

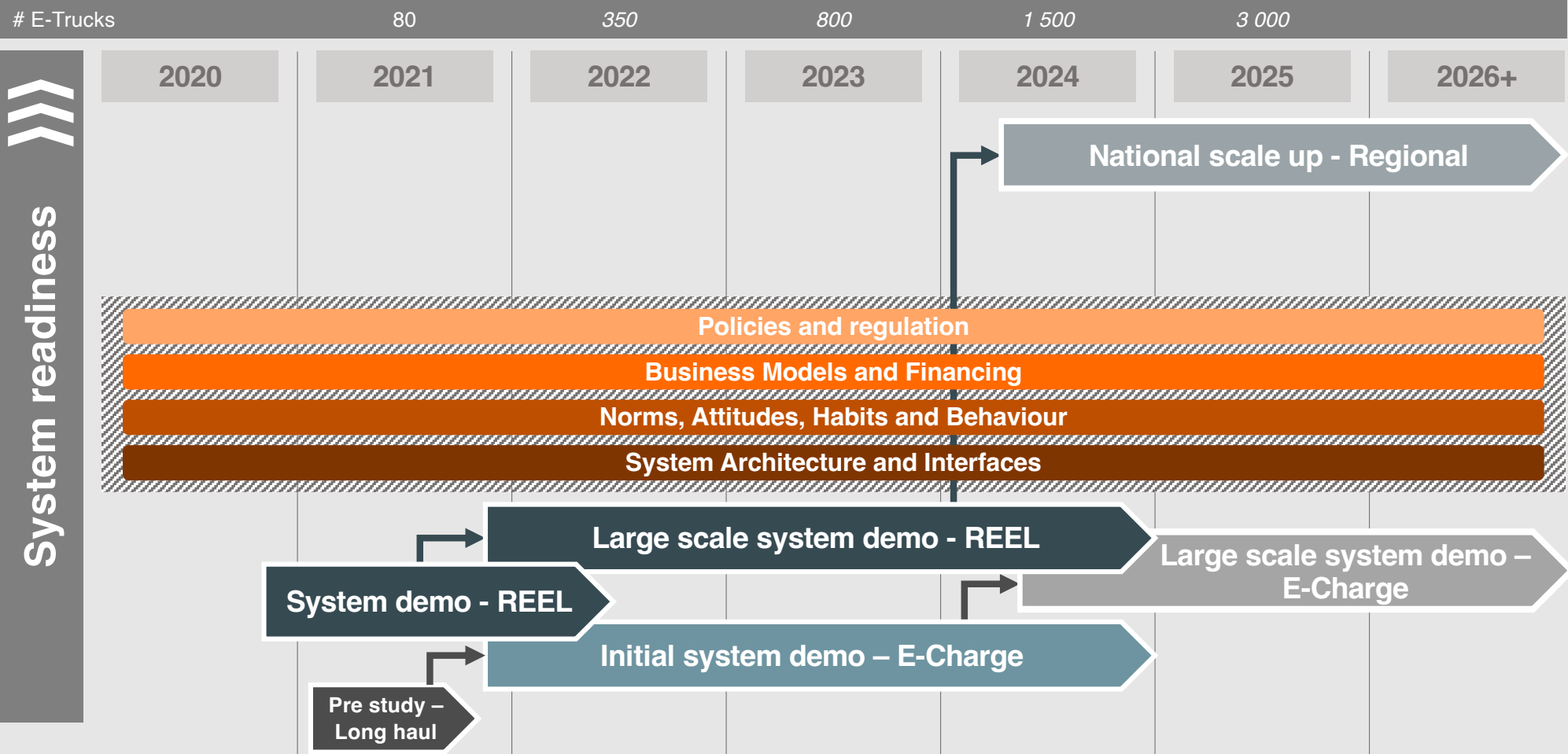
An aerial photograph of a large, calm lake surrounded by dense green forests. A paved road with white dashed lines runs along the right side of the lake, with a few cars visible. The sky is overcast and grey.

