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GHG emissions of an electrified vehicle combined with renewable fuels: LCA and policy implications

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Why?

- Electrification is widely perceived as a silver bullet for GHG mitigation
  - Policy actions favor EVs and largely ignore other alternatives

- What about renewable fuels? Only a few comparative assessments are made
  - These show that renewable fuels compare well with electrification
  - No assessments of combinations of electrification and renewable fuels

How does a combination of renewable fuels and electrification compare to electrification alone?

- Sensitivity analysis with respect to the GHG intensity of the electricity mix and fuel

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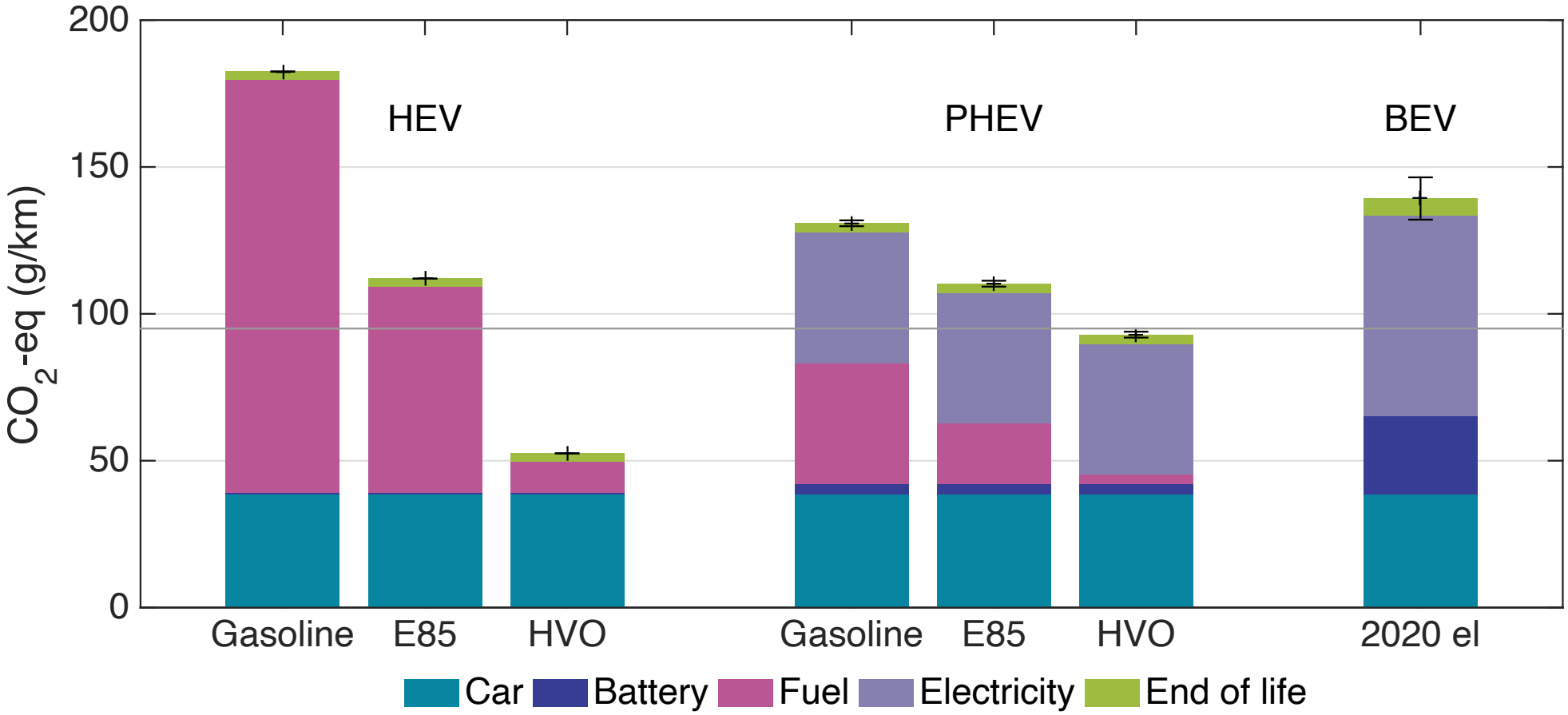
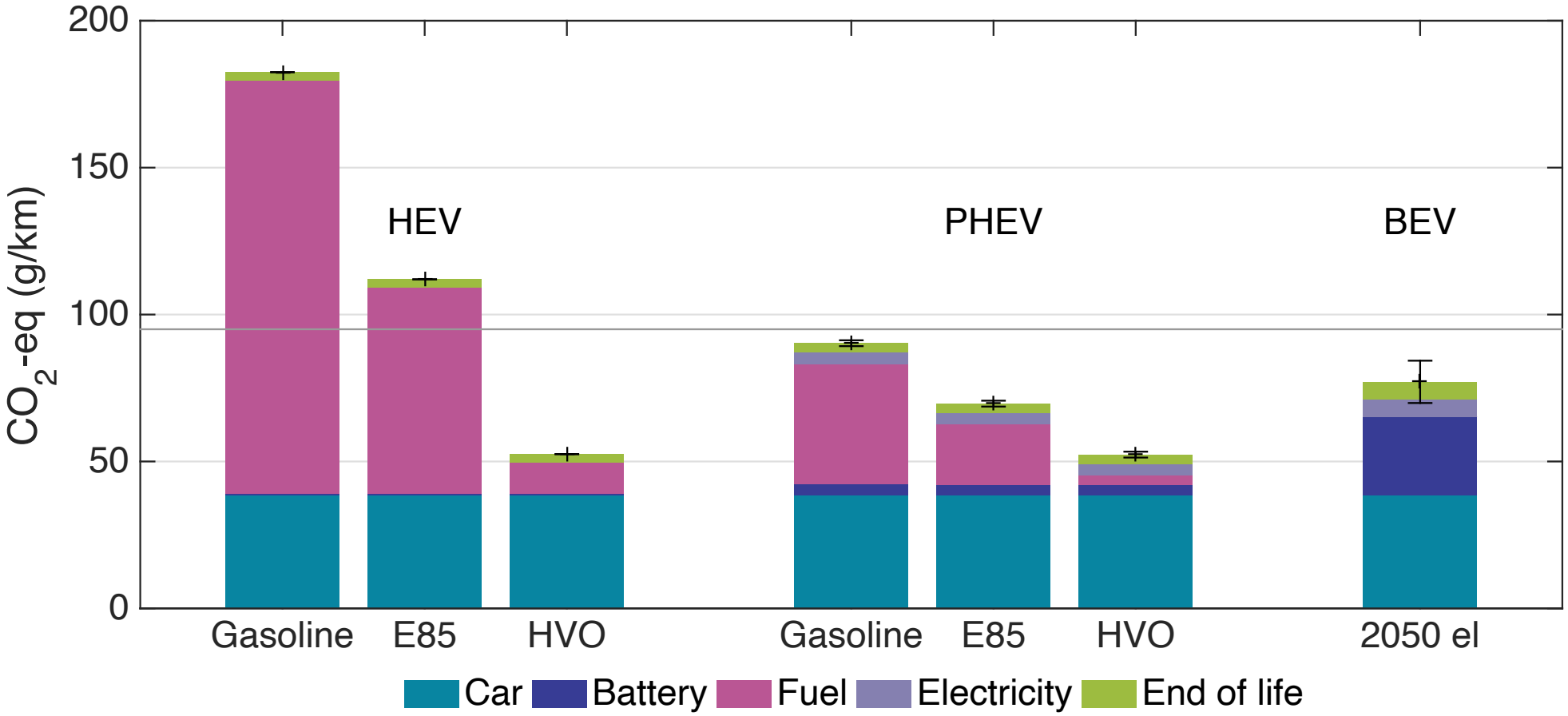
Powertrain	**HEV**	**PHEV**	**BEV**
Engine	1.6 l / 4 cyl / gasoline	1.6 l / 4 cyl / gasoline	
Battery type	Li ion polymer	Li ion polymer	Li ion polymer
Battery capacity (kWh)	1.6	8.9	64
Battery mass (kg)	33	117	457
Fuel consumption WLTP (l/100 km)	4.8	1.4	0
Electricity consumption WLTP (kWh/100 km)	0	no data	15.9
CO_2 WLTP (g/km)	110	31	0

Results with present EU-28 electricity mix (2020)



