“Upscaling challenges with full electrification of road vehicles”

Mats Alaküla, Professor
Industrial Electrical Engineering
Lund University, Faculty of Engineering

Mats Alaküla

- Professor in Industrial Electrical Engineering at LTH since 1994
- Thematic Leader for Swedish Electro Mobility Research Centre 2007-2019
- Senior Advisor AB Volvo 2007-2020

Sixth Assessment Report

Synthesis Report

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INTERGOVERNMENTAL PANEL ON climate change
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The warning

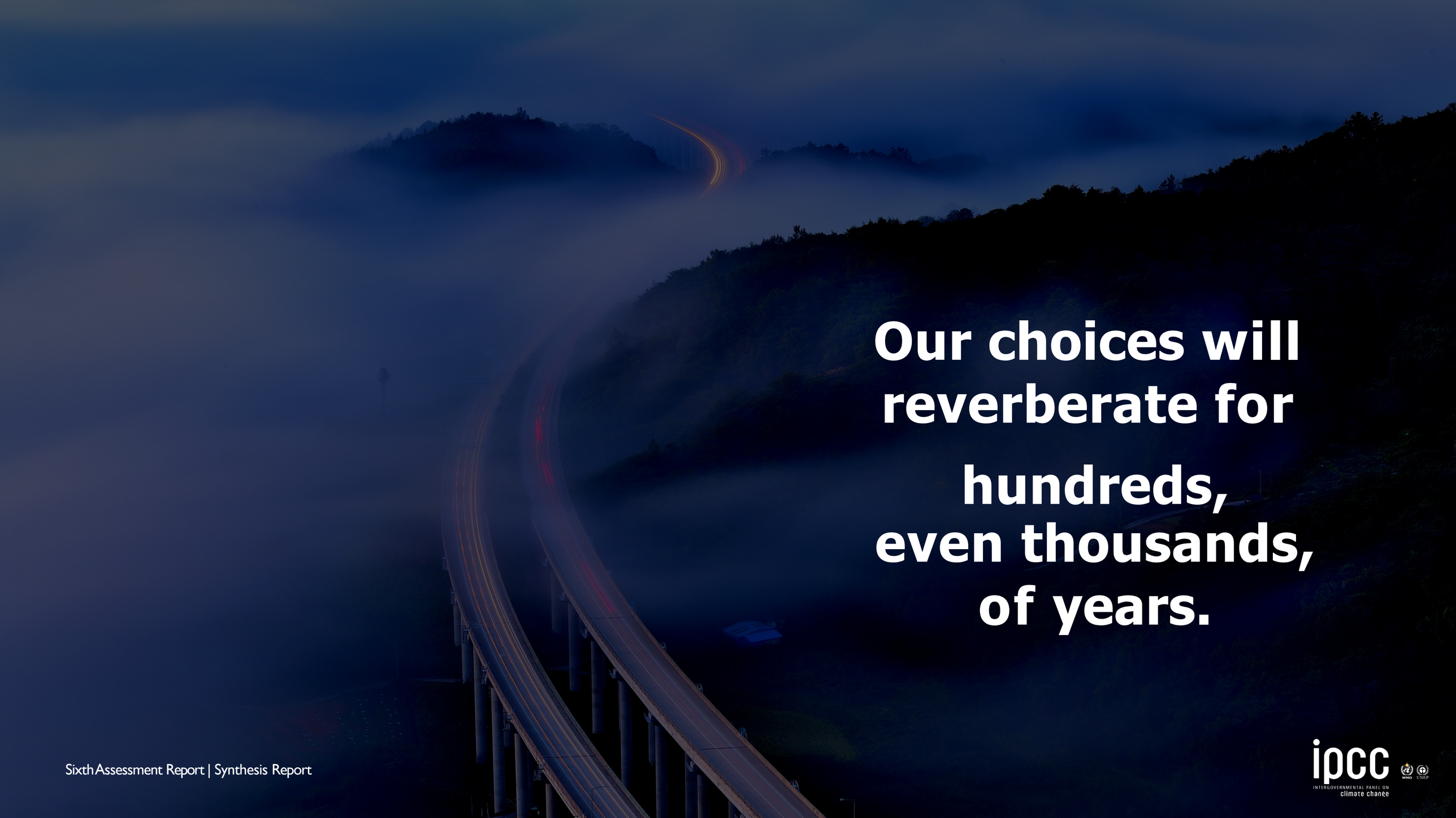
Pace and scale of climate action are insufficient to tackle climate change

The path forward is clear

Tried and tested options available now

Need to be designed for diverse contexts

Need to be scaled up and applied widely



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We have plans …

- Within EU, new Cars and Vans are not allowed to emit any CO_2 after 2035[1]
- The trend points at Full Electric Vehicles as the main solution, at least for cars.
- The expectation is that, with an average lifetime of 20 years, all cars will be emission free (electric) by 2055.
- This requires:
  - *A fast change of EV sales, which we are seeing.*
  - *A significant dissemination of a fast-charging infrastructure*
  - *That enough electric power is made available*

1) https://www.europarl.europa.eu/news/sv/headlines/economy/20221019STO44572/eu-s-forbud-mot-forsaljning-av-nya-bensin-och-dieselbilar

Do we have enough Power and Energy?