Electrification of heavy-duty trucks

REEL and E-Charge projects

Nikita Zaiko

Together with our partners we have created a roadmap showing initiatives for accelerating the transformation



REEL

Regional Electrified Logistics



CLOSER 

FFI

 Swedish
Energy Agency

 TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION

VINNOVA
Sweden's Innovation Agency

REEL paves the way for large-scale electrification of regional logistics systems in Sweden by demonstrating solutions adapted to the logistics needs



Photo: CLOSER, Lindholmen Science Park



Photo: Scania



Photo: Scania



Photo: Volvo Group



Photo: Volvo Group



Photo: Volvo Group

REEL involves 45 organizations all around Sweden, together we establish, operate, and analyze electrified logistic solutions for various types of goods



CLOSER

Participating actors

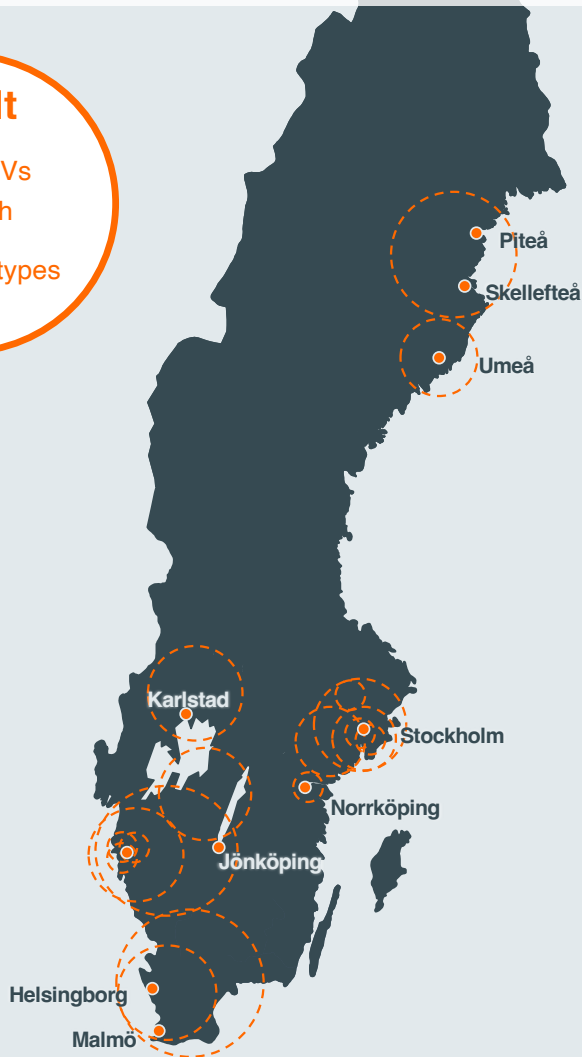
CLOSER

Public co-financing

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In the project 70 logistic solutions are established and cover multiple applications with trucks in the range from 16 to 70+ tons

