 6's book *Principles of Methodology: Research Design in Social Science*. 6 and Bellamy discuss how different factors can affect a respondent's interpretation of the questions. These factors can be mental and specific to the respondent, but they can also be the result of a larger social norm that the respondent is a part of (2012, p. 231). The table below includes a doxastic column, which states the respondent's beliefs; a normative column, which states the beliefs of the group to which the respondent belogs; and a secondary interpretation column which states the interpretation that the researcher has on the information. The final column is takes the other three columns into consideration to create a conclusion.

6 and Bellamy refer mainly to individual respondents and interviewees in their work, but due to the number of data sources the ideas were adapted for interpretation of responses at the scale of decision-making parties. Thus the interpretation test is done on the drivers and the construction companies who were interviewed, both of who greatly affect the purchasing of new trucks. This test helped to qualify themes for the final VP canvas.

Table 1: Interpretation test for data

Customer	Doxastic (Customer)	Normative (Group)	Secondary (Researcher)	Final
Innebandy players	The individual player believes that innebandy is a fun sport.	The group of innebandy players widely accepts that innebandy is superior to all other sports.	The researcher sees that the individual player likes innebandy, but is not passionate about it.	The individual player enjoys innebandy, but may show more interest when she is with her teammates.

3 Literature Review

The Literature Review will explore many different themes in order to examine the factors that can help support the business case for electric trucks in urban building and construction. First there is a brief introduction to the urban building and construction segment, construction logistics, and the different actors and organisations involved. Then some different government programmes and policies will be examined, in regards to their support of the conditions that make electric trucks more optimal in certain situations. Finally, Product Service Systems (PSS) and the VP canvas will be analysed to better understand the academic and business framework into which these factors fit.

3.1 Electric Trucks

The IEA published a report in 2016 on the uptake of hybrid and electric vehicles in its member countries. Part of this report discussed the uptake of electric trucks. The report mentions how at the United Nationas Framework Convention on Climate Change (UNFCCC) Council of Parties 21 (COP 21) meeting in December 2015, the members of the COP agreed to electrify 20% of road vehicles by 2030, including trucks (IEAa, 2016, p. 28).

The report makes many different recommendations on how member countries can encourage the uptake of electric trucks. One such example is partnerships with municipalities, where cities could encourage OEMs to produce electric trucks by raising the number of vehicles ordered. In order for this to take place, the municipalities may need more information on the different specifications of electric trucks that are available today, so partnerships with OEMs would be crucial (IEAa, 2016). The Roland-Berger report mentioned in the introduction, which was commissioned on behalf of a group of OEMs, also recommends that any regulatory framework that is going to help increase zero-emissions powertrains of trucks would need to encourage cost-competitiveness of "ultra low carbon fuels together with vehicle technologies" (2016, p. 84), including electric vehicles.

3.2 The Urban Building and Construction Customer Segment

Urban building and construction is one of the customer segments that Volvo's Advanced Technology and Research department works with. Urban building and construction can be divided into the sub-segments of heavy and light construction, and this thesis focuses largely on the former. Heavy construction often takes place outside of cities because it involves heavy industry such as mining. However many heavy construction projects also happen within urban environments; in this thesis most notably the case of tunnels will be highlighted.

Light construction takes place both inside and outside of cities, but the trucks are more commonly going in and out of construction site within cities, delivering supplies and removing waste. Light construction resembles city distribution in some ways, as the loads are generally lighter and there may be more stops on the route. There is overlap between the two sub-segments, and for the purposes of electrification, many of the characteristics of the routes identified in heavy construction could be adapted or applied to light construction .

The equipment used for some construction applications has been piloted in electric mode, such as the cement mixer used in Stockholm, or electric cranes that have been tested in various cities (Swerock 2015; Cederstav, n.d). These are obvious candidates for electrification given their high electricity usage. This research is mentioned since it marks an important part of the overall emobility industry, in addition to the electric drive trains of trucks.

The difference between truck drivers and truck owners is important to delineate for this thesis. In many cases the owners are also drivers, and in Sweden in particular being a truck driver is the third most common profession amongst men (Sveriges Åkeriföretag, 2016). Most owners have one truck, and one other employee who helps them with the administrative work. There are also companies that own many trucks, and employ many drivers. This difference is important because in the former case, the driver is also the owner and has sole responsibility for the purchasing or leasing of a new truck. In the case of a larger company, it is the owners, but maybe also the fleet managers and other staff who influence this decision.

3.3 Value Chain

Construction projects are diverse in scale and equipment that is needed, and this diversity means that many different types of actors will be involved in a given project (Browne, 2015). Volvo, as an OEM, is a supplier to an actor in the value chain. The basic model always involves transport operations, thus trucks are always an important part. The different parts of the value chain generally include, from start to finish, raw materials producers, stockholding or warehousing companies, transporation companies, developers, contractors, city or country authorities, customers of the developers, and a myriad of sub-contractors.

Coordinating a value chain often involves first mapping the different actors and deciding which has more or less power. For this thesis, the most relevant parts of the urban building and construction supply chain are the municipal and national authorities that regulate the construction and haulage industries, the developers of construction sites, the truck owners and their companies, and of course truck drivers. Volvo is influenced by this chain because the choices that the customers make in terms of sustainability regulations on the building projects, as well as the choices that authorities make regarding regulations that construction projects must comply with, send shock waves down the value chain and require transportation companies to change their technology accordingly.

3.4 Construction Logistics

Little research is available on the connection between construction site logistics and electric trucks. However, many studies have been done on the importance logistics management within building and construction. Logistic can be defined many ways, but in this case largely refers to the trucks that are going in and out of construction sites to different parts of the city, carrying supplies for the site, or waste from the site. The first chapter of the book *Supply Chain Management and Logistics in Construction* details the different ways that inefficiencies in construction site logistics can cause financial losses to construction companies, even suggesting that "inefficiency alone is adding GBR 3 bn to the annual cost of construction" (Browne, 2015, p.17). The author also notes that non-road alternatives to fossil fuel vehicles have been used in various construction projects where sustainability was a high priority. Browne suggests that these non-road alternatives, such as trains, will attract more attention as solutions to sustainability issues within construction. This trend is relevant to the research being done here as well, because it suggests a move towards more sustainable transport in construction, which in turn sheds more light on electrification possibilities. These go in tandem with different logistics management strategies that monitor and dictate how transport related to building and construction can be most efficient.

3.5 Urban Consolidation Centres (UCCs) and Construction Consolidation Centres (CCCs)

Urban Consolidation Centres (UCCs) were first developed as an idea in the 1970's, with the goal of reducing heavy duty truck traffic in urban centres (Allen et al., 2012). The logic behind UCCs is that the goods in question are delivered to the UCC by a large, heavy-duty vehicle, then unloaded and consolidated onto smaller vehicles to be delivered to their urban destinations. These urban deliveries can also benefit from better scheduling, and more targeted deliveries to avoid many vehicles going into one neighbourhood. According to Allen et al "The UCC also offers the opportunity to operate electric and alternatively powered goods vehicles for this urban delivery work. A range of other value-added logistics and retail services can also be provided at the UCC." (2012, pp. 1-2). UCCs are particularly important for his research because the represent the basis for Construction Consolidation Centres (CCCs) and they also underscore a larger logistical ideology of short, strictly-scheduled and planned routes that would optimize conditions for charging and full range maximization of electric trucks.

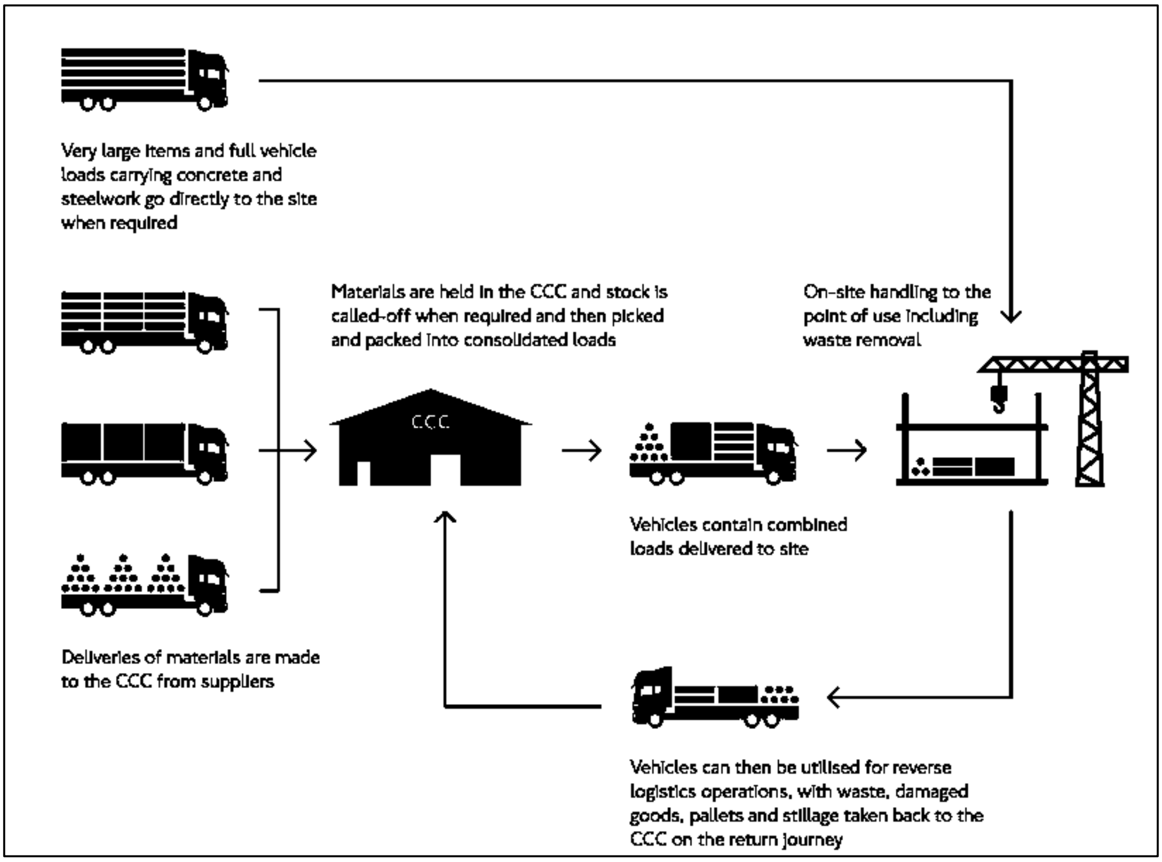
Construction Consolidation Centres (CCCs) are very similar to UCCs, but strictly for construction work only. They were created to deal with the economic issues of waste in the construction industry as a result of goods being ruined when they were left out in construction sites for too long due to poor scheduling (Lundesjö, 2009). As with UCCs, however, CCCs also created an environmental benefit (Caux, 2015). In the case of CCCs, the size of vehicles is even more important, as many construction vehicles are quite large and heavy, and carrying big loads. The main issue with CCCs is that construction transportation companies must give up some of their autonomy, and also help pay to use the site. Urban realestate is generally quite expensive, and most CCCs require funding (Caux, 2015; Policy2, 2016). The many CCCs in London, England, and the case of Stockholm Royal Seaport, in Sweden, will be examined further below to provide more insights into how this system could provide opportunities and challenges for electric trucks.

