HENRIK WENTZEL

AFFORDABLE AND STANDARDIZED POWER TRANSFER TO ELECTRIC TRUCKS

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Electricity or diesel? – price drivers

- In the vehicle, 1 L diesel is energy equivalent with 4.5 kWh.
- The typical energy consumption of a truck is 1.3 kWh (on the drive shaft) per km.
- Battery vehicles are expensive to produce. The higher purchasing price translates to 0,5 SEK – 2 SEK/km.
- When electric trucks can fuel for under 2.5 SEK /kWh most customers will eventually shift.
- Investment support for chargers and CO_2 differentiated road tolls can help the shift.

Power price that leads to electrification of Swedish transports.

Diesel price (before VAT) [SEK/L]	BEV extra cost [SEK/km]	Cost equivalent power price at the pump [SEK/kWh]
13	2,0 (2025)	1,4
13	0,5 (+2030)	2,5

Charging in Sweden – energy need

- 6000 new heavy truck per year.
- 50% BEV sales 2030 - 12000 BEV in total.
- Each BEV consumes 1.3 kWh / km and drives 100 000 km/year → 2 TWh (140 TWh is SE total)
- All trucks by 2030 will have charging capacity of around 1 MW, locally power is an issue.

How to distribute 2 TWh for 2 SEK / kWh?

Charging with cable

Overhead cables

Hydrogen

How to distribute 2 TWh for 2 kr / kWh?

Charging with cable

too late?

Overhead catenary

too expensive?

Hydrogen

Best economy is slow charging ”at home”

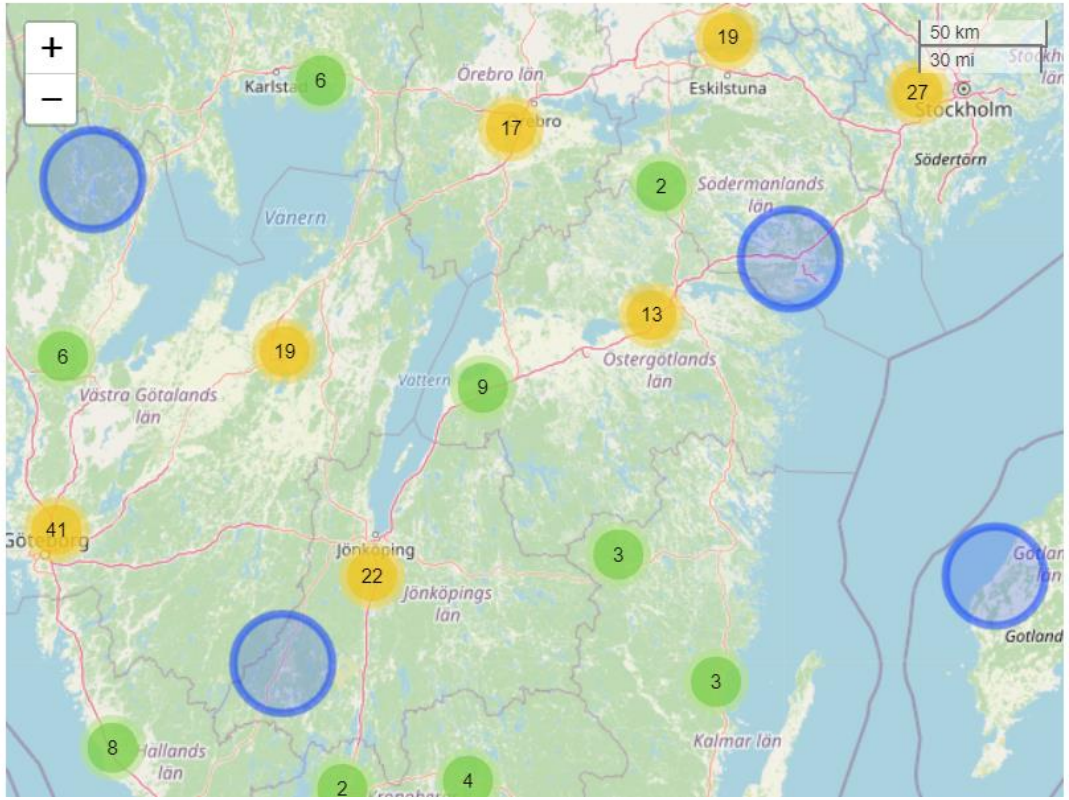
- 3 phase / 35 A exists in principle everywhere, at a cost below 1 SEK / kWh. (0,4 SEK grid fee[1])
- 35 A during night gives only 300 kWh or below 3 h driving. More is need for 4 ½ h shift.
- How extensive is 63A? Cost and time for installation.
- Government investment support for high power grid or depot chargers would benefit many small/medium size haulers.

