Feasibility study of the electrification of the urban goods distribution transport system, part 2

Project within FFI Efficient and Connected Transport systems

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1. Executive summary

Based on the results from FFI project Feasibility study of the electrification of the urban goods distribution transport system (Vinnova reg. no. 2011-01803), this project aimed to investigate how urban goods distribution fleets can be electrified and how new logistics solutions and incentives can influence the transition in a positive way, considering the year 2015, 2020 and 2025.

The project is divided into five work packages (WP). The purpose of the first work package, WP1 Fleet Electrification Study, was to evaluate at what rate it is possible for urban goods distribution fleets to become electrified. WP2, Service Impact Evaluation, is a description of ICT services to support electric trucks for goods distribution in cities. The purpose of WP3, Comparative Fleet Electrification Case and Best Practice Investigation, was to compare the electrification case for TGM/Bäckebol in Gothenburg to a reference case in France and to the findings from research and demonstration projects within Europe. WP4, Method Description, package had two purposes. First, it aimed to broadly describe, from a project management perspective, how the project was executed. Second, it presents a review of the project based on the members' views on how the project was conducted. Finally, WP5, Project Management, included the operative project management activities in the different work packages as well as administrative work such as financial reporting and communications on project progress and results.

The project results show that it is difficult for the EVs to compete in 2015 considering a replacement of the diesel trucks with all-electric trucks. However, in 2020 the switch to an EV produces a small profit. This positive outcome for the EV is repeated in 2025 over 8 years of operation. Comparing the results, the two shifts solution never did get financially competitive with the diesel vehicle used in one shift. The reason for this was that the cost of unsocial hours was greater than the benefit of increased utilization of the EVs. Keeping the amount of unsocial hours down, while maximizing the utilization rate of the EV is therefore paramount. In other cities than Gothenburg, where congestion causes severe delays, the efficiency gained by distributing goods off-hours might balance the higher salary costs.

The starting point in both the previous and in this project was the introduction of new technology to reduce the negative environmental impact of transports. As the project progressed it became clear that many parameters, other than strictly technological ones, influence the possibility to make a transition to electric distribution. One example, as described above, is the case of off-hour distribution, where the increased salary cost was too high to make the business case profitable. Another example is the limited range of electric vehicles. As the cost competitiveness of electric vehicles benefit greatly from specialization, the business relationship between the transport operator and the shippers becomes more important than in the case of a diesel vehicle. Long term assignments with well-defined transport routes are preferable to be able to use the vehicles long term and dare to take the higher investment cost.

2. Background

The results from the FFI project “Feasibility study of the electrification of the urban goods distribution transport system” indicates that there is reason to expect a gradual transition from conventional vehicles to electrified commercial vehicles within the time period 2015 to 2025. During this period electrified trucks are predicted to become cost competitive from a TCO perspective in several urban good distribution applications. Since vehicle utilization is seen to be critical for establishing the business case, the transition to electrified vehicles can be expected to go quicker for urban vehicles with high yearly mileage and/or high energy use per kilometre, e.g. city buses and refuse trucks.

The feasibility of electric and hybrid trucks for city distribution relies on finding the right balance for the route distance of each shift and the frequency of battery charging. Added to that, it is important to maximize the usage of the truck to balance the high initial cost to a relatively low running cost.

Additionally, ICT and business model innovations will have an important role to support the development in the transition period in minimizing financial risks and uncertainties experienced by the vehicle customers. Furthermore, authorities at all levels (local cities to national) need, in the short term, to increase the understanding of the benefits as well as the limitations of electrified urban vehicles and develop policies supporting (i) the unique modes of operation zero tail-pipe emission can offer and also (ii) high vehicle utilization.

Considering these results, there was a need to further study the implementation of electrified urban goods distribution. It was necessary to investigate not only the technical aspects of vehicles and the costs, but also how the benefits with electrified vehicles (zero-emissions and low noise levels) can be used to their advantage. This should be considered from a fleet perspective to realize the full potential of electrified trucks.

3. Objective

Based on the results from FFI project Feasibility study of the electrification of the urban goods distribution transport system (Vinnova reg. no. 2011-01803), this project aimed to investigate how urban goods distribution fleets can be electrified and how new logistics solutions and incentives can influence the transition in a positive way.