2050 EU-28 electricity mix



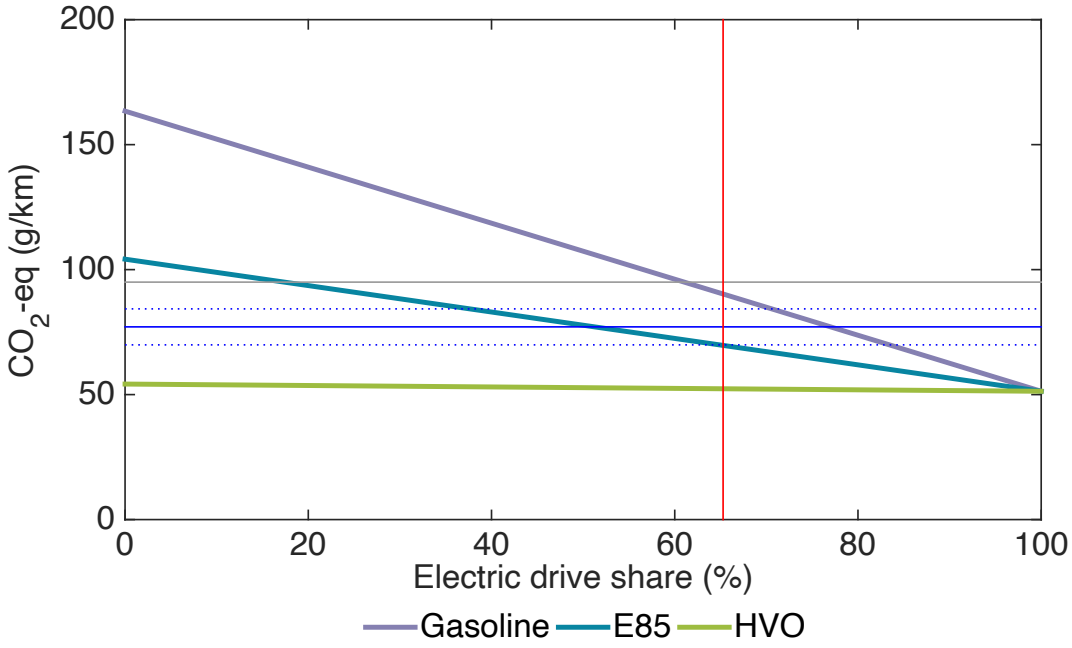
PHEV: Impact of the share of electric drive

- The WLTP CO_2 emissions are based on a weighted average between ICE mode and electric mode
  - The weight is determined by the electric range of the PHEV
  - For Kia Niro PHEV, the electric drive factor is 65 %

- What is the effect of the share of electric drive?

2050 EU-28 electricity

- Gasoline breaks even with BEV at 77% EDS
  - Achieved at 60 km electric range (Plötz et al.)
- E85 breaks even at 52% EDS
- HVO is always better than BEV



Grey line: 95 g/km
Blue line: BEV level (77 g/km)