Sweden as example:

- We use about 80 TWh of Gasoline and Diesel
- When all vehicles are electric, we will need about 27 TWh electricity per year = 74 GWh/day.
- Our maximum power generation capacity is about 30+ GW
  - If we charge in 6 hours: 12 GW charging power – **NOT POSSIBLE**
  - If we charge in 12 hours: 6 GW charging power – **MAYBE POSSIBLE**
  - If we charge in 24 hours: 3 GW – **POSSIBLE**

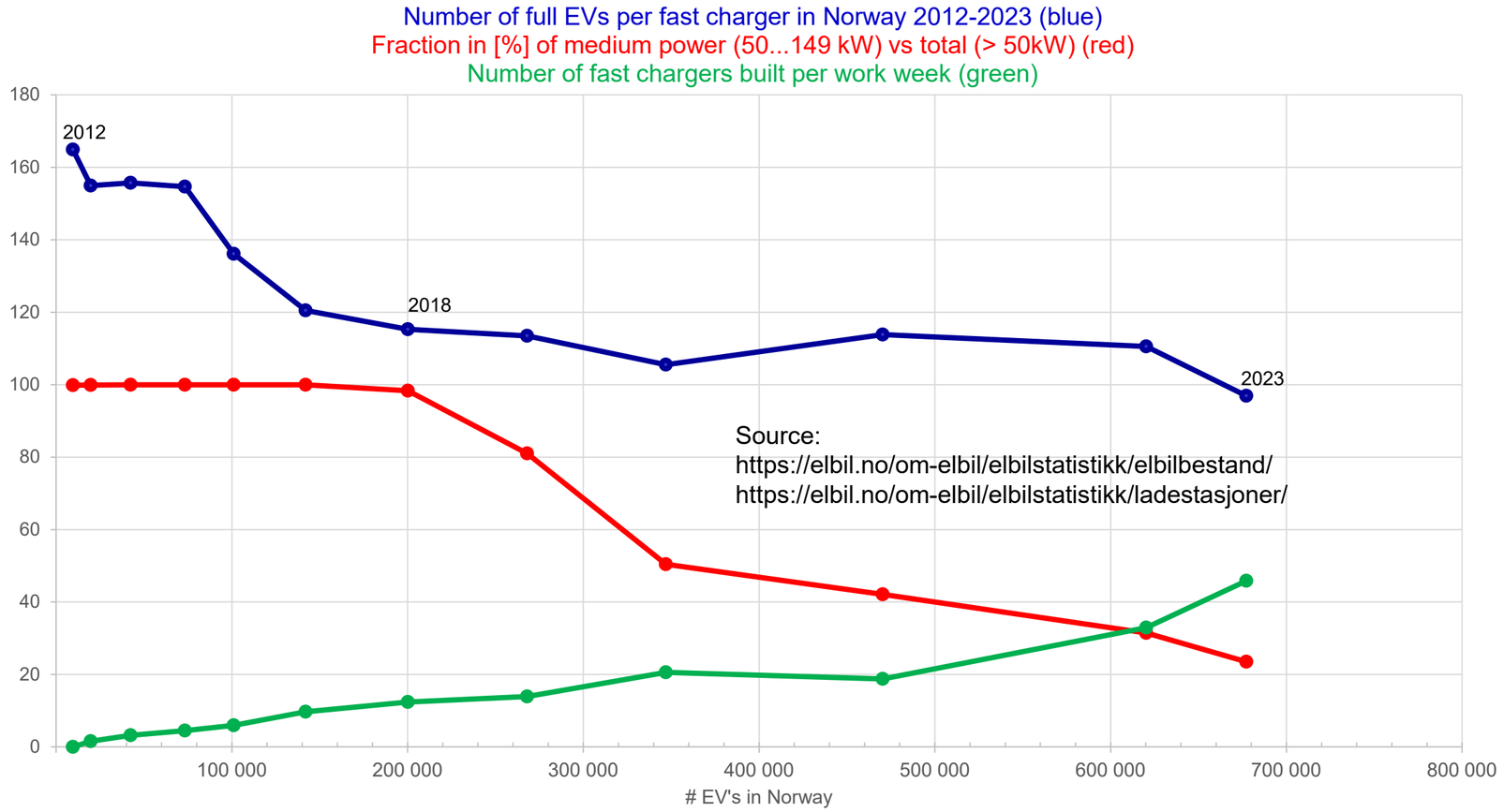
Conclusion? – We need to be smart when charging!

The challenges

- Full electric vehicles need:
  - *Slow charging – for daily commuting*
  - *Fast charging – for longer trips*

- The number of fast chargers (FC) is, currently, assumed to be proportional to the number of full electric vehicles (FEV):

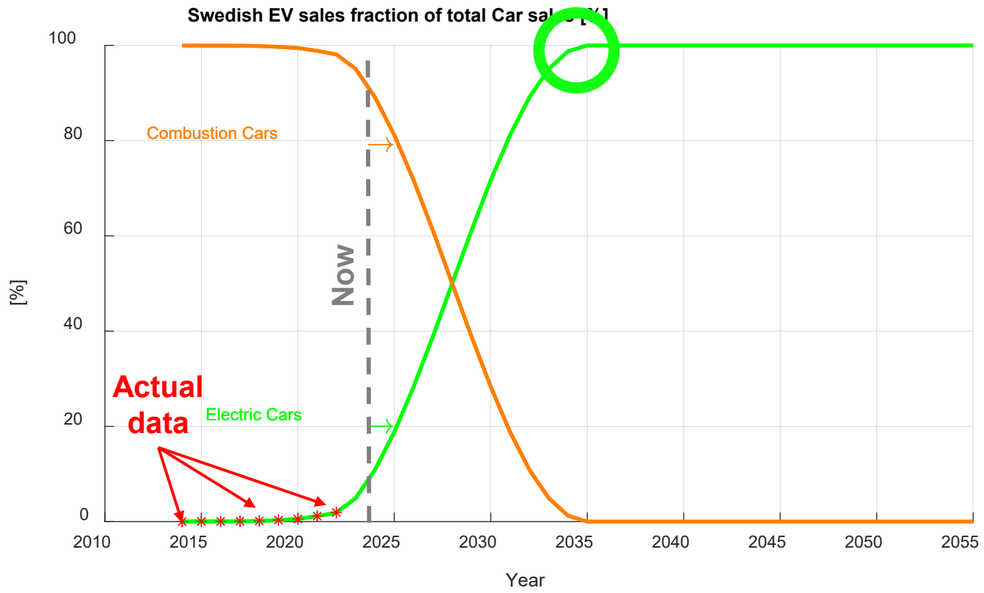
- Let us assume that it is 100 FEV/FC that we need!

