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‘Charging the electric truck fleet’ - Learnings from Dutch frontrunners in zero-emission logistics

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Executive Summary

Electrifying logistics is of vital importance in combating climate change, but the uptake is still relatively low. Through researching frontrunners in the field, current best practices, challenges, and solutions to these challenges are identified. Challenges are split into depot charging challenges and public (fast)charging. The data availability and the linkage between different systems are the biggest challenges for depot charging. The certainty of a charging spot at the right time is the biggest challenge for long-distance logistics. The logistics sector does not know what is already possible with their data streams and the suppliers of IT systems don’t know what the logistics sector needs.

Keywords: Freight transport, Charging, Heavy-duty, Van, Digitalization.

1 Introduction

In midst of the climate change challenges, the transition to electric vehicles is key in meeting international emission reduction targets. A big challenge in the transformation towards zero-emission transport is to electrify road freight vehicles as they are responsible for a large portion of the greenhouse gas emissions of road vehicles. Road freight accounts for 2% of vehicles on the road and accounts for 23% of the CO2 emission by road vehicles (IEA, EEA, 2022). Currently, frontrunners in the logistics sector are implementing Battery Electric Vehicles (BEVs) in their fleets. Although the market share and new registrations are low, the numbers are rising. This incline, combined with the introduction of many new types of electric vans and electric trucks from the OEMs, it’s apparent that the uptake of BEV in the N1, N2 and even N3 segments will climb rapidly [1].

Electrifying the logistics sector is a challenging transition. The sector is known to be conservative and the logistic systems operate in a very efficient ecosystem. The focus is on the automation of logistical processes and increasing cost-effectiveness. In the transition towards electrification, logistics managers are faced with new themes such as a different type of logistic planning, implementing and operating charging infrastructure.

Although the market of BEV vans and trucks is not mature yet, the vehicles are not seen as the largest obstacle to implementing zero-emission transport. The current frontrunners identify the TCO competitiveness and realisation of the right charging infrastructure as the main challenges. Therefore they are key for the further uptake of BEVs in logistics.

In this paper, the focus is on the Dutch frontrunners in electrifying logistics. Chapter 2 explains why this is an appropriate group to use their lessons learned. This is done by depicting the BEV uptake of E-trucks in Europe. In chapter 3 the major trends in zero emission transport and charging infrastructure are outlined, this shows the contexts and knowledge base of the frontrunners. Subsequently, in chapter 4 the exact use cases from which the challenges and lessons learned are derived are descriped. These are implementation- and research projects. Chapter 5 discusses the main challenges that were discovered in the specific use cases and in the final chapter, chapter 7 conclusions are drawn. The conclusions are drawn based on the experiences and lessons from both the implementation- and the research projects

2 E-truck and E-van uptake in Europe

To analyse the challenges of electrifying logistics our research focuses on the frontrunners which already have vehicles in operation. Our report focuses mainly on the larger electrified trucks (N2, N3) and large fleets of delivery vans (N1). For these vehicle categories, the challenges in recharging are larger, for instance, due to the battery size, fleet size, or long-distance travel. Within the European Union, almost 2.000 battery-electric trucks (N2, N3) are in the fleet by the end of 2022 [8]. This is a share of only 0,03% of the total truck fleet (6.200.000 trucks). This shows that only the absolute frontrunners in Europe operate electric trucks. There are 2 countries with an already relatively large fleet of electric trucks, which are Germany (970 BEV trucks) and The Netherlands (306 BEV trucks) (see figure 1). In fleet share, Germany has 0,1% electric trucks (total fleet of 1 mln trucks) and The Netherlands 0,2% (total fleet of 170.000 trucks).