From the project we expect (i) an evaluation of how it is possible for urban goods distribution fleets to become electrified, considering type of trucks, logistics set-up and future environmental regulations for the up to year 2025 (ii) a report on the benefits of ICT services for a transition to electrified vehicles, (iii) a comparison case for one or

more urban goods distribution companies in France and a best practise investigation on research and demonstration projects in Europe concerning the electrification of urban goods distribution, and (iv) a method description of the work in project and how the work with the stakeholders was conducted.

4. Project realization

To get the most out of the collaboration with the different partners and stakeholders the project took an iterative approach in which emerging results were to be evaluated through a series of meetings with involved stakeholders. The project method is thus close to that which is called action research (Reason & Bradbury, 2001). Action research focuses on inclusion of stakeholders in the research process and the measurement and evaluation of action taken by the participants. For ElCity 2, the complexity of the problem is high just as the cost of changing the actual fleet. This means that action was limited to continuous participatory discussion and prognosis making. This process aimed to inform the researchers about the viability of the different scenarios and generate alternatives for these scenarios. The output of the project are tangible and testable alternatives such as business models for involved stakeholders. The combination of the business model concept and the participatory action research method has been used before by Hacklin & Wallnöfer (2012) but this project offered the possibility of not only studying how business models are thought about and used, but also studying how different business model alternatives are evaluated by both managers and stakeholders.

The project is divided into five work packages (WP). The purpose of the first work package, WP1 Fleet Electrification Study, was to evaluate at what rate it is possible for urban goods distribution fleets to become electrified. The study compares four different cases that are based on data gathered from the distribution fleet of DB Schenker and their contractor TGM/Bäckebol in Gothenburg. Data from actual transport assignments, i.e. the distribution deliveries and pick-ups, during one week were used as basis for the study.

WP2, Service Impact Evaluation, is a description of ICT services to support electric trucks for goods distribution in cities. Many services are not specific for electric trucks, but are seen as important enablers to support this kind of vehicles to be able to perform logistics tasks in urban scenarios. The work is based on interviews and observations of DB Schenker’s distribution in Gothenburg.

The purpose of WP3, Comparative Fleet Electrification Case and Best Practice Investigation, was to compare the electrification case for TGM/Bäckebol in Gothenburg to a reference case in France and to the findings from research and demonstration projects within Europe. This was done to increase the knowledge of the challenges for electrification for urban goods distribution, compare the conditions for electrification in Europe, specifically between the Gothenburg case and a transport operator in France.

WP4, Method Description, package had two purposes. First, it aimed to broadly describe, from a project management perspective, how the project was executed. Second, it presents a review of the project based on the members' views on how the project was conducted. Finally, WP5, Project Management, included the operative project management activities in the different work packages as well as administrative work such as financial reporting and communications on project progress and results.

5. Results and deliverables

5.1 Delivery to FFI-goals

This project investigated how urban goods distribution fleets can be electrified and how new logistics solutions and incentives can influence the transition in a positive way. During the project, the roles and views of supply chain stakeholders as well as other stakeholders that influence the conditions of urban freight transport has been considered. With this approach it was possible to evaluate the feasibility of electrified freight transports in Gothenburg, as well as other European cities, and identify the many necessary changes in behaviour and technology to be able to actually implement a change.

The project has contributed to an increased understanding of the possibilities and hurdles of an introduction of electrified or zero-emission vehicles for goods distribution in urban environments. This contribution is a step forward to be able to tackle environmental and climate challenges in the future. The project results give valuable information in finding possible solutions to be able to decrease the negative environmental impact caused by the transport industry, such as greenhouse gases and other emissions. As the project focus is on the cost of using electrified trucks for distribution and how to create viable business models, considering the market conditions of today and possible changes until 2025, the results aims to present realistic business models for the future. The results are considered to be interesting for all stakeholders in the transport industry.

5.2 WP1 Fleet Electrification Study

The purpose of the first work package of the Fleet Electrification Study was to evaluate at what rate it is possible for urban goods distribution fleets to become electrified. The study compares four different cases that are based on data gathered from the distribution fleet of DB Schenker and their contractor TGM/Bäckebol in Gothenburg. Data from actual transport assignments, i.e. the distribution deliveries and pick-ups, during one week were used as basis for the study. The routes used for the different cases were based on addresses that were geo-located using different software and the NAVTEQ map database provided estimated speed and distance of roads in the road network. The first case (D1) is the base case of two diesel vehicles performing the distribution transport in the current route set-up of TGM and Bäckebol. The second case (E1) is a simple replacement of the

diesel trucks with all-electric trucks. The third case is a routing and fleet managing application of the knowledge gained from the first two cases. The routing and loading of the vehicle is changed so that the deliveries that were previously carried out during one single shift now can be conducted in two shifts per working day. This means that we only use one vehicle but increase the utilization of that vehicle. The switch from one shift to two shifts influences the deliveries, environmental performance and costs. The results are presented both for diesel vehicles (case D2) and for all-electric vehicles (case E2).