[1] Energimarknadsinspektionen, https://www.ei.se/om-oss/statistik-och-oppna-data/natavgifter---elnat

Fast charging during day

- All electric trucks will charge overnight for cost reason. During day it is important to charge fast.
- To fill 500 kWh (4 ½ h driving) in a lunch break requires 500 – 1000 kW.
- A relatively small number of public charging places will cover the need for en-route charging.
- This will require extra power in southern Sweden (Gigawatt).

31,145 long-haul stop locations suitable for charging points



Fast charging during day

- Passenger car charging today
  - too expensive, 4-8 SEK/kWh
  - too slow 10-150 kW
  - inaccessible for trucks.
- Charging 500 kWh battery with 950 kW instead of 150 kW saves 2.5 h. (operational cost for driver+truck is 600 SEK / h)
- Heavy trucks need 500 – 1000 kW in order to be competitive with diesel.

There are many DC charging standards currently available… but the Power is too low. Target must be **1 to 3 MW**

	GB/T	New GB/T	CHAdeMO	CCS1 (ChaIN)	CCS2 (ChaIN)	Tesla	Proposed HPCVC
							
Max Power	950V x 250A = **237.5 kW**	1500V x 600A = **900 kW**	1000V x 400A = **400 kW**	1000V x 500A = **500 kW**	1000V x 500A = **500 kW**	410V x 610A = **250 kW**	1500V x 2000A = **3 MW??**
Range add /minute charge	1.5 miles	5.8 miles	2.6 miles	3.2 miles	3.2 miles	1.6 miles	19.2 miles
Communication Protocol	CAN (SAE J1939)	CAN (SAE J1939)	CAN (ISO 11898)	PLC (ISO 15118)	PLC (ISO 15118)	CAN (SAE J2411)	CAN or Ethernet (ISO 15118)
Location Used	China, India	China	Global	US	EU, South Korea, Australia	Global	US?, EU?
Related Standards	IEC 61851	IEC 61851	IEC 61851 IEEE 2030.1	IEC 61851 SAE J1772	IEC 61851	none	none
Notes	none	Liquid Cooled under development in development	Liquid Cooled under development	Liquid Cooled	Liquid Cooled	Liquid Cooled	Liquid Cooled

What already exists?
There are many DC charging standards. See table.

Why do we need another?
Target charge times of 20 minutes (currently possible with today's batteries) on commercial EVs require power levels of **~ 1-3 MW**

Why not AC?
AC charging requires that the inverter be carried on the vehicle, which is a limiting factor in weight and charging speed.

We need a solution that keeps the EU together

- Besides slow depot-charging there is a need for fast day charging.
- By observing truck operations, insight into where charging needs to be available is gained.
- Natural stops are along highways and transport hubs, se the ACEA study: https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2021/ACEA_truckstop_report_update.pdf
- Any solution must be based on intl. standards and have wide support in EU.

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- Main path for the future is charging with cable.
- Support the development of Megawatt DC charging, very important that authorities also support the fast deployment of intl. standards.
- Certification of chargers according to standards is a pressing need – too often public charging doesn't work.
- The deployment of electric distribution infrastructure is the greatest obstacle for the electrification of commercial transports, more efforts are needed.

The future of heavy haulage is electric

- New technology and investments lower the cost for batteries.
- Higher taxes increases the cost for diesel.
- Emission requirements on the combustion engines increases the cost for development and maintenance.
- Production cost for electricity is already low, when the infrastructure is in place the cost for charging will be low, to help the transition:
  - Support haulers that invest in the grid.
  - Support public fast chargers +350 kW.
  - Support standardized solutions with intl. support

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