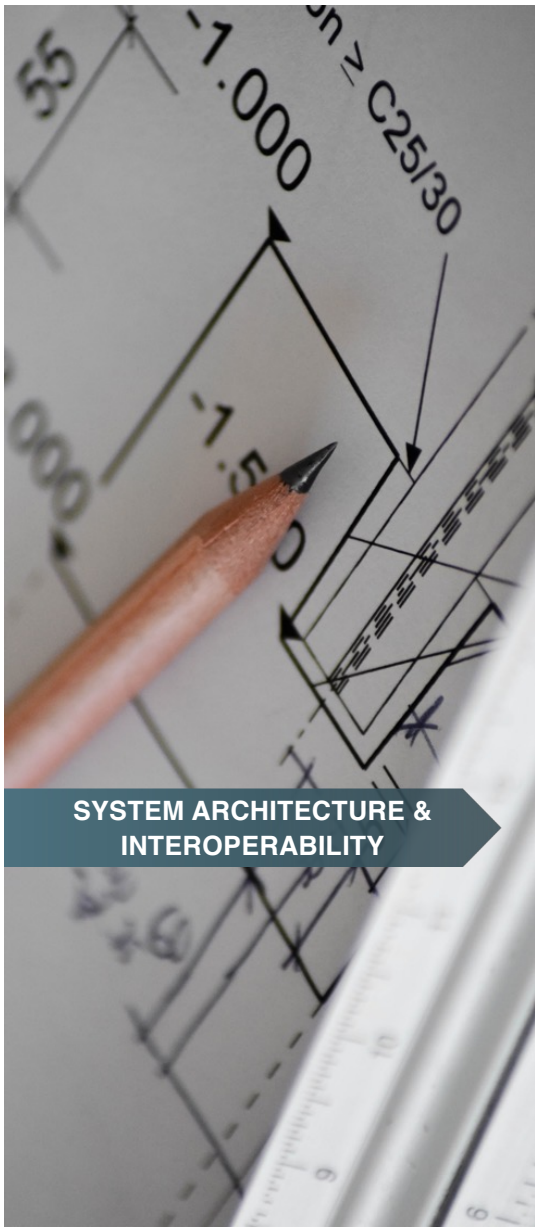
Totalt
70 BEVs
of which
18 prototypes

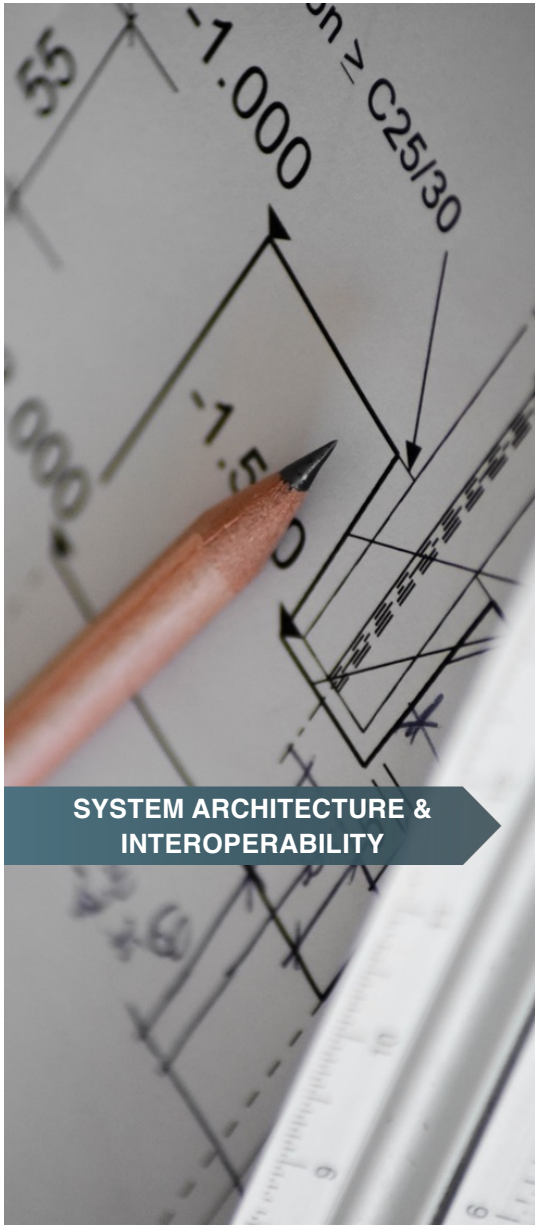


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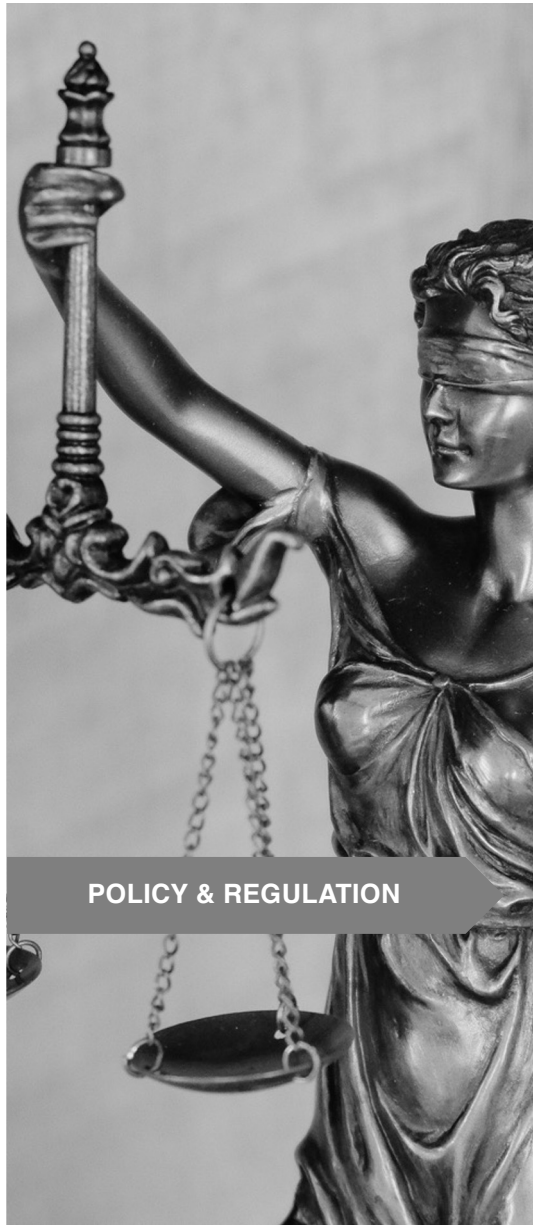
Participating actors

