INSTITUT FÜR ENERGIE- UND UMWELTFORSCHUNG HEIDELBERG

Carbon footprint of alternatively fuelled cars

ERMES plenary 2021

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Several technologies to decarbonise passenger cars exists…

Electric cars…

- Growing number of car models and charging stations
- Direct usage of the (German) electricity mix
- High carbon footprint of the traction battery
- Further decarbonisation of the traction energy and traction battery

Fuel cell cars…

- Higher range but less common technology and low amount of hydrogen refuelling stations
- High carbon footprint of the fuel cell systems and the hydrogen tank
- „Green“ hydrogen offers a storable fuel with a low carbon footprint

Conventional cars using e-fuels…

- Established car technology
- E-fuels (PtX) offer storable fuels with low carbon footprints – but only if additional renewable electricity is used
- Very limited PtX availabilty today and in the near future

Carbon footprint methodology

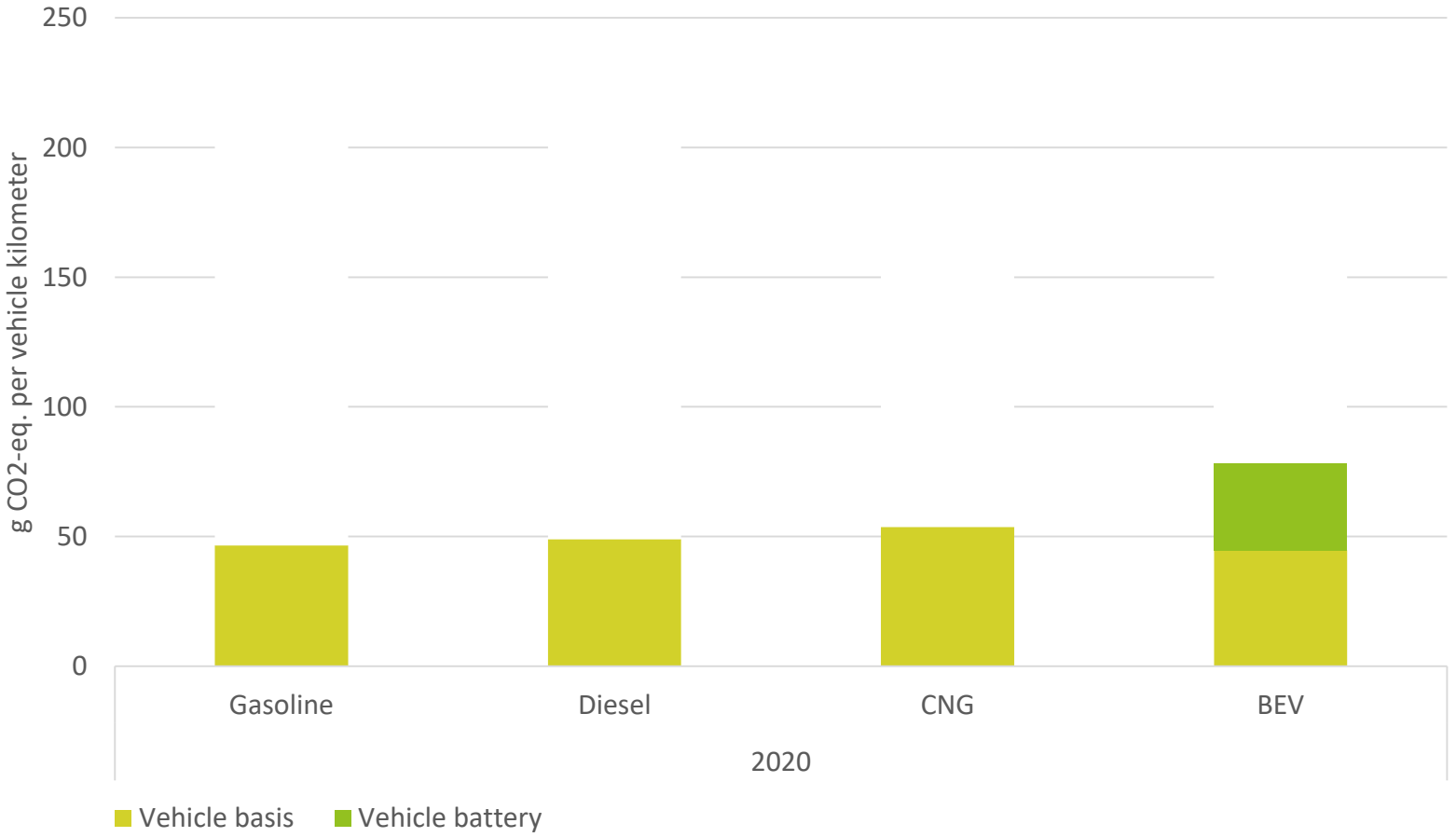
Quelle: „Umweltfreundlich mobil!“ 2020

Carbon footprint methodology

- Generic vehicles with similar configuration (e.g. weight, power,..)
- Mixed average consumption based on generic medium-sized car
  - BEV: 17,3 kWh/100 km (incl. charging losses)
  - ICE: 6,1 l gasoline/100 km or 4,8 l diesel/100 km
  - CNG: 4,2 kg CNG/100km
- Specifications of the traction battery (for BEV)
  - 48 kWh Li-Ion Battery (no replacement needed)
  - NMC Cell with 120 Wh/kg (energy density at system level)
  - Cell manufacturing as a mix of current production countries (CN, JP, KR, US)

Source: „Wie klimafreundlich sind Elektroautos?“ (ifeu 2020)

Carbon footprint of medium-sized cars in Germany



- Higher carbon footprint of vehicle and battery manufacturing for electric car

Source: „Wie klimafreundlich sind Elektroautos?“ (ifeu 2020)

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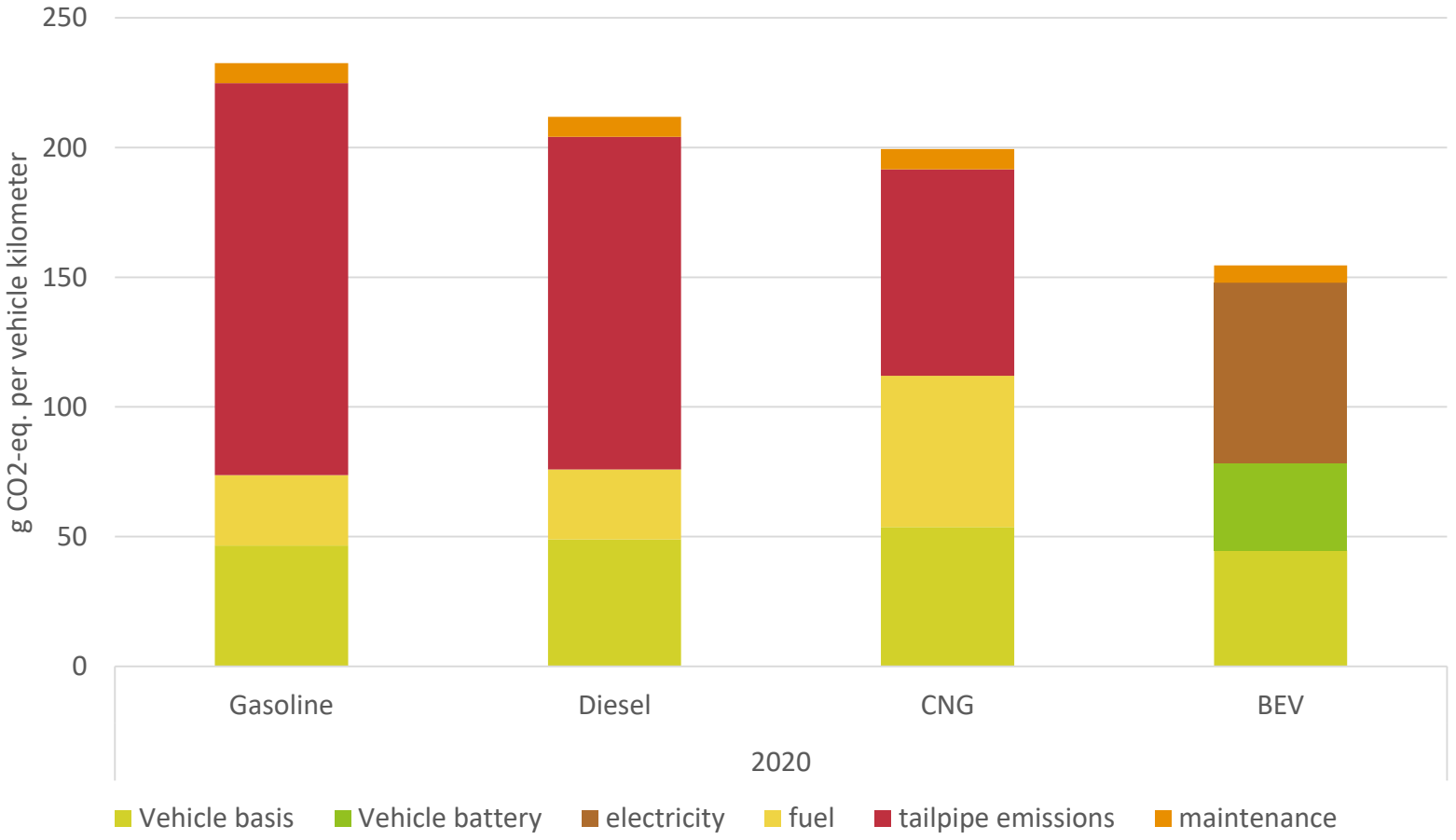

