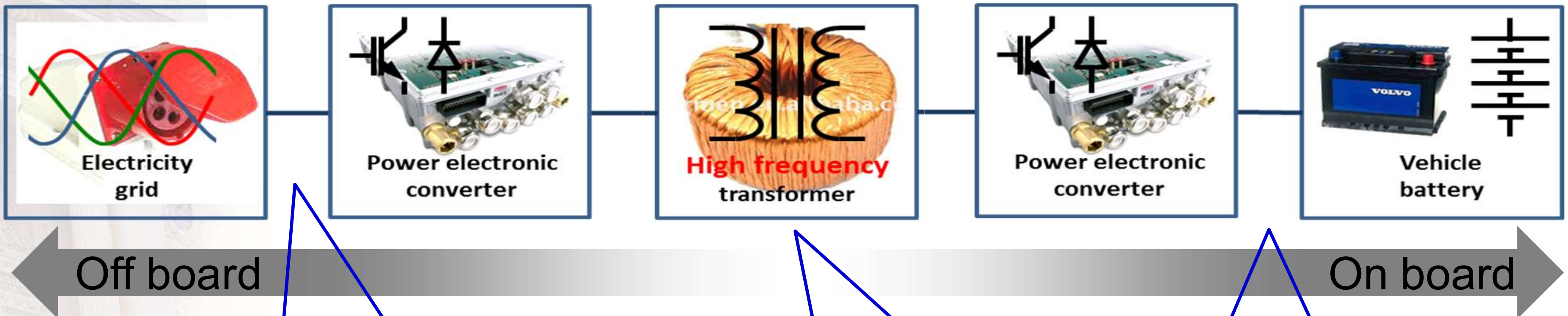
Hybrid Drive Systems for Vehicles

L9 - Charging

Static Charging

On board / Off board = AC / DC



- ”AC Charging”
- **Automation missing**
- **High power plug missing?**
- 10...100 MW/m²

- ”Wireless Charging”
- 10...100 kW/m²

- ” DC Charging”
- **Automation missing**
- 10...100 MW/m²

Who needs an Automatic Charging Connection ... ?

- **Commercial Vehicles**
  - *May be Opportunity Charged up to 10 ... 20 times a day*
  - *The power level is high!*
  - *Automatic connection **absolutely necessary !!!***

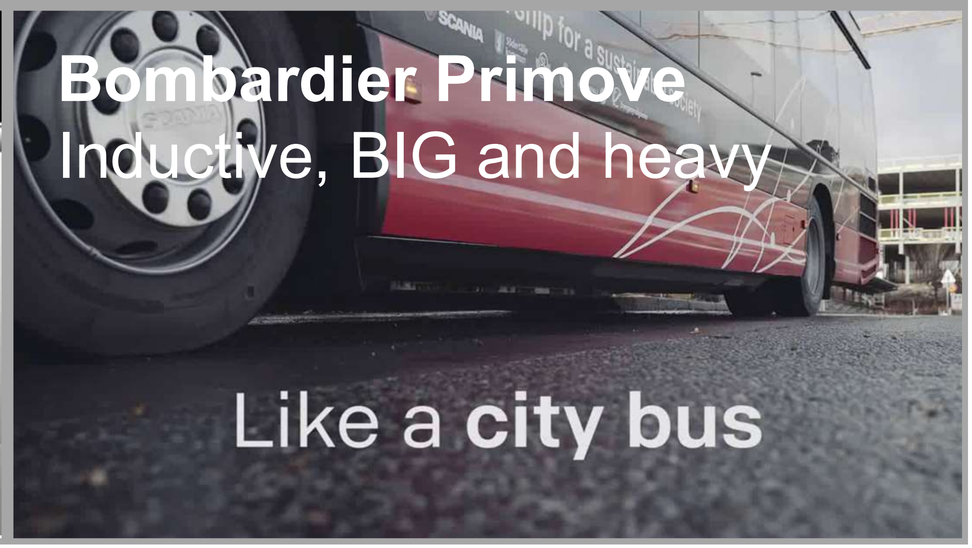
- **Autonomous private (?) vehicles**
  - *Maybe a Spotify/Netflix/Uber kind of vehicle*
  - *Must be able to autonomously arrange washing, charging, workshop visit, ...*
  - Usually connected 1...3 times per day
  - *Automatic connection **absolutely necessary !!!***

OPPcharge
Panto on infra = Low Bus cost

ABB TOSA
Panto on BUS, Drives bus cost

BYD
Manual, Low Cost Infra

Bombardier Primove
Inductive, BIG and heavy



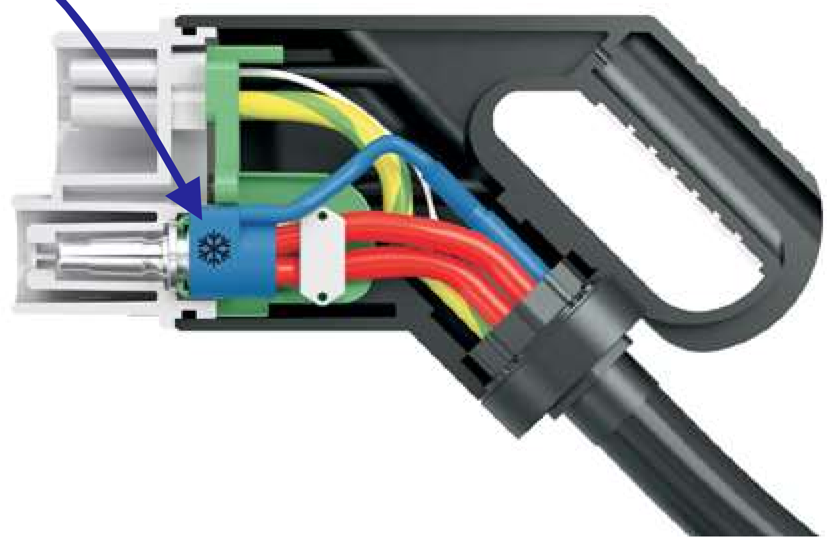
Even the Car industry is trying …

And also Off Road ....

The gardening industry is leading ...

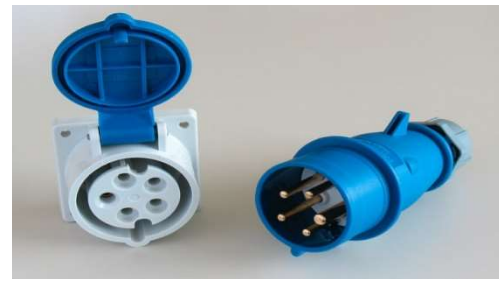
But we are still pushing the limits …

- Same CCS-plug, now called ”CCSplus”, boosted with water cooling.
- Current limits pushed towards 350 Ampére and beyond.
  = 260 … 500 kW, depending
- Still no automation!



Normal fuse levels

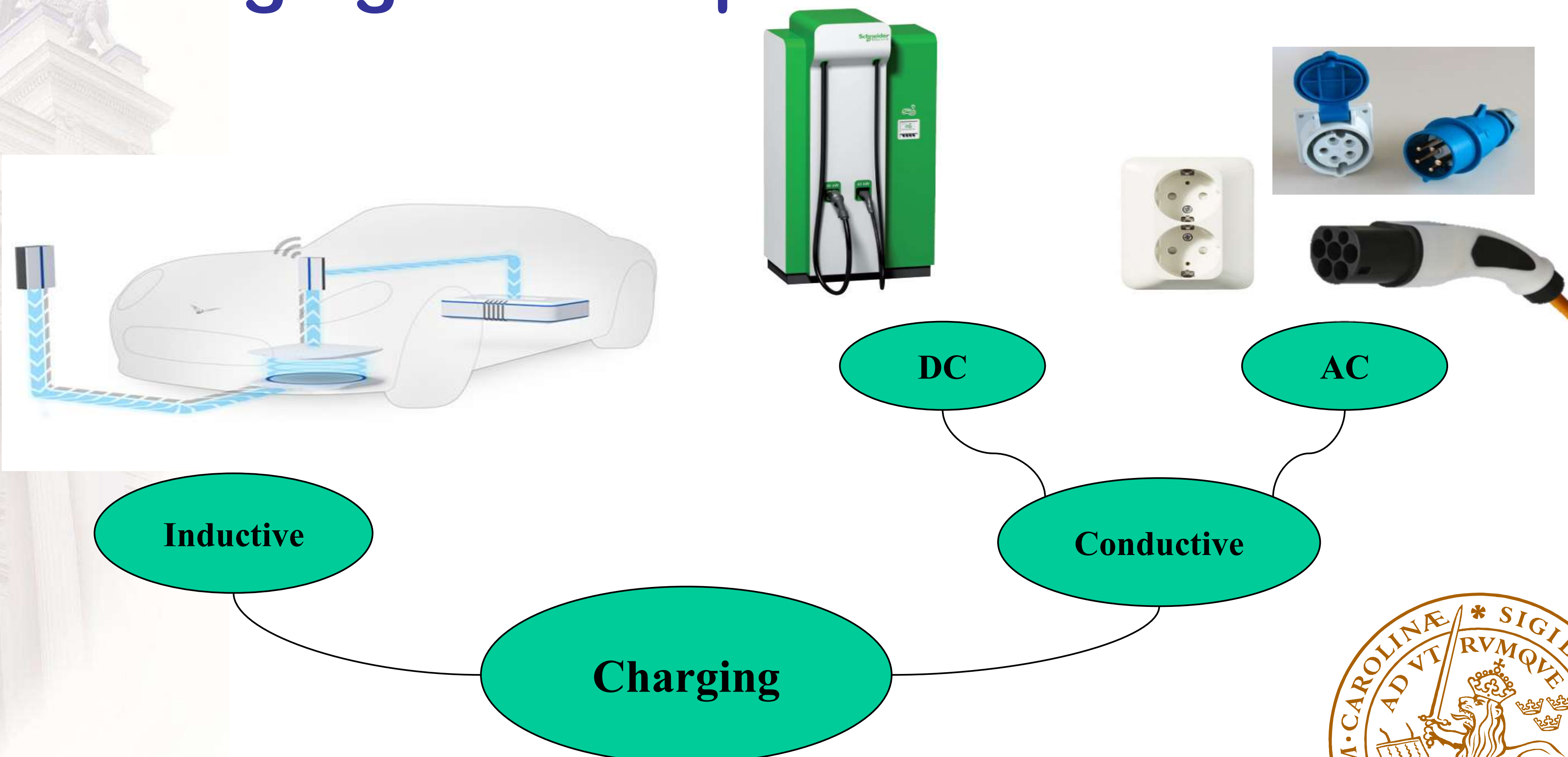
- **Home**
  - 1 phase
    - 10 Ampére -> 2,3 kW
    - 16 Ampére -> 3,7 kW



