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BOBBY HAO CHEN, RISE

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Summary

Most researchers and stakeholders interested in the area of the electrification of road freight have pointed to the need for a diversity of charging infrastructure. Amongst these is the type of infrastructure that can be referred to as ‘opportunity charging’, where charging takes place during natural stops over the course of a freight vehicle’s daily operations. These can be rest stops, stops for loading and unloading, or when a vehicle enters a slow-moving, enclosed area such as a mix-modal rail terminal.

While current literature has described the need for this type of charging and included it in models of charging networks, there has been a lack of studies that examine what the practical and business considerations are for implementing ‘opportunity charging’ on real world sites.

This pre-study has tried to fill this gap by examining three different types of potential opportunity charging sites in Sweden as case studies.

A key finding of this pre-study highlights that every logistics site has different operational as well as business model characteristics, and that the implementation of opportunity charging will face different practical barriers and business driving forces at each type of site.

However, logistics sites in general tend to strive for layouts with as little protruding or fixed infrastructure as possible to avoid creating obstacles for large, heavy vehicles. This means that traditional charging methods utilising cables (and associated power cabinets) will be difficult, or impossible to implement. This suggests that logistics sites of all types could potentially be major benefactors from the successful commercialisation of charging systems embedded into the road surface, such as those being developed for electric road systems.

The pre-study also identifies the drayage segment to be a potential ‘model segment’ of the trucking sector for accelerated electrification. The investment risk in transitioning a fleet to electric drivelines in trucking will be far from uniform across the sector. It is already well-known that city distribution is a low-hanging fruit for truck electrification. But on the heavier end of trucking applications, drayage services have trip profiles that appears well-suited to lead the transition towards electrification. Policy support targeting this segment should therefore be investigated.

A final conclusion is that line-haul vehicles and operators tend to be based locally within a logistics region, and within that region most vehicles used by haulers visit multiple types of logistics sites on a regular basis rather than specialise in shuttle traffic between just one type of site. This has the implication that the roll-out of charging infrastructure at logistics sites should ideally occur in parallel across different types of sites within a regional geography so that the benefits of ‘network effects’ can be properly harnessed.

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Background

Electrification of trucks is one of the key enablers in reaching the EU requirements to reduce CO_2 from new trucks by 15% from 2025, and by 30% from 2030. This will only be possible if the needed charging infrastructure to enable the electrification of trucking is implemented.

This project is a pre-study that looks at what the preconditions are for establishing semi-public truck charging at three logistics sites with different operational characteristics. The project is a collaboration with Volvo AB and funded by Triple F Fossil Free Freight. The two main objectives are:

1. Establish what the operational assumptions and parameters for establishing charging stations at various logistics sites will be; and
2. Document stakeholder views on what business models would be feasible for electric truck charging at these sites.

This project's focus on semi-public logistics sites is due to fleet data from Volvo indicating that the second longest stop for medium and heavy freight vehicles is during loading and unloading at logistics locations (e.g. ports, hubs, distribution centres). As such, these sites will clearly be a very important charging opportunity for electrified freight vehicles in the near-future. There are currently no known examples of charging solutions for freight vehicles implemented at semi-public logistics sites in Sweden.

The methods used in this study consists of interviews with site operators, logistics experts, truck drivers and haulage companies. Site data such as site maps, usage patterns and types of freight vehicles were also analysed.

Business Ecosystem

Trucking is done in many ways that have implications for which areas are likely to electrify first, and where charging infrastructure will be needed.

Figure 1 shows a simplified diagram of the different way freight is trucked in Sweden.

