POWER CIRCLE
Electricity for sustainable energy

Electrification and charging of heavy transport

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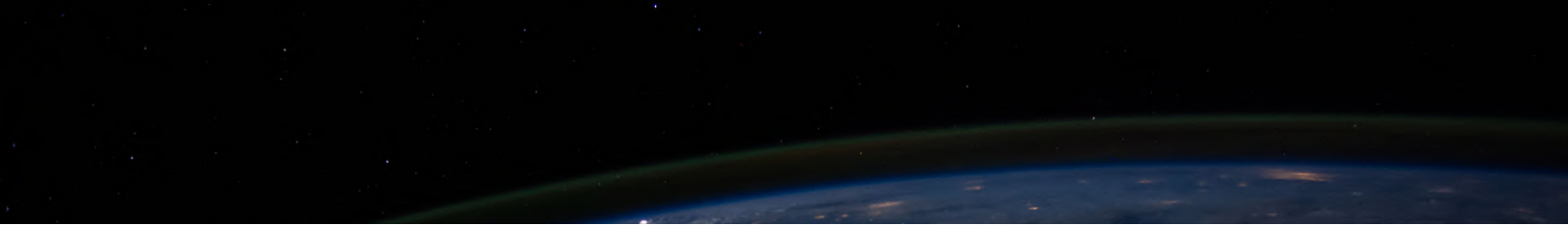


The transport sector is being electrified

Sweden will reduce 70% road emission by 2030

Sweden is aiming to reduce road traffic emissions by 70 percent by 2030 and reach a fossil free status for the entire vehicle fleet by 2045. Electrification has become an important strategy for the transport sector to become fossil independent. As the increase in rechargeable passenger cars reached a record high last year and the battery prices continue to fall, we are approaching the time when electric cars can compete in price with their fossil-fuelled counterparts. This has also paved the way for the electrification of heavier vehicles, perhaps faster and sooner than anyone might have anticipated a couple of years ago.

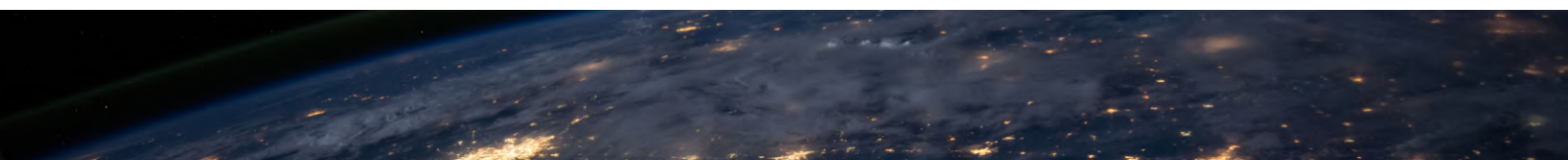
Electrification progress has been advancing in 2020, including the heavy transport sector which accounts for approx. 30% of the total Swedish road emissions. Scania and Volvo Trucks launched new electric truck models, the government commenced a series of initiatives under the Electrification Commission, appointed investigative assignments to the Swedish Transport Administration and supported the electrification pilots with over a billion SEK in investments. Roadmap from BIL Sweden indicates every second truck sold in 2030 can be powered by electricity.

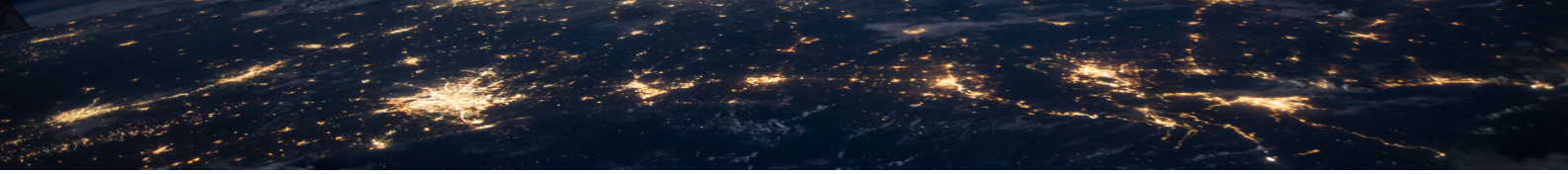
Every second newly registered truck can be electric by 2030

The transition synergy between the energy and transport sectors has given rise to new demands and needs for collaboration among the vehicle manufacturers, charging infrastructure operators, transporters, transport buyers, electricity grid companies, municipalities, regions and new players. Many actors are now investigating how truck charging could be done, what business models would work and how charging, battery size and route planning can be optimised.

In this white paper, we want to provide an overview of the electric trucks potential and probe questions surrounding the charging infrastructure[1], such as: "What type of charging is needed and where?", "What are the emerging solutions and collaborations?" and "How will electrification be profitable?"

[1] Vehicle charging can happen statically or dynamically via electric road technology or charging stations. In this white paper, we focus on static charging for heavy trucks at charging stations. Dynamic and static charging via electric road technology will be presented separately.





The potential of electric trucks

There are 84,000 heavy trucks in Sweden today, but only 30 are electrified

There are approximately 84,000 trucks in Sweden weighing over 3.5 tonnes, I.e., trucks that are categorised as heavy[2]. The Swedish Transport Administration forecasts that the volume of heavy vehicles will reach 120,000 in 2040[3]. While the heavy trucks can be categorized into local, regional and long-distance, each with different preferences from various actors, the graph below gives an approximate idea on the characteristics of the transport in the form of total weight, annual mileage and energy consumption. Based on mileage and total weight, 21% of the trucks are performing local transports, 63% regional, and 16% long-distance transport. By the end of 2020, there were 30 electrified heavy trucks in total[4].