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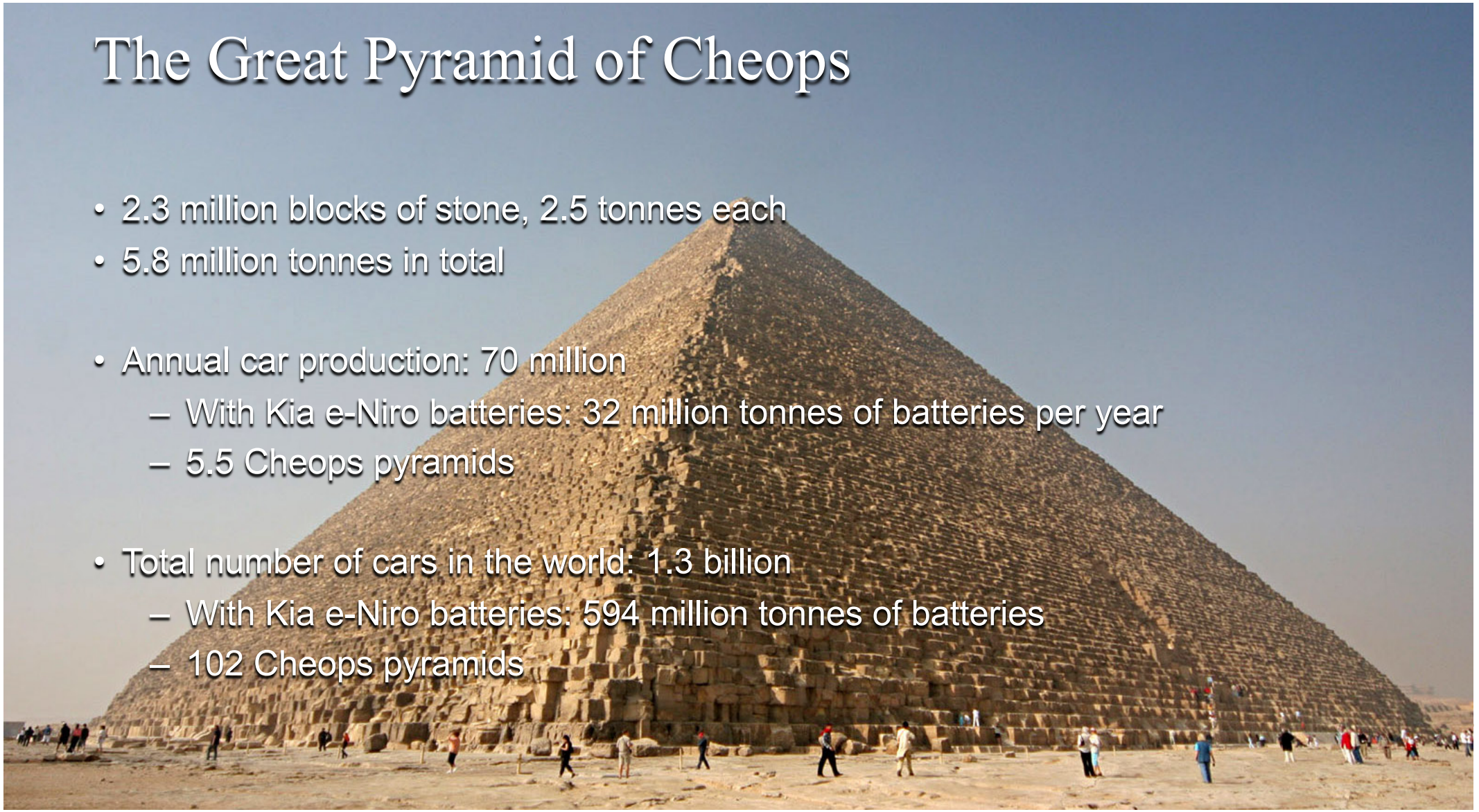
The Great Pyramid of Cheops



- 2.3 million blocks of stone, 2.5 tonnes each
- 5.8 million tonnes in total

- Annual car production: 70 million
  - With Kia e-Niro batteries: 32 million tonnes of batteries per year
  - 5.5 Cheops pyramids

- Total number of cars in the world: 1.3 billion
  - With Kia e-Niro batteries: 594 million tonnes of batteries
  - 102 Cheops pyramids


Niagara Falls, Buffalo, NY

“Lagom”?