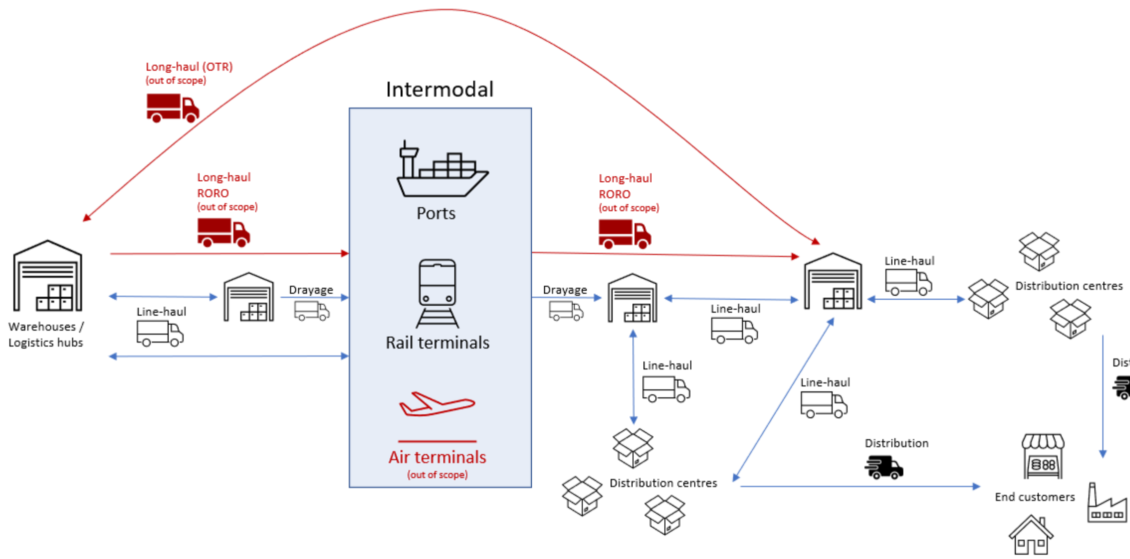

Figure 1 - Simplified diagram of the different types of trucking operations in logisticsFigure 1 - Simplified diagram of the different types of trucking operations in logistics

Long haul trucks, for example, are on the road for weeks at a time with their drivers sleeping in cabins built into the vehicle. These trucks tend to have complex routes that can see the vehicles covering several hundred kilometres per day, broken up by periods where the driver and vehicle are waiting at truck stops for information about their next consignment. The routes are rarely regular and unlikely to be planned out for more than a few days at a time. This type of trucking is likely to be amongst the last to electrify, as operators will likely wait until the charging network is mature and well-covered enough to ensure that they can have access to charging along any routes that can possibly come up. However, other areas of trucking such as drayage and line-haul trucking, have vehicle and route characteristics that are likely to be more amenable to electrification in the short to medium term.

Drayage refers to the specialty logistics service that carries freight over a short distance and plays an important role in intermodal shipping by sea or rail. Due to the short nature of the routes, with a predictable end-destination being an intermodal facility at a harbour or railyard, this segment of trucking appears ideally suited to many models of electric trucks that are already on the market today, offering ranges between 100-300 km (indeed California's 'Project 800' initiative is specifically targeting this segment, with the aim to support 800 zero-emission drayage truck orders to be placed in California in 2021[1]). The rollout of charging infrastructure can also be specifically targeted at those very intermodal terminals in order to extend the range and capability of drayage vehicles.

Line-haul is a broad term in logistics, but here we will use it to refer to the point-to-point movement of freight between intermodal terminals, warehouses, logistics hubs, sorting facilities and distribution centres. These segments are for the most part predictable and regular, however the total route for a truck driver over the course of a shift will likely see them driving between a number of these segments, so that the overall route will differ from day to day. This means it is rare that a specific vehicle and driver will be simply tasked with driving from point A to point B

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[1] https://californiahvip.org/impact/#project-800

and back again. The implication is that the distances traveled by trucks used in line-haul can still vary greatly during day-to-day (and season-to-season) operations and justify ‘range anxiety’ that vehicle owners and fleet managers might feel about transitioning vehicles to electric. But having the opportunity to charge while loading/unloading at logistics sites will effectively increase the useable range of electric truck models – therefore increasing the value that operators can get from an electric truck and reducing the range anxiety barrier to their adoption. Line-haul vehicles and operators tend to also be based locally within a region, so the roll-out of charging infrastructure at logistics sites can happen gradually but still have immediate positive impact on the shift to electrification (unlike for long-haul trucking).