- **Other places**
  - 3 phase
    - 16 Ampére -> 11 kW
    - 32 Ampére -> 22 kW
    - 63 Ampére -> 44 kW
    - 125 Ampére -> 87 kW

Voltage range	Frequency range	Colour code
20– 25 V	50/60 Hz	Purple
40– 50 V	50/60 Hz	White
100–130 V	50/60 Hz	Yellow
200–250 V	50/60 Hz	Blue
380–480 V	50/60 Hz	Red
500–690 V	50/60 Hz	Black
-	>60–500 Hz	Green
None of the above		Grey

Charging Mind Map



Dedicated Charging Stations

Historical Perspective on EV Charging Equipment 1900 to Today ….and Tomorrow

1913- 150A/48vdc coupler (30,000 EVs in 1913)

The electric vehicle – raising the standards

Figure 3.25: 150 A charging plug with handle

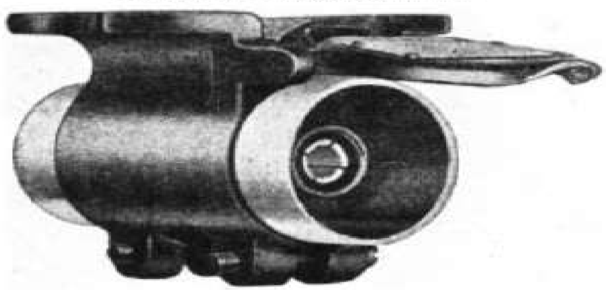
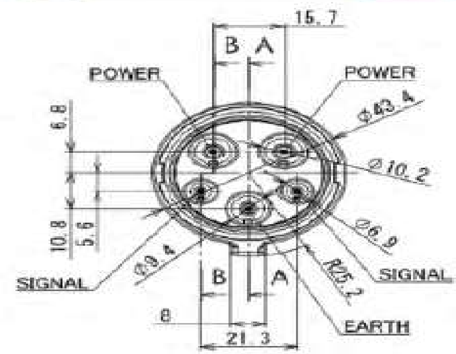


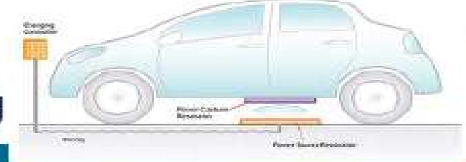
Figure 3.26: 150 ampere-hour (sic) charging receptacle

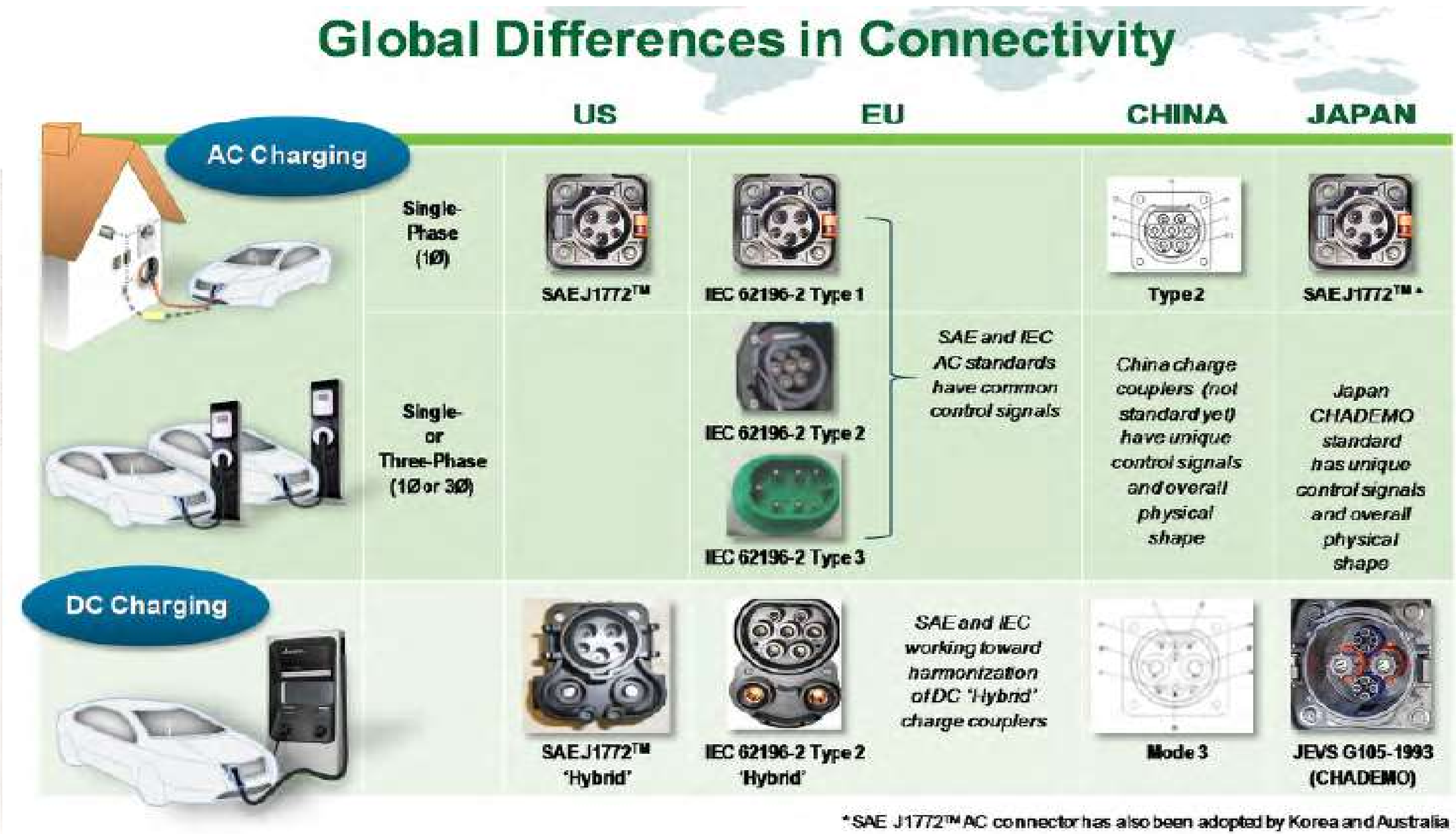
1990's J1772 Conductive SAE J1773 Inductive

2010 SAE J1772 Level 2 240vac/<80A (32A typ.)

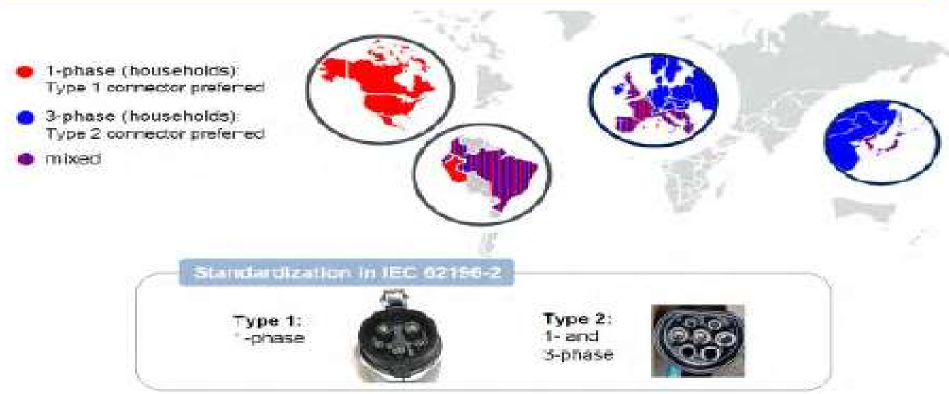


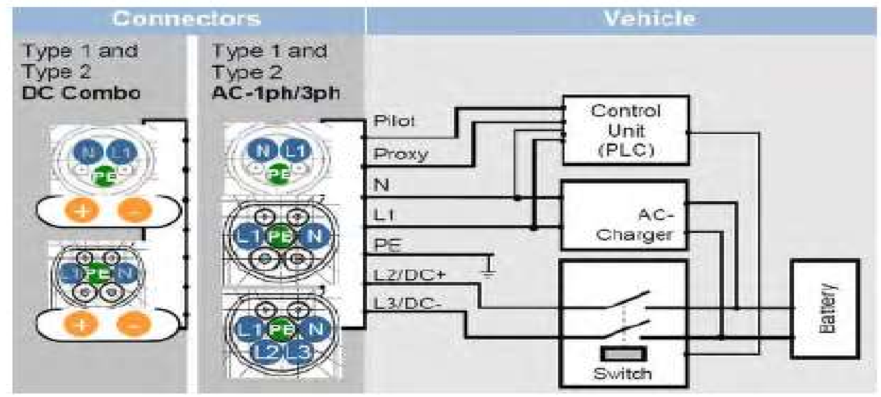
2011 SAE J2954 Wireless Charging

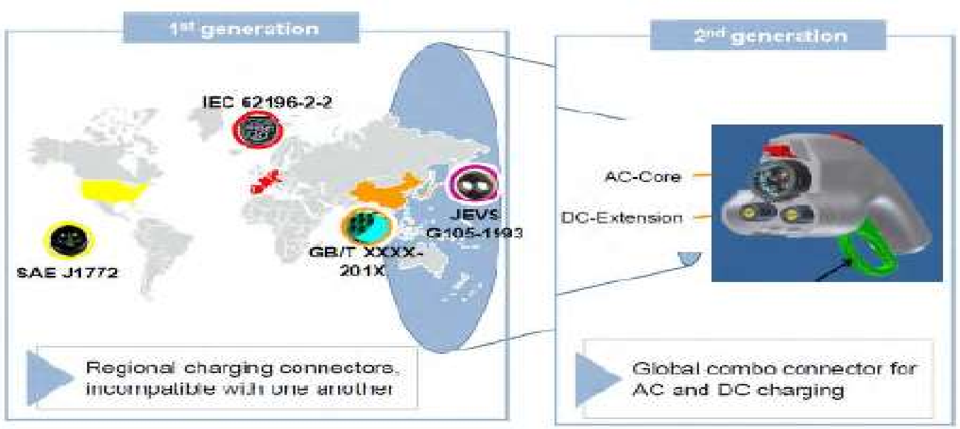



Global Differences in Connectivity
US
EU
CHINA
JAPAN
AC Charging
Single-Phase (1Ø)
SAE J1772™
IEC 62196-2 Type 1
Type 2
SAE J1772™ *
Single- or Three-Phase (1Ø or 3Ø)
IEC 62196-2 Type 2
IEC 62196-2 Type 3
SAE and IEC AC standards have common control signals
China charge couplers (not standard yet) have unique control signals and overall physical shape
Japan CHADEMO standard has unique control signals and overall physical shape
DC Charging
SAE J1772™ 'Hybrid'
IEC 62196-2 Type 2 'Hybrid'
SAE and IEC working toward harmonization of DC 'Hybrid' charge couplers
Mode 3
JEVS G105-1993 (CHADEMO)
* SAE J1772™ AC connector has also been adopted by Korea and Australia