Public co-financing			





SYSTEM ARCHITECTURE & INTEROPERABILITY



POLICY & REGULATION



BUSINESS & FINANCING MODELS



WORKING CULTURE & KNOWLEDGE

Charging infrastructure

The investment in chargers and related infrastructure has been done by the participating companies i.e. no real-estate companies have made the investments.

The utilization rate of the installed chargers is **20-30% for high power chargers (>150 kW)** and around **35-50% for low power chargers (<49 kW)**.

95% of the actors forecast that they will still own and operate their own infrastructure in 5-years from now

All actors also state that they will be able to **provide charging to other logistic actors** that operate on their premisses.

Approximately **95% of all energy charged is assumed to be charged at either transport companies' own or at customers' non-public chargers in the next five years.**

A majority of the actors believe that the **local grid capabilities will be a limiting or a very limiting factor in the near future for many of their terminals and/or depots.** It is regarded as one of the main risks for their strategies of replacing the fleets. In order to cope with this challenge, many actors are currently investigating solutions for local energy production and storage



* total maximum power for all units



System architecture: Other findings

Logistics losses may occur due to:

- Decreased maximum allowed load weight
- Different vehicle specification, e.g. number of axles
- Brake certification
- Additional stand-still time

Additional advantages

- Operation in closed environments
- Elimination of refuelling time at public locations

Challenges for superstructure builders (e.g. cooling units)

Cases with initially failed integration between truck and charger

- An actor taking responsibility for the complete system is lacking

Charger specifications regarding length and operational environment is of importance

Placement of charging infrastructure may be constrained by discrepancy by:

- Insurance companies
- Property owners

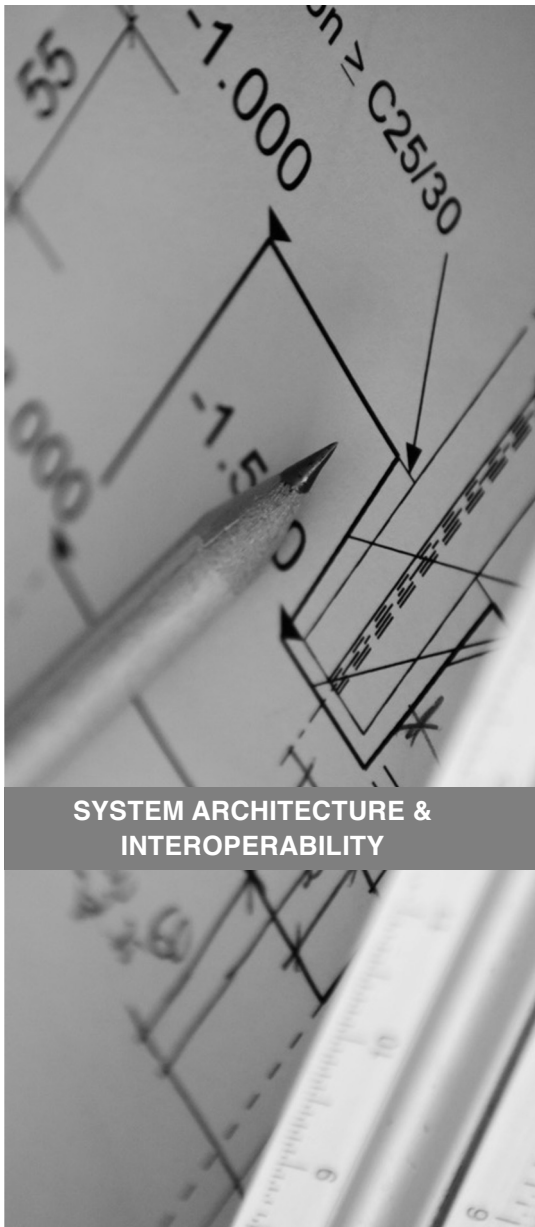
System architecture: Other findings

Preparations

- Close cooperation between transport companies and the truck OEMs
- Preceding simulations to find most feasible routes
- Simulations have been mostly correct apart from a few cases with additional consequences
- An OEM-neutral modelling tool is requested, taking multiple factors into account