The plans of the vehicle manufacturers

Electrification is an important piece of the puzzle for all European truck manufacturers

Electrification is now a key element in all European truck manufacturers' future strategies. Starting this year, Volvo Trucks is providing the entire truck product line with an electric drivetrain, and plans to start mass production in 2022. Scania has launched its first electrified trucks in an electric model and a plug-in hybrid. Daimler Trucks and MAN implemented new strategies in 2020. Daimler aims for volume production of electric truck this year and MAN has already put smaller trucks into series production, with launch of new electric models in 2023.

	Local transport	Regional transport	Long-distance transport
Total weight (ton)	3,5 – 16	16 – 30	30 -
Amount in use (2019)	Approx 18 000	Approx 53 000	Approx 13 000
Share (%)	21	63	16
Daily mileage (km)	150 - 200	300 - 400	400 - 600
Annual mileage (km)	< 50 000	50 000 - 100 000	> 100 000
Energy (kWh/km)	0,5 – 1	1 – 1,5	1,5 – 2
Typical Business	groupage, food transport, garbage trucks, tipper	general cargo, food transport, fuel transport	general cargo, food transport, fuel transport, "bulk"

[2] Trafikanalys (2021). Fordon på väg

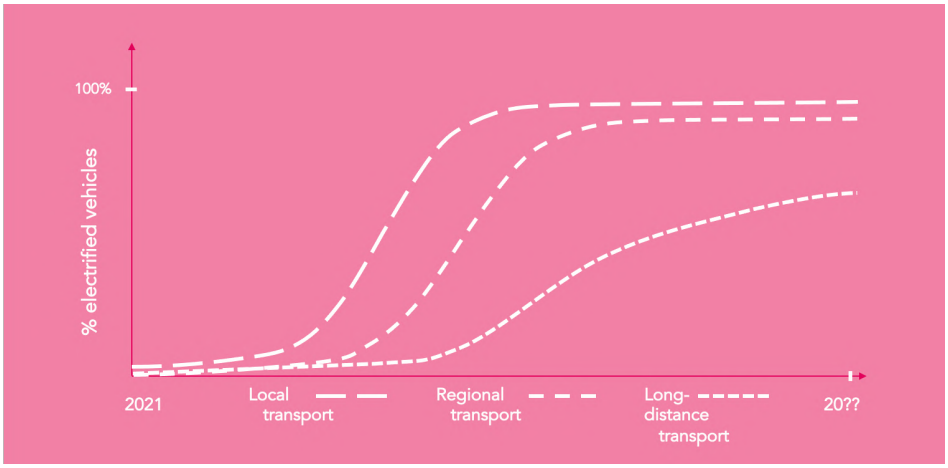
[3] Trafikverket (2021). Behov av laddinfrastruktur för snabbladdning av tunga fordon

[4] Transportstyrelsen (2021). Support order

What truck manufacturers have in common is that they first electrify trucks in their model ranges that are suited for daily short distances, such as garbage collection and distribution in cities, and then gradually develop the range towards longer and more demanding transports. Volvo Trucks accomplishes the electrification of their product range according to the S-curve methodology. The same applies for Scania; the electrification of their model range will occur at different paces for different segments.

The S-curve

When new innovation is introduced into the existing markets, the transition from existing technology can take place as the inovation matures, similar to the shape of an S-curve.



There are electric truck models on the market today that meet the needs of local and regional transport. Scania has a model for up to 29 tons with a 165 kWh battery that gives 150 km range, or a 300 kWh battery with a coverage of 250 km[5]. Volvo offers several medium-heavy models up to 27 tonnes for goods deliveries, construction work and waste management in urban environments with a battery capacity of 400 kWh - corresponding to a range of 200 km. For regional transport, Volvo offers electric trucks up to 44 tons with a 540 kWh battery that runs up to 300 km[6].

There are different strategies for electrifying the long-distance transport

When it comes to the long-distance transport, vehicle manufacturers have different strategies. In general, there are currently three alternatives that can complement each other: electric trucks with public fast charging, electric trucks charged via electric roads, and fuel cell electrics that require hydrogen infrastructure. The Volvo Group believes in a combination of electric models and fuel cell equipment[7].

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[5] Scania (2021). Batteridriven lastbil