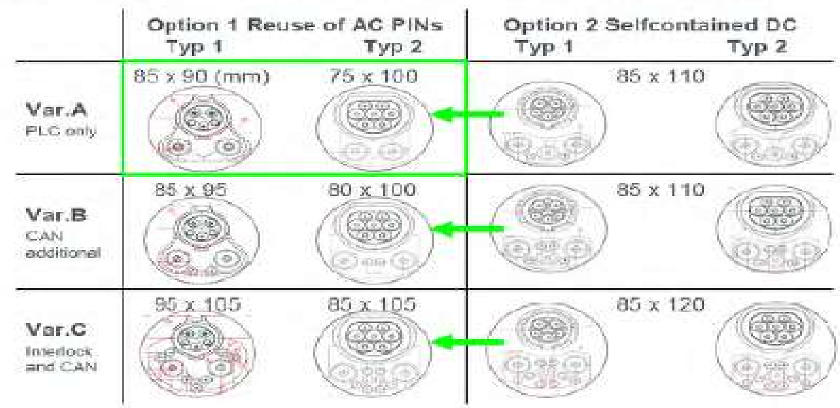
AC/DC Connector Standards Around the World

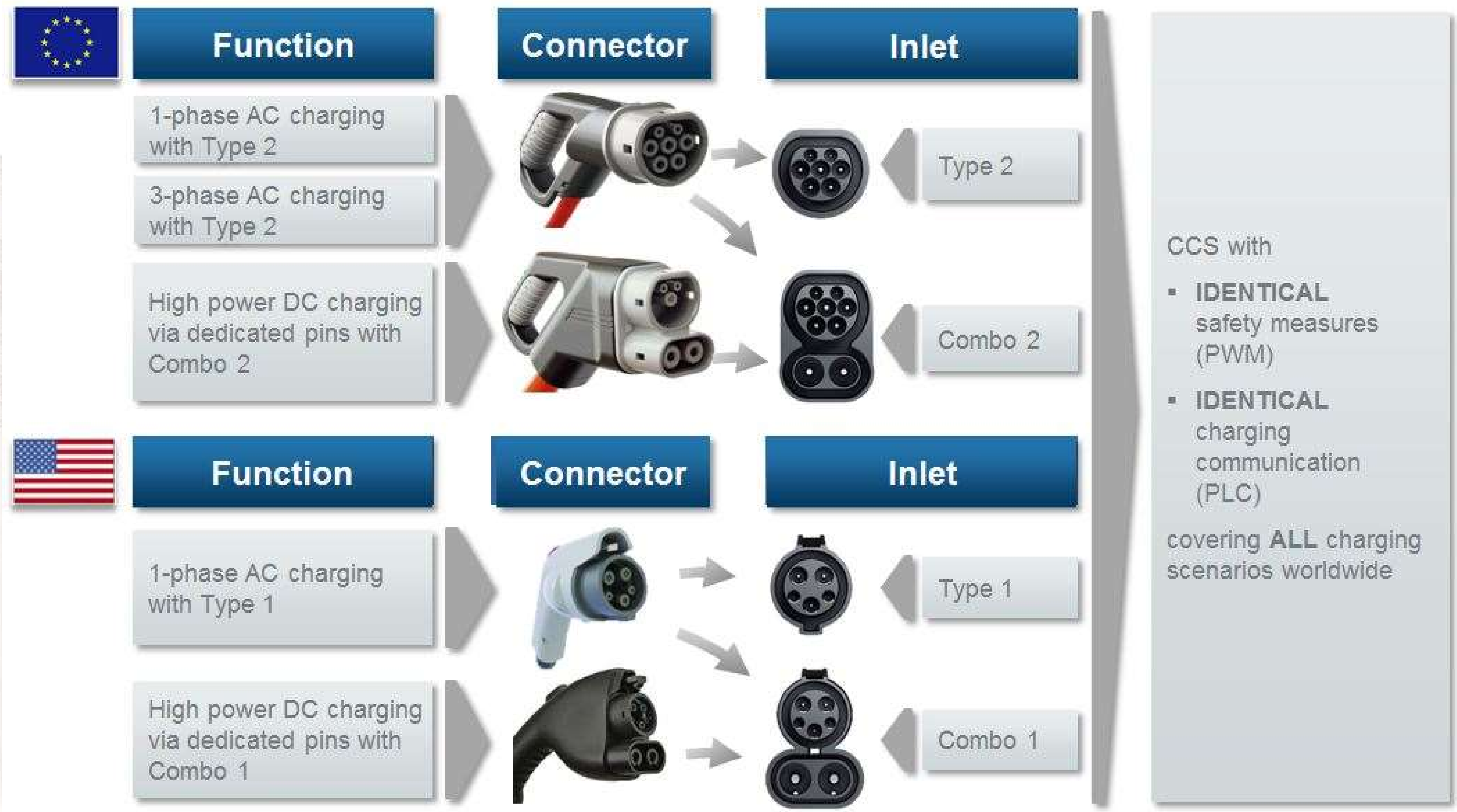




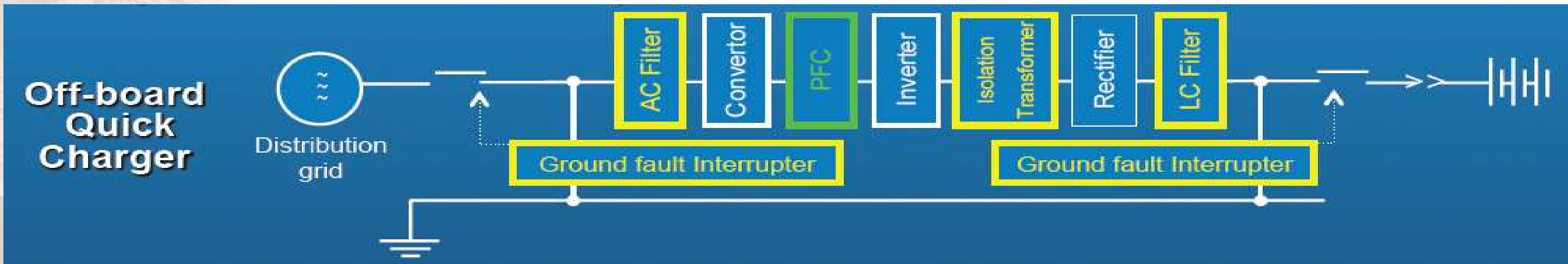


A detailed analysis of design options confirmed the feasibility of lean design.

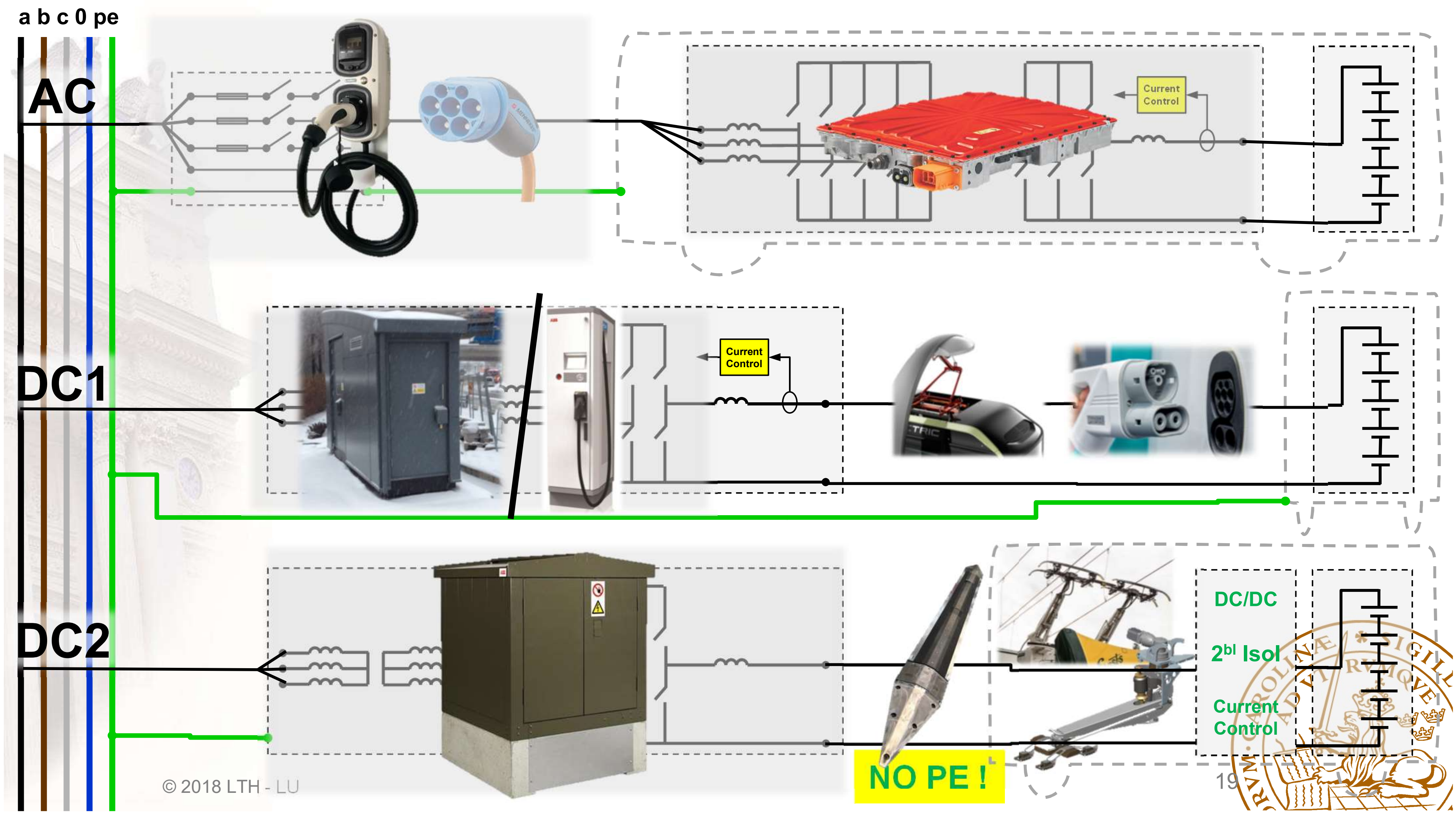



Function
Connector
Inlet
1-phase AC charging with Type 2
3-phase AC charging with Type 2
Type 2
High power DC charging via dedicated pins with Combo 2
Combo 2
Function
Connector
Inlet
1-phase AC charging with Type 1
Type 1
High power DC charging via dedicated pins with Combo 1
Combo 1
CCS with
▪ IDENTICAL safety measures (PWM)
▪ IDENTICAL charging communication (PLC)
covering ALL charging scenarios worldwide