In addition to intermodal terminals and other logistics sites, existing truck stops and fuel stations are likely to also play an important role for the charging of electric trucks used in line-haul operations. While truck drivers and logistics operators would understandably want to avoid purpose-made charging stops, rest stops for drivers can be used for opportunity charging – similar to logistics sites. Under the rules set by Transportstyrelsen:

> *Work may never be performed for more than 6 consecutive hours without a break. If work is performed between 6 and 9 hours, the break must be at least 30 minutes. If the working time exceeds 9 hours, the break must be at least 45 minutes. The breaks may be divided into periods of 15 minutes[2].*

Truck drivers generally have limited options for food and rest stops, as not many areas apart from dedicated truck stops and fuel stations have parking facilities that are suitable for large trucks. Such existing sites therefore present the best opportunity to implement opportunity charging during mandated driver rest breaks for line-haul trucks. Many such truck stops and fuel stations are already strategically located near logistic sites.

Another layer of complexity is whether the trucks are owned by a driver/contractor, or whether it is part of a fleet that is owned by a larger logistics company. Given the larger upfront purchase costs of electric trucks compared to their diesel equivalents, it is likely to be fleets that will make the transition first as they are able to absorb the costs and have access to larger amounts of finance. This will also likely happen at an uneven pace within the industry, with certain logistics companies and fleets leading the transition. A consequence of this would be that the initial selection of intermodal, logistics and truck stop sites to invest in charging infrastructure should be done in direct consultation with those companies that are leading the charge with firm commitments to electrify a portion of their fleets. Later, as the industry sector more broadly joins the transition, selection of logistics sites to implement opportunity charging can be done more on an overall strategic basis as opposed to on a company-by-company approach.

Following the analysis above, three case studies were selected to examine at a high level how electric truck charging could practically be implemented on the sites – including discussions about what considerations were important to the site owners.

Site 1 Mertz Transport Kombiterminal (Malmö) is an intermodal site where road freight is transferred from trucks onto rail wagons, and vice-versa. The site sees a mix of long-haul, line-haul and drayage vehicles transferring and receiving both palletised and container freight.

Site 2 DB Schenker Terminal (Borås) is a logistics hub located near Borås that is part of DB Schenker’s much larger logistics hub network. The hub is used by a mix of line-haul and long

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[2] https://transportstyrelsen.se/sv/vagtrafik/yrkestrafik/vagarbetstid/

haul vehicles, both from within DB Schenker's own fleet of vehicles as well as vehicles operated by contractors and those from other logistics companies.

Site 3 Circle K Vädermotet is a fuel station with secure truck parking and amenities catering to truck drivers. The site is located right outside of the Port of Gothenburg and used by a mix of long-haul and line-haul vehicles, many with deliveries to and from the port.

Site 1: Mertz Transport Kombiterminal (Malmö)

Site description

Mertz Transport Terminal is located in Malmö's Sege Industrialområde about 3.5km from the central station. The kombi terminal has been operated by Mertz Transport since 2014 on behalf of Jernhusen – a Swedish state-owned enterprise that manages many of the key real-estate properties located next to railways (such as railway stations, maintenance depots and kombi terminals). Mertz's kombi terminal in Malmö is one of five terminals owned by Jernhusen, the largest being in Årsta Stockholm. Mertz Transport are themselves a transport logistics provider with a fleet of 150 vehicles and 280 employees. Apart from Mertz's facility, Copenhagen Malmö Port also operate kombi terminals nearby in Malmö's Frihamnen area.

Main features of the site consists of:

- the railway tracks
- two overhead moveable cranes
- an adjacent driveable loop with both incoming and outgoing short-term storage areas
- a multi-day storage area
- a check-in booth at the end of the driveway leading onto the site

All trucks entering the site for either pickup or drop off are required to stop by the check-in booth to submit paperwork. During busy periods, this area can be a source of delay and result in a queue that backs out along the driveway into the site. After completing the check-in process, trucks will then either proceed along the uni-directional loop. From here, the trucks will either drive to an assigned pickup or dropoff area, or enter the multi-day storage zone. In either case, they will need to complete the loop before exiting again – passing by the check-in booth. In most cases, after checking in, trucks will only spend 10-15 minutes on the site, including loading and unloading and the time it takes to proceed around the approximately 800m loop.