[6] Volvo (2021). Eldrivna lastbilar

[7] Volvo Group (2021). Vätebränsleceller

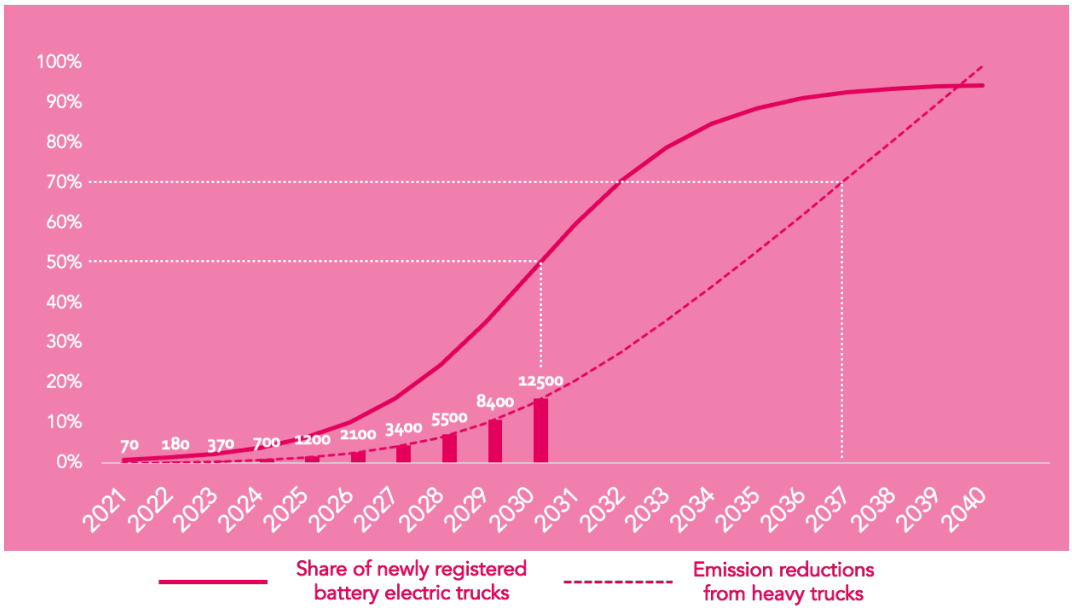
Electrifying today

Of today's approximately 84,000 trucks, 80% have driving distance less than 500 km per day and 60% shorter than 300 km[7]. This means it is actually possible to electrify a large share of truck transport in current existing model range, even if the rate of electrification would largely depend on the expansion of charging infrastructure, the replacement of the fleet, and the time that truck manufacturers need to produce the vehicles.

Likewise, Daimler Trucks plans to start testing fuel cell trucks with ranges up to 1,000 km in 2023[8]. Volvo and Daimler together have also created a roadmap for hydrogen-based fuel cells for long-distance transport[9]. Scania, on the other hand, is open for electric vehicles with both fast charging and electric roads.

How fast can electrification go?

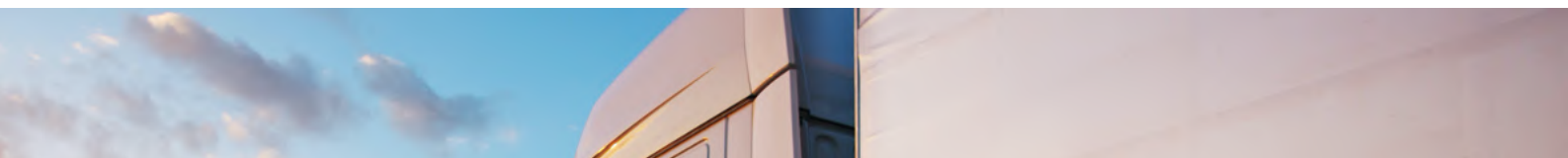
BIL Sweden, in its road map, points out that 50 percent of heavy truck new sales can be electric by 2030[10]. This means that approximately 4,200 new electric trucks will be in operation by 2030, under the assumption that one tenth of today's vehicle fleet is replaced every year. If the electric truck new sales follow an S-curve, in 2030 we will have 12,500 electric trucks in Sweden, which makes 15% of the fleet. This shows the need for supplementary biofuels and a large electrification of lighter vehicles in order to reach the climate goals. Power Circle will, within the framework of the ScandELivery project, produce an in-depth forecast on the electrification of both light and heavy trucks with the consideration of wider environmental coverage.

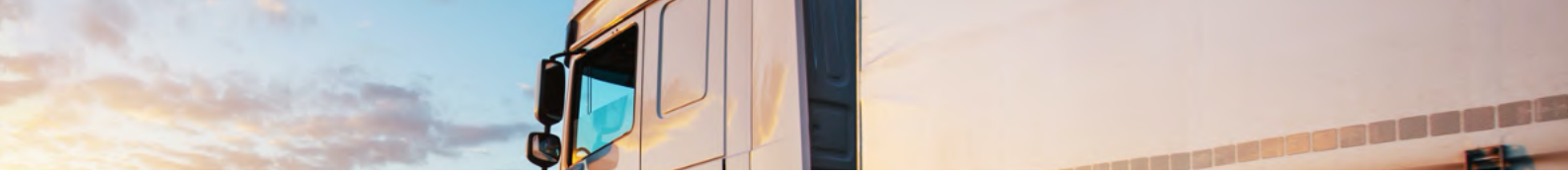


[8] BIL Sweden (2020), Färdplan för tunga fordon

[9] Volvo Group (2021). Volvo och Daimler Truck AG storsatsar på vätgasbaserade bränsleceller

[10] BIL Sweden (2020), Färdplan för tunga fordon





Heavy trucks charging

The charging of goods- and freight transport can be done with different techniques, at different charging capacities and in different places. How charging is applied depends on the vehicle type and driving patterns.

Sweden need 1,200 public and semi-public charging points for heavy trucks in 2030

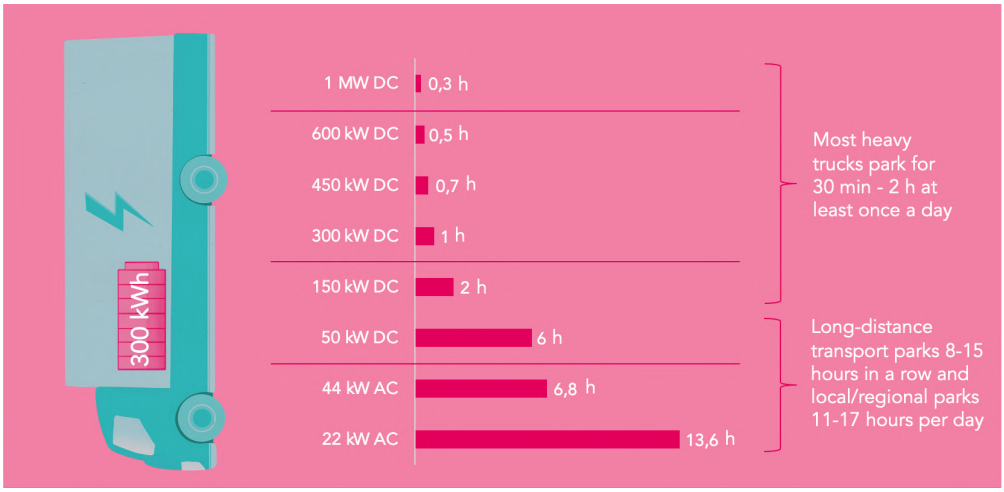
ACEA, the largest trade association for the automotive industry in Europe, estimates a need for 10,000 - 15,000 public and semi-public charging points with high charging capacity by 2025, and 40,000 - 50,000 by 2030 in order to meet the European climate target goals[11]. Today, this infrastructure is almost completely missing. According to the analysis, Sweden is expected to have 350 charging points by 2025 and 1,200 by 2030.