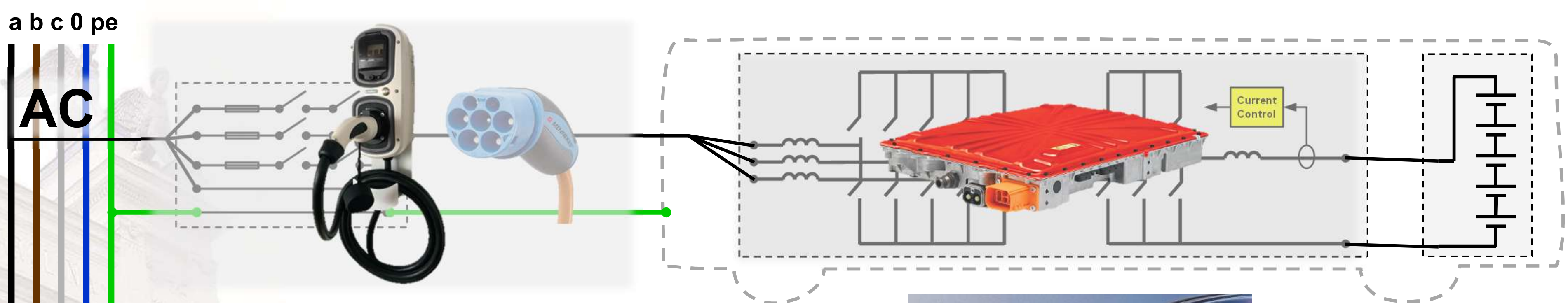
The Chademo Charging Sta



Chademo suppliers



a b c 0 pe
AC
Current Control
DC1
Current Control
DC2
DC/DC
2bl Isol
Current Control
NO PE !



DC&AC
63 -> 150 A/pin
= 104 kW AC

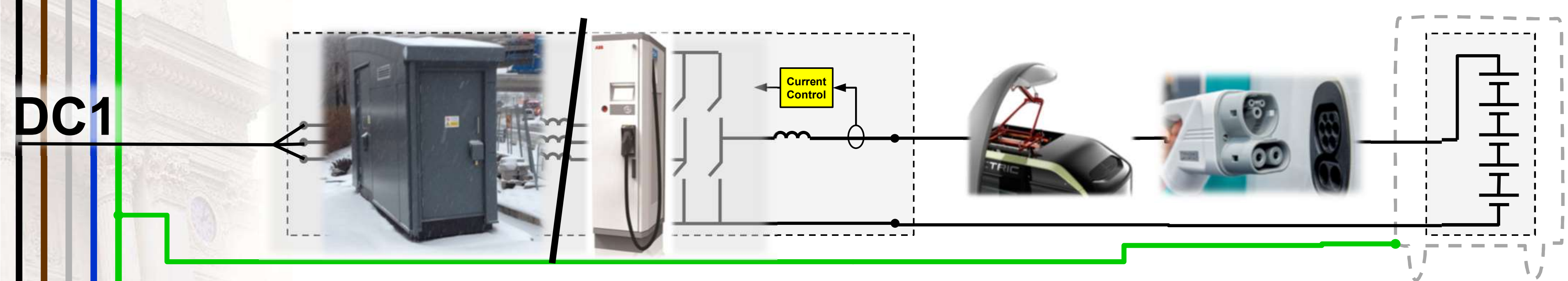
- 3 phase plug limited to 63 A
- Max charging power 44 kW
- Available from all OEMs for night time charging

- E.g. 200 kWh in 5 hours night time.

- NOT Enough for Opportunity Charging at +100 kW? There is a possibility!

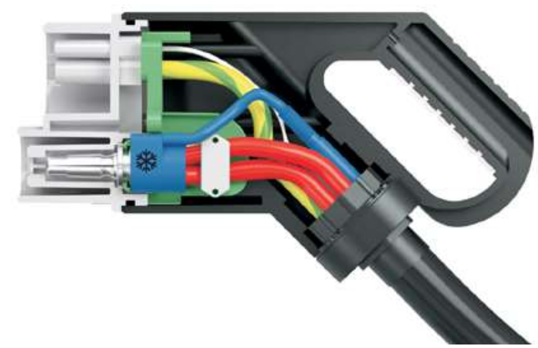
- New Plug Needed for higher power levels!

- OppCharge an open ”standard”, capable of up to 600 kW
- Expensive stations, not compatible with most truck applications



- CCS/DC normally limited to 200 A.
- @ 750 V this gives 150 kW, e.g 4x0.25h = 150 kWh
- NOT automatic

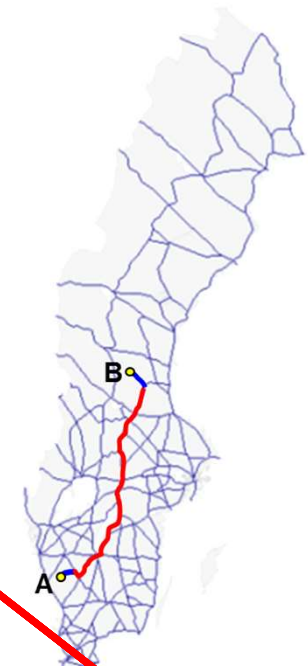
- Pushed towards 500 A with water cooling = 375 kW @ 750 V

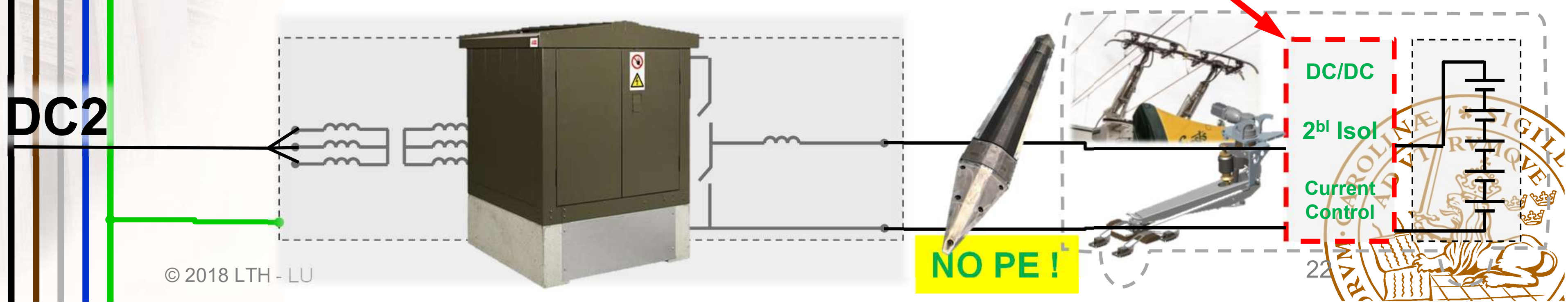


a b c 0 pe

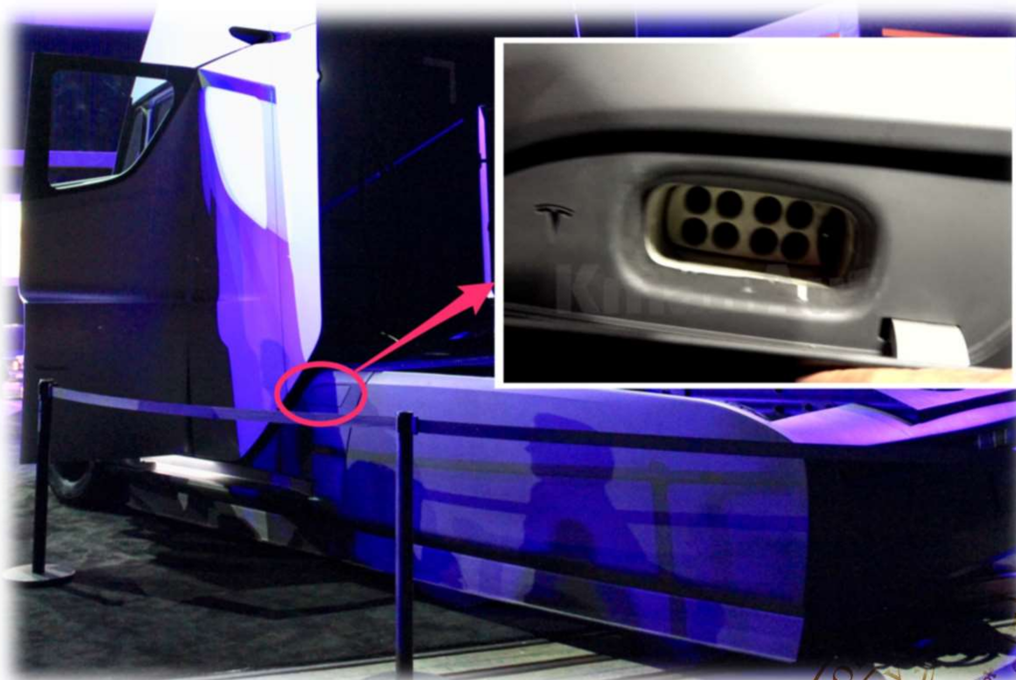
- Siemens eHighway is currently leading
- Others follow very soon
- Significant battery size reduction (-60%...-80%)
- 150 kWh instead of 600 kWh

- No protective earth – requires special safety solutions





Tesla Semi Analysis ...