3.5.1 London CCCs

Transport for London (TfL), the government transport authority within the city of London, recently published a *The Director of London Construction Consolidation Centres*. This directory compiles the activities and services offered of nine different CCCs across London, most of which were organically created. One, in Camden borough, received support from local authorities and EU funding, but the rest were created on their own (Policy1, 2016). TfL The report may not even be entirely accurate, since the CCCs develop on their own, so it is entirely possible that there are more which are not listed. The directory also details the functioning and benefits of CCCs, as follows:

- Deliveries of materials are made to the CCCs from suppliers
- Materials are checked to be sure that they are as specified and damage-free
- Materials are held in the CCC and stock is called-off when required and then picked and packed into consolidated loads.
- Vehicles can then be utilised for reverse logistics operations, with waste, damaged goods, pallets and stillages taken back to the CCC on the return journey

*Note: list taken from (TfL, 2016, p. 6)



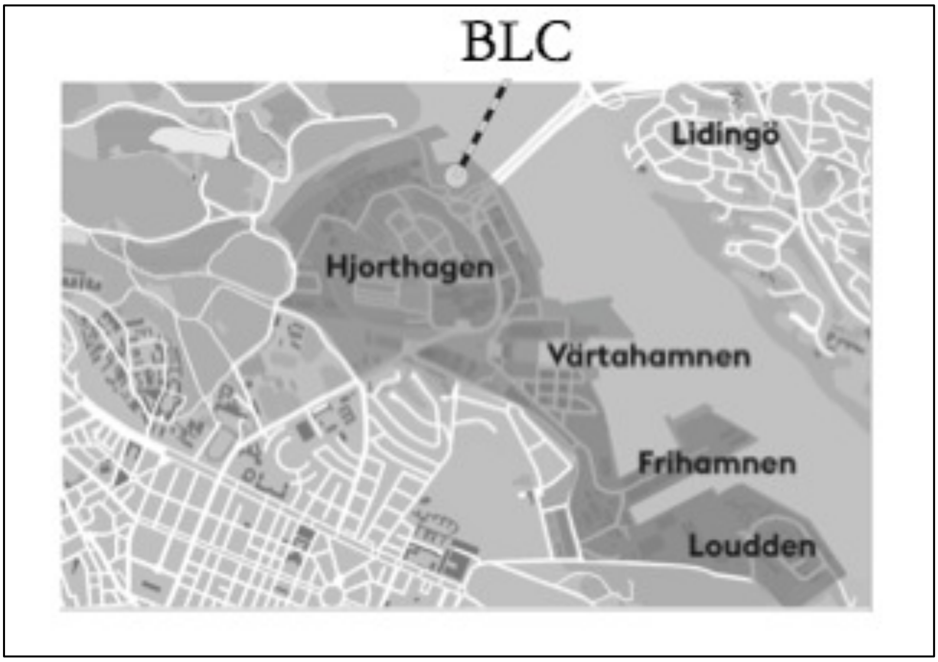
*Adapted from (TfL, 2016, p. 8.)

Figure 10. London CCC diagram.

3.5.2 Stockholm Royal Seaport

The Stockholm Royal Seaport is a newly developed residential and commercial neighbourhood in a formerly industrial part of the city. The area will continue to be developed until 2030, at a rate of approximately 500 homes per year (City of Stockholm, n.d.). In 2011, the planned construction of the area represented a chance for the City of Stockholm to test a Constructon Consolidation Centre (CCC), building on an idea that had come from Hammarby Sjöstad, where a rudimentary CCC had already been used (Stockholm Stad, 2016). The initial funding for the *Bygglogistikcenter* (Building Logistics Centre, BLC) as it is known, came mainly from the City of Stockholm.

Part of the incentive for the creation of the BLC was the increases in efficiency that could be made, and the resulting emissions reductions. Fredrik Bergman, one of the original creators of the BLC, is quoted on the BLC website as saying "A significant environmental impact during construction are transport, waste and energy during production. If we can influence this in the right direction, creating the conditions for a sharper production, we have gained a lot." (Stockholm Stad, 2016). The BLC thus influences the value chain by requiring more sustainable logistics chain, creating incentives for new technology. Since the Royal Seaport area is considered to be inner city, and since the area will continue to grow and house more people and businesses, it is quite important for the City of Stockholm that the construction happen in a resource-efficient manner (Stockholm Stad, 2016).



(Stockholm Stad, n.d., p. 15)

Figure 11. Stockholm BLC within the Royal Seaport.

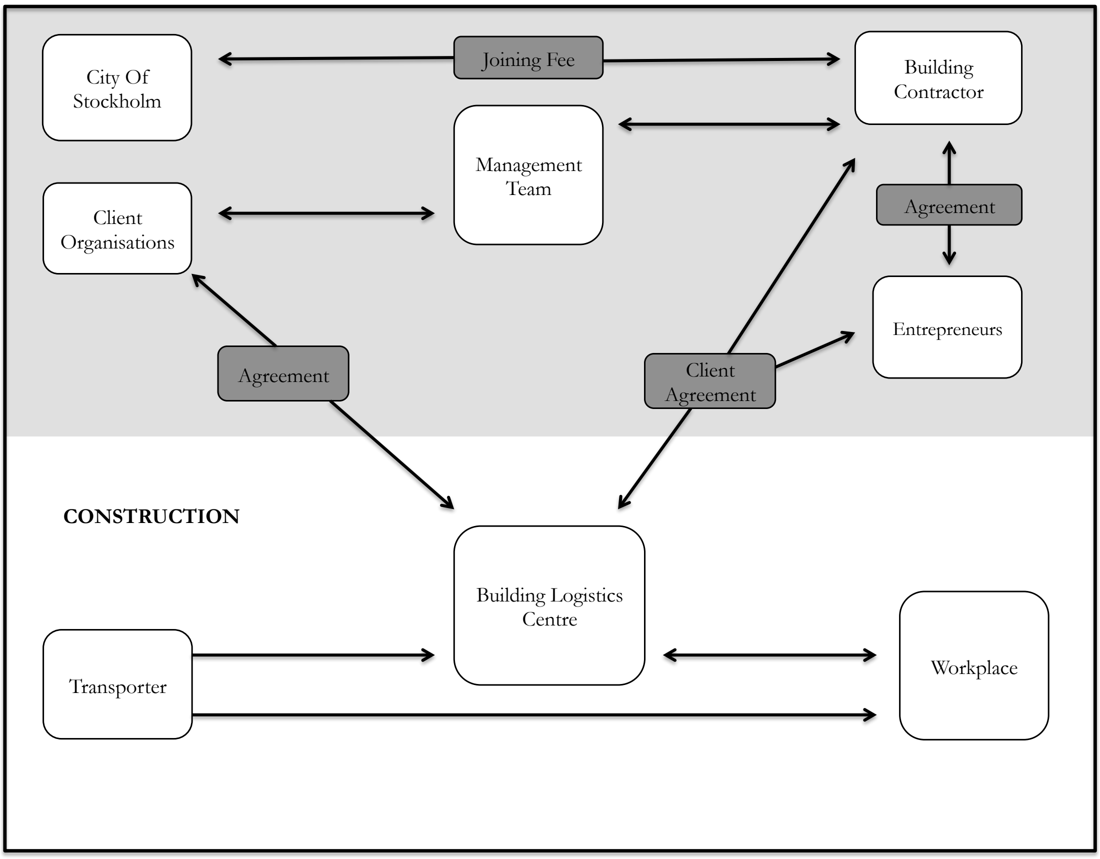
(City of Stockholm, n.d., p. 15)

Figure 12. Royal Seaport neighbourhood within Stockholm city

The City of Stockholm used a competitive system to find companies that would do the final logistics management of the BLC. At the time, this was an untested way to determine who would be in charge of the project. The successful candidates were Wiklunds, a transporting company, and Servistik AB, a logistics company (Stockholm Stad, 2016). Today, Servistik handles the organizational side of things at the BLC: they create schedules, communicate between actors, and do all the administration for the site. Wiklunds provides the trucks and other machinery needed for transport.

Practically speaking the BLC consists of a large area where construction materials can be stored before they go to different construction sites in the Royal Seaport area. If trucks coming from outside the city with goods are fully loaded, then they may continue on to their construction site, but if the truck is not fully loaded it must go through the BLC, unload, and be consolidated to be delivered to the final construction site within the Royal Seaport. The BLC can also be used for storage, and the first two weeks of storage are free (Stockholm Stad b, n.d.). Fully loaded trucks that are delivering goods for storage get a specific time slot to make their delivery. Indoor and outdoor storage is available, but the indoor storage is a simple tent with no heating. The BLC is on land owned by the City of Stockholm and joining fees are created based on the size of the construction site that the company is working on in the Royal Seaport. There are additional fees for extra services such as storage or additional logistics, and every time a fully loaded truck enters the BLC there is a fee as well (Log2, 2016).

The diagram below shows how the BLC fits into the Stockholm Royal Seaport project, and how it is managed by the different actors.



*Adapted from (Stockholm Stad a, n.d., p. 10)

Figure 13. Stockholm BLC Supply Chain

3.6 Lastbilcentraler (LBCs)

The urban building and construction segment in Sweden was important to study in detail because it is characterized by its informal organizations of *Lastbilcentraler* (Truck Centres, or LBCs). These tightly controlled organisations create a unique opportunity for organizational change because the LBC can help to disseminate new technology by taking some of the financial risks, and also spreading awareness and interest around new technology in a very traditional industry.

LBCs are very common in Sweden and also special to the country. For this reason they are referred to in this thesis as *lastbilcentraler*, rather than Truck Centres. If the existence of such organisations was found in a country where another language was spoken it would make sense to translate the title into English, but since LBCs only exist in Sweden it seemed logical to refer to them by their proper name. LBCs are usually organised as cooperatives, so that the owners of the trucks, who might also drive the trucks themselves, are members of the company and also part owners of the company in some cases. At one LBC where employees were interviewed, for example, the company is run by a board, which is made up of truck owners (Con3, 2016). Different LBCs can specialise and organize in different ways, for example at a different LBC interviewed for this research, drivers do not own the trucks, but are employees and members of the LBC.

3.7 Policies

3.7.1 Low Emissions Zones in London

London has a strong incentive to reduce emissions from construction because it is a city growing quickly, and it has a history of very poor air quality. As a result of this, the city has passed many policies that could encourage electric trucks. In 2007, the then-Mayor Ken Livingstone's office released a report called The London Freight Plan, which set out plans for reducing emissions and improving logistics efficiency in the different freight deliveries throughout the city. Construction was a big part of this, and the report, specifically creating construction logistics plans "to improve construction freight efficiency by reducing CO_2 emissions, congestion and collisions." (TfL, 2007, p. 7). Seven years later, in 2014, then-Mayor Boris Johnstone's office released a publication entitled *Transport Emissions Roadmap: Cleaner Transport for a Cleaner London.* This report called for more specific measures towards transport regulation, and most noticeably built on the Low Emissions Zone that was introduced in 2008 by introducing the Ultra Low Emission Zone (ULEZ).

This is particularly important legislation to consider for construction vehicles because the ULEZ limits the type of vehicle that can drive in that zone based on their emissions. For example the LEZ, the precursor to the ULEZ, restricted only certain vehicles to be exempt from the LEZ charges. Most vehicles over 3.5 tonnes, such as those used for construction, had to be licensed as new in 2006 or later, or be given a Low Emissions Certificate, in order to qualify. This was to ensure that the vehicles had a lower level of particulate matter, based on EU standards (TfL, n.d.).

TfL has a range of programs to help with construction logistics, safety issues, and emissions. Many of these also relate in some way to electromobility. The two main programs are the Freight Operator Reconigiton Scheme (FORS) and the Construction Logistics and Cycle Safety (CLOCS). The CLOCS program was started because it became apparent that there was a large number of construction trucks were having accidents in London (Policy1, 2016). TfL took this opportunity to create a program that could work with and influence the entire construction supply chain, targeting an industry that was very influential in London, but had not been addressed as a whole in the past. This also dovetailed well with the CrossRail project, which was being constructed at the time and was able to use it's procurement powers to restrict tenders to companies who were CLOCS certified. Those contractual powers were very important for compliance at a large scale, but even more important was establishing agreed upon standards that could be met by the industry (Policy1, 2016).