Charging types

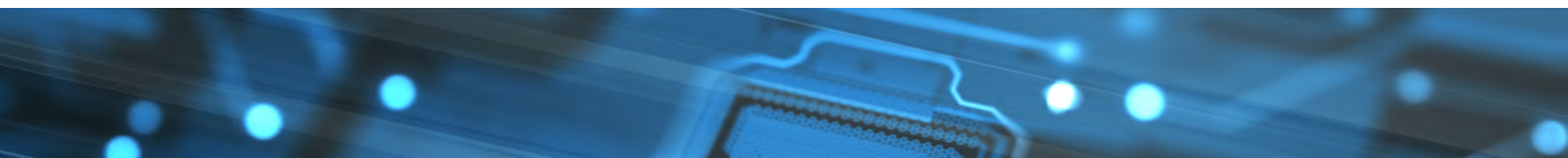
80 % of charging is expected to take place at depots and only 20 % at semi-public and public charging stations

Trucks can have private stationary charging at depots, semi-public charging at unloading and reloading stations such as freight terminals and ports, or public charging along the road. BIL Sweden's roadmap predicts that the majority of charging (approx. 80%) will take place at depots during night with low charging speeds of 22-50 kW, which is sufficient for urban distribution.

For regional distribution, depot charging needs to be supplemented by semi-public and public charging. Semi-public charging for commercial vehicles refers to the chargers that can be accessed and used by several different carriers. Approximately 15% of the charging is expected to take place at the semi-public stations with power output from 150 kW.



[11] ACEA (2021). Position paper - heavy duty vehicles charging infrastructure requirements



Depot: The vehicle's "home charging". Where it is parked during the night and/or returns to during its routes. Depot can provide charging capacity 22-50 kW at night, or higher if the car returns during the day.

Semi-public: The charging takes place where the vehicle travels during its route, for example ports and freight terminals. It provides higher outputs from 150 kW.

Public: The charging takes place along the road network. Mainly provides high outputs from 350 kW.

Above all, it is depot and semi-public charging that needs to be built in the next few years.

It is likely that electric trucks can be charged with megawatt charging systems in 2030

At last, public charging is necessary along the road network for vehicles that drive longer daily distances or where the battery's capacity is not designed to cover the entire daily need. The estimation of such public charging at outputs from and above 350kW accounts for approximately 5% of the total charging demand for these trucks. For long-distance transport, the public charging requires delivering charging capacities above 500 kW. The picture above shows how long it takes to charge 300 kWh, corresponding to a driving range around 200 km, at different charging capacities. High-power chargers with 1MW output makes heavy vehicle fast charging possible within today's statutory rest period (45 minutes) during long shifts.

While depot charging is often associated with lower charging capacity, ongoing pilot projects indicate otherwise. For example, two of the trucks in Project REEL charge at a depot with 350 kW. In order to increase profitability, the electrified trucks are preferred to be driven in two or three shifts per day (the higher the annual mileage, the faster to reach profitability), which in some cases leaves no time for slow charging. Conversely, there is a need for public charging with lower outputs as the drivers can have their 24-hour rest. Therefore, the categorisation on depot, semi-public and public charging shall only represent the locations, and the charging itself shall be divided into high-speed and low-speed regardless of where it is done.

It is important to point out that both depot charging and semi-public charging shall be expanded with priority in the coming years, after all, the electrification takes place first for local and regional transports.

Charging technology development

Today, chargers with CCS outlets can deliver up to 400 kW. For higher charging outputs of up to 600 kW, pantograph charging is currently required. Standards for what high-power charging for heavy vehicles should look like are underway, and the first step towards charging in the megawatt scale has been taken. It is likely that by 2025, we will see chargers capable of handling 750 kW, and by 2030, up to 1 MW. However, it is currently the trucks that set the limits for charging speed - today's models can at most accept 130-250 kW, but plans are in place to accommodate 375 kW and eventually 1 MW via CCS outlets.

Where should the chargers be placed?

The regional traffic often has distributional patterns within a defined area and moves along recurring routes. This means that establishing strategic semi-public charging stations at places such as freight terminals and ports within a region might be sufficient to start with. Later on the charging points can be scaled up to accommodate an increasing proportion of electrified transport, and eventually be placed to link the regions together, enabling electrified long-distance transports.

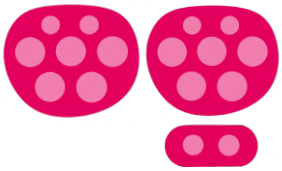
Suitable locations for public charging can be identified through analysis of how the combined truck fleet drives in the country. It is critical to consider charging break pauses, so that the charging does not result in costs in the form of idle personnel and vehicles. Fraunhofer ISI has carried out a study for ACEA based on 400,000 trucks from seven trucking companies in Europe[12]. The study identifies roughly 30,000 clusters where vehicles from several truck manufacturers stop today and where charging could be established. The result shows 30-50% of these places are at rest areas near the highway, 25-45% are at companies and logistics centers, and 1-5% at ports. ACEA has also released an interactive map that indicates more than 4,000 clusters of importance to regional transports. Among them, around 100 clusters have been identified in Sweden, especially in the southern part of the country.[13] Blue circles shown below highlight places with many stops, for example, there are 20 blue circles around Gothenburg.