Technical facts

Given Facts

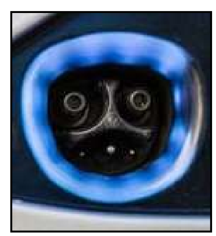
- GVW = 80000 lbs = 36 287 kg
- Drag Coefficient = Cd = 0.36
- Drivetrain: 4 PM motors from Model 3
- Acceleration 0-60 mph = 0-97 km/h
  - Tractor only: 5 seconds
  - Full load (80000 lbs): 20 seconds
- Hill climbing: 5 % slope @ 65 mph = 105 km/h
- Range: 300/500 miles = 483/805 km
- Charging time: 400 miles = 644 km in 30 minutes

Calculated Facts

- Energy consumption = about 1 kWh/km
- Tractor weight = 9 tons
- Traction motors = 4 x 137/192 kW (cont/peak)
- Battery Energy = 850 – 950 kWh (depends on DoD)
- Battery Weight = 4.2 – 4.7 tons (@ 0.2 kWh/kg)
- Charging power

  = almost 1.3 Megawatt for Fast Charging

  = 100 kW for Night Time Charging
- MEGA Charging Connector: Seems to be 4xSUPER Charging Connector



X 4 =

The Perfect Charging Connection ...

Is **automatic**

Works with both
small and **BIG** vehicles

Can be used both when
standing still and when moving

Can be used both
in the city and on the highway

Dynamic Charging

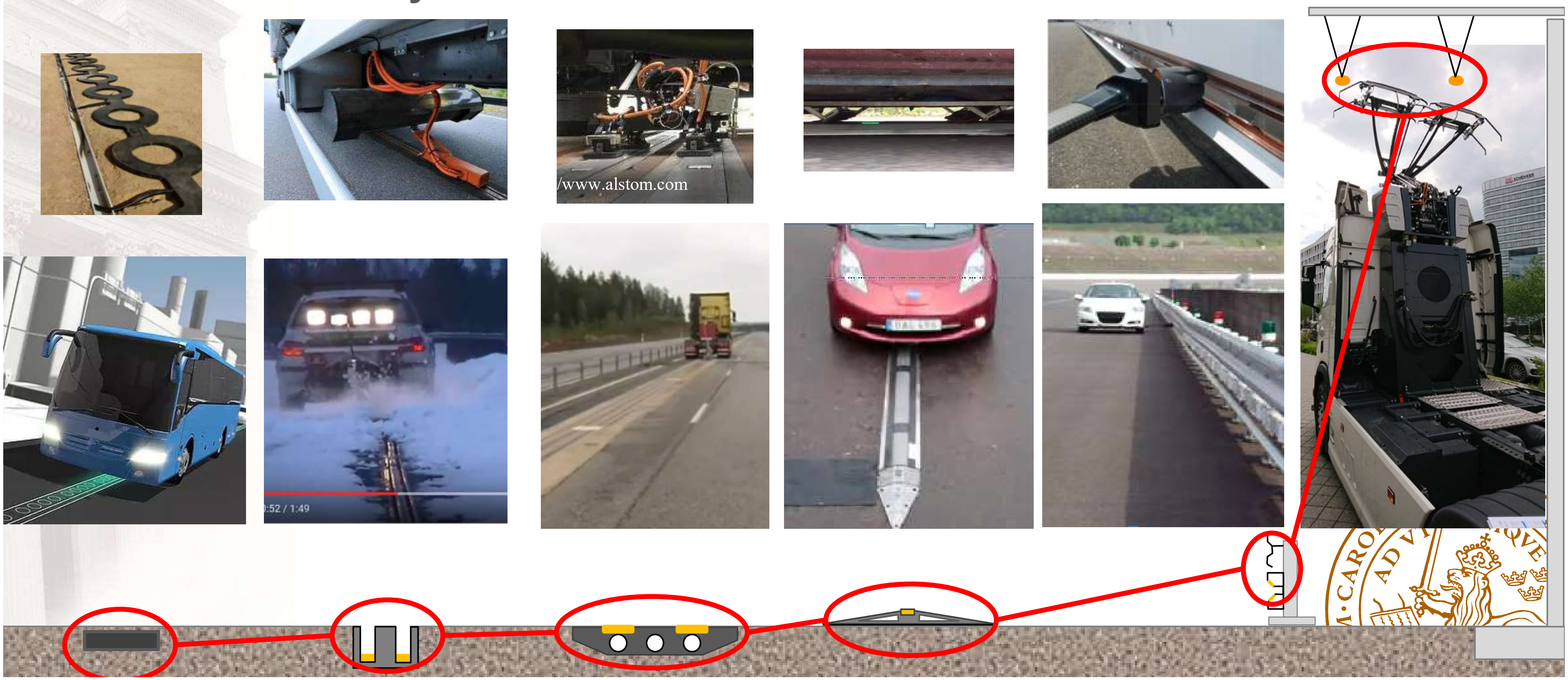
Dynamic charging ?

- Charging when the vehicle is moving
- Also called ”Electric Road Systems” (ERS)
- Traditionally used in Trams, Trains and Trolley buses
- Different technologies, different connections
- Many new suppliers developing
- Several demonstrations on public road

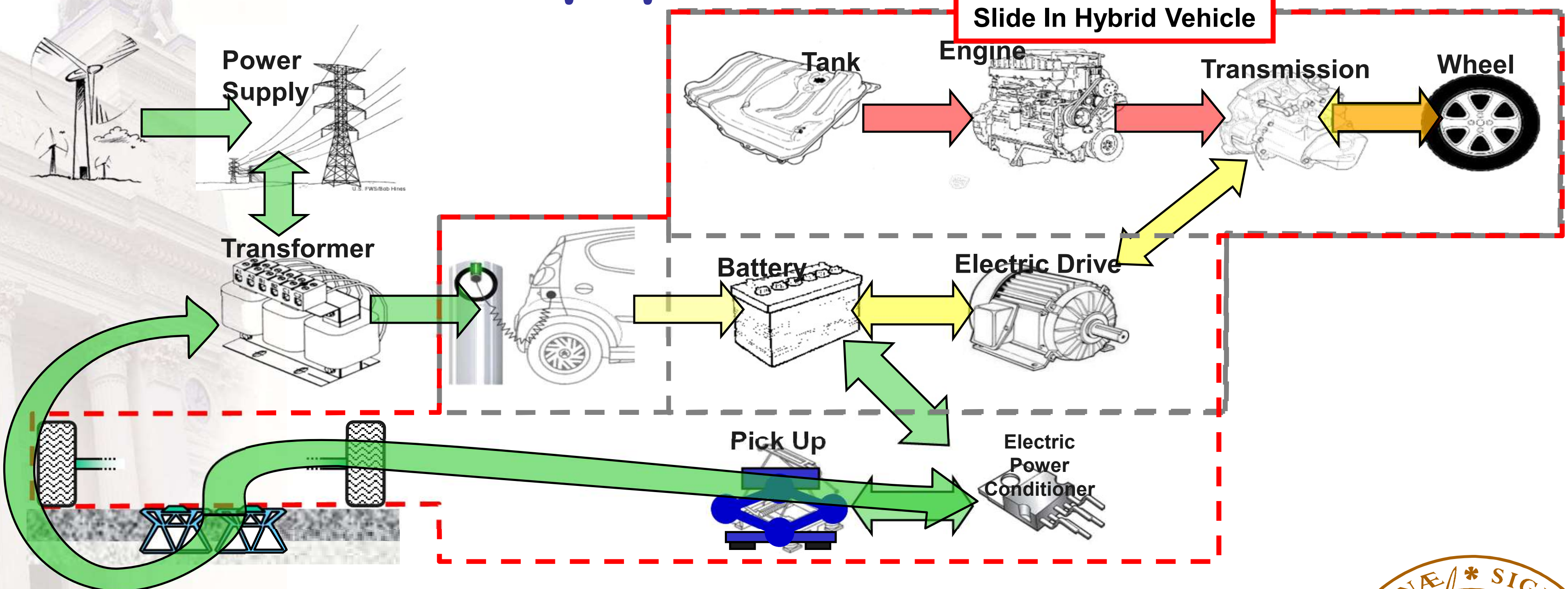
	Above	Side	Under
Conductive			
Inductive	X	X	
Capacitive	X	X	

Some ERS versions interesting for Sweden

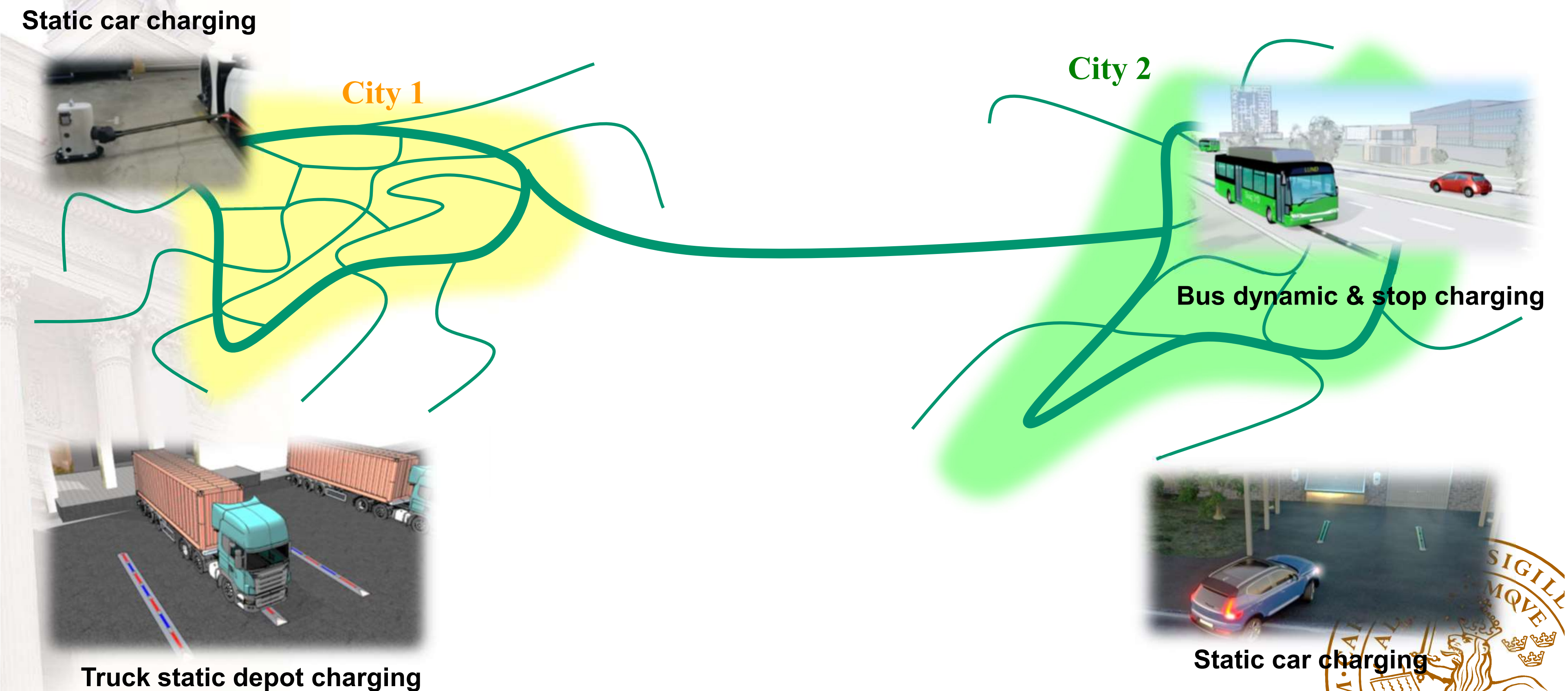
Electreon | Elways | Alstom | Elonroad | Honda | Siemens