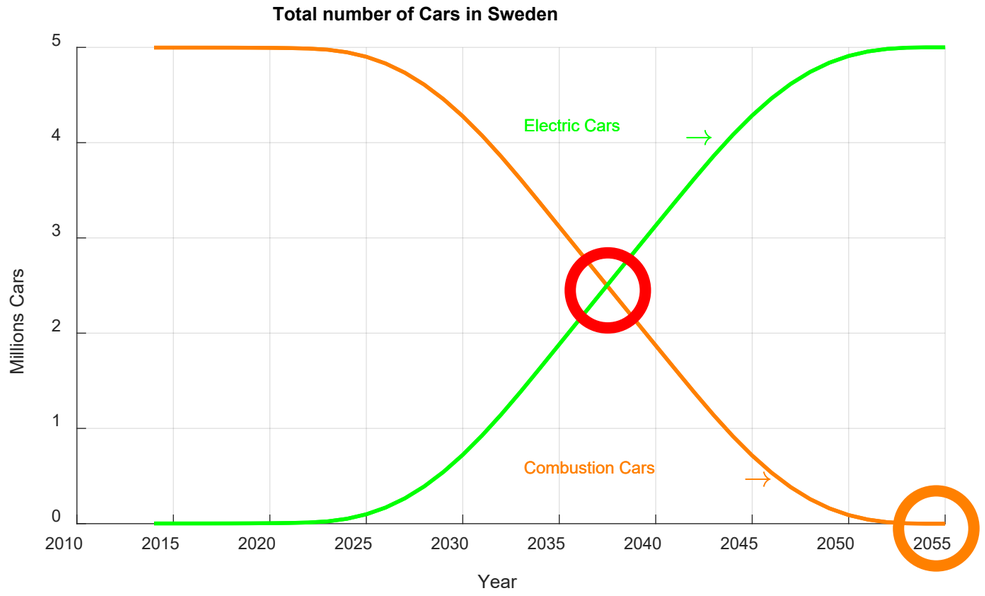


Example with cars, in Sweden

- Assume that:
  - *The car fleet is 5 million cars, constant*
  - *The EV sales increase as in figure 1*
  - *The EV sales reach 100% in 2035*

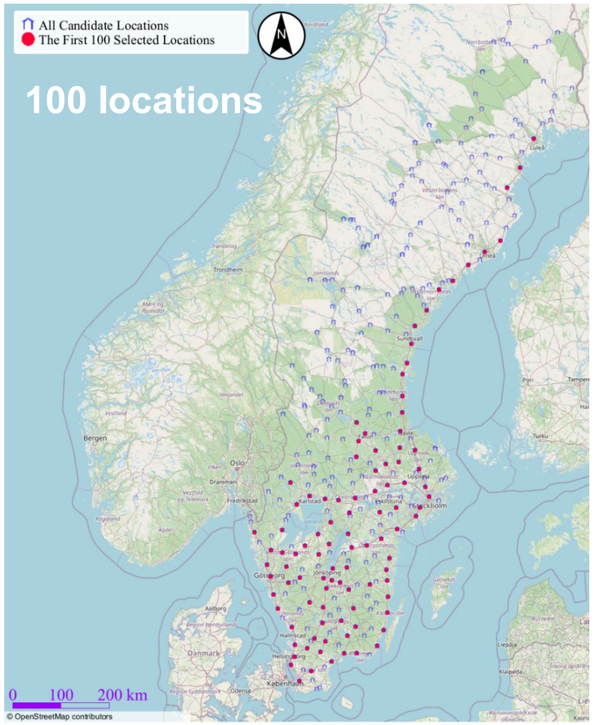
- Then:
  - *Half the fleet will be full electric in 2037*
  - *Combustion cars are phased out 2055*