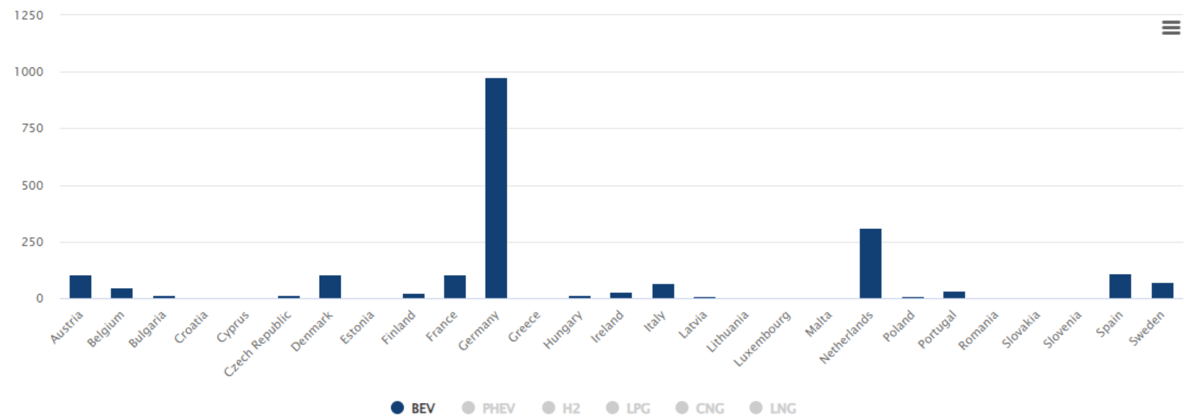

Figure 1 Fleet electric trucks in EU countries(N2, N3)

Within *the European Union*, *a total of 230.000 electric vans* (N1) *are in the fleet by the end of 2022 which is 0,8% of* the *total fleet of vans (29 mln).* From these electric vans, the largest amount of vehicles is 80.000 in the fleet of France (1,3% fleet share), 60.000in the German fleet (1,9% fleet share) and 14.000 in the Dutch fleet (1,3% fleet share). Also in this category, The Netherlands is in the top 3 fleets.

2.1 E-truck and E-van uptake in The Netherlands

As we concluded in absolute numbers The Netherlands has the second largest fleet of BEV trucks (N2 and N3) in the European Union, with the largest fleet share compared to the total fleet.

Within the electric truck fleet in The Netherlands, there was no uptake in the COVID years 2020 and 2021, but in 2022 the growth rate was above 50% which is a comeback of the trend before COVID with a very high relative uptake in 2019. In figure 2, an overview of the growth of the Dutch electric truck fleet is shown.

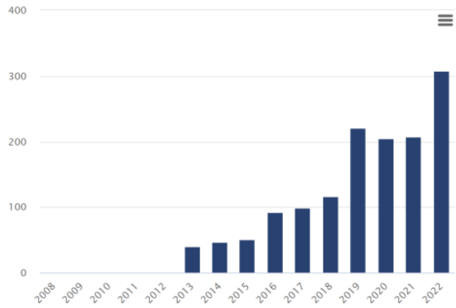

Figure 2 Growth of electric truck fleet in The Netherlands

The Netherlands also has a decent share of electric vans (N1) with a market share of almost 8% of total registrations. Within the European Union, the market share of electric vans is 5%

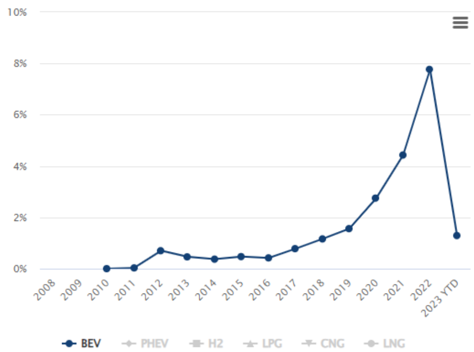

Figure 3 Uptake of electric vans (N1) in the Netherlands

The fleet of electric vans in The Netherlands grows steadily and didn't have a downfall due to COVID because the Dutch government stimulated electric van sales by a purchase grant that didn't exist before COVID. In figure 4 a detailed overview of the electric vans fleet is presented. At the end of 2022 there were almost 14.000 electric vans in the Dutch fleet which is a fleet share of 1,3 % of the total fleet (1 mln vans):

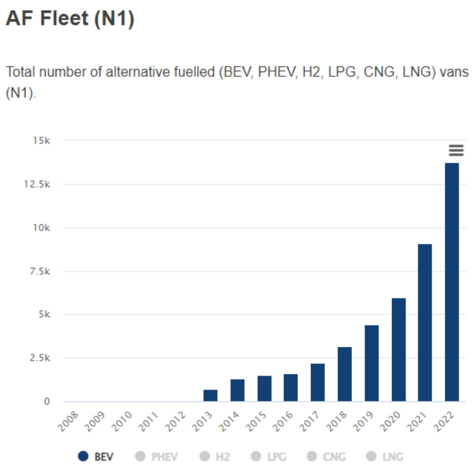

Figure 4 Fleet of N1 vehicles in the Netherlands

Our focus in this research will be on the front-running Dutch logistics companies with fleets of electric trucks (N2, N3) with some relevant case studies and also on electric vans (N1) including relevant case studies.