Additional equipment needed



ERS inter city and static/night in city



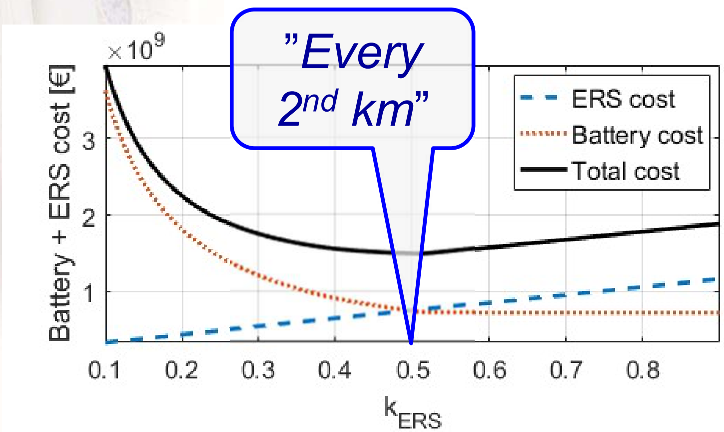
Not ERS all the way

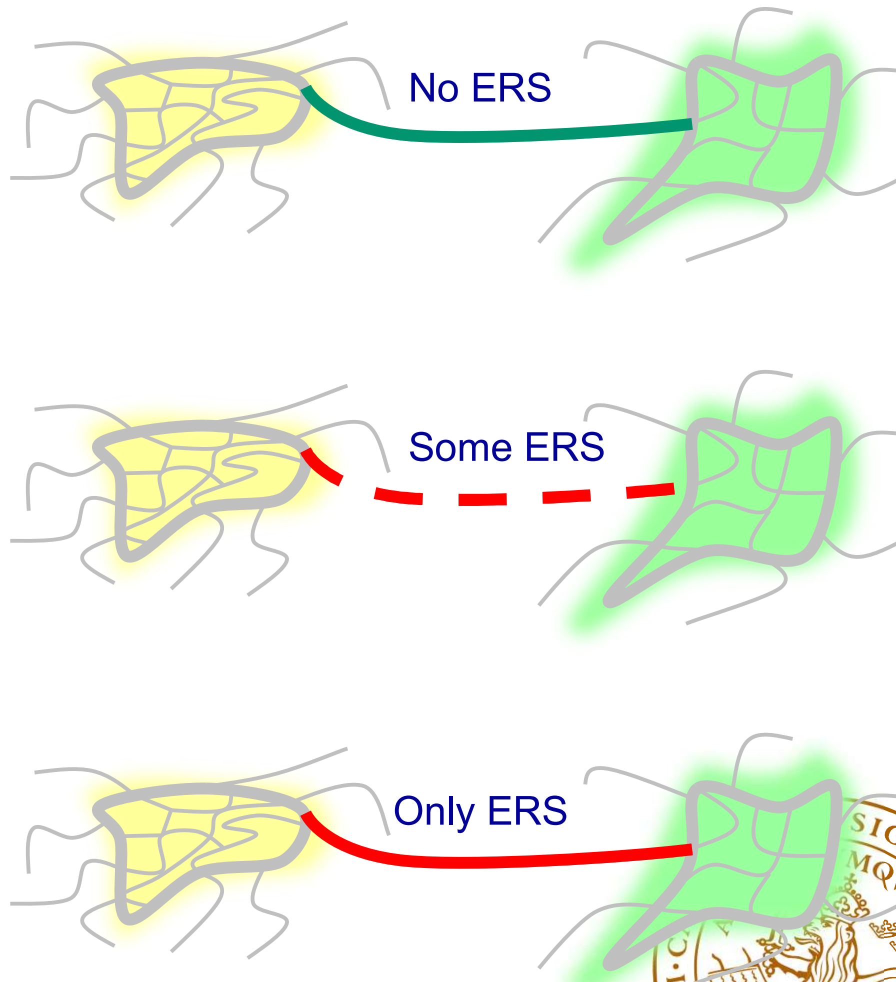
- No ERS

  = High battery costs, No ERS costs
- Some ERS

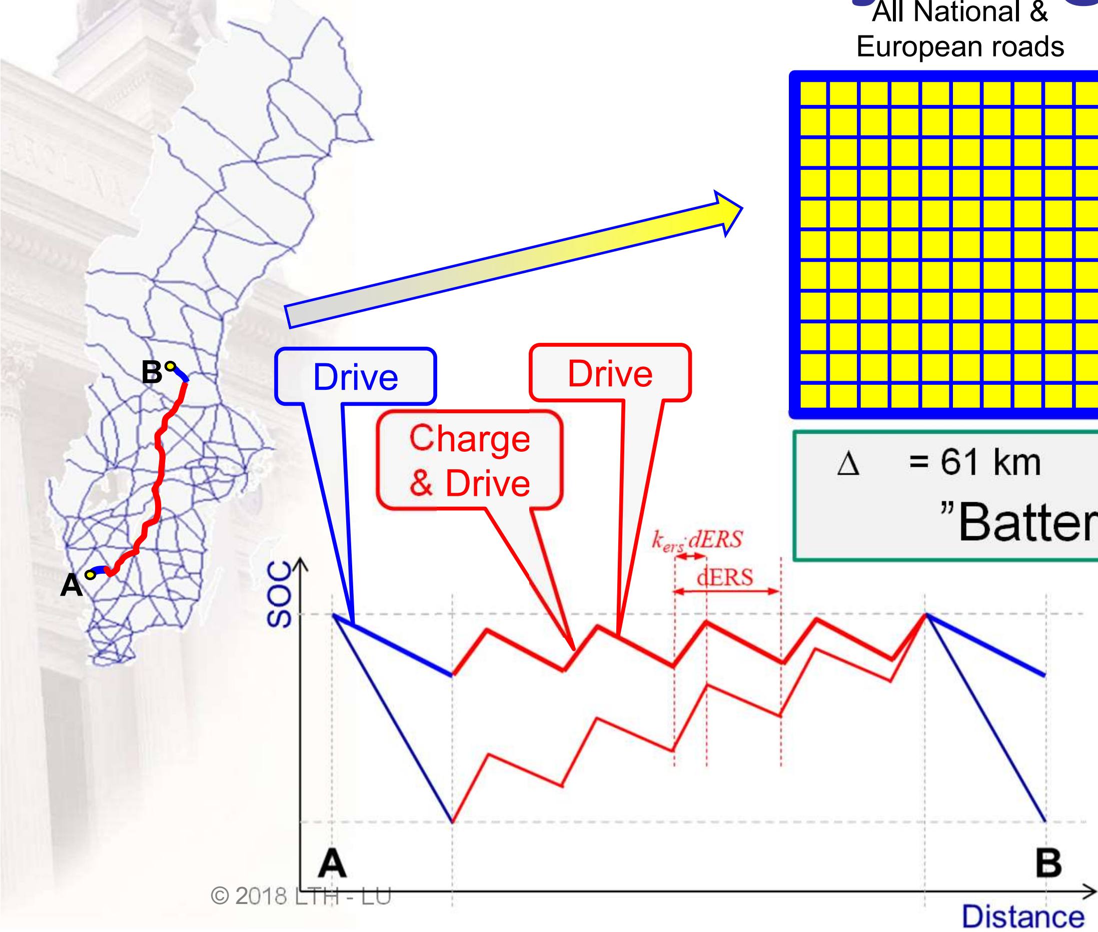
  = Lower battery costs and ERS costs
- Only ERS

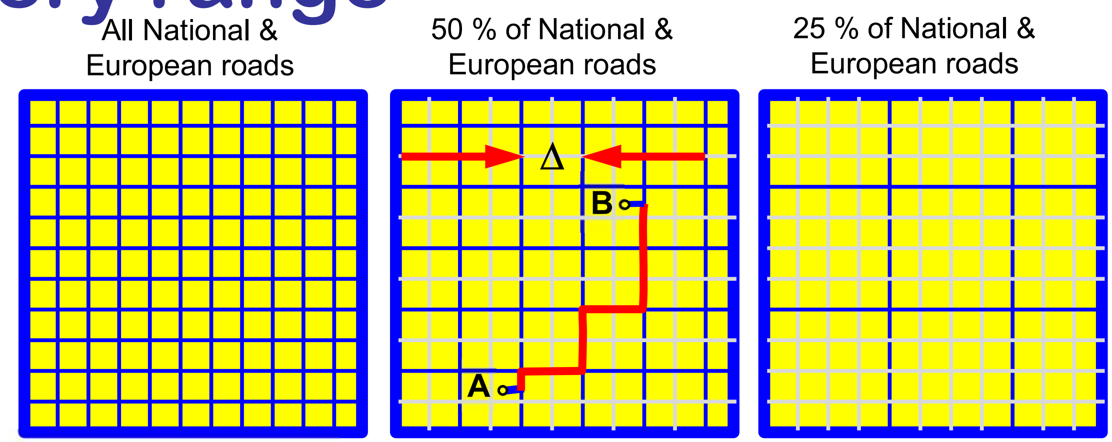
  = Low battery cost and high ERS cost
- ERS cost + Battery cost has an optimum