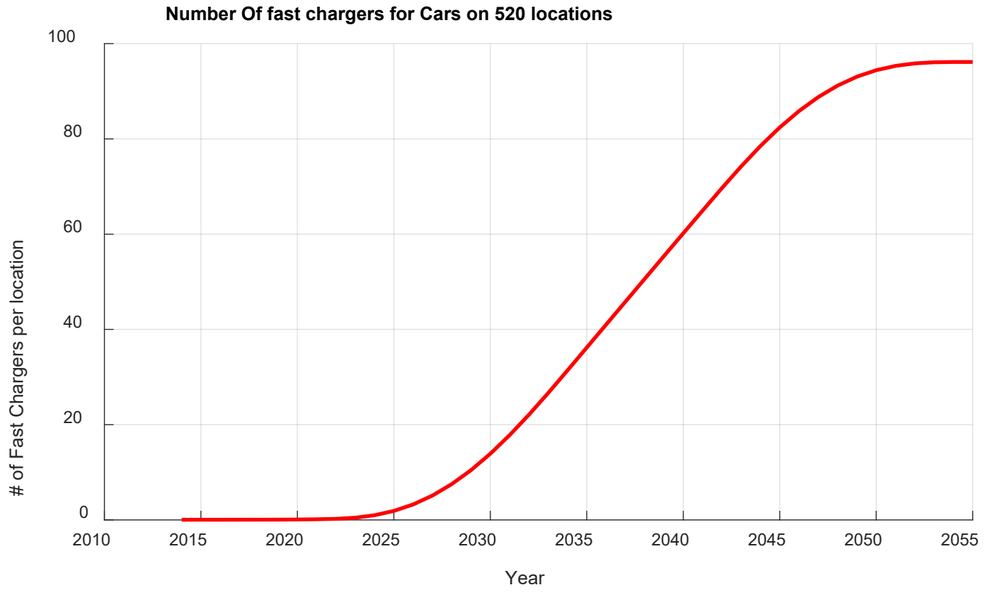




And we need fast chargers

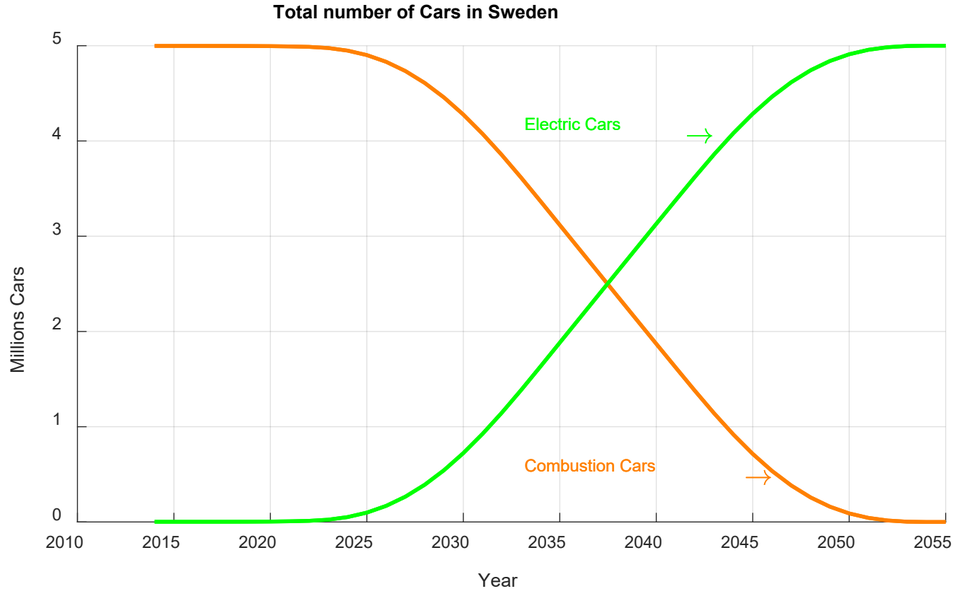
- We have 15600 km National and European road in Sweden
- We want access to fast charging as dense as every 30 km
  - *15600/30 = 520 locations*
- With 1 Fast-charger per 100 full electric vehicles, we end up with almost 100 fast chargers per location.
  - *In average!*
  - *Tesla's largest has 40 fast chargers*
  - *(We have today about 700 gas stations with service and 10-15 pumps each!)*
- It is, indeed, a lot!

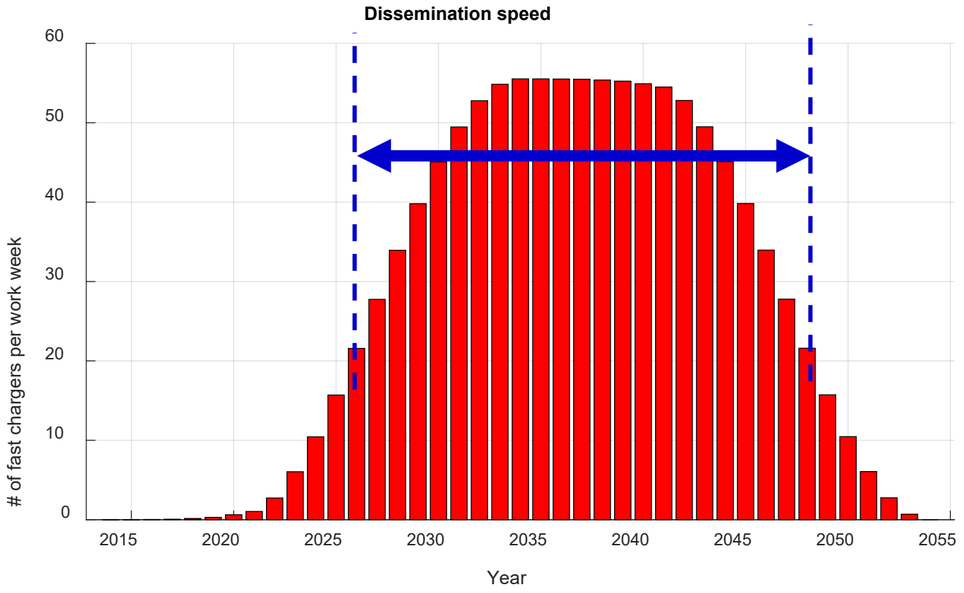




And how fast do we have to build them ?

- Assume:
  - *That we work 45 weeks per year*
- Then:
  - *We need to install 20…55 fast chargers PER Workweek, all work weeks for over 20 years*
- That is, indeed, a high pace!