For each case, TCO were calculated for 8 years of operations. These calculations relied on estimates of future cost developments for vehicle components, maintenance and energy. Each case was run three times with 2015, 2020 and 2025 as starting years. Since resale value for electric vehicles (EVs) is highly uncertain and impacts the TCOs calculations greatly, the TCO calculations are provided both with and without resale values. Since the two shifts solution in D2 and E2 meant 7 hours of supplement pay per working day it was necessary to add the cost of labour to the TCO calculations in all of the cases.

The calculations show that it is difficult for the EVs to compete in 2015. However, in 2020 the switch to an EV (going from D1 to E1) produces a small profit of € 1 043. This positive outcome for the EV is repeated in 2025 with a net value to the operator of € 23 485 over 8 years of operation. Comparing the results, the two shifts solution never did get financially competitive with the D1 case. The reason for this was that the cost of unsocial hours was greater than the benefit of increased utilization of the EVs. Keeping the amount of unsocial hours down, while maximizing the utilization rate of the EV is therefore paramount. Considering these results, a shift to electric trucks seems feasible in the coming years. However, an introduction of EVs might require other changes in the logistics value chain. Changes that need to be introduced in cooperation with relevant stakeholders.

5.3 WP2 ICT Service Impact Evaluation

The purpose of WP2 ICT Service Impact Evaluation was to describe communication services to improve the business case for electrified distribution fleets used in goods distribution in cities. The results are based on knowledge gathered from experts from carrier companies, municipal representatives, union representatives and representatives from property owners. Open-ended questions were used during the interviews and on-site observations during operations, both in the terminal and during deliveries, were used to complement and verify the data when possible.

Two ICT-services have been prioritized based on the potential to support the introduction of electric vehicles in city distribution. The Digital waybill with route planning and packaging service is highlighted since it could have a potential impact on transport efficiency and reduce the time spent on non-value adding activities such as sorting of goods at the terminal. A digital waybill could also be an enabler for other ICT-services

that require real time information regarding the cargo. Secondly, ICT for off-hour delivery is presented for its possible impact on the utilization of electric vehicles in city logistics. A necessity for receivers to assist the off-hour deliveries is identified as an obstacle for off-hour deliveries to sustain without subsidies. The presented ICT-services could facilitate unassisted deliveries by enabling access to locked compartments and also to contribute to a required mutual trust between the carrier and the receiver. Off-hour deliveries could potentially increase the utilization rate for an electric transport vehicle since it enables multiple shifts during a day, which is commonly not accepted for a corresponding noisy combustion vehicle.

Three additional ICT services have been identified since they were perceived by experts as conceivable to benefit to electric transport vehicles, yet their feasibility and definite value require additional research. The need for smart charging strategies is clear as it is time consuming and expensive to manually manage vehicle charging. ICT could allow vehicle charging to be optimized depending on predefined requirements. This could be when energy prices are the lowest while still ensuring that enough charging is achieved before each vehicle should be used. It could also be possible to prioritize some vehicles if necessary. The peak power required is balanced to achieve the lowest charge cost while also avoiding overloading the charger. Additional services that have potential to support the introduction is a service to provide prioritized parking for electric vehicles and a monitor service of the state of the battery to be able to better predict its lifespan as a truck battery, as well as value on a second hand market.

Some of the services described are not specific for electric trucks, but are seen as important enablers to support this kind of vehicles to be able to perform logistics tasks in urban scenarios. They are judged as important to enable efficient use of electrified trucks in urban distribution.

5.4 WP3 Comparative Fleet Electrification Case and Best Practice Investigation

The purpose of WP3, Comparative Fleet Electrification Case and Best Practice Investigation, was to compare the electrification case for TGM/Bäckebol in Gothenburg to a reference case in France and to the findings from research and demonstration projects within Europe. This was done to increase the knowledge of the challenges for electrification for urban goods distribution, compare the conditions for electrification in Europe, specifically between the Gothenburg case and a transport operator in France.