3 Major trends in zero emission transport

The road freight sector, like all sectors of the economy, needs to reduce its carbon footprint over the next decade if it is to succeed in the energy transition. Road freight transportation is an integral part of commercial, industrial, and logistical activities. It is essential to reduce CO_2 emissions from road freight transport while maintaining the competitiveness of the companies involved so that the government's CO_2 emissions targets can be reached.

There are therefore some significant developments in the market. In this chapter, the major trends in the ZE transport sector are discussed.

3.1 Market availability of electric vans (N1)

The market of electric commercial vans has taken a short while to fully develop. The passenger vehicles market is still far ahead in model offerings and production volumes but the N1 segment is increasing in both aspects. The market is still developing, and only for a couple of years, there are models with a real-life range of 200 kilometres and above. Also, the charging speeds are increasing with every new model introduced.

Two important aspects that are currently (partly) missing in the market for the N1 category are the weight that can be towed and the availability of the electric chassis cab versions. The maximum weight that an N1 vehicle can pull is 3.500 kilograms, very few electric vans can do this. The chassis cab versions are coming into the market, this is especially important for logistical companies wanting to make use of N1 vehicles.

3.2 Market availability of the zero-emission Medium and Heavy Duty Vehicles (MHDVs): Rigids

In this market, several OEM truck manufacturers offer BEV trucks including DAF, MAN, FUSO, Mercedes-Benz, Renault, Scania, and Volvo. The Gross Train Weight (GTW) or maximum permitted combined mass of the vehicle and attached trailer. of the available models varies from 7.5 to 64 tons. There are batteries of various capacities (gross) ranging from 83KWh to 624kWh which can travel from 100 km up to 560 km

OEMS are offering BEV rigid trucks in all weight classes. Except for a couple of examples, most of these vehicles can drive over 200km on one battery charge, with a small number capable of between 400 and 560 km.

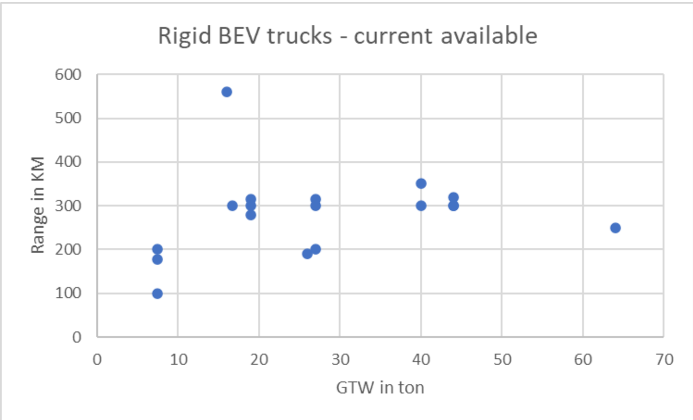

Figure 5 Available rigid BEV trucks

Another development worth noting is that some OEMs are offering different battery sizes to meet the demand of their customers. This affects the cost price of the truck, the cargo weight and the available range.

3.3 Market availability of the zero emission MHDVs: Tractor units

Within the heavy duty tractor unit market, only a few OEMs are offering electric trucks commercially. These include Mercedes, Scania and Volvo.

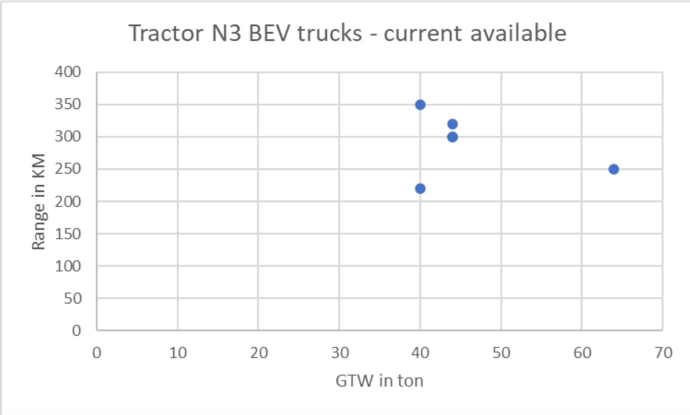

Figure 6 Available tractor BEV trucks

The figure shows the relation between the range and GTW of BEV OEM tractor units in the market. As presented in the figure all of the models have a weight between 40 and 64 tons. There is no truck with a range under 220km.

Often, tractor units operate on high daily millage. The range of the BEVs is a limiting factor. On the other hand, the market for these trucks is significant. Therefore most OEMs have announced a ZE tractor unit to be available in 2023 and 2024.