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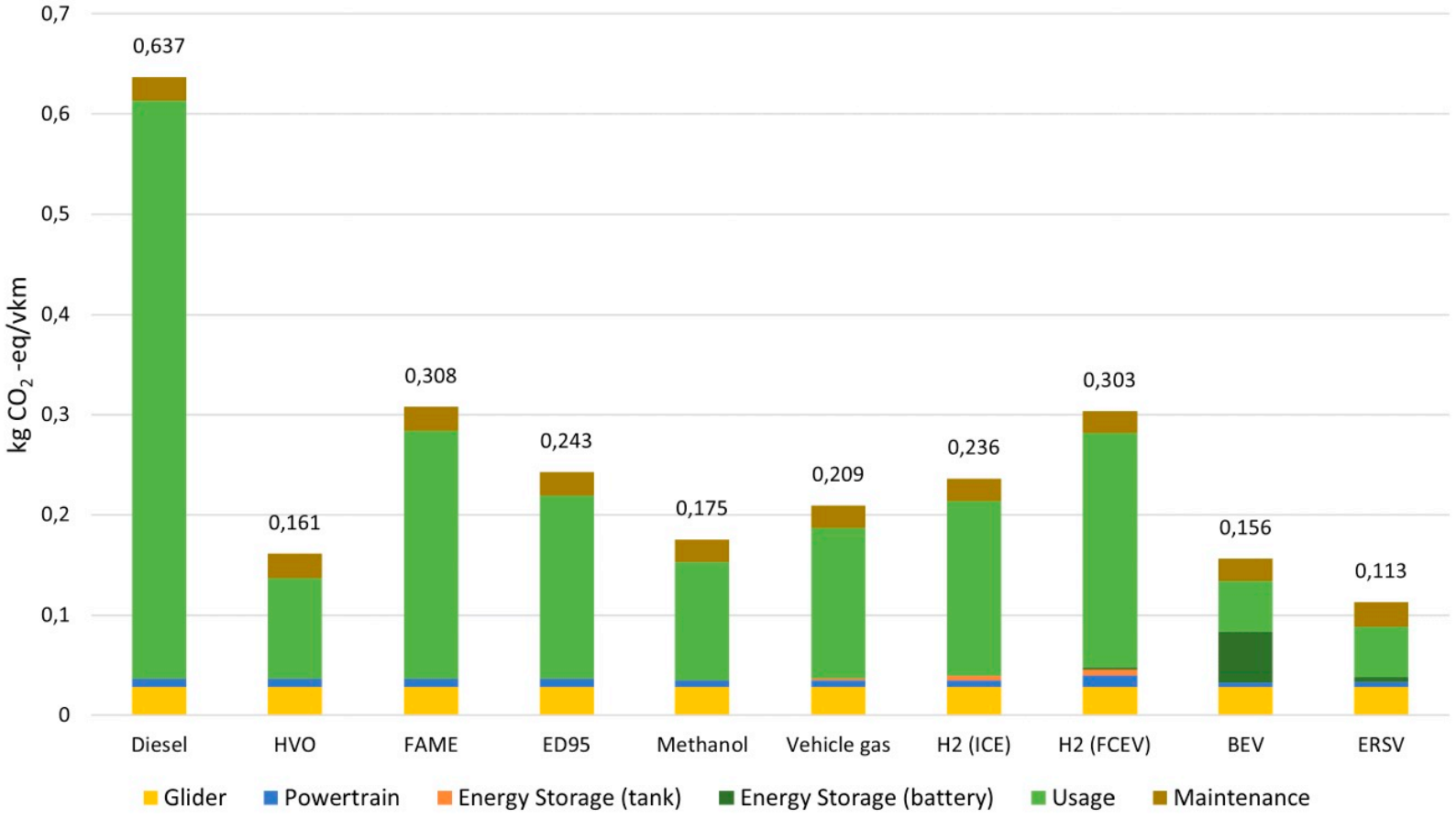
The potential of PHEVs

A number of interesting features

- With gasoline, GHG emissions are comparable to those of a BEV
- Smaller batteries enable a limited supply of battery minerals to electrify a larger fleet
- Smaller batteries reduce the production GHG footprint compared to BEVs
- Large EDS enables a limited supply of renewable fuels to cover more of the demand for fuel

Distributionslastbil



What we need to meet the climate targets

1. Drastic reduction of the grid GHG intensity
   - Needed to achieve meaningful GHG reduction with electrification

2. Increased production of sustainable, renewable fuels
   - Enables reduction below what is allowed by electrification alone, now and in the future

3. Transfer of transport work from the car fleet to less energy intense modes of transport
   - Public transport, bicycling, and walking enables reduction below the limits of technology