Charging standard

Type 2 outlet: European standard for charging electric vehicles with alternating current. It is used for lower outputs <50 kW.

CCS outlet: European standard for charging at higher outputs. It uses type 2 sockets for alternating current but also has a special socket for higher power via direct current.

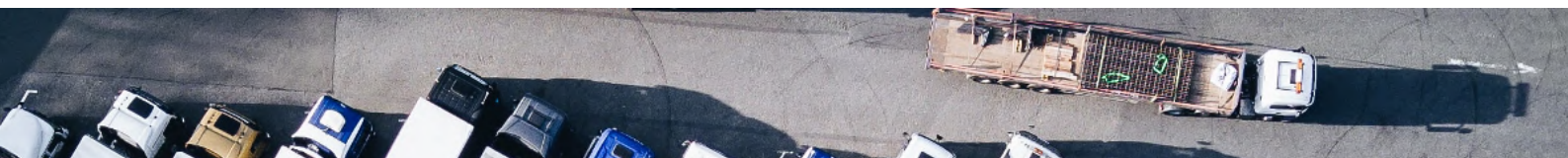
Type 2 CCS



100 clusters have been identified in Sweden that are particularly suitable for charging regional transports.

[12] Fraunhofer ISI (2021) Truck stop locations in Europe

[13] ACEA (2021) Interactive map – Electric trucks: regional stop locations fit for charging point deployment in Europe



Trucks charging and the grid

The interaction between the logistics perspective and the energy perspective is important to the transition

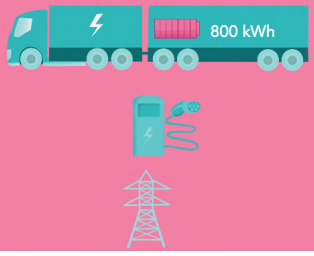
Sufficient grid capacity plays a crucial role in the electrification of heavy road transport. Hence, it is important to take both the current and the future grid conditions into account from a logistics perspective. In the case of semi-public charging, one should also consider the property's total power needs. In terms of public charging, the grid connection may need to be scaled to supply both private and commercial vehicles. To fully utilise grid connections, charging can be done both during the day and at night - the graph below gives an example of how an electrical connection can be used during a truck stop. Smart charging will certainly be important for trucks as well, even if the margins are smaller than those for passenger cars.[14] For high-power charging, external batteries may act as an important partial solution. Power Circle will explore the synergies between grid and the logistics in an upcoming white paper.

A grid connection for fast public charging can also be used by long-distance transports for charging at night.

Truck stop planning

In case of larger truck stops, the power needs can be significant, but by planning smartly, the power can be used efficiently. One way to size charging stations at these public truck stops is based on the need for overnight charging, so that the available power can be used for fast charging at fewer stations during the day.

The image below shows how a truck stop can be dimensioned in a scenario with a nearly 100% electrified fleet. This scenario is far in the future, and realistically by 2030, it might involve needing about one-fifth of the sites and power (approximately 1 MW).

Truck stop with 75 places	24-hour rest	Fast charging
	60 spots	7 / 14 spots
	80 kW	700 / 350 kW
	5 MW	5 MW

[14] Read more about smart charging from Power Circle's white paper.

Ongoing pilot project

There are already several pilot projects on electric trucks and charging stations in Sweden, here are some of them.

In Skåne, Oatley has electrified two distribution routes with trucks from Einride and charging from E.ON: four trucks drive the routes between Landskrona - Helsingborg (about 25 km) and Tingsryd - Helsingborg (about 175 km). The shifts start at 6 a.m. in the morning and end at 1 a.m. at night. Primarily, the charging takes place at the depot with 44 kW, but high speed charging at 150kW can also be done in Helsingborg in connection with unloading if necessary.

The REEL project tests regional transport electrification up to 300 km.

The REEL project tests regional transport of up to 300 km at two locations in the country[15]. One demonstration consists of an electric truck and a plug-in hybrid from Scania that delivers food in Greater Stockholm. The truck will be charged with 30 kW in the warehouse between 10 p.m. and 5 a.m., supplemented by auxiliary charging while reloading at a semi-public charging point and warehouse with 130 kW. In the second project, DHL drives a 60-tonne electric truck from Volvo between Gothenburg and Jönköping (150 km). The charging takes place at DHL's terminal in Jönköping and the Volvo Truck Center in Gothenburg with chargers that can deliver 320 kW.

In Gothenburg area, a public charging station with 40 truck charging spots is planned.

The coordination of charging at semi-public charging stations becomes important as more trucks are electrified. The company Rearq leads a Vinnova-financed project together with Martin & Servera and Mathem, where the need for charging from the various carriers and merchandise owners will be analysed to create the conditions for a joint semi-public charger[16].

Today there are only a few public charging stations designed for heavy transport in Sweden. This includes the 175 kW fast charger that Göteborg Energi has installed. The charger has so far mainly been used by taxis and passenger cars, as there are only two electric trucks operating on Gothenburg's streets. However, this is expected to change as more

[15] CLOSER (2021). REEL

[16] Vinnova (2021). Öppen plattform för delad laddinfrastuktur

trucks are electrified. Several players are planning for the public charging infrastructure expansion, both energy companies and fuel suppliers such as Circle K and OKQ8. Circle K has recently prepared one of its stations in the Gothenburg area with cabling and a new transformer station, which has the potential to provide 40 charging spots for trucks[17].

In the upcoming years, we anticipate seeing an increase in both the scale and number of projects as electrified vehicles become more prevalent and the necessary charging infrastructure is established to accommodate them. For instance, the REEL project has plans for a follow-up phase that will incorporate approximately 100 electric trucks, 50 fast terminal charging points, and 100 depot charging points during the years 2021-2024.[18] The government has allocated just over a billion in support to regional electrification pilots in 2021 and 2022.