Operation

- Driver has the main monitoring responsibility
- Fleet Management Systems (**FMS**) are used in parallel
- Integration between those is desired by some actors
- Increased importance is expected due to the impact of drivers individual driving styles



SYSTEM ARCHITECTURE & INTEROPERABILITY



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WORKING CULTURE & KNOWLEDGE

Input to the following TCO calculations

- Cost data have been obtained through interviews with project participants during year 2022
- For competitive reasons, a specific cost breakdown can not be reported in detail, and revenues are not presented.
- For diesel and electricity the average price for the period July to September 2022 are used
- Sweden is divided into four geographical electricity areas, with various electricity prices.
- Costs for grid transmission and power outtake varies depending on geography, time, and subscription model, also electricity energy tax varies depending on geography and type of business sector, each case's specific conditions are therefore reflected in the calculations.
- Interest rate is set to 4%
- Incentives in Sweden currently allow for 20% public co-funding of electric trucks and 40% for non-public charging infrastructure



Energy	Average Jul-Sep 2022
SE 1 (SEK/kWh)	0,561
SE 2 (SEK/kWh)	0,679
SE 3 (SEK/kWh)	1,960
SE 4 (SEK/kWh)	2,2422
MK1 Diesel (SEK/lit)	19,8

Rigid truck with a refrigerated superstructure and a total weight of 27 tons

- Operates 07:00-16:00 on weekdays, 250 days a year
- Installed battery capacity is 300 kWh
- The total vehicle incl. refrigeration consumes 1.25 kWh/km
- Operates approximately 40,000 kilometres per year.
- In this case, the extra weight of the batteries has no impact on the operation, as the goods are rather limited on volume
- The truck is charged at the terminal during night and sometimes during lunch break if needed, using a 40 kW DC charger
- The truck operates within electricity area SE 4

Cost element	Electric (SEK/yr)	Electric with current incentives (SEK/yr)	Diesel (SEK/yr)
Truck (incl. superstructure)	700,400	560,400	333,733
Charging infrastructure	33,333	20,000	0
Interest	88,048	69,648	40,048
Insurance, vehicle & road tax, parking wash, IT	70,447	70,447	70,447
Tires, service, maintenance	158,280	158,280	153,280
Energy	98,000	98,000	218,160
Grid transmission and energy tax	20,500	20,500	0
Power tariff	0	0	0
Staff	647,420	647,420	647,420
Total cost	1,839,528	1,667,795	1,463,088
% from diesel option	+26%	+14%	

Tractor that operates in a repetitive hub-to-hub flow, transporting semi-trailers with consumer goods

- Operates 06:00-15:00 and 16:00-23:00 on weekdays, 250 days a year
- Installed battery capacity is 300 kWh
- The total vehicle consumes 1.2 kWh/km, while the equivalent diesel vehicle consumes 0.35 l/km
- Operates approximately 87,500 kilometres per year.
- In this case, the extra weight of the batteries has no impact on the operation, as the goods are rather limited on volume
- The truck is charged at the terminal during breaks, between shifts and at nights with a maximum of 150 kW
- The truck operates within electricity area SE 2

Cost element	Electric (SEK/yr)	Electric with current incentives (SEK/yr)	Diesel (SEK/yr)
Truck (incl. superstructure)	581,133	464,467	197,800
Charging infrastructure	128,333	77,000	0
Interest	85,136	64,976	23,736
Insurance, vehicle & road tax, parking wash, IT	78,366	78,366	78,366
Tires, service, maintenance	205,625	205,625	191,625
Energy	205,800	205,800	618,538
Grid transmission and energy tax	48,216	48,216	0
Power tariff	48,600	48,600	0
Staff	1,234,221	1,234,221	1,234,221
Total cost	2,615,431	2,427,271	2,344,286
% from diesel option	+12%	+4%	

Rigid truck and trailer that operates in a line-haul operation between two major terminals

- Operates 06:00-15:00 and 18:00-03:00, 350 days a year
- Installed battery capacity is 600 kWh
- The total vehicle consumes 2 kWh/km, while the equivalent diesel vehicle consumes 0.43 l/km
- Operates approximately 210,000 kilometres per year.
- In this case, the extra weight of the batteries has no impact on the operation, as the goods are rather limited on volume
- The truck is charged at the terminal during breaks, and between shifts with a maximum of 300 kW
- The truck operates within electricity area SE 3