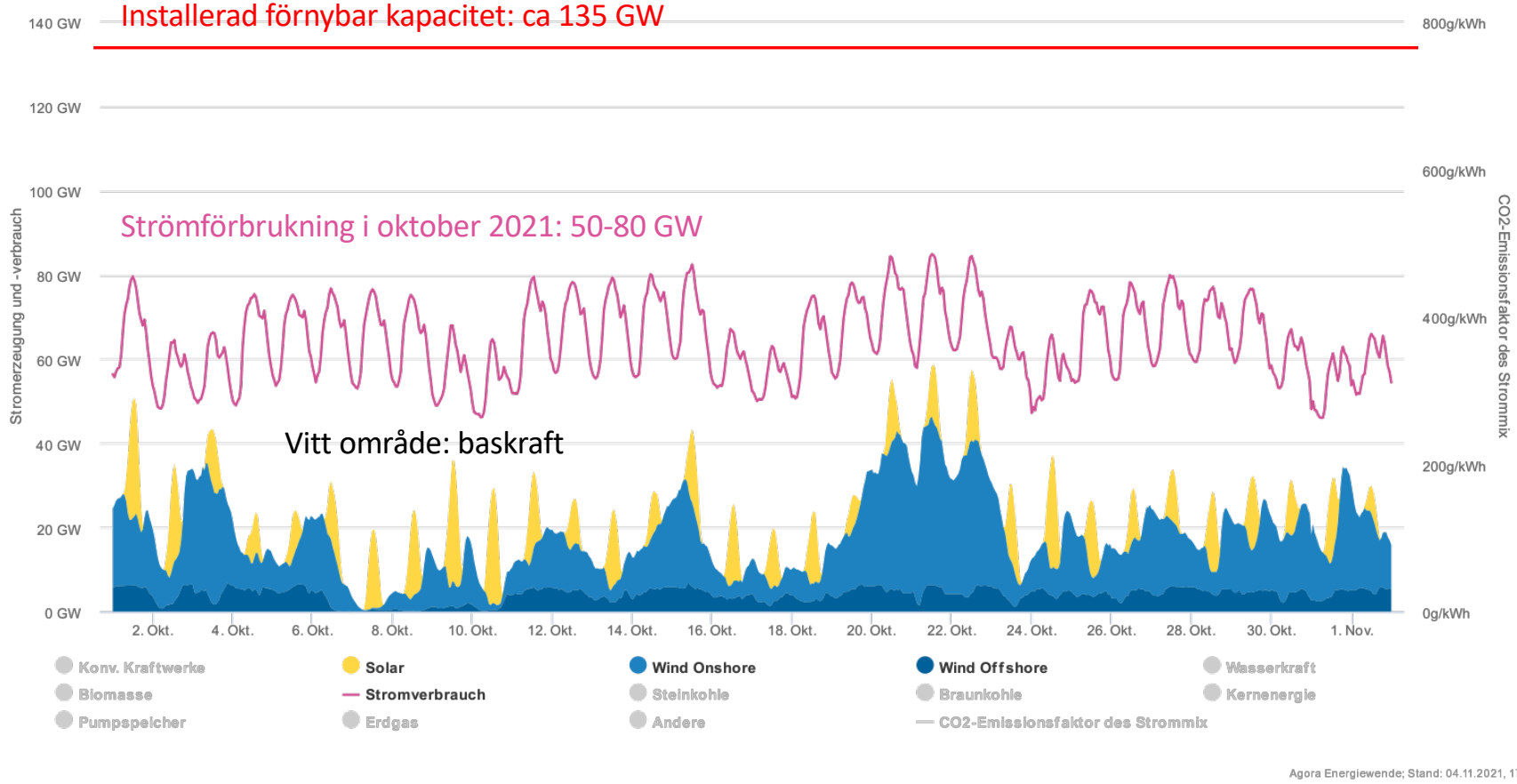
Conclusions

1) The zero emission vehicle definition leads to zero emissions only on paper
   - A technology-neutral, lifecycle-based certification method is needed

2) Electrification is unlikely to reduce fleet GHG emissions by 90% until 2050
   - Renewable fuels increase the potential to reach the climate goals of the car fleet
   - By favoring electrification over renewable fuels, current policy instruments reduce the potential to reach this goal

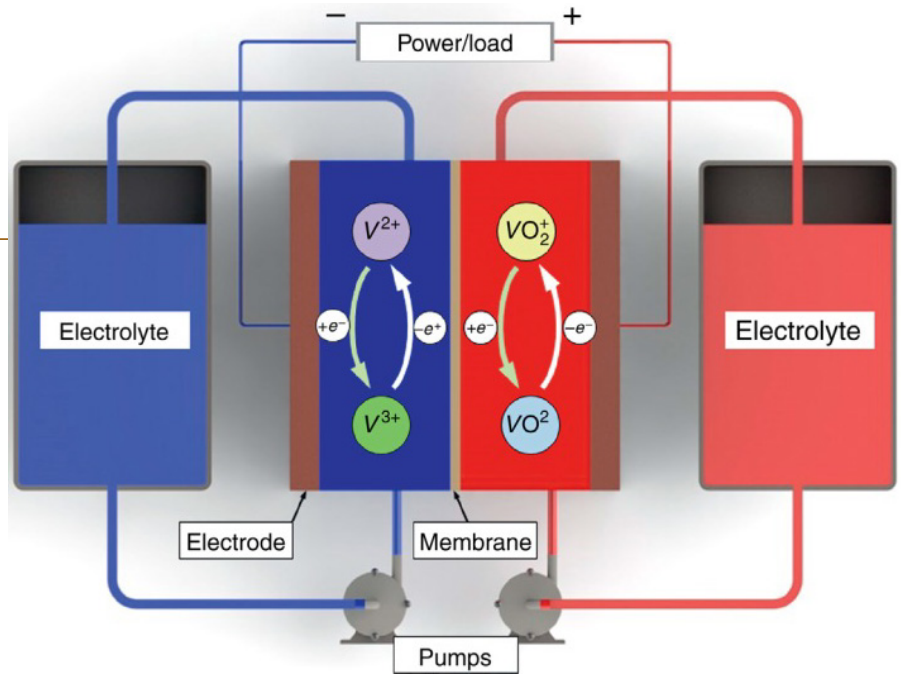
3) PHEVs, rather than being viewed as transitional, could be seen as an enabling technology for meeting more ambitious climate goals