Impact on battery range

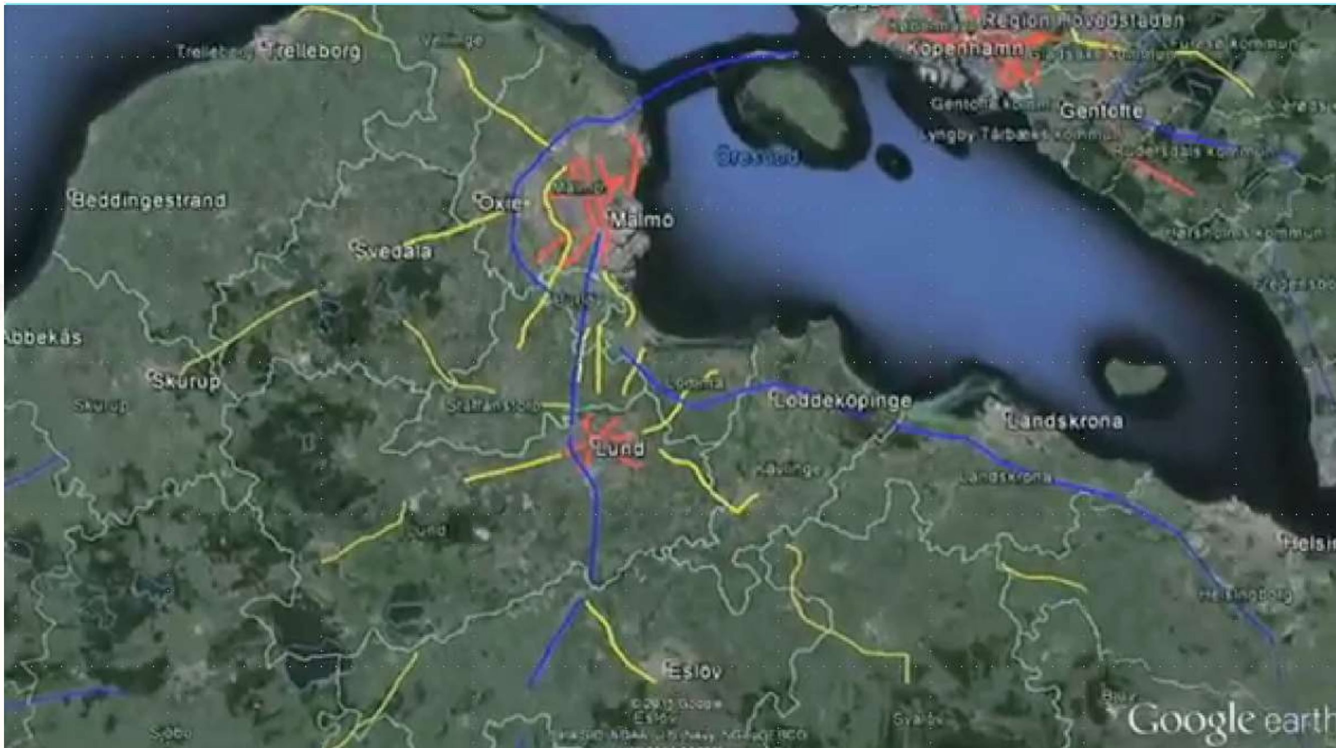




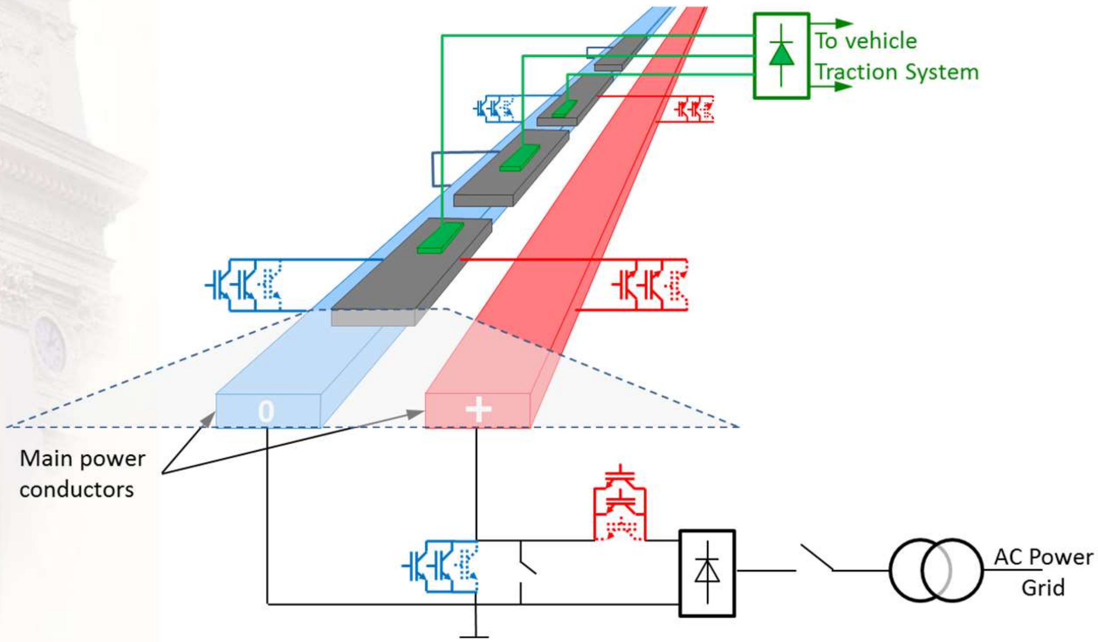
Δ = 61 km   Δ = 134 km   Δ = 336 km

”Battery range for infinite range”

Vision of one technology supplier ...



A technology example...



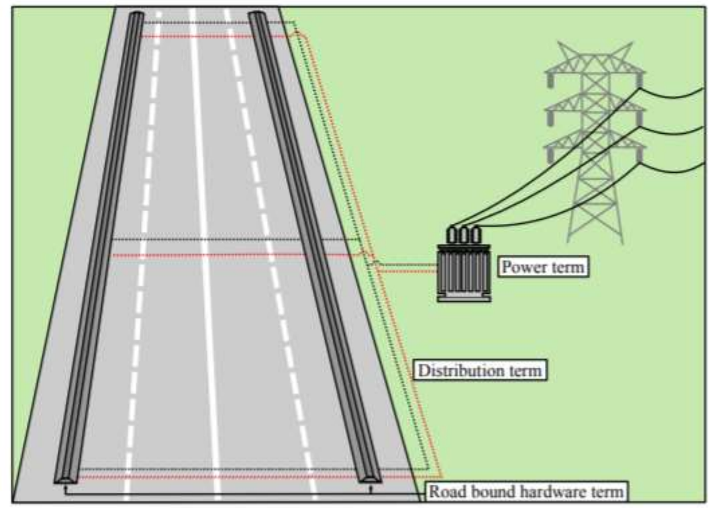
ELONROAD

Cost of Charging

COST OF INFRASTRUCTURE

- Static chargers priced at 350 € /kW based on the previous models
- ERS cost modelled as:

$$C_{ERs} = k_0 \, P_{ERS} + k_1 \, L_{ERS} + k_2 \, k_{ERS} L_{ERS} \, N_{Lanes}$$



POWER TERM

- Proportional to the traffic flow
- 2.5 peak to average ratio
- Transforming and rectifying stations

k_0 = 300 10^3 €/MW

DISTRIBUTION TERM

- Proportional to the length of the ERS
- Distribution cables going along the road supplying the rectifying stations

k_1 = 150 10^3 €/km

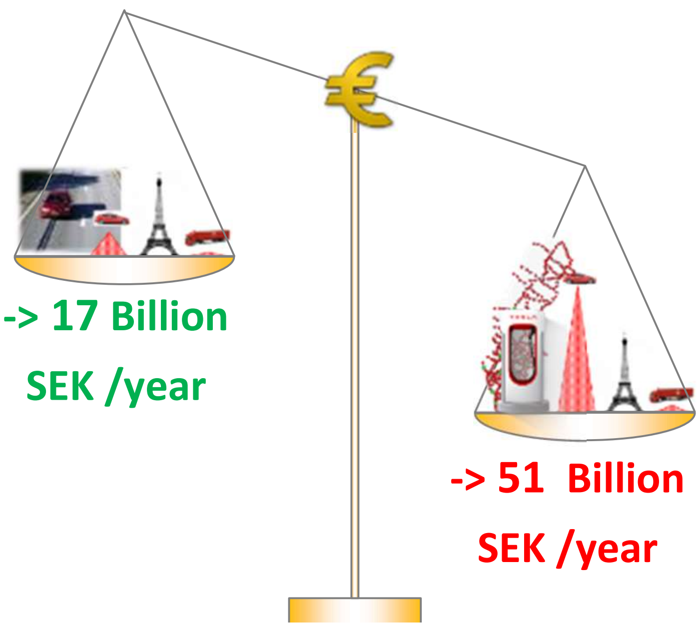
HARDWARE TERM

- Proportional to the electrified section of the ERS
- All hardware installed "on the road"

k_2 = 500 10^3 €/kW

Some cost analysis …

- 5 million **cars** á **15 kWh** batteries á 1000 SEK/kWh @ 10 years lifetime
  -> 7 Billion SEK/year
- 50 000 **Heavy Duty Trucks** á **100 kWh** batteries á 1000 SEK/kWh @ 2 years lifetime
  -> 2 Billion SEK/year
- 15 600 km National and European road á 10 Million SEK/km @ 20 years lifetime
  -> 8 Billion SEK/year