3.4 Expected trends in ZE MHDV development 2025 – 2030

ZE truck manufacturing is undergoing rapid development. Although truck manufacturers are offering BEVs, (P)HEVs and FCEVs, the majority are currently focussing on the more mature BEV technology. Accordingly, in the near future, this ZE technology seems to be emerging as the preferred choice for truck propulsion. Technical breakthroughs with regard to other types of ZE technologies may change this.

While truck manufacturers are often not clear about their technology roadmap or availability timeframes, there are some discernible trends:

- Trucks are going to be offered with a variety of battery sizes and drive trains;
- The sizes of the batteries are increasing without a more negative impact on the payload due to improved battery technology;
- On average, purchase prices seem to be relatively stable compared to the development of the purchase prices of diesel trucks. It is expected that the purchase prices of BEV trucks will be lower in the future due to economies of scale, and further improved technology;
- Charging is gradually evolving from AC to DC, which results in a lighter and cheaper truck but creates the need for dedicated DC truck chargers.
- The speed of fast charging is also increasing, with current models capable of charging with up to 250kW. Future technologies with charging speeds over 1MW are expected to be commercially available in 2024.

3.5 Trends in charging infrastructure

There are two types of chargers, broadly, AC (alternating current) and DC (direct current). AC chargers have a lower power output and DC chargers have, generally, a higher output. Light vehicles, such as passenger vehicles and N1 vehicles usually charge with AC chargers and can charge with a DC charger on long-distance travel. Heavier trucks, N2 & N3, often charge with DC chargers. The benefit of a DC charger is the charging speed, but also, the vehicle can be cheaper because there is no need for an inverter in the vehicle.

3.5.1 Charging strategies electric freight vehicles

There are several charging strategies, the image underneath shows three different charging strategies. First, a profile in which there is no need for fast charging. In that scenario, all needed kilometres can be driven during the day without recharging. For that scenario, there is no immediate need for fast charging (DC charging). In the second scenario, there is a need for a single recharge, for instance, along the highway to make it back from a delivery. In the third scenario, there are a lot of smaller (fast) charging sessions needed. The image shows that the availability of a fast charger enables a higher distance per day for the truck. This increases the utilization of the truck and decreases the overall costs. Currently, we see that most fast chargers for trucks are located on depots. The expectation is, and the development is already visible, that shortly there will also be sufficient fast charging available along highways. This will enable longer trips for electric freight vehicles.

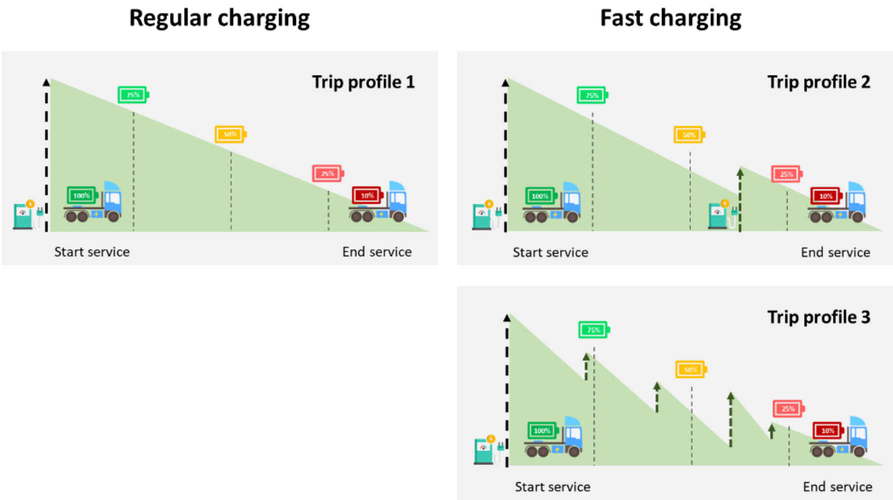

Figure 7 Charging with different trip profiles

3.5.2 Charging speed

A major development in charging for trucks is the MCS standard, this will enable megawatt charging (1.000 kilowatt). This technology is being developed, both on the vehicle and the charger side. Current charging goes up to 250 kW. Future technologies with charging speeds over 1MW are expected to be commercially available in 2024. There are also developments in the way of charging, which currently is via cables. Developments of, for instance, battery swapping, overhead charging, and inductive charging are ongoing, but cabled charging will be used for the foreseeable future.