Electric trucks may reach cost parity with conventional trucks in TCO around the mid-2020s.

How is electrification profitable?

The electric trucks today are still more expensive than their conventional counterparts in terms of both purchase price and total cost of ownership (TCO). However, different analyses shows they can become cheaper within 5-10 years without financial support but with high initial investment cost[19]. Transport & Environment predicts that electric trucks with stationary charging and electric road solutions could reach cost parity in TCO with fossil-fuelled trucks in the mid-2020s[20].

There are several aspects that affect an electric truck's TCO. The battery is the main cost driver; thus, decreasing technology costs for batteries is crucial. Another factor is the total mileage during the vehicle's lifetime, as driving more shifts can lead to more profitability. Ongoing cost of charging also matters. In addition, optimisation and data analysis in choosing which vehicles and routes should be electrified first, optimising battery sizes and developing charging strategies are vital as well.

To bring down the electric trucks' TCO, investment support for the vehicle itself and for those who build the charging infrastructure is pro-

[17] Circle K genom IUC Syd (2021). ScandELivery Eldrivna lastfordon - inspelat seminarium

[18] Regeringskansliet (2021), Elektrifieringslöften

[19] Anders Grauers (2021). Är det kostnadseffektivt att köra ellastbil?

[20] T&E (2021) How to decarbonize long haul trucking

bably necessary for the coming years. Environmental friendly heavy trucks currently can receive support for up to 20% of the purchase price, and such support is expected to last until 2023[21]. Today, there are no list prices for electric trucks, however, the estimated support would be around 1 million SEK for a purchase price of 5 million. 120 million SEK has been set aside for the support, which also includes electric buses and work machines. The Swedish Transport Administration has calculated that an electric truck may need SEK 350,000 in investment support in 2030. As the utilization of charging infrastructure increases and transport companies, together with charging infrastructure operators, make joint and long-term commitments to secure investments from both sides, the need for governmental support will decrease.

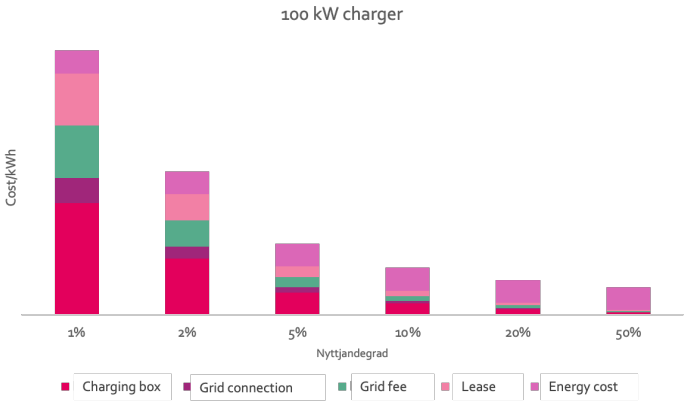
Investment support is needed for both vehicles and charging stations

Charging cost

The charging cost is primarily affected by the investment and operating costs of the charging station. Charging stations with a lower power output have lower investment costs in hardware and grid connection, hence it is generally beneficial to charge as much energy as possible at those stations when the vehicle is parked for longer periods.

In addition, the cost is also affected by how much the charging station is used - the higher the occupancy, the lower the cost per charged kWh. The figure below explains the concept[22]. The observation is not only clear when the transporters or carriers have invested in the charging stations themselves, but also should be reflected on the charging price in the long run when an external energy supplier is involved. In order to increase the utilisation rate, booking services will probably become important at semi-public and public charging stations.

The more a charging station is used, the lower the cost per charged kWh.



[21] The Swedish Energy Agency (2021), Klimatpremien

[22] Anders Grauers (2021). Det är kostnadseffektivt att köra ellastbil

Drive-through charging points can increase the charging stations' utilisation rate as they allow charging for different types of vehicles.

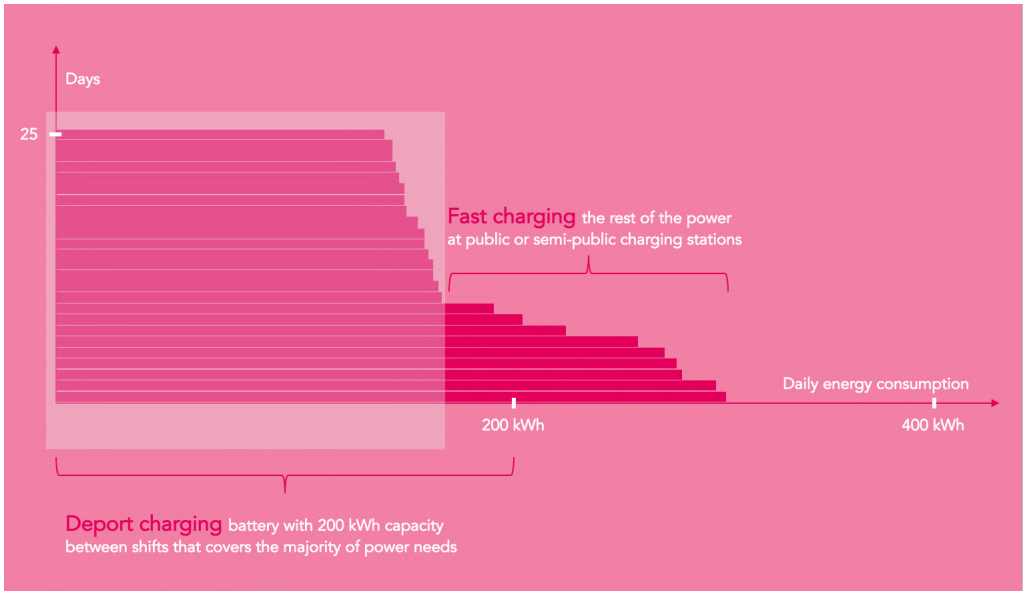
To combine service for private individuals and commercial traffic, public charging stations may provide the opportunity to share the costs of groundwork and grid connection. Although private and commercial vehicles in most cases do not charge at the same charging point, building drive-through charging points like Circle K does could be an alternative. This means that at least smaller truck models and private vehicles can charge at the same charging points. This may be important at the current stage as the fiscal coverage is not high enough for fully commercial chargers.