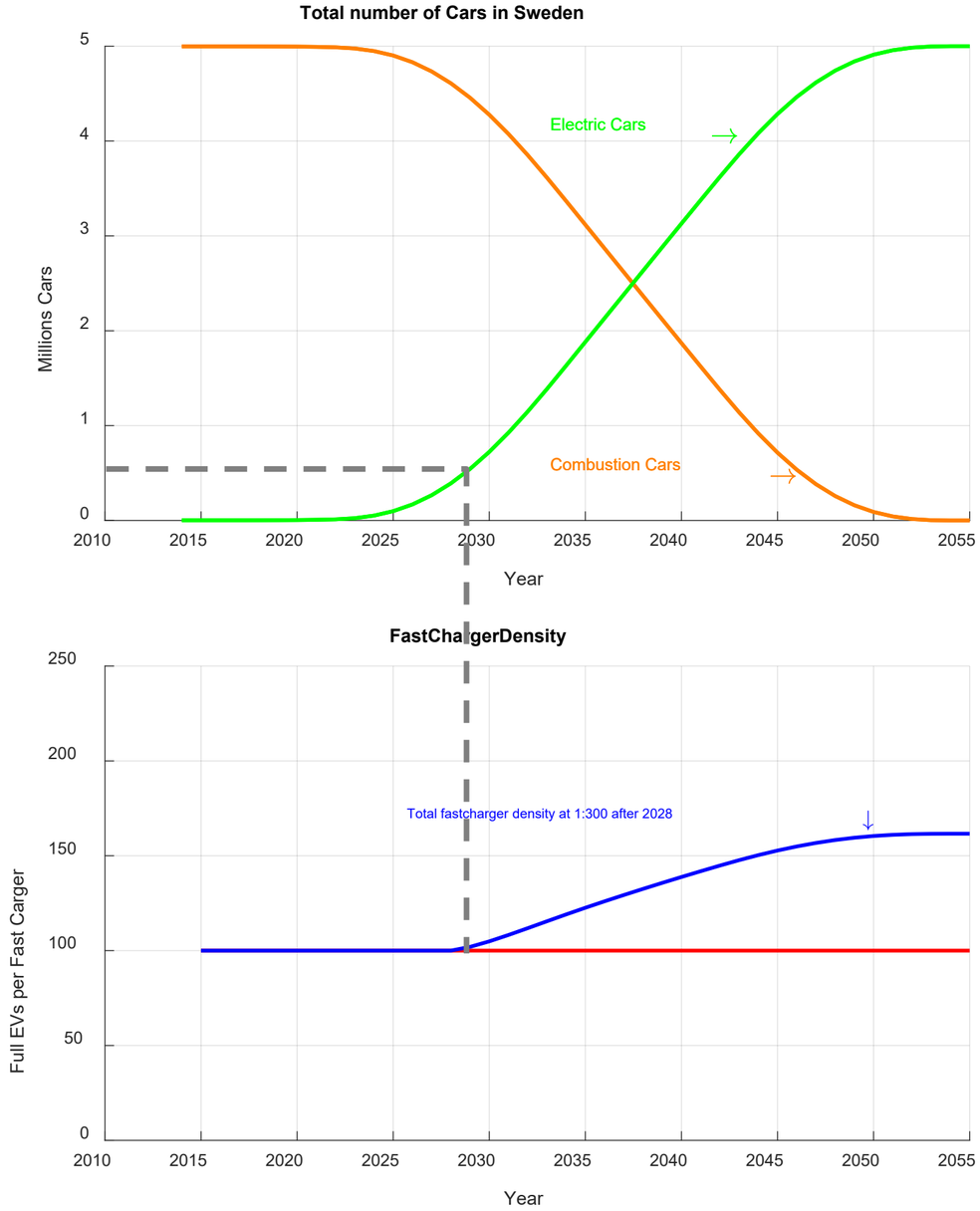


1:100 is maybe too dense …?

- Those who have full EV's today are "early adopters"
  - *Maybe a bit more adventurous*
  - *Maybe make more and longer trips*

- What if the expected fast charger density drops when the vehicle fleet grows?

- Assume that:
  - *When 10% of the fleet is electric, the ratio starts to change FROM 1:100 towards 1:300 as the fleet grows.*

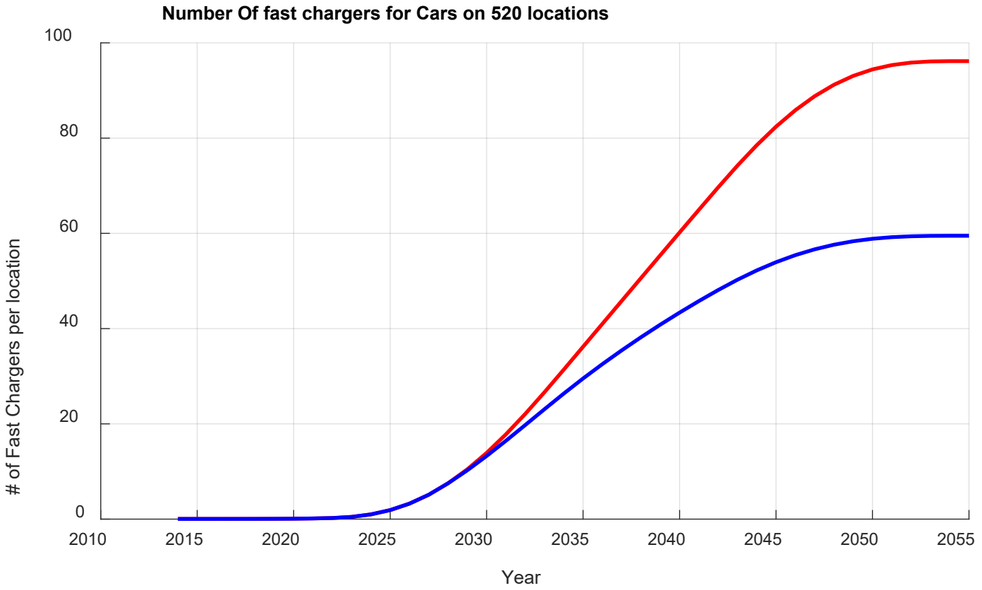


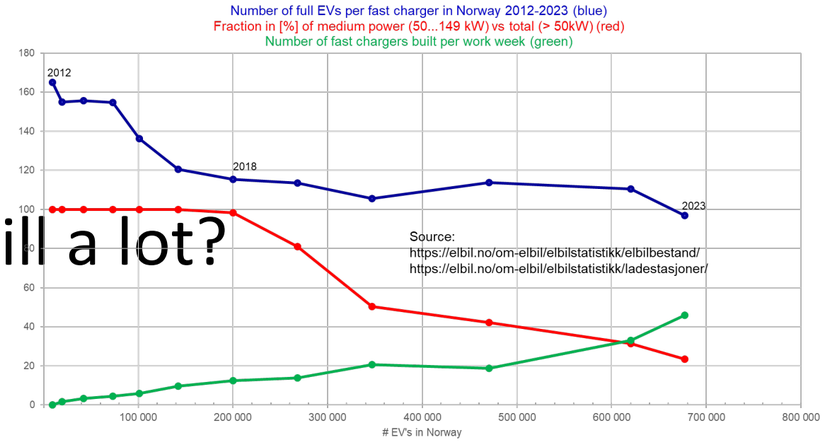
Results, with the reduced need for fast chargers