3.5.3 Impact on the electricity grid

The charging infrastructure brings with it serious challenges for the electricity grids. The upscaling of electric trucks heavily increases the strain on the grid. Developments such as smart charging and the use of BESS (battery energy storage system) in combination with PV installations are aimed at mitigating the issues for the grid. In the future, grid connections must be used more efficiently by using technologies such as smart charging and the flexibility of a BESS. Most of the frontrunners are already working on these solutions.

3.5.4 Constructing an electric freight ecosystem

The upscaling of electric fleets has the effect that electric trucks can no longer be seen as stand-alone. Transport companies have to create an entire *ecosystem* of electric freight. This contains the vehicles, the charging infrastructure, the route planning, and the energy supply. All these need to cooperate with each other to make sure that the vehicle has sufficient energy to complete the selected trip, the contract capacity is not exceeded, and the company’s operation is efficient and thus profitable. However, connecting all these different IT systems is easier said than done. In the coming years, this will be an important focus for providers of EMS (energy management systems) and transport companies.

3.6 Total Cost of Ownership (TCO) assessment

The starting point of assessing the viability of alternatively fuelled vehicles is to understand how different drivetrain technologies perform in terms of the economics of their operation. This is expressed in terms of their Total Cost of Ownership (TCO), which is a standardised calculation of running cost by a unit of distance.

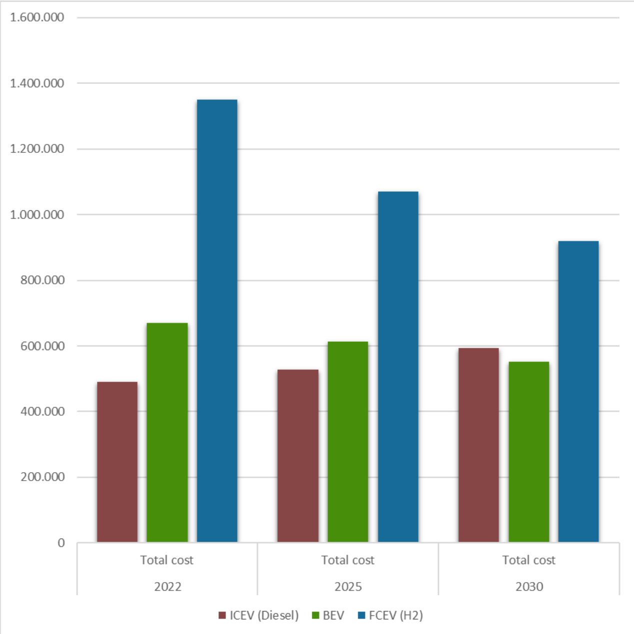

Figure 8 TCO calculation 40t Tractor unit for long-haul transport

To calculate the purchase cost, the capital expense (CAPEX) of trucks and charging infrastructure has been collected. The expected residual (or resale) value is calculated based on existing research and includes potential second-life applications of components (e.g., batteries used for stationary energy storage). For the operating expense (OPEX) calculation the energy costs (renewable energy and fuel, grid connection fees), cost for service, repairs, and maintenance, and insurance costs were used. Next to the TCO assessments of the current technologies, the future TCO values for 2025 and 2030 are also estimated. This can be seen in figure 8.
The TCO calculations for the BEV include the higher cost of public charging (20% of the kWh charged are estimated to be at more expensive public chargers). The BEV TCO premium of approximately 36% in 2022 is significant, but it is expected that also between 2025 and 2030 TCO parity with diesel will be achieved.

4 Researched use cases

4.1 Introduction

The uptake of electric trucks will be important in the coming years, so developing knowledge and experience with electric trucks and the charging of electric trucks is crucial. In the early phase of technological uptake, a lot can be learned from frontrunners. Companies that have already made the step towards electric trucks, developed the knowledge and gained experience. In the Netherlands there is a relatively high share of electric trucks compared to other European countries, therefore, the Netherlands is a logical place for finding the lessons learned and paving the way for faster uptake of electric trucks.

FIER Sustainable Mobility has since 2012 been involved in accelerating zero emission trucking via policy advice, research, and implementation of electric truck use cases. These have led to many different lessons learned on the uptake of electric trucks and the needed charging infrastructure. In this chapter, the most relevant implementation use cases are described.

4.2 AZED

In this, by the Dutch government (partly) funded project, a consortium was formed with stakeholders to electrify the fleet of the Albert Heijn Home Shopping Amsterdam. This department delivers groceries that customers ordered online. The deliveries are done from regional distribution centres using N1 vehicles (commercial vans). Deliveries are done in two shifts, the morning shift between 7 am and 2 pm, and the evening shift between 4 pm and 11 pm. The vehicles have a high utilization rate, they are used in both the morning and the evening shifts. Albert Heijn Home Shopping has an entire fleet of over 200 vehicles in the Netherlands, the use case in this project was Amsterdam with a fleet of 60 N1 vehicles.