Finally, indirect costs could arise when charging is not adapted to the rest period or unloading/loading schedules, as both the drivers and the vehicles are not used optimally.

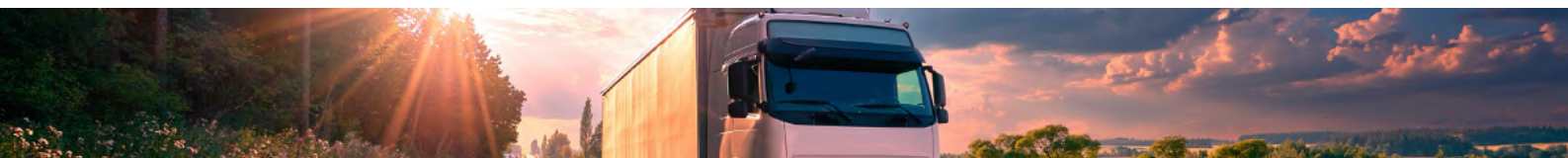
Battery size and charging strategies

To analyse the behaviour patterns of carrier vehicle fleets becomes important as it helps to identify which vehicles and routes are best suited to be electrified first. Vehicles that can do the main charging at the depot - where charging is the cheapest - should be electrified first. To electrify vehicles that run similar mileages everyday around the year is also more profitable, as the battery capacity can be utilised to the maximum. CLOSER has carried out an analysis for a couple of transport companies in Gothenburg area, and more will be conducted within the REEL project[23].

Truck battery capacity shall be made for routes that are driven everyday at 60-70% of the year.



[23] CLOSER via Power Circle (2020), How do we get charging infrastructure in place? – webinarium



In order to increase profitability within a truck fleet, it becomes important to ask whether today's routes can be planned differently.

The battery size should be determined by a typical daily mileage rather than the extreme cases. If the vehicles are used for extra long routes with few days off in between, they could benefit from public charging instead of opting for larger battery capacities, even though charging is more expensive per kWh. The figure above explains the concept.

In addition to the analysis on vehicles' existing driving patterns, it will also be important for the carrier companies to optimise their fleet usage in the future – for example, is it possible to avoid long distances transportation for certain vehicles?

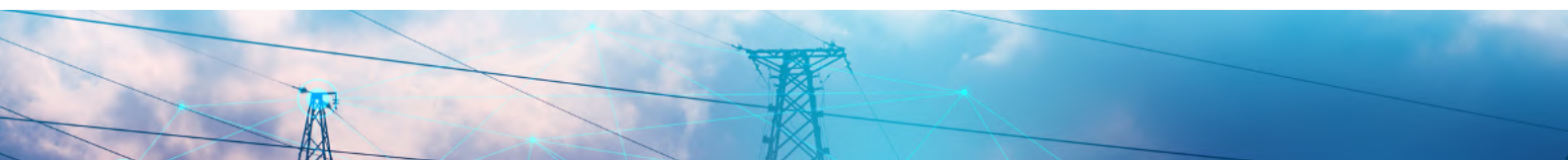
The driving patterns of the vehicles are also necessary for developing charging strategies that optimise charging with respect to economy, range, and the driver's comfort. Since the battery range is influenced by external factors, the logistics must also be planned based on factors such as the route's topography and speed limits, road conditions, traffic, battery age, and load weight, to name a few parameters.

High-power charging can improve heavier trucks' TCO

A Swedish study from SEI has demonstrated that a substantial availability of high-power fast charging (1 MW) could enable heavier trucks to operate with smaller batteries and become competitive[24]. The study modeled various battery parameters and shows that with optimistic values on battery cost, number of cycles, and energy density, competitiveness increases with the load weight. This is a reversal from many previous studies, which suggest that lighter trucks are the most suitable for electrification.

Interestingly, given that high-power fast charging is available, the cost per transported weight and km improves with the load weight, regardless of the battery parameter, due to the relationship between load capacity and the weight of the battery pack. Generally, it is advantageous to increase the truck's total weight since the load capacity increases more than the energy consumption and the cost of the vehicle.

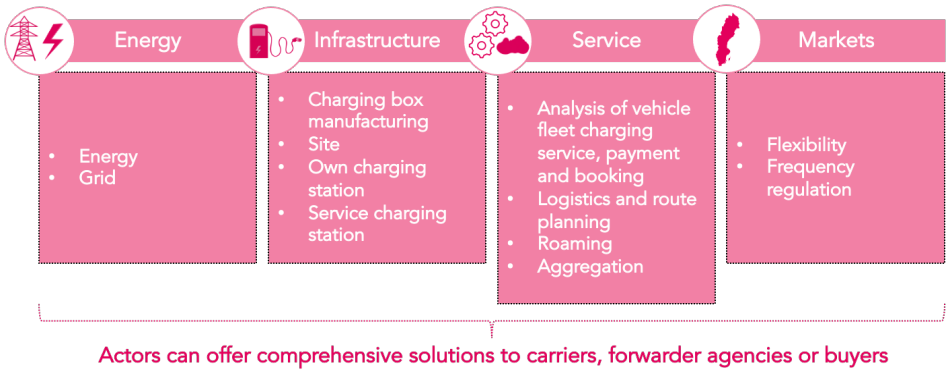
[24] Nykvist, B. och O, Olsson (2021) The feasibility of heavy battery electric trucks



New solutions and partnerships

Choices on vehicle electrification types and charging and routes optimisation will be important for the profitability of electric trucks.