Please refer to Attachment 1 for a detailed plan of the site from Jernhusen.

Trucks that use the site are a broad mix of long-haul, regional and local line-haul, as well as drayage. This includes trucks from Mertz's own fleet. However, it is unclear whether Mertz has specific trucks that are dedicated to drayage duties – what is more likely is that they assign trucks depending on availability of the fleet and the characteristics of the load that needs to be drayed. This means a specific vehicle may be involved in more general line-haul operations for a portion of the day, and drayage operations for the other portion.

Feasibility for onsite charging infrastructure:

For this and many other such kombi terminals, establishing charging infrastructure using existing means (of plugging in a cable) would be improbable given that trucks do not remain static on any portion of the site for very long. However, the slow-moving nature of vehicles on the site and the simple loop layout could be a promising application for dynamic charging technologies, such as conductive rails along the road surface or even inductive charging. This could be extended to the entrance area near the check-in booth and someway along the driveway, given these are points where queues can form during busy periods. Conductive overhead wires would however not be feasible as the loading and unloading process (for this and almost all other such sites) rely on reach stackers, which lift cargo loads well above the height that overhead wires would need to be.

Figure 2 - Reach stacker commonly used at intermodal sites (Source: Wikimedia Commons)

A business case challenge associated with dynamic charging technologies will be the additional cost involved for individual trucks to purchase and install the receivers needed in order to be able to charge. This adds complexity and risk for truck owners, and it is not clear how these added systems and components will affect manufacturers' attitudes towards warranty issues. Notwithstanding that, the added cost of installing receivers may not be seen as justified if they are only used on intermodal sites alone for 10-15 minutes of charge per session – given visits to intermodal sites may only account for a small proportion of a vehicle's overall stops. This would however not be a barrier for fleets that are predominantly dedicated to drayage duties.

Apart from the challenge associated with the receiver units for dynamic charging, the overall systems themselves have still not been commercially proven. In the interview with Karl-Johan Mertz, Mertz's Chief Operating Officer, Mr. Mertz stated that while they would be open to new technologies that could help to enable electrification both of their own fleet and that of their clients', interruptions to site operations from unproven technologies is a concern. Given these systems also require installing infrastructure into (or under) the road surface, disruptions during the installation and commissioning stages is also a barrier – as the site is operational almost the whole year round.

However, despite these challenges there is a clear window at intermodal sites such as kombi terminals for opportunity charging to occur. This will likely need to be explored in combination with a range of other logistics sites where dynamic charging technologies could also be practical (or necessary) in order to ensure that there is enough of a business case for fleet owners to invest in receiver units for individual electric trucks. Kombi terminals could also potentially be ideal sites for early commercial trials of dynamic charging infrastructure, given that concerns of terminal operators around interruptions to site functions during both the installation and use-phases can be alleviated.

Site 2: DB Schenker Terminal (Borås)

Site description

DB Schenker's terminal in Borås is located in Viareds Företagspark and is one of about 20 freight terminals owned by DB Schenker in Sweden.

As a company, DB Schenker is one of the market leaders in Sweden when it comes to domestic general and consolidation goods transport, as well as warehouse logistics. Nationally, DB Schenker utilises a subcontracted fleet of over 3100 vehicles from about 150 different partnerships with local haulers – many of which are family-owned businesses. In addition to these, Schenker has its subsidiary Schenker Åkeri, which owns and operates a fleet of approximately 600 vehicles.

Schenker's terminal in Borås conducts overnight traffic to other terminals in the surrounding region, such as Gothenburg to the west, Skara to the north and Jönköping to the east. Regional and local distribution is also undertaken from the terminal. Godsservice i Borås AB is the local hauler that is based at the terminal with a fleet of 22 trucks, 7 trailers and 3 vans. Other haulers working for DB Schenker, including Schenker Åkeri also utilise the terminal.

Viareds Företagspark is itself a logistics hub, with terminals and warehouses from several other logistics companies such as DHL, DSV and Aditro Logistics.