Figure 9 Electric vehicles of Albert Heijn

Charging such a large fleet of vehicles, driving up to 120 km per shift daily, comes with several challenges. First of all, such a fleet of vehicles requires a lot of energy from the electricity grid and does so daily. There also needs to be certainty and monitoring of the charging sessions, making sure that the risk of a low battery is reduced as much as possible. Lastly, the communication between the planning system, the chargers, the vehicles, and the electricity grid is essential.

In the AZED project, the charging hub is installed with 60 chargers, a 500 kWh battery, and an energy management system (EMS). The goal is to find a way to charge a large fleet of vehicles in a logistics company with a limited grid connection. The battery is used to utilize the grid connection fully, offering flexibility when the energy demand is higher than what the grid connection can supply. The EMS combines all data sources, for instance, the planning for the vehicles and the state-of-charge (SoC) of the battery per vehicle, to determine what amount of energy the vehicle need and divides the available power from the grid and the stationary battery accordingly.

FIER plays a key role in the project, as we have initiated and developed the project in cooperation with the lead partner Albert Heijn. We are currently supporting the lead partner Albert Heijn in both project management as well as in the strategic decision-making process.

4.3 eGLM

Another example pilot project was Electric Green Last Mile (eGLM). The overall goal of the eGLM-project was to kick-start the market of heavy-duty electric trucks and show the transport sector that dedicated electric trucks can be applied for specific applications in a commercially viable way. This goal was achieved by the implementation of 4 full electric heavy-duty trucks, including a network of publicly available ultra-fast charging stations.

Figure 10. eGLM truck from Meulenberg Charging

FIER has analyzed the routings, calculated TCOs, created the minimum requirements for vehicles and chargers, liaised with truck manufacturers and charging infrastructure suppliers, implemented the EU tender for the purchase of trucks and charging points and was supporting the implementation of the vehicles in the fleet and realization of the (ultra-fast) charging stations. www.eglm.eu

4.4 ZEBRH

FIER is the initiator and project manager of the ZEBRH project. This is a Dutch DKTI Pilot project with next-level OEM ZE MHD trucks. It is a large, 12-truck strong pilot with a large variety of utilization of the trucks. The frontrunners in this project are testing the latest versions of the OEM trucks, Renault and DAF trucks. The utilization ranges from moving companies, mainly operating within the boundaries of inner cities up to 18-hour daily shifts supplying grocery stores from a DC including Ultra-fast charging on strategic locations.

Figure 11. ZEBRH electric DAF truck driven by VSDV

The pilot case is different from eGLM. In eGLM, the main lessons learned were on vehicle technology. The lessons learned in ZEBRH will be more on the broader topic of electrifying logistics. This means the complexity of charging hub implementation, logistic planning with limited range, etc.

The trucks are being tested and analyzed by TNO in cooperation with FIER. TNO is focussing on technical analyses about SoC+SoH, whereas FIER is investigating the business case of the ZE trucks. This includes as well various scenarios including analyses of adding ultrafast charging, which is also being tested in real-life situations.

4.5 De Rooy

FIER has researched De Rooy as a use case in research into data streams and data linkages on (private) charging hubs for logistics companies.

De Rooy is a logistics company that operates N2 and N3 vehicles for their distribution. A lot of their deliveries are done in cities in the Netherlands. Because they are operating in the Netherlands, most of their routes are below 250 kilometres De Rooy has around 50 trucks (N2 & N3) and already deployed the first electric truck 8 years ago. They have been operating electric trucks in their fleet ever since. The electric fleet consists of 6 trucks, at the moment. At their charging hub, the old batteries from the first electric truck have gotten a second life. They do serve as stationary battery storage. On-site there are also 2.500 solar panels for the generation of green energy.

The goal for De Rooy is to run a sustainable business, in the economical- and ecological sense of the word. The challenge for De Rooy is to utilize the energy from the PV installation as much as possible for charging the electric trucks. When looking at the future, the entire fleet of 50 trucks will have to be electrified, offering a severe challenge for the energy supply.

4.6 PostNL

FIER has researched De Rooy as a use case in research into data streams and data linkages on (private) charging hubs for logistics companies.