The value chain for charging heavy transport is in many ways similar to that of passenger cars — to establish on-site charging, energy and electricity grid suppliers are required; access to land; manufacturing, investment, and operation of the charging stations themselves; as well as services towards the end customer, which in this case is the carrier or haulier owning the truck.[25] Sales of flexibility and other ancillary services to the electricity grid are likely to become relevant as well. However, the margins for commercial traffic are lower, and additional services based on data analysis and optimisation are added. Several companies are now developing comprehensive services that may include everything from analysing which vehicles to electrify, planning charging and routes, to direct services for the driver such as booking of charging stations and payment solutions. These solutions also serve the purpose of simplifying the transition for carriers and transport companies. The uncertainty and perceived complexity among carriers and transport companies can be one of the biggest barriers to electrification of goods and freight transport today.



The question of who will invest in the charging infrastructure also arises. Is it the transporter, the forwarder agency or the buyer in the case of depot loading? Is it the real estate owner of the logistics center, a charging operator or several transporters or buyers jointly in the case of semi-public charging? What will it look like with the public charging? Here, both energy companies and fuel suppliers are showing interest. Or will both charging, vehicle and associated optimisation be a joint offering from the truck manufacturers or a third party? Ongoing and upcoming pilot projects may provide us with more insights on this.

[25] Read more about the charging value chain in our white paper Smart charging.

Joint commitments are needed to create security for those who invest in trucks and charging infrastructure.

It is also clear that collaboration and partnership are becoming increasingly important as the energy and transport industries integrate. All parties in the value chain need to work together to accomplish the new solutions – those parties can be the suppliers of charging infrastructure, vehicle manufacturers, carriers, transport buyers, charging operators and service providers. In order to secure access to the charging infrastructure for the carriers and guarantee occupancy for those who made the investment, joint and long-term commitments are needed between transport buyers, carriers and charging operators.

Cooperation with cities and regions as well as grid companies will also play a crucial role in accessing land and grid capacity for charging infrastructure. Many cities and regions have their own goals in reducing environmental impact from transportation, hence are interested in facilitating the transition. In Stockholm, Ellevio, Scania, Volkswagen and the Stockholm City have entered into an electrification pact that aims to have a fossil-free vehicle fleet by 2030. The pact includes, among other things, developing a rollout plan for heavy transport electrification.[26] In Gothenburg, Volvo, Gothenburg Business Region and RISE have initiated the Gothenburg Green City Zone, which will achieve completely emission-free transport in the zone by 2030.[27] In May, a long series of additional regional electrification initiatives - or "electrification promises" - were launched as part of the Electrification Commission's work. [28]

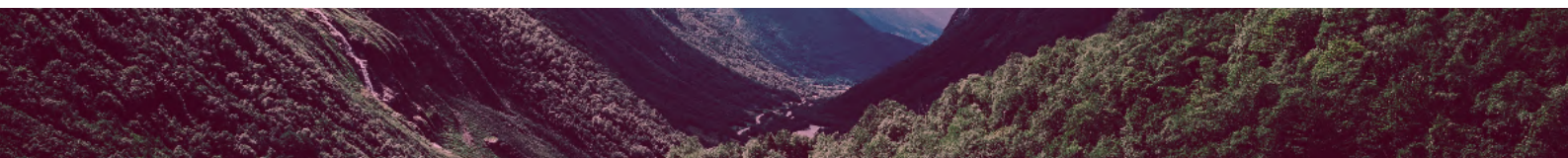
Electrification promises

Recently, 16 regional electrification promises were launched with a total of 252 involved actors. The promises include things such as electrification pilot projects planning, mapping suitable places for charging, investment in charging stations, and that forwarder and carriers shall offer buyers electric transport while the buyers, municipalities and regions must vice versa procure them.

[26] Dagens Industri (2021). Elektrifieringspakt gör Stockholm fossilfritt

[27] Business Region Göteborg (2021). Gothenburg green city zone

[28] Regeringskansliet (2021), Elektrifieringslöften



Summary

Electrification has become a a key element on the journey towards fossil-free heavy transportation. The potential is vast; 84% of Sweden's 84,000 trucks today operate locally and regionally, and a significant portion of these could be electrified with the available truck models.

To realise this potential, the charging infrastructure needs to be expanded. From the current situation with around 30 electric trucks and a handful of charging points designated for these vehicles, we could have 12,500 electric trucks on the roads by 2030, neding over 1,000 public and semi-public charging points, as well as depot charging. To electrify local and regional transport, the focus for the next few years should be on expanding depot and semi-public charging within regions. Afterward, these charging stations can be gradually scaled up and supplemented with public charging to connect regions and eventually enable electric long-distance transport. By analyzing the driving patterns of trucks, suitable locations for charging stations can be identified.

For a successful transition, profitability is required for both the carriers and the charging infrastructure operators. Initially, subsidies are needed for both the vehicles and the charging stations. Joint long-term commitments between transport buyers, carriers, and charging infrastructure operators reduce uncertainties and could potentially decrease the need for support in the long run.

Meanwhile, the technology must continue to evolve to allow for charging at higher outputs, especially for long-distance transport. New solutions for optimising route planning and charging are under development. Numerous pilot projects are ongoing to create learnings around charging strategies, driver experiences, technology, and business models. In the coming years, we expect to see more and larger projects, including those within the framework of the electrification pledges.

Last but not least, the expansion of the charging infrastructure must go hand in hand with the development of the electricity grid. We at Power Circle, we believe that smart charging, battery storage, and a closer exchange of information between grid companies and the transport sector, both during the planning of charging stations and operations, will be important components moving forward.