Note: Initially, the broader area of Viareds Företagspark was examined as a potential case study for this prestudy. Given the density of different logistics companies operating in the area, the opportunity for setting up semi-public electric charging infrastructure that could theoretically be used by any of the local haulers or vehicles frequenting a logistics terminal in the industrial park was discussed. However, this would mean that vehicles would be unable to charge during the loading/unloading process and would instead need to make a dedicated charging trip to a specified location, negating the benefits of opportunity charging. Following interviews and discussions with representatives from the City of Borås and transport consultants, DB Schenker's terminal was identified instead for this case study. Freight terminals such as DB Schenker's site at Borås are themselves semi-public in nature in that vehicles from many different haulage companies tend to use them, given the decentralised nature of the haulage industry in Sweden.

Feasibility for onsite charging infrastructure:

During interviews and discussions with DB Schenker representatives for the site, several technical and operational challenges for implementing opportunity charging at freight terminals in general were identified and raised.

The positioning of the charging port on electric trucks tend to be close to the driver's cabin. However, terminals are designed so that trucks dock to the terminal by reversing the rear end, so that the rear compartment opens up directly onto the terminal bay. Depending on the length of the truck and its load configuration (tractor with a semi-trailer, truck with a wagon, or a rigid truck) the charging port on the truck can then end up further than 10-15 metres from the terminal building. While manufacturers of electric rigid trucks could theoretically place an additional charging port further towards the rear of the vehicle, this would not solve the challenge for tractors with semi-trailers (which are amongst the most common vehicles used at freight terminals) as the semi-trailer is detachable and has separate components (and manufacturers) to the tractor. Refer to Figure 3 below to see an example of the distance from the terminal building to the driver's cabin of a medium sized rigid truck.

Figure 3 - DB Schenker site at Borås (observe the distance from the cabin of the rigid truck to the terminal building)

This distance of the charging port from the freight terminal itself poses both a practical and technical issue for implementing charging infrastructure at these sites, as DC charging cables are rarely longer than 3-4m due to the powerful current they are carrying and their need to have active cooling systems embedded in them. Having to manage long lengths of electrical cables on a worksite with heavy machinery rolling around also adds an additional layer of risk that must be carefully managed. Furthermore, many existing terminals may lack the physical space for the power cabinets that are needed to be positioned in proximity to the charging cables, as the freight docks are positioned fairly close to each other and power cabinets for DC fast charging tend to require a large volume of space. For example, the power cabinet from Tritium (a popular supplier of electric vehicle supply equipment) has dimensions of 2,310mm (H) x 610mm (W) x 1060mm (D). Refer to Figure 4 below showing the narrow separations between the loading bays.

Figure 4 - DB Schenker site at Borås (observe the narrow spaces separating each loading bay)

These practical and technical challenges suggest that custom solutions will need to be designed by the EVSE industry in order to meet the needs of existing freight terminals, as well as that future freight terminals should be designed with charging infrastructure in mind to avoid the need for potentially costly custom solutions.

Ground based charging solutions, such as those discussed above for intermodal terminals, could also be a solution here for freight terminals – given they would also solve the need here to avoid cable obstruction as well as overcome the space limitations for the installation of power cabinets near the cables.

Site 3: Circle K Vädermotet

Site description

Vädermotet is a Circle K fuel station located near a number of strategic industries in Gothenburg. First and foremost, the Port of Gothenburg lies just 1 kilometre to the south of the station. Due to the presence of the port, a large number of logistics centres and terminals are also located in the vicinity. Volvo Car's Torslanda factory lies approximately two kilometres to the north-west of the Circle K site. Several light industrial and retail-warehouse areas such as Biskopsgården and Amhult are also nearby. As such, the Circle K site at Vädermotet serves as a refueling as well as a food and rest stop for predominantly commercial vehicles, ranging from light vans to heavy trucks.