3.7.2 Low Emissions Zones in Sweden

In Sweden Low Emissions Zones exist in seven places: Mölndal, Lund, Malmö, Gothenburg, Helsingborg, Uppsala, and Stockholm (Policy6, 2016). The regulations for these zones are simply that a vehicle can drive in those zones for six years after it has been first registered, including the year of registration. But the following exclusions also apply:

- Vehicles that meet emission standards higher than EUR 2 (from September 1, 2013, more than EUR 3) may drive in environmental zones for eight years, not counting the year of registration,
- Vehicles that meet emission class Euro 4 may drive in the environmental zone until the end of 2016, and
- Vehicles that meet the Euro 5 emissions class may drive in an environmental zone until the end of in 2020.

*This list is adapted from the Transportstyrelsen webpage (Transportstyrelsen, n.d.)

Environmental zones in Sweden are not strict enough now to encourage the use of electric trucks. However, some of the policy interviews predicted that environemtnal regulations at the municipal level will become stricter in the future (Log2, 2016; Policy5, 2016). In this case, they could be leveraged as a tool for promoting electric trucks. The Swedish Transport Agency (Transportstyrelsen) completed a report for the Swedish Government in 2010 with new recommendations for LEZ in Sweden, and the same organisation is currently updating that report. This update will look at the restrictions on heavy duty trucks as well, and is aimed to be finished at the end of November 2016. Transportstyrelsen has consulted with some companies and agencies that will be affected by this new legislation. They have already provided advice on alternatives that affected organizations can explore (Policy5, 2016).

Currently, Transportstyrelsen is researching different options for electrification, for example HEV versus BEV requirements. They have recieved positive feedback from OEMs. Due to a lack of information it was hard for Transportstyrelsen to provide a full picture of what the future of LEZ in Sweden will look like (Policy5, 2016), but they are certainly moving towards stricter regulations. It is important to mention as well that once these regulations are created for LEZ, it is the local communs in Sweden that make the decision to set up an LEZ and enforce it. The national authorities create the rules for LEZs, but they are carried out at a local level (Policy5, 2016).

3.8 Projects

Any new system needs support in order to get started, and electric vehicles are no different. CCCs and LBCs are part of the picture, but larger government-sponsored programmes are also crucial. A few such programmes are detailed below to demonstrate how state funding can be leveraged to aid in the transition to electric trucks, even if the programmes are not directly targeting the construction industry.

3.8.1 FREVUE

FREVUE is an acronym for Freight Electric Vehicles in Urban Europe. The project was started in 2013 and its aim is to promote the spread of electric freight vehicles in European cities. According to the first FREVUE update report, this is largely dependent on the operational, financial and technical effectiveness of Electric Freight Vehicles, and not just their environmental benefits (Dalle-Muenchmeyer et al., 2016). FREVUE presents an interesting case for electric vehicle market integration because of its scale: most experts suggest that EFVs are difficult to create national policy for because regulatory frameworks relating to vehicles are largely controlled at the city level. Government policy is a strong driver for the uptake of EFVs, because it directly affects driver purchasing decisions – for example, the limitations imposed on vehicles by the London LEZ suggest that it would be much more beneficial for drivers to purchase vehicles that comply, rather than having to pay an extra fee. But if these types of regulations are different in every city, it is very difficult for OEMs and national governments to work together to incentivize EFVs, and build the necessary infrastructure.

FREVUE circumvents this issue by creating opportunities for demonstration projects using EFVs in many different cities. By March 2016 the project had procured and made operational 77 EFVs in its eight partner cities, and more cities are joining the project. The cities that are highlighted in this thesis, Stockholm and London, are members of FREVUE and are involved in numerous demonstration projects.

In Stockholm, the Royal Seaport BLC has used an electric van for some of their deliveries, and they are exploring the use of larger electric vehicles to be used in conjunction with an urban consolidation centre closer to the centre of the city (Nesterova and Quak, 2015). Stockholm has the goal of becoming fossil-fuel free by 2040, and their involvement with programs like FREVUE could help to achieve this.

In London, FREVUE aims to build on the construction consolidation centre model that has worked so well by connecting consolidation centres with new end users. This will expand the model away from construction, so the details of the project will not be further described here. In 2015 TfL released a document titled *An Ultra Low Emission Vehicle Delivery Plan for London: Cleaner Vehicles for a Cleaner City* (TfL, 2015). This report lays out a 15-point action plan that the city will follow to encourage vehicles to comply with an ULEZ. One of the points is to "Increase the uptake of Ultra Low Emission Vehicles in freight and fleet organisations" (ibid, p. 8). Implementation for this point is suggested through further regulations such as local air quality schemes that encourage electric vehicle uptake by providing charging infrastructure.

3.8.2 LoCITY

This report also led to the creation of the LoCITY program, which was introduced by TfL in January 2016. LoCITY builds on the model of the CLOCS program in that it is meant to be industry-driven, so that freight operators and fleet operators can provide their input about what is best regarding the switch to alternatively-fuelled vehicles (electric or other). The programme is not specifically aimed at construction vehicles, but its findings can to some extent be applied to the construction industry. Vehicle sizes, route distances, and payloads can be similar, and in some cases one operator may cater to both construction sights and another type of industry. Another important difference between the focus of LoCITY and the focus of this thesis is that LoCITY looks specifically at how to help operators procure vehicles that may enter a ULEZ. These can be any vehicle classified as ultra-low emission, and the different alternatives that were looked at in the first LoCITY reports included vehicles fueled by biomethane, hydrogen cells, liquefied petroleum gas, and electricity (LoCITY 2016b).

LoCITY did extensive consultation with fleet operators and other truck owners within the City of London to guage opinions about a new ULEZ. The initial response from the survey showed that 26% of fleet operators surveyed were positive towards the integration of ULEVs, 34% were neutral, and 40% were negative (LoCITY, 2016a, p. 3). The negative group included a smaller fraction of operators who had researched electric vehicles and other low-emissions alternatives to diesel, and after doing the research were not interested in investing. The report also went further into the different response groups to see why different operators had certain reactions to using ULEVs, and makes the suggestion that LoCITY could create different tools for increasing operator knowledge of the costs and benefits of different types of alternatively fuelled vehicles (LoCITY, 2016a).

3.9 Past Customer Studies

Surveys and targeted interviews regarding electric trucks for use in urban building and construction have already been carried out by Volvo and Renault Trucks. These provide excellent information regarding the customer perspective towards HEV, PHEV, and BEV trucks both in terms of the more widespread, high-level gains such as green branding, company-level emissions reductions, and Corporate Social Responsibility (CSR). The studies also cover issues such as the way that driving an electric truck feels for the driver, and what technical issues and advantages the driver experiences. This helps demonstrate the different perspectives from the drivers and the owners, who are more usually the decision makers related to the trucks. The main finding of interest is that both drivers and owners remain open to electric trucks and see the multiple benefits they can gather from them, but are still concerned with the price.

3.10 Product Service Systems (PSS)

PSS can be part of a circular business model strategy (Bocken et al., 2016). A circular business model is defined by Bocken et al. as "generating profits from the flow of materials and products over time"(2016, p.1), rather than the traditional method of selling products and receiving profits with a clear start and end to the process. There is overlap between the circular economy and PSS regarding the idea of providing a service to the customer, rather than selling a product. The shift from reliance on the product towards reliance on the flow of services as a source of profit can also represent a shift towards more sustainable uses of resources. This in turn can mean more control for on the part of the provider over the way that those resources are used (Tukker, 2004). In PSS literature, Tukker divides PSS models into Product-Oriented, Use-Oriented, and Result-Oriented. He describes product lease as a Use-Oriented sub-category of PSS business models. Interestingly, using a PSS strategy for electric truck market integration would likely involve many of Tukker's categories.

Customer needs are an interesting part of PSS literature, especially when the customers are regarded as either sustainable or unsustainable based on the way that they want their needs fulfilled. Osterwalder and Pigneur found that reacting directly to customers needs at a certain point in time will not necessarily make a strategy more competitive, and this belief is shared by other academics when writing about PSS specifically (Bocken et al, 2016). This could directly contradict other PSS literature, such as Tukker's 2004 article, where the PSS approaches are largely focused on customer needs.

Tukker suggests that Result-Oriented PSS business models are the most likely to have positive environmental impacts, because the provider is able to have the most control over the results, and in doing so can create a process that is more environmentally sustainable. This will also meet the customers' needs, ensuring economic sustainability for the provider. This way of thinking does not give any examples of a technology push, which is to some extent the focus of this thesis: how can electric trucks be integrated into the urban building and construction industry? How can those trucks become a customer need?

One of the major drawbacks of more Result-Oriented PSS that Tukker describes is that the provider takes on more risk to ensure that the result is satisfactory, whereas before this onus was on the customer (Tukker, 2004, p. 251). If the main focus of the PSS is not customer needs, as is advocated by Bocken et al, then the provider is taking on even more risk in trying to simultaneously integrate a new product, and a new business model.

The opportunity here lies in the holistic approach. If many PSS business models are used they can target both existing customer needs, and integration of new sustainable technology such as electric trucks. In this case, it would make sense to offer a product lease of the truck, but also a service contract that would train the drivers and other company executives on the best way to use the new technology. By Tukker's definitions, the product lease would be Product-Oriented, and the service contract would be Use-Oriented. There could also be room in the future for Function-Oriented results, such as truck pooling or fuel sharing through the shared use of charging stations.

3.11 SED Research

In April 2016 a group from the IIIEE created a similar VP canvas for Volvo Group as part of the Strategic Environmental Development course. That diagram mapped the pains and gains that urban distribution companies face today, and then matched those with a value proposition using electric trucks. There is also an arrow at the bottom that shows how the diagram should be read from right to left, so that the customer needs are considered first. This VP canvas is shown in Figure 14.

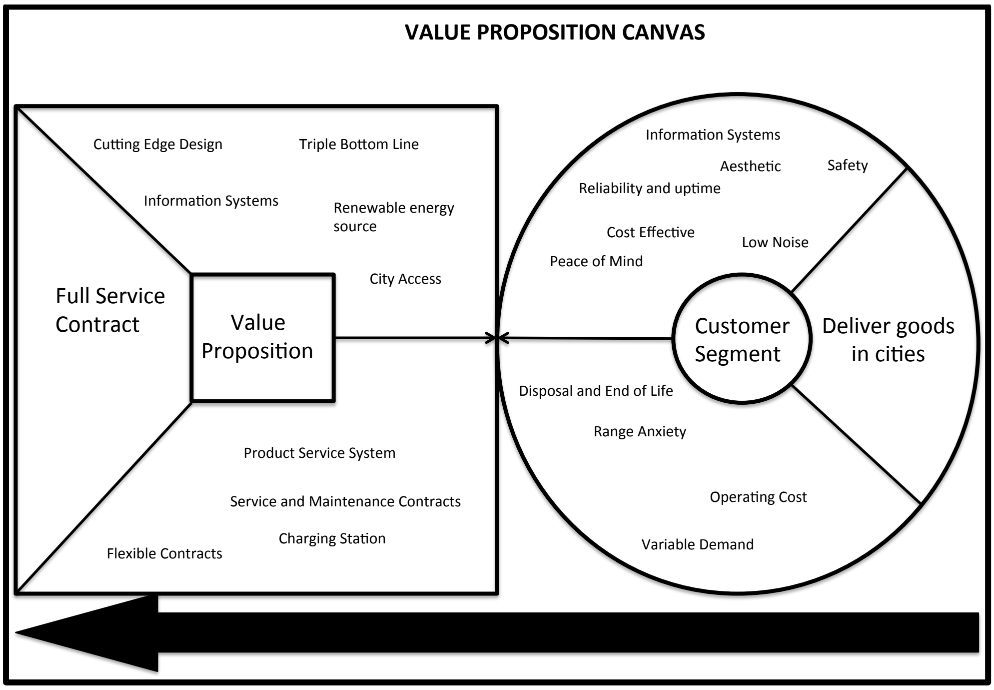


Figure 14: SED Project VP Canvas

For this thesis, a similar VP canvas has been created, based on the interviews with truck drivers and owners, LBC administrators, transportation agencies, OEMs, and other experts in the field, and supported by survey data. As was mentioned in the introduction, the 'gain creators' section of the VP canvas represents the findings of this thesis, and also answers the research qestions. This VP canvas is presented in the discussion section.