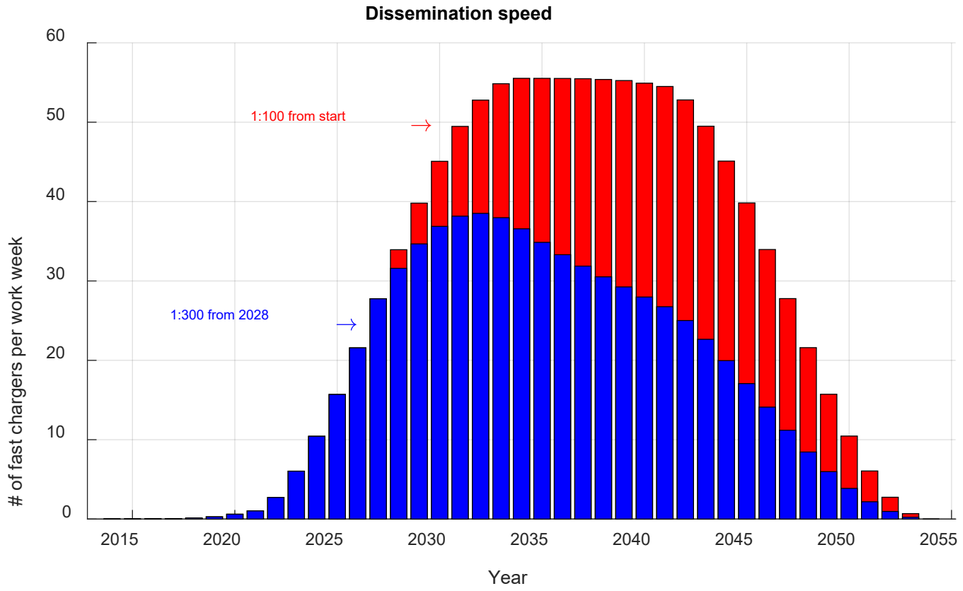
- The number of fast chargers per 520 stations is reduced from almost 100 to almost 60
  - *In average!*

- The building rate is also changed, from a peak at 55 fast chargers per week to 40 per week.

- Is it, indeed, still a lot?

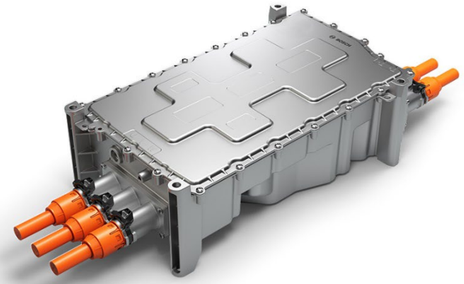






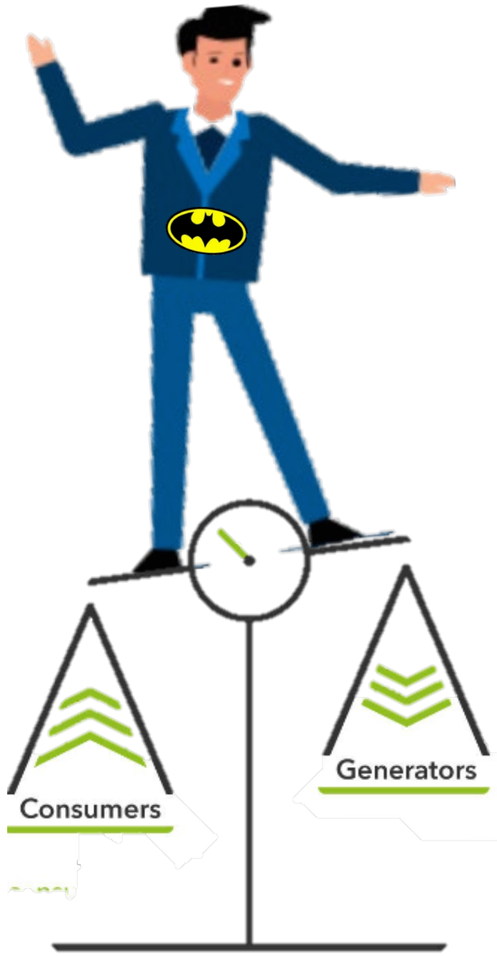
The EV's have batteries and shed batteries

- 5 million Cars (in Sweden) with 80 kWh average battery size = 400 GWh
  - *Enough to run Sweden in Battery Mode for 10-20 hours … with V2G chargers*
- 5 million Cars with 20 years lifetime shed 400/20 = 20 GWh of 2nd life batteries per year!
  - *Can be used to support fast charging stations with 20GWh/520 = 38 MWh/station*
- 5 million cars with 200 kW average traction drives and 20 years lifetime shed 50 GW power electronics every year
  - *That have to be replaced …*
  - *Can we do that?*
  - *What about recycling / repurposing / re… ?*