The fuel station has recently expanded to include a secure parking area with parking spaces for up to 35 road trains (of 25.25m each), or for a large number of smaller-sized commercial vehicles. The secure parking area is fenced, gated and monitored by surveillance cameras. The area is intended to make it more attractive for commercial vehicle drivers to make longer or overnight rest-stops by offering protection against possible vehicle damage and goods theft. The fuel station itself has shower facilities as well as food services and other amenities, such as wireless internet. At the time this case study was undertaken, Circle K did not charge for entrance to the secure parking area – however this could be part of the site's future business model. It is also worth noting that adjacent to the newly setup secure parking area there is also a large unpaved plot of land (about one third the size of the secure area) that is regularly used as a truck stop

Overnight parking and fueling sites designed to serve predominantly commercial and heavy vehicle users are relatively common throughout Sweden and Europe, and are often strategically located near major highways, on the outskirts of cities or near major logistics infrastructure, like ports and freight hubs. Circle K's Vädermotet differs slightly from other such sites by having the possibility of an additional revenue stream from charging entrance fees to its gated, secured parking area.

A survey of truck drivers at the site's secure parking area was undertaken as part of this pre-study to determine whether vehicles using the area were driving long-haul, line-haul or distribution routes, as well as some other characteristics of those routes However, only 18 survey responses were able to be completed over several days due to the majority of truck drivers using the area not having good verbal English or Swedish skills. The responses received, in combination with a survey of the country of origin of vehicle number plates, indicated that a majority of the trucks using the secure parking area at this site were long-haul trucks rather than local haulers doing line-haul.

Feasibility for onsite charging infrastructure:

Circle K already operates three DC fast chargers on the site next to the service station. While these existing fast-chargers are intended for passenger vehicles only (as they are positioned next to passenger vehicle parking spaces), Circle K is also considering installing a number of even higher powered fast-chargers in the secure-parking area with the intention that they will be utilised by electric commercial vehicles, such as vans and heavy trucks. Circle K confirmed that as the site was recently reconstructed, the availability of electric capacity for scaling up the number of chargers should not be an issue for the foreseeable future.

The secure-parking area is a gated, asphalted area with clearly marked lines delineating parking spots for up to 35 trucks up to approximately 25m long each. There are otherwise no curbs or any other structures or protrusions on the area's surface. Circle K have identified the highlighted truck parking bays (see Figure 5 below) as the first areas to deploy the chargers. The plan would be to install the bulky power cabinets outside the secure parking area and only have user units with charging cables and plugs next to the three parking spots within the secure area – cabling connecting the power cabinet to the user units will be run underground between them. However, this would still mean that the user units will become the only protrusions from the ground within the entire secure parking area. It is likely that high visibility signage and protective barriers will need to be put around the user units (where the charging plug is connected to) in order to prevent any potential accidents from large trucks driving into them. This may have the unfortunate side effects of reducing the number of parking spaces available as well as increasing the level of complexity for drivers to maneuver in and out of the parking spaces which otherwise would not have any fixed infrastructure to act as obstacles. This once again suggests that charging systems embedded into the road surface may be an option worth considering here and for other such sites.

In terms of the site's suitability for potential users of the truck charging infrastructure, a challenge here may be that the majority of vehicles currently using the secure parking area appear to be long-haul trucking operations with licence plates registered from overseas. These are unlikely to be the type of vehicles that will be amongst the early adopters of electric trucks. Over the course of four visits to the site during October – November 2020, notes were taken on the type of trucks, their country of origin and the haulage companies they belonged to. Approximately 280 vehicles were counted with the sample indicating that over 80% of the vehicles using the secure-parking area were from abroad – which also likely meant they were driving long-haul. Some vehicles did belong to Swedish based haulage companies, but these tended to be the ones that often stayed for the shortest periods of time, presumably while their drivers were stopping by for a mandated break.

Circle K has stated that it has plans to implement gate-fees for use of the secure-parking area, where the truck charging stations will be installed. In implementing this, they should be aware that the most likely users of the charging stations will be trucks from local hauliers, which the survey and stock-take visits showed tend to stay for the shortest periods of time (between 15-30 minutes – coinciding with the length of rest periods mandated by Transportstyrelsen). The fee structure for entry into the secure parking area should therefore not discourage short stays of such lengths.