The starting point for the comparison between Gothenburg and Paris cases has been to compare the specific situation for the two companies in the different cities and how city distribution stakeholders influence how transports are performed. The comparison case in France was Deret, a company that is currently using electrified vehicles in distribution. At the end of 2009, Deret Transporteur created the first French urban delivery network using

electric-powered lorries, with the biggest fleet in Europe (54 vehicles). It also moved up to top position with its 22 hybrid HGVs. In comparison, the transport operator TGM/Bäckebol does not have any electrified vehicles in their fleet.

The main factors contributing to Deret's successful introduction of all-electric and hybrid-electric vehicles were found to be (1) the type of customers transporting high end and luxury goods, who are willing and able to pay a premium for "green" transports, (2) Deret's long term relationship with and complete service offer to their customers, (3) Deret's environmental focus and the willingness to invest by the family owned company, (4) the possibility to customize the logistics to enable the use of electric vehicles when setting up a distribution offer in 2009, and (5) the expectation of future environmental regulations in Paris.

Figure 1. Distribution work at Deret in Paris and TGM for DB Schenker in Gothenburg.

Summarizing the best practice investigation, we present results from the application of an analytical framework on 49 different case studies gathered from ERTRAC ALICE Urban Freight Research Roadmap (2014). The results were grouped in three categories that are presented ¬under the following broad headings: 'collaborative efforts', 'restructuring of the urban freight value chain' and 'technological development'. The first category contains attempts at tackling a particular challenge such as climate change in ways that maintain the active actors or established roles within the urban freight value chain. These cases therefore build on the ability of governments and private actors to shape incentives and implement restrictions (i.e. use both carrot and stick) through formal and informal tools. The second category does instead present the introduction or removal of roles in the value chain as a method of achieving some specific goal. This was achieved, for example, through the introduction of automated delivery and retrieval points (i.e. lockers for goods) or the introduction of an urban consolidation center (UCC). The last and rather self-explanatory category contains cases where the goal was to be achieved through a change or improvement of a specific technological component or the entire technological system involved in the value chain.

The results show that improvements in the urban freight value chain are possible but often arduous. With improvements we mean positive environmental or economic outcomes that are generated from changes in a range of diverse characteristics that the

cases contain examples of. The different routes through which improvement was achieved are just as diverse as they are complex but a fundamental aspect for all of the projects is that the role of the private sector has to be acknowledged. Consequently, in order to create and maintain change there has to be a viable business scenario for the firms that are involved. This means that each firm in the urban freight value chain needs to find a business model that works with its stakeholders, the existing policy setting and the technology that is employed.

When contrasting the results from best practice investigation with those from the case investigations in Gothenburg and Paris we draw the following conclusions. As has been ascertained in the discussion above, a viable business is paramount for the long term feasibility of the electrification of urban freight. When the demand is sufficiently large, as in the Paris case, demand can be met by service providers and transport operators can gradually shift parts of the goods over to this costlier alternative. However, there is no guarantee that this transfer will be permanent or spread beyond a niche market segment. This is especially the case, since it is difficult for transport operators to make the benefits of the EV tangible to mass market customers. Moving to a new 'normal' (i.e. one with widespread adoption of EVs) in urban freight require some kind of sense of urgency for the entire market. Single stakeholders may try to achieve this by marketing, public relations or implementation of incentives but it is highly unlikely that such moves will be successful on their own. For mass markets to embrace EVs cost competitiveness is paramount. Consequently, we argue that, unless there is a radical shift in customer demand, it will be necessary either to have strong political leadership pushing for the implementation of EVs or for several stakeholders in the urban freight value chain to change behavior collectively. The latter alternative is however unlikely to happen due to the intrinsic costs that such a transformation entails.

5.5 WP4 Method Description

Work package 4, Method Description, has two purposes. First, it aims to broadly describe, from a project management perspective, how the project was executed. Second, it presents a review of the project based on the members' opinions on how the project was conducted.

In order to make the most out of the competence and ambition found in the group of partners that participated in the project, it was decided at the application stage that the project should adopt an iterative and reflective approach. Participants were thus included at all stages of the project as a way to assure consistency, transparency and quality in the work. The overarching project approach is therefore similar to so called participatory action research.