Cost element	Electric (SEK/yr)	Electric with current incentives (SEK/yr)	Diesel (SEK/yr)
Truck (incl. superstructure)	699,167	557,500	257,500
Charging infrastructure	533,333	320,000	0
Interest	199,800	153,000	30,900
Insurance, vehicle & road tax, parking wash, IT	132,421	132,421	132,421
Tires, service, maintenance	258,340	258,340	242,340
Energy	823,200	823,200	1,832,880
Grid transmission and energy tax	204,750	204,750	0
Power tariff	129,600	129,600	0
Staff	2,089,822	2,089,822	2,089,822
Total cost	5,070,433	4,668,633	4,585,863
% from diesel option	+11%	+2%	

Public co-funding: Charging infrastructure

Co-funding applications by participants in REEL



For co-funding of charging infrastructure, most applications have been sent to **Klimatklivet** - **70% of the applications were approved after additional information was provided, and 30% were rejected.**

All actors that have applied funding via Klimatklivet **regard the application process as challenging or very challenging.**

They emphasize the **difficulty of making accurate environmental and profitability calculations**, and how these calculations can be controlled and assessed equally as they are based on assumptions and forecasts.

Further on, data on **historical driving patterns is often requested, even if this does not relate to the future operation.**

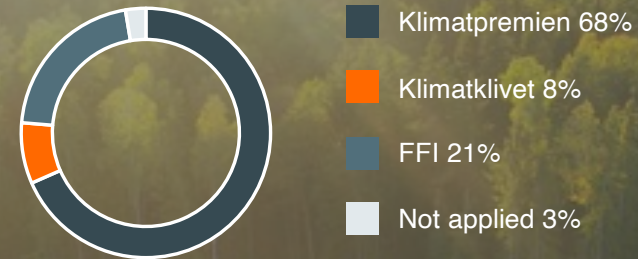
Actors also find it difficult to adapt their businesses to the few specific time windows when it is possible to submit applications, and the long lead-times between application and decision.

The **long lead-times have also led to increased costs compared to the original budget** due to updated quotes from suppliers.

No application was approved without the applicant stating additional information.

Public co-funding: Electric trucks

Co-funding applications by participants in REEL

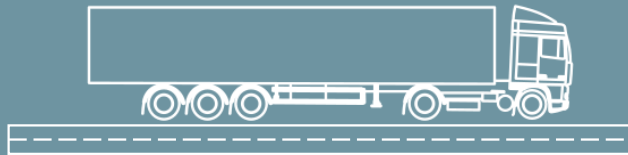


Applications to **Klimatpremien have in most cases been handled by the OEMs** in relation to the sales process, which has not caused any difficulties for the logistic actors.

No major difficulties have been experienced in the process. They also emphasize the advantage that applications can be submitted at any time.

A few actors have applied for co-funding through **Klimatklivet. In general this process is seen as more burdensome.** For all applications to Klimatklivet for trucks, as for charging infrastructure, additional information to the application has been requested.

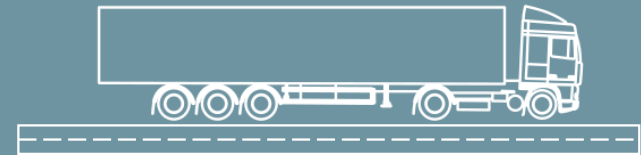
E-Charge: System demonstration of electrified long-haul transports



4.5 h



45 min



4.5 h



4.5 h



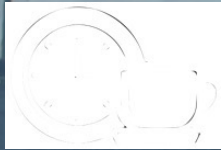
1 - 2 kWh/km

1.6 - 3.2 kWh/mile



360 - 720 kWh





45 min



500 – 1000 kW

Megawatt Charging System (MCS)

CCS \leq 350 kW



Megawatt Charging System (MCS)

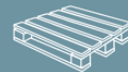
- Max power output: 3.75 MW
- Max voltage: 1250 V
- Max current: 3000 A

Standard finalized by 2024

Applications

- Heavy duty trucks
- Maritime applications
- Electric aircrafts

E-Charge: System demonstration of electrified long-haul transports



V O L V O





<https://closer.lindholmen.se/en/project/reel>

lindholmen.se/en/project/e-charge
lindholmen.se



@Lindholmen Science Park AB



nikita.zaiko@lindholmen.se