Varför lagra el?



Flödesbatterier

- Elektrolyten hålls i två separata tankar
  - Skiljs åt av ett membran varigenom jonutbyte sker
    - » Kan drivas åt båda håll
- Ingen självurladdning alls
  - Lätt att skala upp, bara bygga större tankar för mer lagring
  - Större membran för ökad effekt
- Lång livslängd
  - > 20 000 cykler
- Låg energidensitet
- 800 MWh batteri byggs i Kina
  - Driver Sverige i fyra minuter



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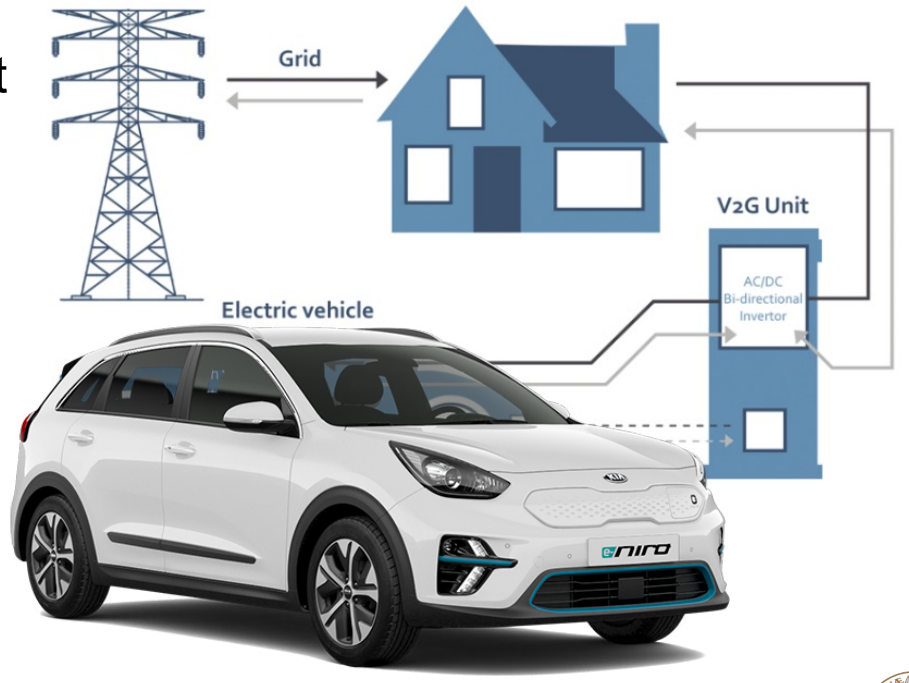
Smart grid?

Om vi byter ut alla bilar mot elbilar finns potential att använda dem som balanskraft när de är inkopplade



Exempel:

- Kia e-Niro
  - 64 kWh Li-jonbatteri
- 5 miljoner bilar i Sverige
  - 0,32 TWh kapacitet
- Driver Sverige i 21 timmar!

Inte ens i denna enorma skala är batterier lämpliga för säsongslagring av el. Dock fungerar de utmärkt för frekvensreglering och korttidslagring.

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Vätgas som reservkraft?

Avicii Arena (f.d. Globen):

- Höjd 110,4 m
- Volym 605 000 m^3

Fyll den med flytande H_2:

- Driver Sverige 2 dygn*

* Bränslecell med 50% verkningsgrad

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