Although the work carried out within the frame of the project did not produce actual organizational or behavioral changes, such as testing electrified trucks or implementation of new business models, the project has meant that its members have been engaged in an

active and continuous dialogue on topics critical for the electrification of urban freight. Furthermore, the results that came out of the project form a basis on which stakeholders may discuss the implementation of both technology and business models.

Challenges that had to be overcome during the project was to find the appropriate way to fulfill assignments and handle information sharing, especially considering the amount of actors involved in the project. Additionally, the different characteristics of the participating organizations as well as the inherent evolving nature of those organizations meant that project management was at times more resource and time consuming than expected. Although the project encountered obstacles, it can be concluded that the collaboration worked and the participants are satisfied with the results. The project thus exemplifies how the collaboration between organizations that are of disparate size, with different cultures and goals can work together and overcome challenges. It also shows how project members with different expertise and academic background can form a common ground on which to discuss complex problems.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The report highlights the roles and influence different stakeholders have to change the way urban freight is done to lower its negative environmental impact. Therefore, the results from the project form a basis on which stakeholders may discuss the implementation of both technology and business models for urban distribution. The project results will be spread via the FFI Efficient and Connected Transport systems conference, within the partners' organisations and specifically with the Gothenburg freight network, where researchers, industry and policy makers come together to discuss challenges in Gothenburg, as well as collaborating to find ways to make transports more efficient.

Several of the project members had expected that societal pressure and environmental technology had developed in a higher pace than they did during the project period. These project members expressed a disappointment with the slow progress and hoped that there would be a more assertive dedication to progress both from the industry and from policy makers. With a greater sense of urgency on reducing the environmental impact of transports from all stakeholders involved in urban freight, the project results could guide future technology and business models more efficiently.

6.2 Publications

The project has not resulted in any publications so far, but articles for conferences and papers are being considered.

7. Conclusions and future research

Based on the results from the results from FFI project *Feasibility study of the electrification of the urban goods distribution transport system* (Vinnova reg. no. 2011-01803), the project scope was to investigate how urban goods distribution fleets can be electrified and how new logistics solutions and incentives can influence the transition in a positive way.

The project results show that it is difficult for the EVs to compete in 2015 considering a replacement of the diesel trucks with all-electric trucks. However, in 2020 the switch to an EV produces a small profit. This positive outcome for the EV is repeated in 2025 over 8 years of operation. Comparing the results, the two shifts solution never did get financially competitive with the diesel vehicle used in one shift. The reason for this was that the cost of unsocial hours was greater than the benefit of increased utilization of the EVs. Keeping the amount of unsocial hours down, while maximizing the utilization rate of the EV is therefore paramount. In other cities than Gothenburg, where congestion causes severe delays, the efficiency gained by distributing goods off-hours might balance the higher salary costs.

The starting point in both the previous and in this project was the introduction of new technology to reduce the negative environmental impact of transports. As the project progressed it became clear that making changes to the logistic setup of urban distribution can lead to significant costs. The project has shown that many parameters influence the possibility to make a transition to electric distribution. One example, as described above, is the case of off-hour distribution, where the increased salary cost was too high to make the business case profitable. Another example is the limited range of electric vehicles. As electric vehicles are not flexible to be used in many different kinds of transport assignment, the business relationship between the transport operator and the shippers becomes very important. Long term assignments with well-defined transport routes are preferable to be able to use the vehicles long term and dare to take the higher investment cost.

There are many hurdles to overcome to be able to introduce electric vehicles, a number of them highlighted in this report. Although future technology development and ICT can support the implementation, such as the case of smart charging solutions, there are additional costs related as well as new ways of working. Moving to a new ‘normal’ (i.e. one with widespread adoption of EVs) in urban freight require some kind of sense of urgency for the entire market. Single stakeholders may try to achieve this by marketing, public relations or implementation of incentives, but it is highly unlikely that such moves will be successful on their own. For mass markets to embrace EVs or other potential zero-emission vehicles, cost competitiveness is paramount. Consequently, we argue that, unless there is a radical shift in customer demand, it will be necessary either to have strong political leadership pushing for the implementation of zero or lower emission transports or for several stakeholders in the urban freight value chain to change behavior

collectively. The latter alternative is however unlikely to happen due to the intrinsic costs that such a transformation entails. Consequently, there is a need in future research to focus on how urgency can be increased.

8. Participating parties and contact person

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