PostNL, the postservice in the Netherlands, has a separate division that deals with package delivery. This organization has 5.000 N1 vehicles doing deliveries daily. This is for a part done by PostNL-owned vehicles, around 1.250, and the rest is done by subcontractors. These vehicles drive around 80 kilometres per day, leaving at 8 am and returning at 5 pm. Out of the 1.250 PostNL-owned vehicles, 375 are electric at the end of 2022. For charging these vehicles, PostNL has 20 charging hubs with 20 chargers. These charging hubs are available for PostNL vehicles and subcontractors. Because of that, the charging hubs are officially *semi-public*.

Having a semi-public charging hub has brought challenges for PostNL. For instance, how to have the right company pay for the right amount of energy. At the charging hubs, a Charge Point Operator (CPO) handles the transactions which have to be activated via an RFID.

5 Challenges frontrunners are facing in electric road freight

Logistical firms can be characterised by having a high degree of automation to increase efficiency and be the most cost-effective. To accomplish this, data exchange between various logistical processes is essential. With the introduction of electric vehicles, logistical managers are confronted with new systems that need to be integrated into the existing processes to maintain the desired level of efficiency and maintain cost efficiency. In particular, the integration of charging hubs and related energy infrastructure poses challenges for the logistical manager to introduce and upscale BEVs into its fleet. Besides that, he is confronted with new complexity in the route planning of BEV as these have limited range and may require en route charging.

5.1.1 Grid connection and energy supply

Often logistical entrepreneurs do not have a high power grid connection. In their transition towards e-freight, it is expected that power consumption will increase dramatically. This calls for a substantial upgrade of their grid connections. For example, the Netherlands is confronted with congestion in the electricity network, and increasing grid connection capacity to the desired level is in many areas not possible. The illustration below lists the most common mitigation solutions, listed according to the severity of the grid capacity shortage.

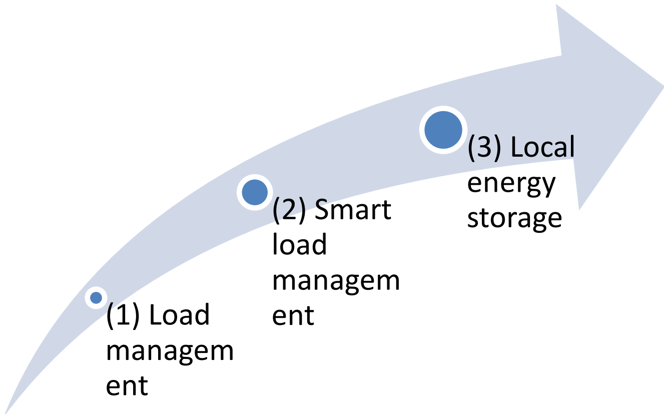

Figure 12 Different levels of energy management technologies at charging

Load management is becoming increasingly mainstream in charging hubs at depots. What's currently less widespread, is what is called *smart load management*, where the energy management system incorporates various data sources to optimise the planning of the charge sessions. Both logistical and technology providers see potential as the introduction of charging planning reduces the need for grid connection reinforcements, but can also reduce the energy costs for charging. Data sources with smart load management are presented in below's illustrations.