Figure 5 - Sitemap of Circle K Vädermotet site depicting fuel station, secure parking area, and unofficial plot on bottom right used as truck parking. Highlighted areas show existing passenger EV chargers and planned location for truck EV chargers.

Broader considerations for fuels stations and EV truck charging

General considerations for fuel stations

Charging for passenger vehicles vs. heavy vehicles

The business model of fuel stations is generally at least as reliant on earnings from diversified revenue streams such as food, groceries and other services that appeal to customers when stopping by for fuel as it is on fuel itself. However, this business model is potentially under threat from the transition to electric passenger vehicles, as EVs can charge from a flexible range of sites other than at fuel stations. This means that each passenger EV will on average visit a fuel station much less frequently compared to an ICE vehicle. In addition to this, electric vehicles generally require longer stops to recharge compared to a vehicle refueling, which lowers the maximum vehicle throughput per square metre of a site.

The combination of these two factors, lower fuel station visits per vehicle and lower maximum throughput per fuel station site, threatens the viability of fuel stations aimed at servicing the passenger vehicle segment even if they are to completely switch over to electric vehicle charging. However, these two factors would not apply to fuel station sites like Circle K's Vädermotet that are designed and situated to serve a mostly commercial and heavy vehicle market. Whereas passenger EVs can stop at a range of locations for rest stops and charging, such as cafés and shopping centres, heavy vehicles will continue to be limited to fuel station sites due to parking limitations. Electric heavy vehicles will unlikely have access to the same varied landscape of charging opportunities that passenger EVs do outside of fuel stations, given that not only do they required much more powerful chargers in general, but for those chargers to be located in sites with suitable parking. This will likely mean that electric heavy vehicles will remain as dependent on fuel station sites, both for rest stops and for actual charging, as current ICE trucks. Even if dynamic charging (i.e. electric road systems) become widely implemented, electric heavy vehicles will still rely on fuel stations for rest-stops. The issue of throughput for electric vehicles at fuel stations should also not affect heavy vehicles, as many fuel station sites designed to serve the heavy vehicle market already have parking (away from fuel pumps) that are intended for vehicles to stay for longer periods of time.

In summary, these fundamentals point to:

1. The passenger vehicle segment will become less reliant on fuel stations both for energy and other complementary services (e.g. rest stop amenities and food) as it electrifies rapidly.
2. The heavy vehicle segment will likely continue to be just as reliant on fuel stations for both energy and complementary services even as the segment electrifies.

The key take-away here is that while the locations and business models of fuel stations serving the passenger vehicle segment may face strong pressures from the transition to electric drivetrains, fuel stations serving heavy vehicles are likely to face less fundamental challenges when it comes to the pattern of vehicle visitations. In the short term however, given electrification of the heavy vehicle segment is less mature than in the passenger segment, challenges associated with long-investment horizons and low initial utilization rates will still be roadblocks.

From fuel retailer to electricity retailer?

Sweden's fuel retail market is highly concentrated amongst the 4 market participants, Circle K, OKQ8, St1 and Preem. In terms of vertical integration in the fuel supply chain, Circle K is the least integrated, providing only retail sales of fuel. OKQ8 is involved in retail as well as direct sales of fuel in bulk to business customers with their own fueling infrastructure and sites (e.g. logistics companies). St1 and Preem are the most vertically integrated, with retail, direct sales and refinery operations. From a business model point of view, being more vertically integrated further up the fuel supply chain means that the business is less reliant on non-fuel sales, such as convenience store purchases at fuel stations, as the business is able to capture a larger share of the margin from fuel sales.

As electrification of transport matures, fuel retailers will need to make similar decisions in the future about which level of vertical integration on the electricity supply chain they want to operate in. The current approach of owning and operating charging equipment while reselling electricity from energy retailers (such as Vattenfall) is likely to result in a similar level of reliance on non-fuel revenue that Circle K and OKQ8's current business model is based on. However, by playing a more active role further up the electricity supply chain, fuel station businesses such as Circle K may be able to benefit from network effects and unlock higher margins on the sale of electricity. They may also consider converging their business model into that of a full-fledged electricity retailer in order to fully realise economies of scale and capture value in other ways, such as through energy storage, participation in flexibility markets as well as potential revenue streams from V2G in the future. This will of course result in greater risk exposure as well.