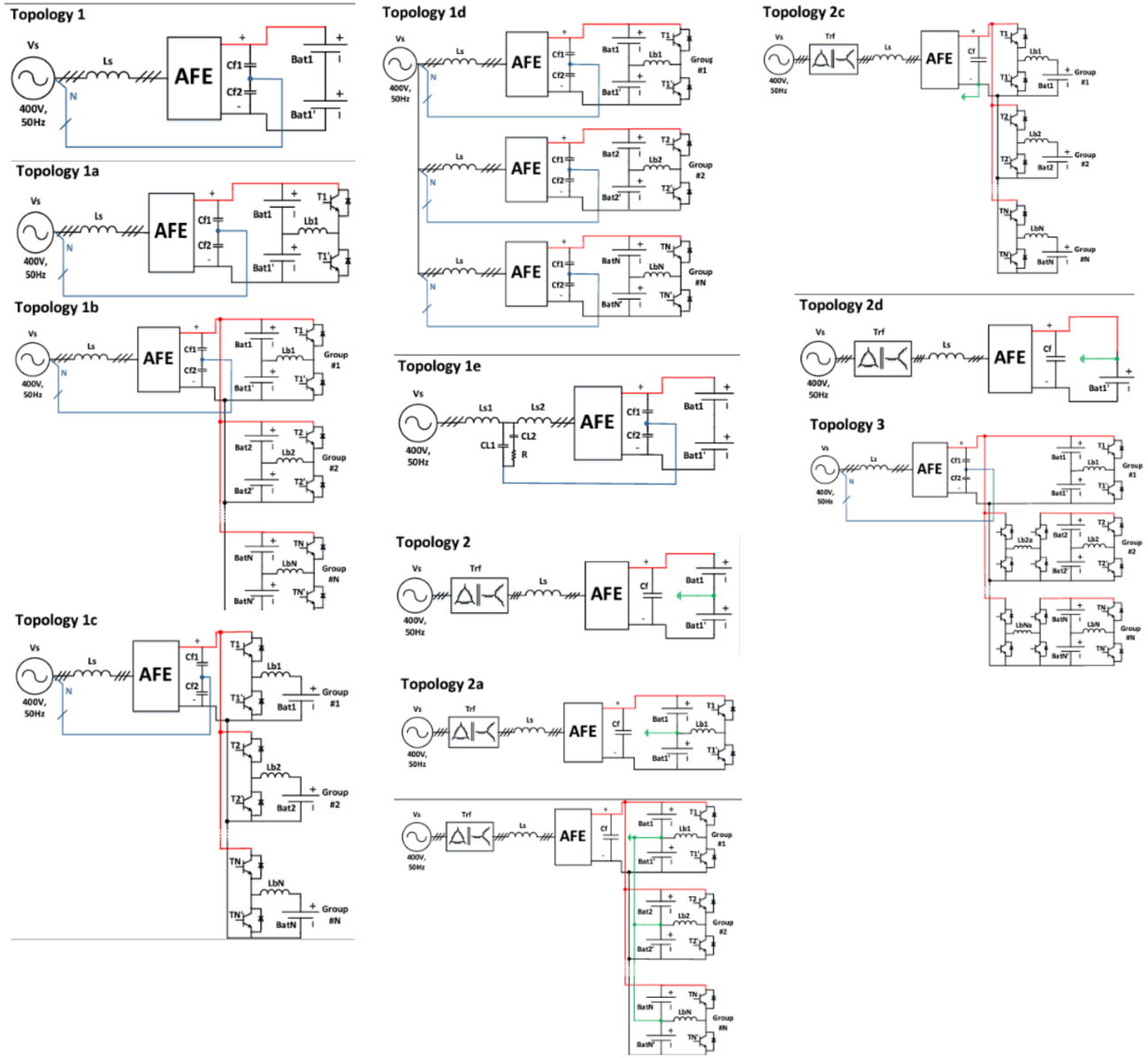
Lot’s of challenges …

- The electric power system will become an electric energy system …
  - *Batteries with and without wheels will have an enormous potential …*
- There is MAYBE a challenge to provide the EV market with new Power Electronic Converters as the fleet evolves …
  - *I do not know …*
- Grid batteries is a new business



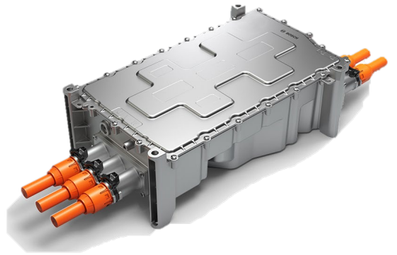
Grid batteries

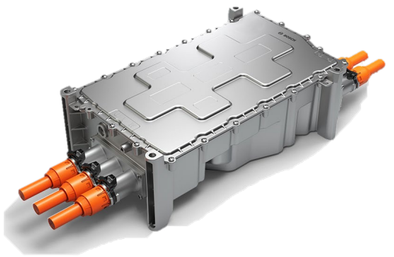
- Annual influx of 20 GWh, or about 250 000 used EV batteries, every year (in Sweden only)
- These are different
  - *Brands, Chemistry, Capacity, Age, History, SOH, …*
- These need
  - *To be characterized, connected, used to the best of their abilities …*
  - *A lot of power electronics !*
    - Can it be the EV motor drives?



Can EV batteries and motor drives go “hand in hand”?

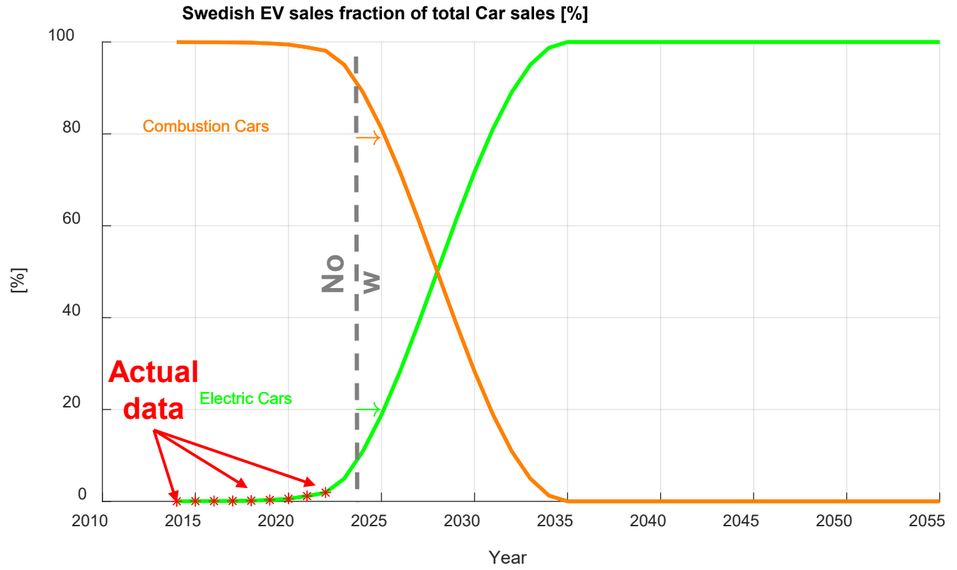
- Can an EV motor drive and its’s battery be prepared for a 2nd life?
- Which are the compromises needed to make an EV drivetrain converter a grid battery converter?
  - *Is it worth it?*