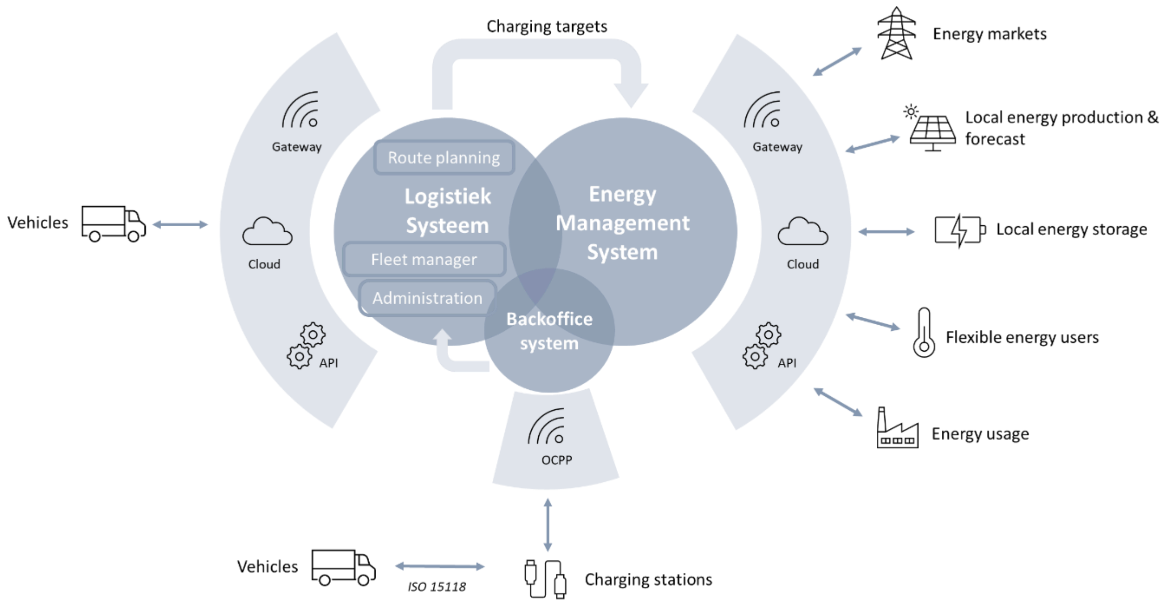

Figure 13 Data streams on the charging hub for logistical companies

In particular, for the logistics sector, there is vast potential to incorporate the daily energy demand of vehicles in charge planning. As many firms use route planning software, it's relatively straightforward to produce data such as energy needs and planned starting times for those vehicles. With these *charging targets* the energy management system can optimise the charge planning and thereby reduce the required capacity of the network connection but also further reduce the energy costs.

5.1.2 Access to vehicle data for route optimization

Route planning is becoming more complex for logistic managers due to the limitations posed by BEVs, such as limited range and the possible need to recharge en route. This calls for higher importance of the integration of EV vehicle data into the logistic process. In particular, real-time information about the State of Charge (SoC) of vehicles, will be increasingly important for planning purposes. Besides SoC data, vehicle performance data can play a big role in optimising the route planning for BEVs on variables such as vehicle load, ambient temperature, and driver behaviour, and present, access to vehicle data is mostly done by third-party devices and software. This seems like a workaround solution as most BEVs sold today are equipt with a data connection and even make certain data available on their proprietary platforms against subscription fees. So although access is usually possible, there are barriers to obtaining the information in the logistic data cloud for processing in the route planning systems. Making vehicle data easier to access for its users can lower the barriers for logistic firms in expanding their fleet with BEVs. This calls for renewing the regulation on the accessibility of BEV data.

5.1.3 Public charging

Next to depot charging, the need for public charging will also be crucial for the BEV truck uptake. There needs to be a sufficient number of public chargers available, and more importantly, they need to have a high charging speed and be available at the right time. To integrate this in the logistic planning, a system to reserve a charging location and timeslot are crucial for the efficiency of long-distance logistical movements. Many long-haul transportation companies, for instance, are worried that if such a system is not in place, the efficiency of the system will be low due to waiting times.

6 Conclusions

The market of ZE transport is growing fast. This is due to certain policy developments, but also because of the industry which is picking up the pace. OEM truck manufacturers are maturing the market of ZE trucks, by increasing the number of ZE models they produce, increasing the battery sizes and charging capabilities.

It is expected that in the future, the OEMS will offer all trucks with a variety of battery sizes and drive trains. The surplus of the purchase price of a ZE truck over a conventional diesel truck is currently rather large, and although it is expected to decrease over the next few years, the purchase price will still be higher. Due to the overall lower operational costs, it is expected that TCO parity will be reached between 2025 and 2027.

The electric freight vehicles also need to be charged. Especially with the expected upscaling in mind, the charging of this rapidly growing ZE fleet will be one of the key challenges for shippers and carriers. In the Netherlands, several front runners are facing challenges with charging infrastructure, but are also testing the solutions.

Often, there is a need for increasing the energy grid connection, due to the higher power demand. Since there is in the Netherlands a serious challenge to get an upgraded grid connection, (smart) load management, BESS and other mitigating solutions will play a serious role in assuring the demand for energy for the ZE fleets. Another challenge is related to getting access to the right information and data and using the data in optimizing the operational logistic processes.

The frontrunners show what is currently possible concerning electrifying logistics, which is encouraging, but it also shows what still needs to be developed for the large-scale electrification of logistics.

Acknowledgements

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Presenter Biography

Edwin Bestebreurtje MSc is a partner and senior consultant of FIER Automotive & Mobility**.** Edwin has specialized in business development projects in the automotive and mobility sector. He was responsible as project manager for developing the Automotive Campus in Helmond and project manager in European projects on (e-) mobility, such as ENEVATE, I-CVUE and FREVUE. Currently, Edwin is responsible for the European Alternative Fuels Observatory (EAFO) which is THE knowledge platform for alternatively fuelled transport in Europe owned by EC DG Move.