An alternative business model approach to further integration up the electricity supply chain could be complete vertical separation, whereby instead of owning and operating their own charging infrastructure, fuel stations choose to lease or enter into partnership agreements with electricity retailers (who are currently much further along in investing in EV charging infrastructure) to install and operate the charging equipment. This would in-turn mean that fuel stations will be entirely dependent on non-fuel revenue streams when it comes to EV customers.

Capturing unlocked value along the supply chain

The small but growing market for electric trucks is currently heavily dependent on depot charging. But most trucks do not return to the depot for a significant amount of time (or at all) during daily operations. This effectively limits their daily operational range to the range of one full charge, which typically varies from 100 – 300km depending on loading. This range in turn limits the number of use cases that they can be deployed for to predictable, intra-regional routes – resulting in a lack of operational flexibility which is highly valued by fleet owners.

Chargers located at fuel stations could play an important role in increasing the operational range, and therefore the number of use cases that electric trucks can be deployed across. This in turn increases their operational flexibility and overall value proposition, which is important given electric trucks currently have a much higher upfront capital cost. There should hence be the possibility of partnerships with OEMs to share the risk of investing in charging infrastructure at fuel stations, given that a significant amount of value that can be unlocked will flow towards them. Cooperation with potential customers (i.e. fleet operators) looking to invest in transitioning to an electric fleet should also be explored, as this can reduce the investment uncertainty for both the customer and fuel stations looking to install truck charging infrastructure. Ideally, all three parties (fuel stations, OEMs and fleet owners/operators) would work closely together to optimize the creation, management and sharing of both value and risk from the investment in charging infrastructure.

Conclusions

Every logistics site has different operational as well as business model characteristics. This pre-study has looked at which of these characteristics matter to the provision of semi-public charging infrastructure specific to three case studies and attempted to discuss why they matter. The study has made use of interviews and virtual workshops with a range of stakeholders in the logistics field, not least those from the facilities covered by the case studies. Some concluding observations can be made about findings which stood out and were either not immediately obvious or expected at the beginning of the study:

- Opportunity for electric road systems: Logistics sites tend to strive for layouts with as little protruding or fixed infrastructure as possible to avoid creating obstacles for vehicles. This means that traditional charging methods utilising cables (and associated power cabinets) will either be, at worst, completely unsuitable such as in the case of kombi terminals, or at best, difficult to implement – requiring customised solutions or compromises to the functionality or ease of use of the site. This suggests that logistics sites of all types could potentially be major benefactors from the successful commercialisation of charging systems embedded into the road surface, such as those being developed for electric road systems.
- Investigate drayage segment for accelerated electrification: The investment risk in transitioning a fleet to electric drivelines in trucking will be far from uniform across the sector. It is already well-known that city distribution is a low-hanging fruit for truck electrification. But on the heavier end of trucking applications, drayage services is also another segment that is well-suited to lead the transition towards electrification. This has already been acknowledged by programs in other jurisdictions such as California (Project 800 Initiative) that specifically targets this segment. Further research into drayage operations in Sweden should be undertaken to understand the size and nature of this sub-segment and whether policy measures targeting it for accelerated electrification should be considered.
- Regional but parallel across types of logistics sites: Line-haul vehicles and operators tend to be based locally within a logistics region, and within that region most vehicles used by haulers visit multiple types of logistics sites on a regular basis rather than specialise in shuttle traffic between just one type of site. With the exception perhaps of special cases such as drayage, the roll-out of charging infrastructure at logistics sites should ideally not occur in a sequential fashion that prioritises certains types of logistics centres (e.g. electrify X number of logistics terminals, before X number of distribution centres, before X number of kombi terminals) but rather in parallel within one region. This concept of a ‘region’ here refers to that used in logistics as opposed to regions as understood in a cultural or municipal sense.

Attachments

1. Site plan of Malmö Kombiterminal
2. Site plan of Circle K Vädermotet