Conclusions, this far …

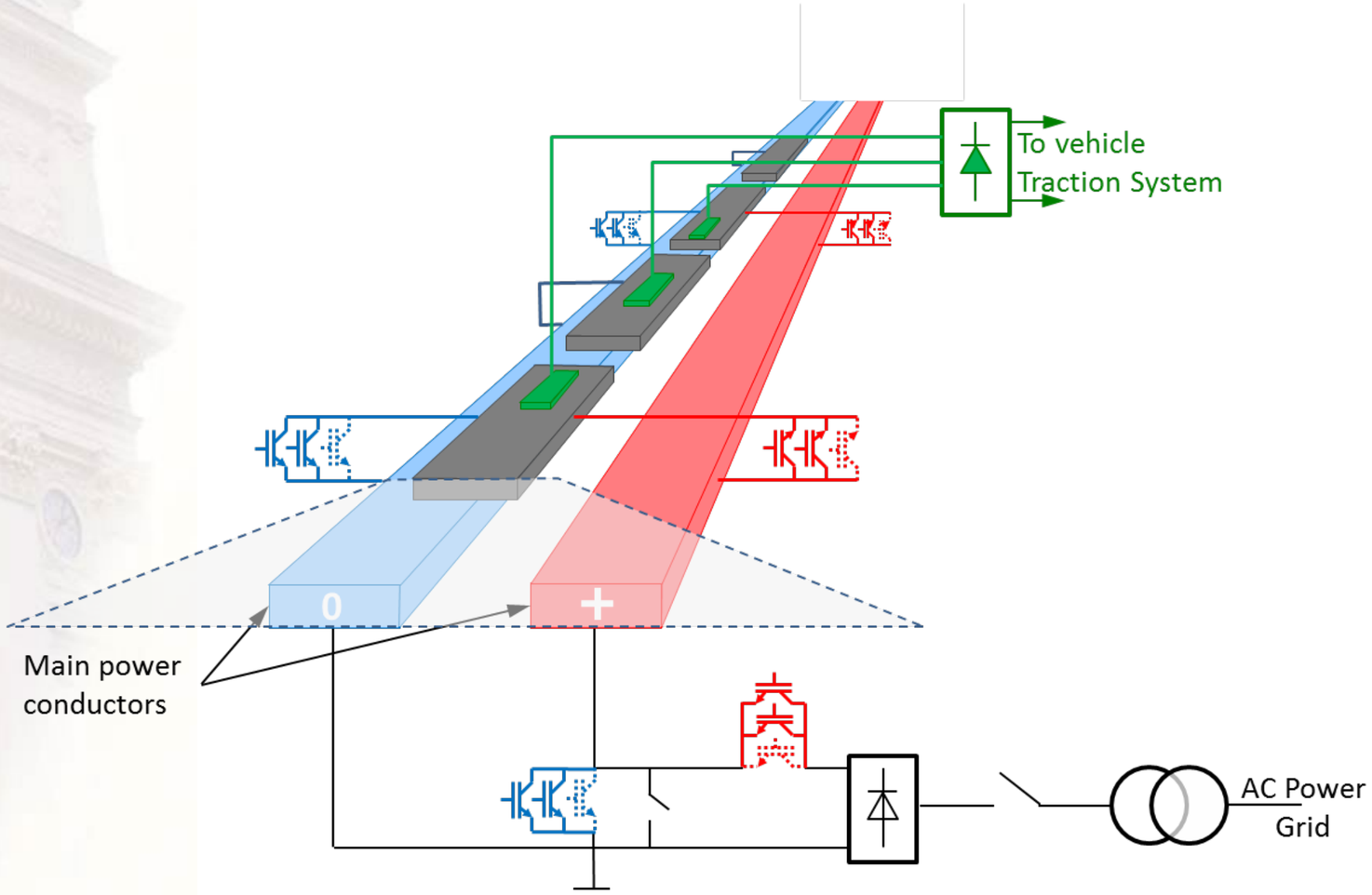
- Upscaling electro-mobility, to keep European environmental goals, requires a significant pace of
  - *Sales of cars*
  - *Installation of fast chargers for cars*
  - *Provision of a high number of high-power grid connections to the medium voltage grid, or stronger.*
  - *The preparation of many charging fields, each at the size of a soccer field.*
- The challenge is maybe not the goal itself, but the pace needed
- The full EV fleet will shed extreme amounts of batteries and power electronic converters
  - *How can these be (re-)used ?*

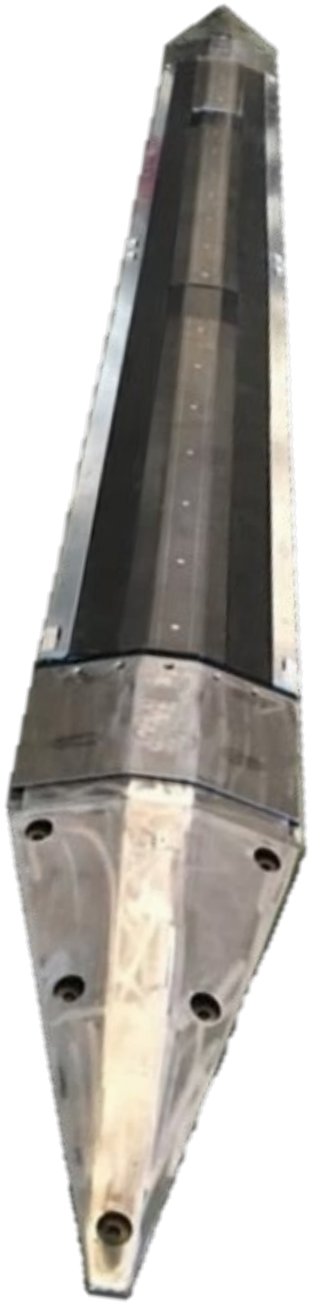


An alternative

- Electric Road Systems (ERS)
  - *Reduce the need for fast chargers to a small fraction*
  - *Reduce the need for EV batteries by at least 50%*
  - *Can be built at a speed of at least 1 km/day*
  - *Would be needed on 3000 - 6000 km of national and European roads in Sweden, i.e. take 3000-6000 hours to build = 6000/5 = 1200 days or 60 months or 5 years with 5 parallel building sites.*
- ERS is not only an alternative to fast chargers
  - *Also replaces the need for night time chargers for those who cannot have*

A technology example...





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Latest news...

How do we scale up electrification of road transportation – fast enough?

The need to address climate change and reach the emission targets in transportation has become more pressing than ever before.

https://chargingahead.confetti.events/


- Thanks!