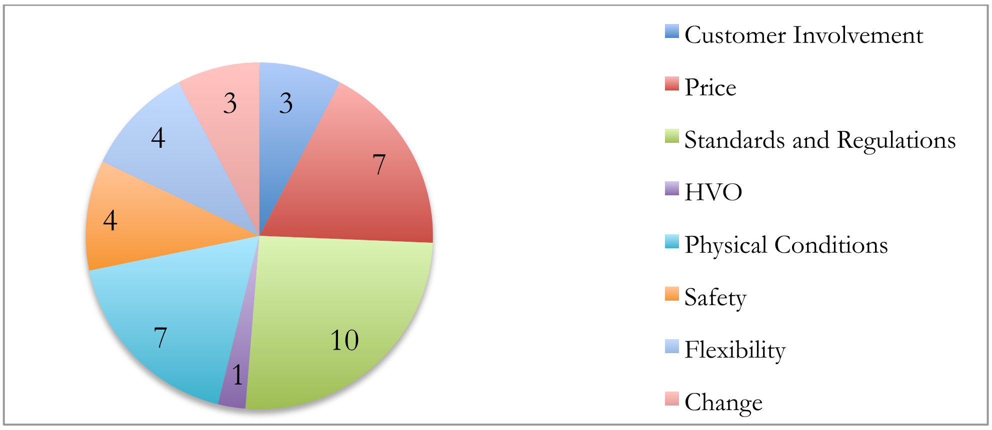
4 Results

4.1 First Set of Interview Findings: Theme Frequency among groups

There are different types of qualitative content analysis, and the first version used here is known as conventional content analysis, as opposed to directive or summative content analysis. Conventional content analysis involves reading through the text and creating a coding system based on the patterns found there. This method is usually used when literature on the subject is limited and the goal is to describe that subject (Hseih and Shannon, 2005). The subject here is the potential for large-scale uptake of electric trucks in the urban building and construction segment in Sweden, and these interviews are used to describe and analyse the various parts of that phenomenon. The following section will give a brief overview of the themes identified in the coding process, and present the raw data. Both will be analysed in more detail in the "discussion section". The coding process was done by reading through the interview transcripts and finding common themes, and then these themes were sorted into broader categories, as is shown below.

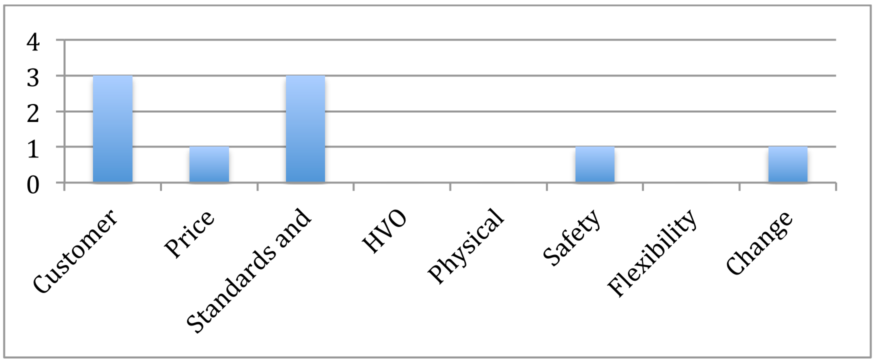
The pie chart below shows how many interviews each theme was mentioned in during the interviews with the Construction, OEM, and Logistics group. Each theme could have been mentioned a total of 12 times, once by each respondent in each interview.

Figure 15. Construction, OEM, and Logistics Interview Theme Frequency



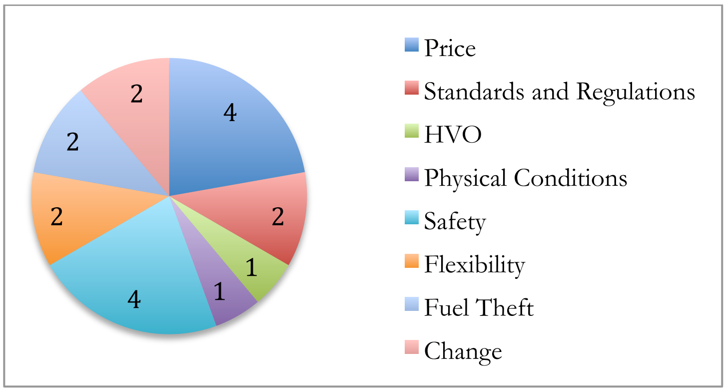
The bar chart in Figure 16 shows the how many policy interviews each theme was mentioned in. Each theme could be mentioned a total of four times, as there were four interviewees. This category of interviews is demonstrated with a bar chart because it was important to show that HVO, Physical Conditions, and Flexibility were not mentioned. These omissions will be further analysed in the discussion section.

Figure 16. Policy Interview Theme Frequency



In Figure 17 the truck driver interviews are divided into a slightly different set of categories. Physical conditions was omitted as a category, because there were many close-ended, direct questions asked about the physical conditions of a driver's route during the interviews, in order to inform a different part of the thesis. Fuel theft was added as a category here because it was a very important part of half of the driver interviews, but was not mentioned at all in any other interviews.

Figure 17. Truck Driver Interview Theme Frequency



4.2 Interview Themes

4.2.1 Customer Involvement

This first came up during scoping interviews with OEMs as part of the basis of the thesis. Then during further interviews with policymakers it became a clear theme. It was largely mentioned as a method for creating successful policy that customers felt accountability towards due to their part in its creation.

During the interviews this theme emerged when new projects, such as the CLOCS and FORS projects in London and the Stockholm Royal Seaport project, were being discussed. The main idea here was that customers are already participating in whatever system precedes a new programme, and thus they understand the current landscape best.

This theme did not make sense to include in the Truck Driver interviews, since that analysis was in itself customer consultation. Some drivers did talk about the customers in their value chain, however, and how communication with them is very important. For example, one main driver for changes in technology for truck owners is what the contractors that they work for require. The requirements of the contractors can be based on the standards and regulations described in Section 4.2.3, but contractors can also have individual interests that set them apart. For example, the city of Ängelholm has a co-distribution programme for eggs and milk that requires companies to use a common depot outside the city (Driver3, 2016).

4.2.2 Price

The cost of electric trucks compared to diesel trucks will always be one of the main topics of this debate. During the interviews it emerged early as the largest issue to be dealt with in terms of convincing customers to pay extra for new, untested technology. However the theme of 'price' has also been expanded here to include the mention of government incentives; buying, leasing or other financing of vehicles; the decision-making influences involved; and the mention of tight profit margins.

One interviewee mentioned that "You rent a truck and driver for one fourth of what it costs to rent a management consultant"(OEM6, 2016), which clearly shows the tight margins that truck companies must operate with. Another interviewee, when talking about truck companies purchasing a BEV, stated "Yes they can buy it, if they get paid for more it" (Con1, 2016). This demonstrates the position of the truck companies in the value chain: they are not the end customer, and they have very strict guidelines for what they need to be able to offer the end customer.

The issue of buying versus leasing was very interesting in the interviews, particularly those with the truck drivers. All of the drivers owned their trucks or worked for companies who owned trucks, and the reasons for this ranged from a feeling of comfort and security, to better cost awareness, to "I don't know" (Driver 2, 2016). When leasing an electric vehicle with a service contract and electricity source were discussed, the drivers suggested that it would be better for them to lease because then they would have assistance adapting to the new technology.

One theme that came up relating to mitigating the risk of the higher initial purchase price for electric trucks was the theme of a bigger organization taking the risk, whether that is a Lastbilcentral, or another governing company. This was a particularly salient topic in one of the Construction interviews, where the interviewee suggested that it since his company was very serious about making practical changes that could have environmental benefits, it was in their best interests to take the risk to try electric trucks, and then hire their employees to drive them, rather than trying to convince their employees to lease or purchase the trucks themselves.

The issue of the small margins in the urban building and construction industry came up frequently as well. In one interview it was mentioned how in cement trucks sometimes the designers will even try to take away the passenger seat, because payload is so important due to the small margins (OEM4, 2016). Modern, light-weight, efficient trucks are very important for the cement industry (OEM1, 2016). Also, in one of the driver interviews it was explicitly stated that when the cost of petrol rises, the company cannot afford to raise their prices to match because it will make them less competitive (Driver2, 2016).

Total Cost of Ownership (TCO) of the vehicle was touched on in some of the interviews. TCO usually includes the initial purchase price of the vehicle, the cost of fuel over the lifetime of the vehicle, and any other costs that go into keeping the vehicle running, such as maintenance and repairs. One driver mentioned that it was important to know what kind of condition the truck was in, and what kind of work it might need, as that would be factored into his prices (Driver2, 2016)

4.2.3 Standards and regulations

Standards and regulations were mentioned during many interviews, sometimes as important drivers for electromobility, and sometimes as weak legislation that interviewees were not fully aware of. Due to the diversity of interviewees, many different and valuable perspectives were provided on this subject. Interviewees' thoughts on standards and regulations also depended heavily on their own background as a truck driver, political actor, or construction company executive.

In one of the very initial OEM interviews, it was mentioned that truck owners had approached the interviewee at a tradeshow to specifically talk about future regulations, and voice their concerns over being left with obsolete technology (OEM3, 2016). This was echoed by one of the Logistics interviewees. When asked about how municipal or national policies regarding trucks might change in the next five to ten years, they answered that they will certainly get stricter in terms of environmental goals (Log2, 2016).

An interesting point that came up during the interviews was the idea of company autonomy, and how it can hinder efficiency in transportation. The interviewee who mentioned this took the angle that if each company that delivers a separate item wants to do so in their own truck, this will mean more deliveries, more trucks, and more emissions. But if these companies are willing to combine their freight and to one truck, thereby releasing some of their autonomy, the goods can be delivered in a much more efficient manner. This is also the logic behind Construction Consolidation Centres and Urban Consolidation Centres. The logic might also be more conducive to electric trucks, as routes that are well planned and scheduled can better organize charging stations (OEM7, 2016).

The issue of standards did not come up during the interviews for this thesis, but it was mentioned during the SED interviews. One expert in particular explained how there are no real standards yet for electromobility, but it is likely that the standardization will start with electric busses, which are more developed (Policy6, 2016). An ideal set of standards would comply with as much of the existing standardization for electric cars as possible, so that the existing infrastructure can be used. The interviewee also maintained that it can be beneficial not to be the leader in new technology that will become standardized. A good competitive strategy can be to observe other companies, learn from their mistakes, and wait for more information about the different standards that will be necessary. On the other hand, Tesla did the opposite of this with their electric cars, and they are very well situated in the current market.

4.2.4 Hydrotreated Vegetable Oils (HVO) Diesel

HVO diesel is made from vegetable and animal fats and reduces tailpipe emissions between 30-90%, depending on the components used to create it (Volvo Trucks, 2015). It can be used interchangeably with regular diesel in most truck engines. More than once, when asked about emissions reduction, interviewees immediately brought up HVO. Opinions differed regarding its effectiveness in terms of performing as well as diesel in a truck engine, but the point was salient enough to mention here, since it seemed to be a distraction from any potential shift to BEVs, or perhaps another part of that shift.

In 2014, the Swedish Transport Administration (Trafikverket) reported that biofuel use had risen from 9.6% to 11.4%, mainly because of the increased useof HVO (Trafikverket, 2014). During the interviews, HVO was commonly mentioned as the new and progressive method of being more sustainable. In most cases it was a sort of "gateway" to a changing industry, to doing things slightly differently. It is still new enough to be treated with suspicion by some drivers, one of whom stated the following:

"I get a little confused about HVO diesel as fuel. I don't know if it's good for the engine. I heard a lot of people get worms stuck in the engine. But that some years ago so maybe not now, anymore."

(Driver2, 2016)

This claim is unsubstantiated in terms of the research done for this thesis, but it represents the general feeling towards HVO that came through in all the interviews: it is new, it is a change, and therefore it is also a risk because the long-term effects are unknown. This interviewee in particular thought that companies should be wary of taking this risk, spending more money, before they really know what the benefits are.