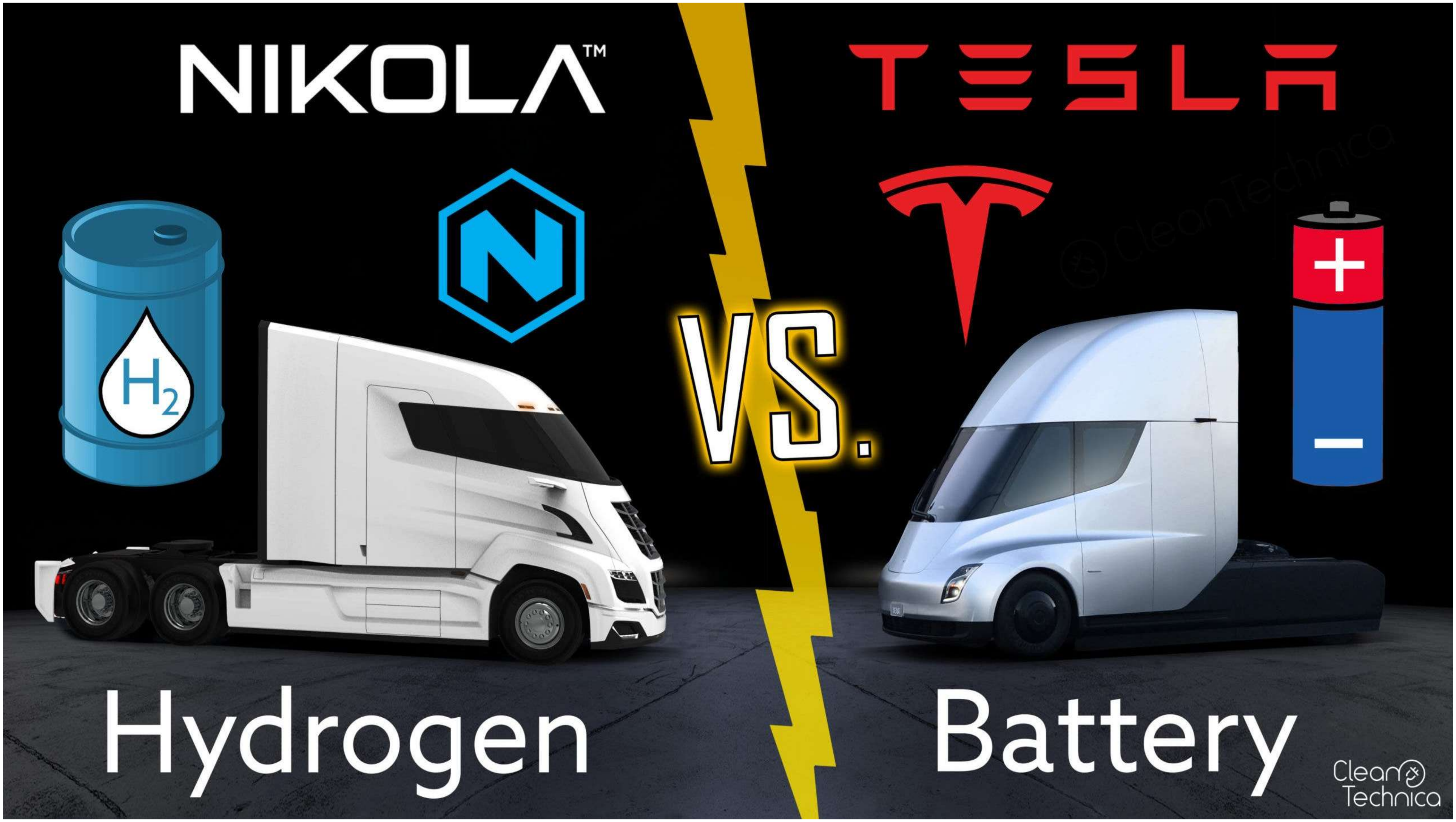
-> 17 Billion SEK /year

-> 51 Billion SEK /year

- 5 million **cars á 75 kWh** batteries á 1000 SEK/kWh @ 10 years lifetime
  -> 38 Billion SEK/year
- 50 000 **Heavy Duty Trucks á 500 kWh** batteries á 1000 SEK/kWh @ 2 years lifetime
  -> 12 Billion SEK/year
- 50 000 ”**Super**Chargers” á 150 kW á 6000 SEK/kW @ 25 years lifetime
  -> 1 Billion SEK/year

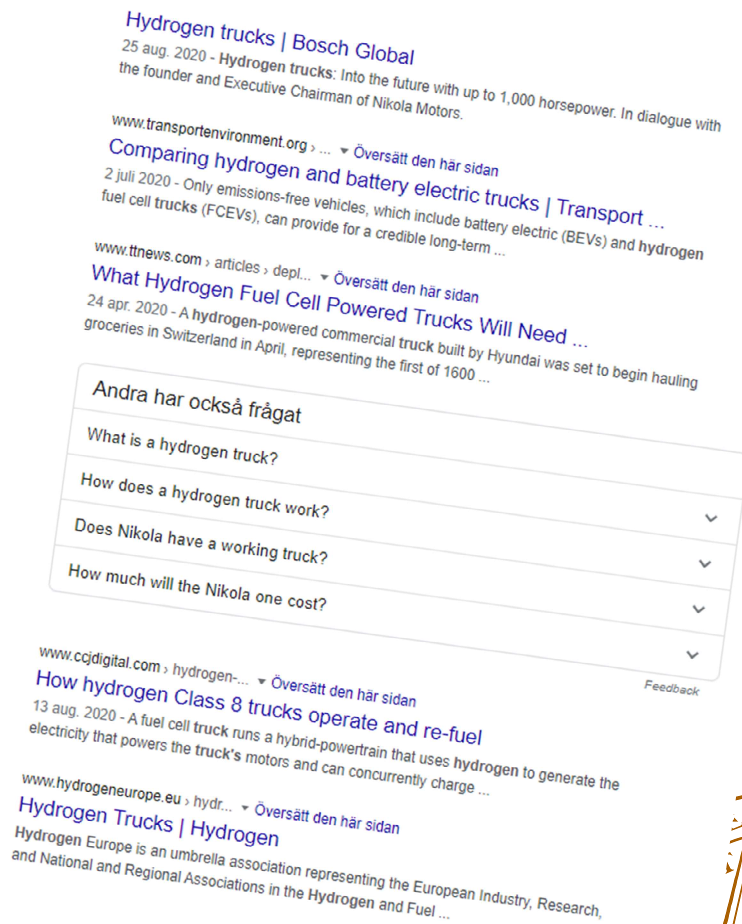
500 ”**MEGA**Chargers” á 1000 kW á 6000 SEK/kW @ 25 years lifetime
-> 0,12 Billion SEK/year

Fuel cells


NIKOLA™
TESLA
H2
VS.
Hydrogen
Battery
Clean Technica

All over the news

- Benefits:
  - Higher energy density than batteries.
  - Faster “charge time”
- Drawbacks
  - Lower efficiency
  - No infrastructure


Hydrogen trucks | Bosch Global
25 aug. 2020 - Hydrogen trucks: Into the future with up to 1,000 horsepower. In dialogue with the founder and Executive Chairman of Nikola Motors.

www.transportenvironment.org › ... ▾ Översätt den här sidan
Comparing hydrogen and battery electric trucks | Transport ...
2 juli 2020 - Only emissions-free vehicles, which include battery electric (BEVs) and hydrogen fuel cell trucks (FCEVs), can provide for a credible long-term ...

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What Hydrogen Fuel Cell Powered Trucks Will Need ...
24 apr. 2020 - A hydrogen-powered commercial truck built by Hyundai was set to begin hauling groceries in Switzerland in April, representing the first of 1600 ...

Andra har också frågat
What is a hydrogen truck?
How does a hydrogen truck work?
Does Nikola have a working truck?
How much will the Nikola one cost?
Feedback

www.ccjdigital.com › hydrogen-... ▾ Översätt den här sidan
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13 aug. 2020 - A fuel cell truck runs a hybrid-powertrain that uses hydrogen to generate the electricity that powers the truck's motors and can concurrently charge ...

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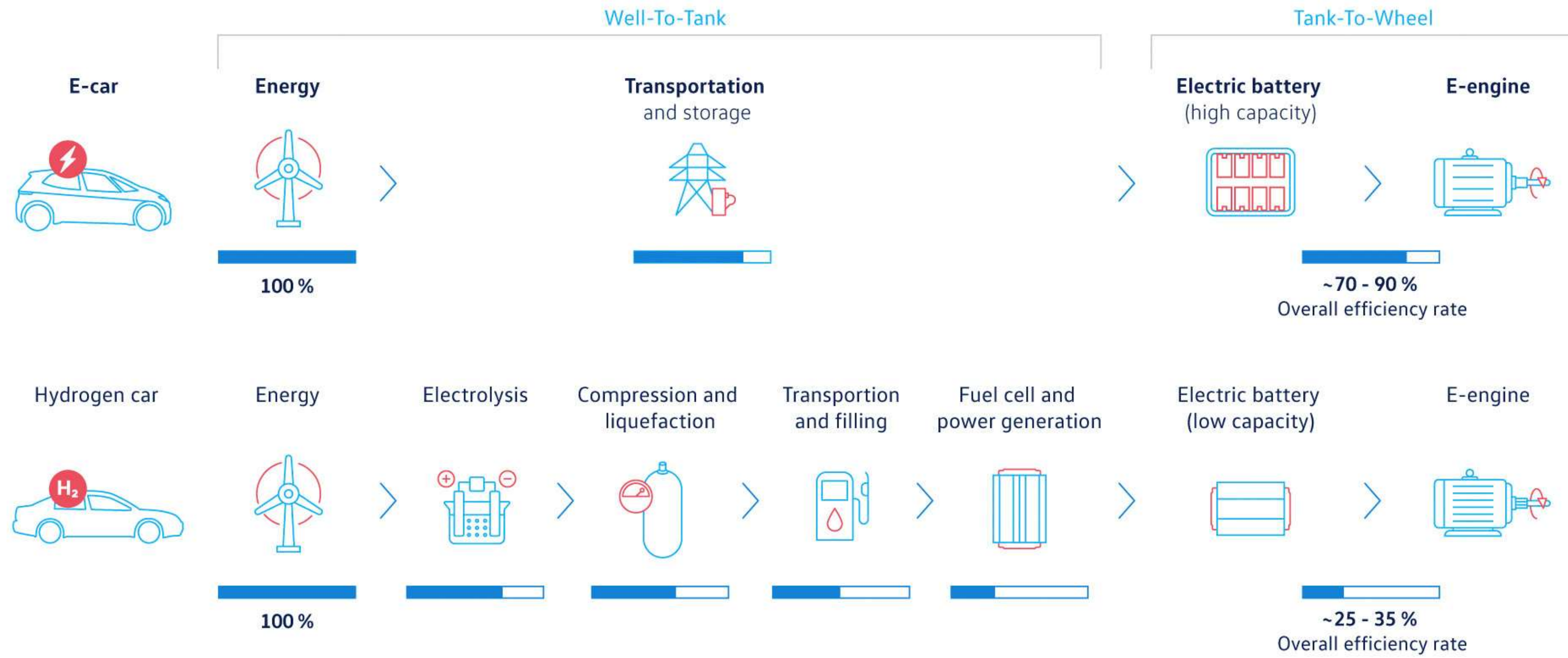
Hydrogen Trucks | Hydrogen
Hydrogen Europe is an umbrella association representing the European Industry, Research, and National and Regional Associations in the Hydrogen and Fuel ...

Hydrogen **and electric drive**

Efficiency rates in comparison using eco-friendly energy



Source Volkswagen

https://insideevs.com/news/406676/battery-electric-hydrogen-fuel-cell-efficiency-comparison/