In other interviews, most notably with construction company executives, HVO was touted as being a great fuel and very good for the environment, the only problem was that there was not enough of it in Sweden (Con1; Con2, 2016). HVO, according to the interviewees, is competitively priced to diesel and performs exactly the same function, with the added benefit of 90% less emissions and the green branding that can go with

4.2.5 Safety

Safety concerns during the transportation part of construction projects are one of the main reasons for creating construction logistics programmes: they are measureable, tangible issues that affect society as a whole. Safety was mentioned first by the academics that were interviewed, but all of those involved with driving and purchasing mentioned it as well during their interviews.

The drivres tended to worry about the many pedestrians and cyclists they encounter when in cities (Driver1; Driver2, 2016). Some of the interviewees were worried about the quiet motor that would come with an electric truck. Rather than citing the benefits of being able to drive during restricted hours, the interviewees worried because they thought the silence would make it more difficult for cyclists to hear trucks advancing. One interviewee in particular was very aware of the non-vehicle activity around his truck. When asked about the different services that he thought would be good to go with his truck, he said "Something that teaches cyclists to learn what a truck and a car is, and to respect them." (Driver1, 2016).

Two interviewees thought that telematics systems that help manage the speed of trucks would be beneficial, since drivers do not always obey speed limits, especially in construction sites. Volvo already offers a service called (Volvo Trucks Sweden, 2016), which can record and save the speed of trucks during their route. These interviewees were both owners of small companies, and they felt especially sensitive to this issue since their brand was on the trucks. They found it is very difficult to ensure that all driveys obey speed limits, even in more dangerous areas such as construction sites (Driver3; Driver4, 2016).

These same interviewees were also worried about the unknown aspects of safety that could come with electric trucks. Both mentioned explosions as a potential fear, although this is not something that was brought up by the interviewer and is not something that was found in the literature review. Explosions seemed for this reason to be one of the worst-case scenarios that drivers imagine, and also a representation of the lack of easily accessible knowledge about BEV trucks.

Noise and comfort for drivers came up as very important during two driver interviews. These interviewees stated that it can be difficult to recruit truck drivers because the working conditions due to the noise of the engine are not ideal (Driver3; Driver4, 2016). In addition, half of the survey respondents chose “no noise” as a reason to be open to electric trucks. However, this was contradicted by one of the other Driver interviews, who stated that the noise levels of their trucks were fine (Driver2, 2016). This suggests a need for further research into this issue.

4.2.6 Flexibility

Flexibility connects to the theme of tight margins because if a company has multiple vehicles that can do different jobs, they are able to perform more tasks on short notice, thus creating more opportunities for profit. This theme was first touched on during OEM interviews, then also with construction companies.

It is important to note that some drivers didn’t mention flexibility explicitly, but they talked about how other drivers that they work with do very different jobs, drive different distances every day, and carry different payloads. So these responses were not counted as ‘flexibility’, but they are important to note because they could relate to the physical conditions necessary for electrification.

The traditional definition of flexibility that was gleaned from the interviews and literature is a truck that is able to drive a short or long distance, with a heavy or light payload, at short notice. Therefore electric trucks, in their current state, are seen as being inflexible because they do not have a range over 150-200 km on one charge, and the battery lowers the amount of payload that is possible. Especially in the construction industry, it was clearly stated by one interviewee “ The biggest issue is flexibility. Distance, weight, what kind of terrain, and we don’t know what the job will be the next day.” (Con1, 2016).

4.2.7 Resistance to change

One of the main themes of this thesis overall is an unwillingness to accept change. The urban building and construction industry is certainly not unique in this aspect, but from the start of interviews the industry was viewed as very conservative, traditional, and unlikely to be open to any new ideas that could create new ways of operating. This was both confirmed and contradicted during the interviews and surveys.

The initial feeling that came out of the scoping interviews and when the topic of this thesis was mentioned in academic settings was that the topic would be challenging to research because the construction industry is conservative, traditional, and very adverse to change. To an extent, this was confirmed by the interviews. Fear of the new technology, worries about reliability, and a strong group mentality regarding purchasing practices were explicitly stated by many interviewees.

However, the interviews that were the most interesting regarding change came from some of the logistics and policy experts. They suggested that once actors have participated in the creation of a project those actors are much more likely to want the project to succeed. This was true with the CLOCS programme in London, where the companies helped to create the guidelines, and responded positively to the rewards system that they helped to create. To an extent this is also true of the member-driven organisations in Sweden such as the LBCs and the BLC at Stockholm Royal Seaport: these organisations rely on the adapation and success of all of their members in order to keep services running for all.

4.2.8 Fuel Theft

Fuel theft was not mentioned in many interviews, but it was a very important problem when it came to light. Fuel tanks that are sitting on a construction site are vulnerable to theft in a way that electricity is not. In some cases, these tanks are not only vulnerable to break-ins, but also to theft from employees, depending on the monitoring system in place. Electricity as fuel would easily solve this problem.

4.3 Truck Driver Interviews: Theme frequency between interviewees

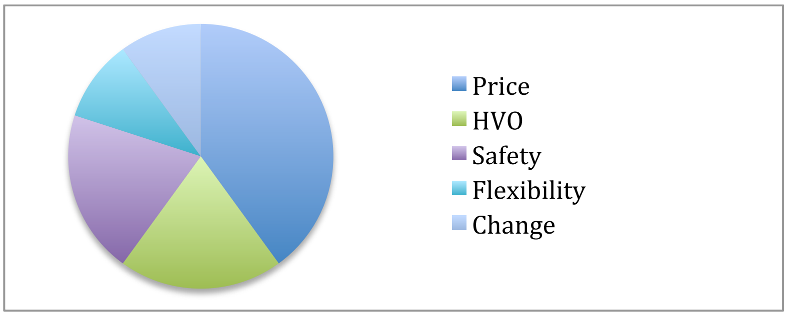
The following graphs depict the different number of times each interviewee mentioned each theme, with the goal of showing which other factors are important to drivers. Directive content analysis was used to analyse these interviews again, independently from the other 16. As stated in the Methods section, this is because there was already much existing data suggesting that truck drivers were not interested in electric trucks, mainly due to the high initial purchase price. Directive content analysis, in this case, helps to further examine why and how price is so important to drivers in this context, and what other themes also affect their decision-making.

The data is displayed in individual interviews because some of the interviews were longer than others due to different time availabilities on the part of the interviewees, and it also was useful for the research to use the time to collect as much data as possible. This means, however, that if theme frequency was to be compared between interviews the representation would not be accurate, since some interviewees had the opportunity to mention themes many times, and some did not.

These interviews will be analysed further in the discussion section, but it is important to mention here that since each driver had their own individual style, in some cases a theme was not mentioned directly, but it was counted. For example, the word 'flexibility' was mentioned many times, but there were also times when drivers spoke about the different jobs that they need their trucks to be able to do, without directly mentioning flexibility.

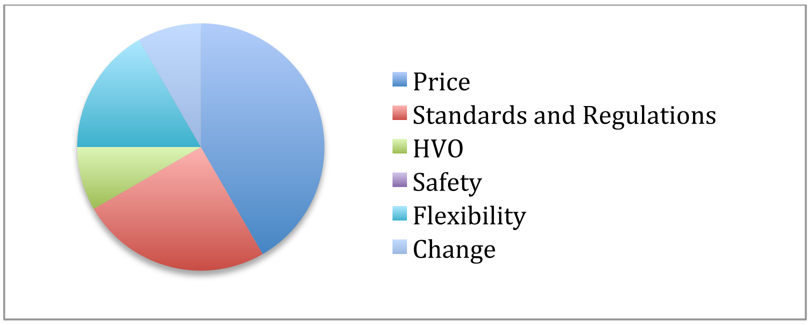
When drivers were responding to a specific question, such as "Are there many cyclists on that route?" an over-emphatic response was not counted towards a theme. For example, if a driver responded "Oh yes, cyclists are everywhere!" this could be interpreted as a safety issue, but since it there was no mention of the danger that cyclists incur to themselves or others, this was not counted.

Figure 18. Driver 1 Theme Frequency



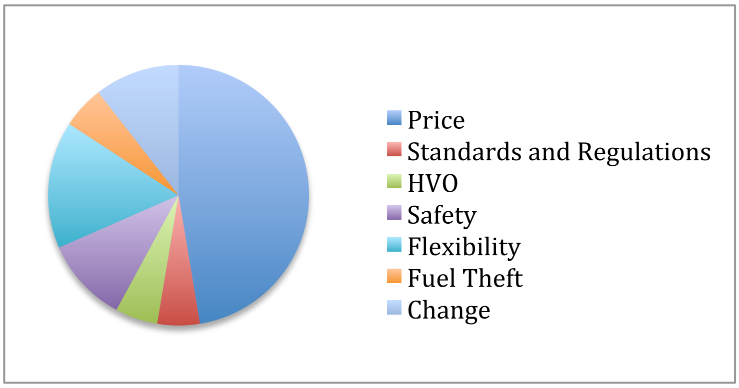
The interviewee in Figure 18 did not make any mention of fuel theft or standards and regulations. They did talk at length about safety and HVO.

Figure 19. Driver 2 Theme Frequency



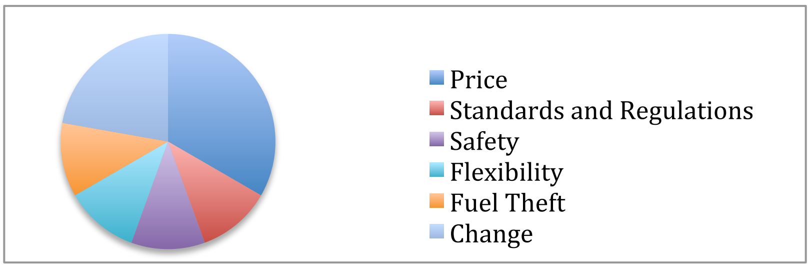
The interviewee in Figure 19 did not mention fuel theft and safety, despite mentioning cyclists and pedestrians multiple times.

Figure 20. Driver 3 Theme Frequency



The interviewee in Figure 20 mentioned all topics, with a strong emphasis on price.

Figure 21. Driver 4 Theme Frequency



The interviewee in Figure 21 mentioned all themes, with a strong emphasis on pirce, and also a strong emphasis on the different changes that electromobility would represent in the urban construction and building industry.

4.4 Physical Conditions Findings from Interviews

The physical conditions of a route are very important when deciding on if an electric truck is appropriate for the given tasks (OEM1; OEM6, 2016). The urban building and construction segment was already known from the literature review to have the potential for BEV trucks, especially with the development of CCCs. But in order to better understand the specifics of how the working day of a truck driver would change if they were to have a BEV, it was necessary to ask drivers a set of questions that targeted the details of their everyday routes. These questions are in Appendix 2. Other interviewees also mentioned physical conditions, as can be seen from Figure 17, but they were not asked the same long, specific list of questions.

The physical conditions questions were direct and were meant to help verify the concept that some routes that truck drivers take into and out of urban construction sites could be good for electric trucks, based on the specific parametres that already exist such as distance between points, time spent unloading, and payload needed. The responses from these questions were added to the data from the interviews and literature review, resulting in the following examples as being good potential candidates for electric trucks.

Truck Mounted Attenuator (TMA) Vehicles

These vehicles are necessary at every construction site to direct traffic, and are required by municipalities (Driver3, 2016). They carry a large electric sign with an arrow for this purpose, and generally move very slowly. They drive few kilometres per day, and do not go very far from the depot.

Waste Trucks for Tunnels

Tunnels are often constructed in urban spaces for metro systems or other underground transportation. The removal of rock from the tunneling operation sometimes takes place at night, when noise from the acceleration of diesel trucks is very unwelcome and sometimes forbidden in cities. These trucks go from the site of the tunnel to a site outside the city, where the sound of the rock being unloaded is not problematic because the area is not urban (Con4, 2016). These trucks do not go very far, but their payload is very important. They are usually subcontracted, and the owners of the trucks want to maximize the amount of rock that they move (Con4, 2016). The payload issue would be a challenge for an electric truck, under the current battery/payload specifications.

West Link Tunnel Project

The West Link project is a planned railway expansion in and around the city of Gothenburg. It will include 8 km of new tunnels, 6 km of which will be underground (Brunbäck, 2014, p. 5). West Link will ease transportation issues both within the city of Gothenburg, and the larger area of Western Sweden. The funding for the project is from both regional and national sources, and in total is estimated to be approximately 20 billion SEK (Brunbäck, 2014, p. 5). Construction is planned to start in 2018 and finish in 2026, and Trafikverket has already started the procurement process for contractors.

One important part of the construction project will be the excavation of rock and soil management. This represents a good opportunity for electric trucks because it is a publicly funded project, and the procurement is very strict and focussed on ensuring a calm construction process for those living nearby. Electric trucks could remove stone from the tunnels at night quietly, which would reduce congestion in Gothenburg city during the day.

Trucks Used with CCCs

As is discussed in the Literature Review, CCCs create efficient, short routes and tight schedules for trucks that would create the ability to plan ahead for charging of a BEV. In some cases, such as the Stockholm Royal Seaport, CCCs are engaged with municipalities and can receive financial aid for the purchase or lease of a BEV. Stockholm Stad has expressed interest in helping Stockholm Royal Seaport with the purchase of a BEV, but their truck suppliers have yet to offer anything that would be appropriate for the project in terms of payload. In the future, when the technology is economically feasible, this could become a more realistic option.

Crane Vehicles

Trucks that have cranes on the back to unload goods into houses make short trips around cities a few times per day (Driver4, 2016). Payload is not crucial for these trucks, and lowered emissions and noise would be beneficial since they operate in residential, urban environments. Range is also not too important for these trucks, and they tend to do the same application all the time (Driver 4, 2016).

4.5 Background on the survey

This was a paper-based survey that was handed out to members of the construction company Cliffton AB. The survey underwent much different iteration, starting with an original version that was 25 questions. After a very limited response to this survey, a new survey was created with an introduction designed to draw the respondent in by explaining how the research was going to be used for a thesis project at Lund University in partnership with Volvo Trucks.

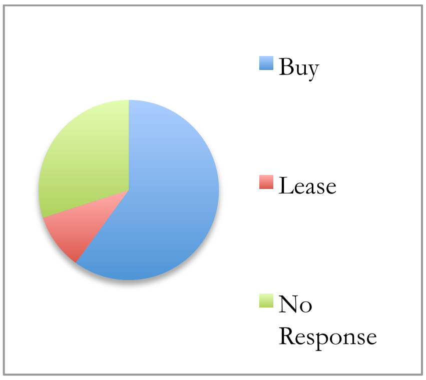
The initial longer-form survey was tested with different classmates and family members, including family members who work currently or who have worked in the past with heavy duty trucks. The purpose of this testing was to ensure that the survey questions were clear, and that the questions were also relevant to those in the construction industry.

A great deal of effort was put into making sure that the survey was not too long, because the qualitative research up to this point made it very clear that truck drivers have very strict schedules and therefore would likely not be interested in taking the time to do a survey. Once the initial 25-question survey yielded only two responses after three weeks of being available to respondents, the shorter survey was created and yielded a much stronger sample of 21 responses (approximately 25% response rate).

Survey Results

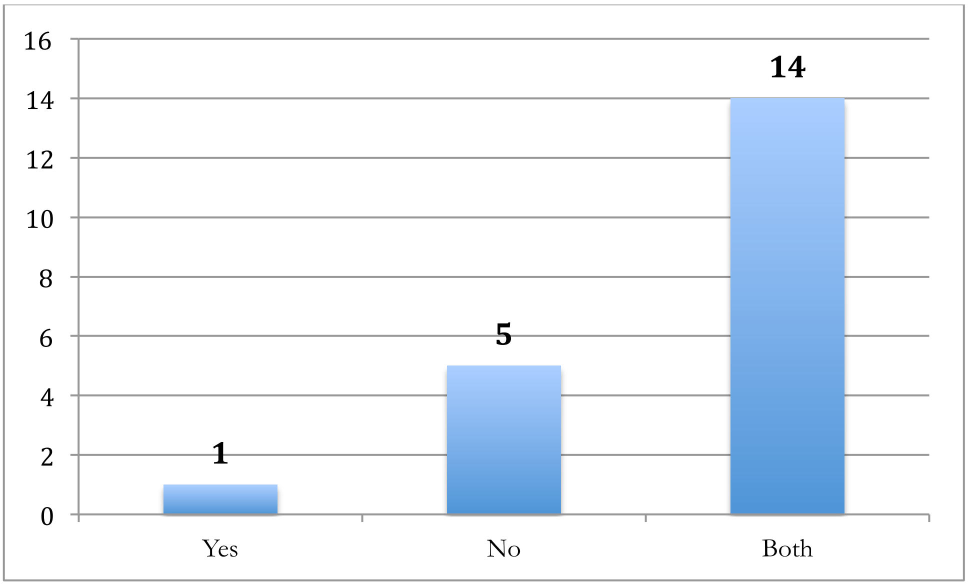
Of the 21 people who completed the survey, six identified themselves as owners, 12 identified themselves as drivers, two as CEOs, and one as the site manager. One survey was removed because the driver specified that they drove long distances, rather than specifically for construction.

Figure 22. Buy or Lease Pie Chart



In Figure 22, we see that the majority of respondents would rather buy than lease a truck. More than a quarter of the respondents did not respond to this question. This could be because they are not involved in the decision-making process, but this is not possible to know with any degree of certainty. The surveys offered no chance to elaborate on the reasoning behind this, but this tends to match the industry norm that was agreed on in most interviews, that owning truck is more traditionally preferable than leasing them. This was confirmed verbatim in one interview when the respondent said "We are traditional, not big enough to lease" (Truck Driver 3, Interview, 2016).

Figure 23. Responses to the question: "Are you open to electric trucks?"

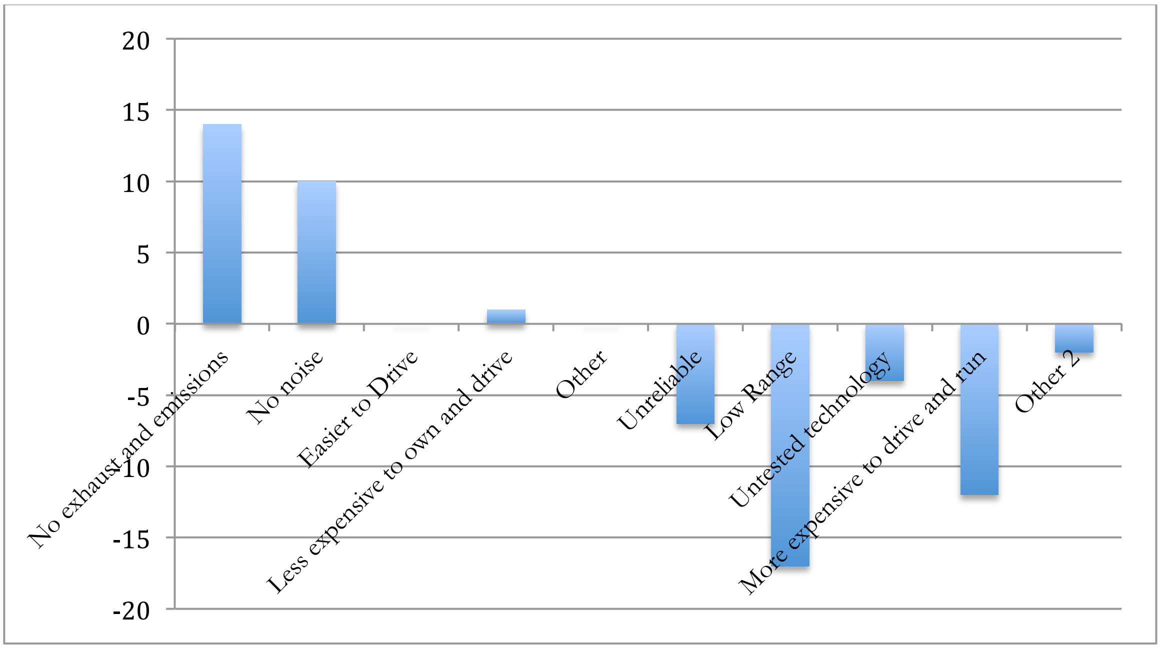


In Figure 23 there is a display of the responses to the survey question "Are you open to the idea of electric trucks?". This question, which is listed in the survey in Appendix 1, offered respondents the opportunity to say yes and no, and then choose from a list of answers or write their own unique answer to the question. The vast majority chose both yes and no, or rather, these respondents found reasons for why they could be open to electric trucks, and reasons why they would not be open to electric trucks. As we see from the graph above, there was also one respondent who simply said yes, and 5 respondents who said no.

Figure 24 below breaks down these numbers more finely to see how many times respondents chose the given reasons, or offered their own reasons for saying yes or no. This graph shows that while there was a total of 25 times that respondents picked a 'yes' reason, there were also a total of 42 times that they picked a 'no' reason. Futhermore, it was a negative reason, low range that was picked the most times of any reason.

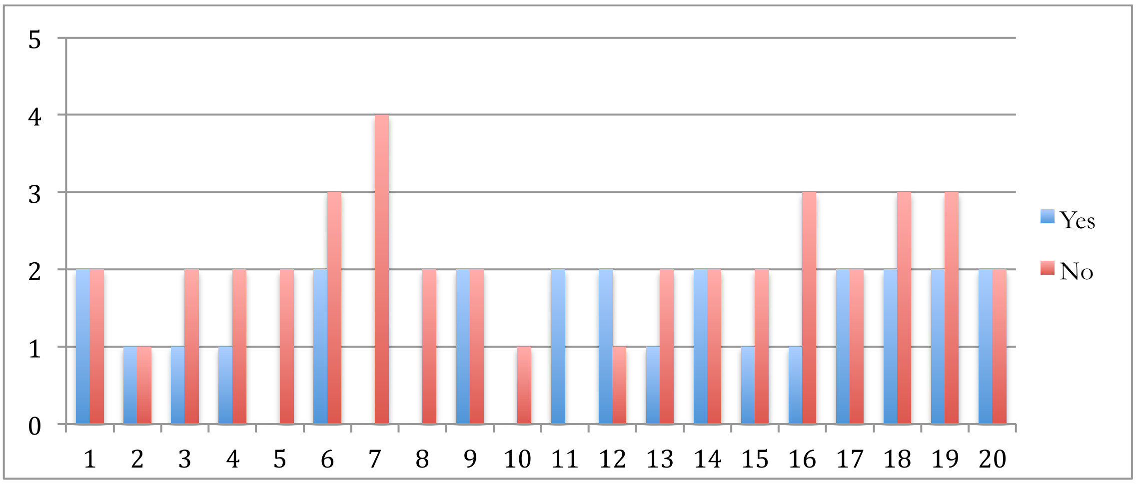
However, this graph also shows that no exhaust and emissions were picked more times than more expensive to drive and run, which was originally thought to be the most important negative answer. It also shows that low noise was picked more times than unreliable, untested technology, and 'other' (where respondents gave their own unique negative reason). Finally, Figure 24 does also show that more expensive to drive and run was picked more times than no noise and less expensive to own and drive, showing that it is still a salient point. Likely because none of the respondents had the opportunity to drive a hybrid or electric truck, no one picked easier to drive as a positive reason.

Figure 24. Reasons for yes or no response



In Figure 25 the answers of each individual respondent are compared, with the 'yes' reasons in displayed in blue and the 'no' reasons displayed in red. This graph shows that the of the 20 respondents, one had only positive reasons towards being open to electric trucks, one had more positive than negative reasons, and six had the same number of positive and negative responses. Of those who had a higher number of negative reasons, 4 respondents had a 2:1 negative: positive ratio, three had a 3:2 ratio, and one had a 3:1 ratio. The remaining respondents chose negative reasons only, and of those two respondents chose 2 negative reasons, and one chose 1 negative reason.

Figure 25. Individual yes and no responses



5 Discussion

5.1 Price

Often this comes back to the bottom line of the difference in initial purchase price between a BEV or a diesel vehicle, but the nuances that surround price and subsequent profits are important as well. The initial statement of "Yes they can buy it, if they get paid for more it" (Con1, 2016), may change when other services are brought into the picture, or when the value chain is tweaked to allow companies to make more for the services offered with an electric vehicle. Truck companies are not the end customer in the urban building and construction value chain, and they have very strict guidelines for what they need to be able to offer the end customer. Thus if they are going to spend more money on transportation, appropriate changes need to be made in the value chain. This could mean that the end customer pays more for the service being provided to them by the BEV; for example a municipality might pay a premium to have a silent truck used to deliver renovation matierials to a project in a residential area.

Buying will likely continue to be the dominant form of truck acquisition, but leasing does offer more opportunities for services that could make BEVs more profitable for OEMs. This will have to be taken into consideration by OEMs in the future as they create new sales strategies. Currently, the idea of a BEV seems to be more of a liability than an asset in the traditional sense that a diesel truck can be considered an asset (Driver3; Driver4, 2016). In order for OEMs to mitigate this wariness towards BEV technology, services that help drivers adapt to the technology could be offered. These could include training on how to optimize driving and maintenance of the vehicles, how to use any included software, how to best charge and treat the battery, and general tips about the differences between BEVs and diesel engignes, to dispel any myths or unwarranted fears that drivers may have. Furthermore, in the case of LBCs or mid-size construction companies, if the company takes the initial risk to purchase a BEV, this can be a step towards acclimatizing drivres to the idea of using an electric vehicle without also asking them to make a financial sacrifice.

Once the drivers are comfortable with the technology, they may consider a lease or purchase themselves. Another interesting option here could be an after-market potential where LBCs or companies sell slightly-used BEVs to drivers who are interested in the technology. The different PSS business models that were mentioned in the Literature Review could also be considered: a Product-Oriented truck lease, a Use-Oriented service contract, and finally the potential for more Function-Oriented offers in the future, such as vehicle sharing.

Finally, the TCO will change depending on the financing of the truck. If the truck is leased, these costs could be amalgamated into a monthly cost, with extras for larger repairs or emergencies. Also, this is where the benefit of electricity prices would come into the picture: electricity costs less than diesel as a fuel, which would be a crucial selling point for OEMs to highlight when discussing TCO with potential customers.

5.2 Policies and Projects

Both the literature and the interviews showed that in order for policies and projects related to electric trucks to be successful, they must have government support (IEAa, 2016; van der Slot et al., 2016). From the customer side, there is fear regarding the technology. From the OEM side, it is impossible to create prototypes without the demand. From the government side, information regarding what types of vehicles are available, and their environmental benefits, is crucial to matching new technology to the success of future low-emissions policy.

At the European level, FREVUE is a good example of a project that is creating small changes at the municipal level in different countries. But more can be done by local governments in cities such as Stockholm and London to engage with OEMs. These types of partnerships help to determine the best possible vehicles not just for projects today, but in 5-10 years from now.

For the urban building and construction industry specifically, the different actors along the value chain all need to be brought together in discussions. Subcontractors who cannot take the risk of purchasing or even leasing new technology need to be made aware of the programmes that can allow them to try these new trucks without risking profits. The benefits of these experiments will come to the smaller players in the value chain when they are well informed about the available technology in the coming years, when they have to contend with stricter LEZs.

In Sweden, LBCs are an excellent opportunity for one-truck companies or other small players to become accustomed to PHEV or BEV trucks. CCCs, such as Stockholm Royal Seaport, also represent a good chance for companies to be exposed to the new technology, and for the logistical benefits that come with CCCs to be used for charging stations and other technical requirements.

5.3 Flexibility

The construction industry is ruthlessly competitive and for the most part, price is the main factor that wins a tender and every minute is valuable, so a truck that has to be stopped for one hour to re-charge will be a huge disadvantage to any company. This is the reality under the current system.

But, as the system changes, so too could the idea of flexibility. For example, in inner city areas, like the Stockholm Royal Seaport, there is more and more pressure on low noise, low emissions vehicles that will not bother the locals. Being able to offer a truck that is quieter and cleaner is suddenly a new form of flexibility: being flexible under the changing rules and regulations that will govern the construction industry in the future. London's ULEZ also represents a good example of this: an electric truck qualifies as "ultra low emissions" and can be used for any project within the ULEZ.

This new flexibility is reliant on governments and developers setting new standards and regulations that companies have to abide by, and it is also reliant on construction consolidation centres creating logistics that allow for shorter distances on strict schedules, so that charging can be planned for. But this also represents another new flexibility: adhering to the systems of these logistics centres, either the CCCs in London or the BLC in Stockholm, or the others that will follow. Electric trucks can enter into the storage areas without creating local emissions for workers, and the schedules of the logistics centres will go well with the schedules that the trucks must keep to in order to maintain their batteries Level of Charge. There is a lesson to be learned from the success of electric busses here, where the strict schedules allowed for clear charging times.

5.4 HVO

The drivers were less interested in the green branding, although one of them mentioned that it would depend on what the customers wanted. This leads to the salient point regarding HVO: if there is enough pressure from some direction, be that higher-level executives in construction transportation companies, customers, or municipalities, HVO is a fairly safe, available possibility for change in Sweden.

The important follow-up question to this is: will HVO be able to act as a gateway to larger change? Does the phenomenon of using a new and untested fuel open drivers and other actors in the construction industry to the bigger risk of electrification? Based on the answers given by the drivers who were very unsure of HVO, the researcher would argue that yes, it does. If the big fear is change, regardless of whether or not it has been verified as safe or not (which in the case of HVO, it has), then taking one risk will help to alleviate that fear, and maybe even encourage an interest in further risks, if the benefits are seen to be good. The key will be positive encouragement, from customers most likely, that using HVO or taking other outside-the-box steps is a good move for business and a positive way forward.

5.5 Customer Interpretationt test

The drivers and construction companies were analysed in the following table to better understand their customer perspective on the value proposition of electric trucks for urban building and construction. These actors react very strongly to the opinions of their peers, and also work in an industry with very small profit margins. Therefore buying trucks based on industry norms and known operational capabilities is a very rational choice. In order to think about creating a new industry norm of BEV trucks, which remain untested, Volvo and other OEMs should consider a combination of public private incentive programmes and new branding strategy, as well as the offer of a lease with a service contract. Table 2 analyzes these ideas in the context of the data that was collected from truck drivers and construction companies, who represent the customers that data was collected from.

Table 2. Interpretation test for Customer responses.

Customer	Doxastic (Customer)	Normative (Group)	Secondary Interpretation (Researcher)	Final
Drivers	Varying levels of uncertainty towards electric trucks, some were completely negative, and some had positive reactions when the idea was combined with services.	All drivers mentioned that their industry is conservative, and changes would be difficult to accept. Drivers talk to each other during the buying process, so group think is reinforced.	More options for companies to take part in pilot projects and receive training and information about electric trucks.	Services contracts that train drivers and assuage fears.
Construction Companies	Three of the four interviewed were very interested in environmental goals.	Small margins, maximum payloads and tight schedules characterize the construction industry.	Construction companies are interested in making progressive environmental decisions, but they are very wary of taking financial and operational risks.	Government programs to help finance, and to facilitate communication between OEMs, developers, construction companies, and government on new regulations.

5.6 Pains, Gains, and the Policy Context

5.6.1 Pains and Gains

The pains that stood out during the interviews, supported by the survey data and literature review, were noise, tight margins, the price of fuel, change, the risk of accidents, and an uncomfortable working environment. The gains that drivers would like to experience were steady profits, safe conditions, and adaptation to changing conditions. The last gain, adapting to changing conditions, includes the awareness from drivers that regulations and standards are constantly changing, and it is important for them to stay updated on these. This is interesting because it goes against the general fear of new, untested technology – the difference seems to be that when there is no choice, companies will make the changes because they feel they have to. In this equation OEMs can help companies to make the change by offering the vehicles, while municipalities, contractors, and national authorities set the initial standards.

5.6.2 Gain Creators and Pain Relievers

The gain creators that can be offered include pilot project or other temporary training programs that give customers information and allow them to establish trust regarding the new technology. Customers who are willing to lease or purchase the trucks can also have the option of green branding. Finally, government programs can be leveraged to help with initial financing so that there is enough demand and OEMs are financially able to produce electric trucks.

The pain relievers that can be offered through the value proposition of electric trucks start with Product Service System (PSS) leasing contracts that allow for monthly set costs with the price of elecitricty included. This addresses tight margins and the price of fuel, and also mitigates the chances of fuel theft. The vehicles could be silent and zero-emissions, therefore classified for any Low Emission Zone, and would be able to operate at night or in sensitive areas, thus relieving the pain of stricter regulations. As part of a PSS lease plan, OEMs could offer telematics systems and training to help with safer driving – many companies do this already, but the service could be re-marketed and adjusted as necessary for electric trucks.

5.6.3 Policy Context

Another interview brought up the point that once customers have used technology, they are much more likely to trust that technology. Thus they may be more open to purchasing or leasing it. One interviewee was quoted as saying:

> "*It's always a thing with a community, with all of us. Concerns are bigger when we don't know about things, how they work. When we have used something, we become certain that it's a good thing.*"

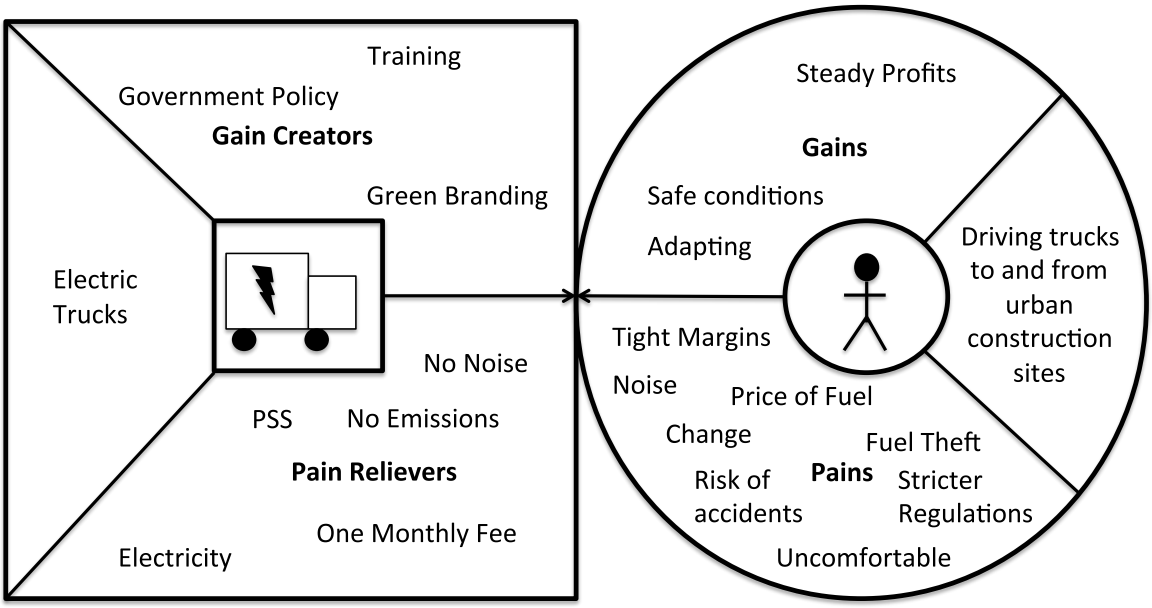
(Logistics3, 2016)

This 'community' can be interpreted as the companies that are members of an LBC, but it can also be expanded to include OEMs and municipal governments. OEMs can help with the communication regarding the new technology, explaining not only how it works but also the best financing options and services that make the transition easier. Municipalities can incentivize the uptake of new technology through projects like the Stockholm BLC, and also through the creation of new regulations such as LEZs that call for low-emissions and low-noise vehicles.

These pilot projects or other support mechanisms from government can also represent a chance for customers, that is LBCs or construction companies, to use green branding and see how it affects their customers and their business before they purchase or lease a truck.This way customers can see if the branding actually can translate into profits and a competitive edge before they make a purchase.

Figure 26. Thesis Value Proposition canvas

*Adapted from (Osterwalder et al. 2014, pp. 36-37)



6 Conclusion

6.1 Conclusions

The research questions that were set to guide this research at the beginning of this thesis were the following:

> **RQ1:** What are the major customer pains and gains for truck customers in the urban building and construction sector, and why?

This question was answered with the VP canvas above, but it bears repeating here to remind the reader about the methods used. The most important pains that were identified include noise, tight margins, the price of fuel, change, the risk of accidents, and an uncomfortable working environment. The most important gains included steady profits, safe conditions, and adaptation to changing conditions. The VP canvas is ultimately customer-focussed, and much of the research centred around interviewing and surveying potential customers, and those who influence or work with them. The findings suggest that customers are very comfortable with the status quo, but they desire the profits that come with constant adaptation to the changing policy context that may eventually make electric trucks competitive.

Henry Ford's quote that a customer would have asked for a faster horse, rather than a new, modern car, is important to remember here. It can be difficult for customers to anticipate future pains and gains, but it was evident in interviews that although customers are adverse to change, they also realize that is inevitable. Standards and regulations will become stricter, and truck customers want to be able to compete in the new policy context. As was also mentioned in the introduction, these customers do not just want a horse. They want the new technology, but they also want support as they start to use it. This is where the next research question comes in.

> **RQ2:** What are the gain creators and pain relievers that can OEMs offer customers through a Value Propsition that includes electric trucks?

It is important for any policy maker or OEM to understand that the uptake of this technology relies not only on customer willingness to pay. The uptake of electric trucks in urban building and construction also relies on customers trusting the operational capabilities of the technology. In order for this trust to be established collaborative research is important, starting with the interviews and surveys done in this thesis. Customer involvement in any project, to design, pilot, or finally sell these trucks is crucial.

The pain relievers that can be offered through the value proposition of electric trucks start with Product Service System (PSS) leasing contracts that allow for monthly set costs with the price of electricity included. This addresses tight margins and the price of fuel, and also mitigates the risk of fuel theft. The vehicles could be silent and zero-emissions, therefore classified for any Low Emission Zone, and would be able to operate at night or in sensitive areas, thus relieving the pain of stricter regulations. As part of a PSS lease plan, OEMs could offer telematics systems and training to help with safer driving – many companies do this already, but the service could be re-marketed and adjusted as necessary for electric trucks.

The gain creators that can be offered include pilot project or other temporary training programs that give customers information and allow them to establish trust regarding the new technology. Customers who are willing to lease or purchase the trucks can also have the option of green branding. Finally, government programs can be leveraged to help with initial financing so that there is enough demand and OEMs are financially able to produce electric trucks.

> **RQ3:** How can government policies encourage the electrification of trucks used in urban construction?

The gain creators and pain relievers that are stated in the VP canvas rely in part on partnerships with government as well. Both urban building and construction, and electric trucks involve complex value chains, and government programmes can help to target different actors in those value chains with financial or other support. This in turn can help generate demand, which can give OEMs the financially capability to produce electric trucks.

The different government policies and projets mentioned in this research offer a good start towards creating this kind of support, but it is important to consider the diversity of political and infrastructure systems in question. In reality, every country has a different policy context, and so programmes such as FREVUE at the continental level will be very important for the uptake of electric trucks. In contrast, urban building and construction industries differ from country to country, as the existence of LBCs in Sweden shows. Thus governments must be ready to create strict legislation at the local level that will encourage the use of electric trucks within cities, but also communicate multilaterally at the global level to share information and create consistent infrastructure. OEMs cannot afford to build electric trucks one at a time for pilot projects; they must have a larger demand that comes with wider international support.

In conclusion, this thesis determined that electric trucks can be part of a VP that offers many gain creators and pain relievers to customers in urban building and construction sites, but there are many challenges before customers will think seriously about purchasing or even leasing a BEV. First, the pricing issue must be tackled either through government incentives or leasing service contracts. Second, existing efforts to shift towards electromobility in construction must be supported, through public funding or municipal regulations that make tenders more competitive for companies with electric vehicles. Finally and most importantly, clear communication from OEMs, government, and construction company executives is needed to demonstrate the safe, efficient benefits of electric trucks, and dispel unwarranted fears.

6.2 Reflections

This research uncovered many areas that would benefit from future research, including but not limited to: the different specific applications of BEV trucks in CCCs, how larger companies can support the uptake of new technology by taking some of the financial risk and allowing their sub-contractors or members to test the new technology, and how local governments can benefit from EU or other funding to create public/private partnerships that pilot new technology which can meet new emissions standards in cities.

The research methods that were used for this thesis were appropriate for collecting primary data from actors in the urban building and construction sector. However, a comparison to another context would be interesting to do as well. Specifically, this area of research could benefit from a detailed comparison between the LEZ policies in London and Stockholm, together with the context of CCCs and LBCs in Sweden and England. This could create a deeper understanding of the different decision makers in the urban building and construction value chain. Mapping the pains and gains of each actor in the value chain could help OEMs and municipal governments to create programmes that are best suited for the urban building and construction industry, thereby creating the most optimal conditions for the uptake of electric trucks.

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7.1 Interviews

Construction Industry Experts

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Con2. (2016). *Personal Communication.* June 27th, 2016.

Con3. (2016). *Personal Communication.* July 11th, 2016.

Con4. (2016). *Personal Communication.* August 31st, 2016.

Truck Drivers

Driver1. (2016). *Personal Communication.* July 18th, 2016.

Driver2. (2016). *Personal Communication.* July 19th, 2016.

Driver3. (2016). *Personal Communication.* July 26th, 2016

Driver4. (2016). *Personal Communication.* July 26th, 2016.

Logistics Experts

Log1. (2016). *Personal Communication.* June 20th, 2016.

Log2. (2016). *Personal Communication via email.* August 9th, 2016.

Log3. (2016). *Personal Communication.* August 26th, 2016.

Original Equipment Manufacturers (OEMs)

OEM1. (2016). *Personal Communication.* May 30th, 2016.

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OEM6. (2016). *Personal Communication.* June 3rd, 2016.

OEM7. (2016). *Personal Communication.* June 16th, 2016.

Policy Experts

Policy1. (2016). *Personal Communication.* July 11th, 2016.

Policy2. (2016). *Personal Communication.* July 12th, 2016.

Policy3. (2016). *Personal Communication via email.* June 27th, 2016.

Policy4. (2016). *Personal Communication via email.* July 18th, 2016.

Policy5. (2016). *Personal Communication.* September 5th, 2016.

Policy6. (2016). *Personal Communication.* April 2016.

8 Appendix

8.1 Appendix 1: Survey in Swedish

Enkät om intresse för elektriska lastbilar inom en nära framtid

Hej,

Jag heter Ella och läser Miljövetenskap på Lunds Universitet. Under sommaren gör jag mitt examensarbete för Volvo Lastvagnar. En del av arbetet handlar om att undersöka potentialen för elektriska lastbilar i stadsmiljöer i framtiden.

Jag skulle verkligen uppskatta om du har möjlighet att svar på några korta frågor. Dina svar kommer att behandlas anomymt. Jag skulle behöva **dina svar senast 29 juli.** Var snäll och lämna tillbaka denna undersökning till Linus på kontoret i Helsingborg eller skicka den till linus.jonsson@cliffton.se .

Skulle du vara intresserad av att ta del av resultaten från studien, kan du gå in på www.iiiee.lu.se till hösten.

Stort tack på förhand

Ella Rebalski

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1. **Vilken position har du inom företaget?**

2. **Vilken typ av arbete används din lastbil till?** *(ex. grustransport till vägarbete)*

3. **Vänligen ange vilken ålderskategori du tillhör:**

a. 18-29 b. 30-39 c. 40-49 d. 50-59 e. 60-69 f. >70

4. (endast för lastbilsägare) **Föredrar du att köpa eller leasa lastbilar?**

5. **Skulle du vara intresserad av att ersätta din befintliga lastbil med en elektrisk, och varför/varför inte?** *(Vänligen kryssa för alla de alternativ som du håller med om)*

a. Ja, för att det innebär…

O inga avgaser och utsläpp
O inget buller
O lättare att köra
O billigare att äga & köra
O annat *(Vänligen beskriv på baksidan av papperet)*

b. Nej, för att ...

O de är opålitliga
O de inte kan köra långa distanser
O de har oprövad teknologi
O dyrare att äga och köra
O annat *(Vänligen beskriv på baksidan av papperet)*

8.2 Appendix 2: Physical conditions questions for Truck Drivers

Topography

- How many hills?
- How steep are the grades?
- How long are the hills?

About the truck

- What is the truck model?
- What kind of body does it have?
- What kind of equipment and Auxiliary PtO does it have?
- What is the Gross Vehicle Weight?
- What is your payload?
- What is the payload needed?

About the trip

- Where do you start and end the trip? Is it a loop?
- How many stops are there on the trip?
- What is the distance between stops, and distance overall?
- What is the time that it takes you to drive between the stops, and time overall?
- How much time do you spend idling during the trip and unloading at the destination?

Traffic

- How many traffic lights (approximately) do you go through?
- Do you have many starts and stops? (not just traffic lights but also stop signs, roundabouts, crosswalks, etc)
- Are there congested roads?
- Do you go on the highway?
- Are there busy roads with lots of pedestrians, cyclists, other types of vehicles?
- What type of city, and which part of the city, do you drive in?

Geography

- Can it be very hot or very cold?
- Are there lots of bridges?
- Tunnels?
- Lakes or other geographic formations make the route longer?
- Is there any kind of weather pattern that is usual for the route?

Lunch Break

- Do you always take your lunch break in the same place?
- If yes, where? If no please explain.
- Are there many other trucks in this location at this time? Throughout the day?
- How long is your lunch break?
- How many hours into the shift is it?

8.3 Appendix 3: Raw Interview Data

These tables show the method used for coding themes that were found in the interview transcripts using qualitative content analysis. A '1' means that that interviewee mentioned the theme, which is represented by a number in the top row. A '0' means that the theme was not mentioned.

Urban Building and Construction Interview raw numbers

Interview	1	2	3	4	5	6	7	8
OEM1	1	1	0	0	1	0	0	0
OEM2	0	1	1	0	0	0	0	0
OEM3	0	0	1	1	0	0	1	0
OEM4	0	1	1	0	1	0	1	1
OEM5	0	0	1	0	1	1	0	0
OEM6	1	1	0	0	0	0	1	1
OEM7	0	1	1	0	1	1	0	0
Logistics1	0	0	1	0	1	1	0	0
Logistics2	0	0	1	0	1	0	0	0
Construction1	0	0	1	0	0	0	1	0
Construction2	0	1	1	0	0	0	0	1
Construction3	1	1	1	0	1	0	0	0

Figure 27. Policy Interviews raw numbers

Interview	1	2	3	4	5	6	7	8
Policy 1	1	0	0	0	0	0	0	1
Policy 2	1	1	0	0	0	0	0	0
Policy 3	0	0	1	0	0	0	0	0
Policy 4	1	0	1	0	0	0	0	0

Figure 28. Truck Drivers raw numbers

Interviews	1	2	3	4	5	6	7	8	9	10
Driver 1	1	1	0	1	0	0	1	0	0	1
Driver 2	0	1	0	0	1	0	1	0	0	1
Driver 3	0	1	0	0	0	0	1	1	1	0
Driver 4	0	1	0	0	0	0	1	1	1	0