- Higher carbon footprint of vehicle and battery manufacturing for electric car
- No tailpipe emissions for electric cars but electricity provison included

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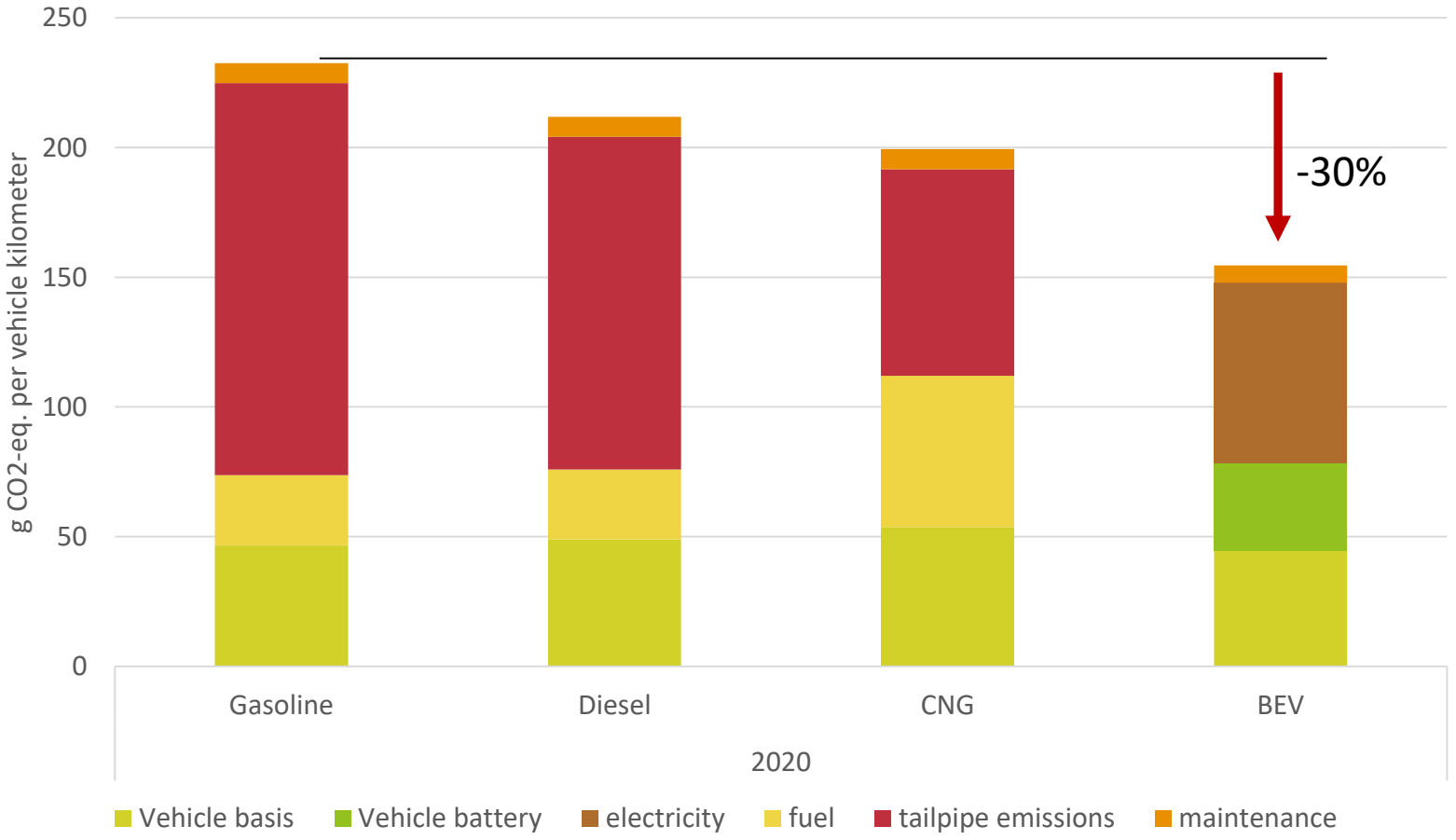


- Higher carbon footprint of vehicle and battery manufacturing for electric car
- No tailpipe emissions for electric cars but electricity provison included
- 30% GHG reductions over the car lifetime using the German electricity mix (402 g CO2eq/ kWh)

Source: „Wie klimafreundlich sind Elektroautos?“ (ifeu 2020)

Carbon footprint of medium-sized cars in Germany 2030

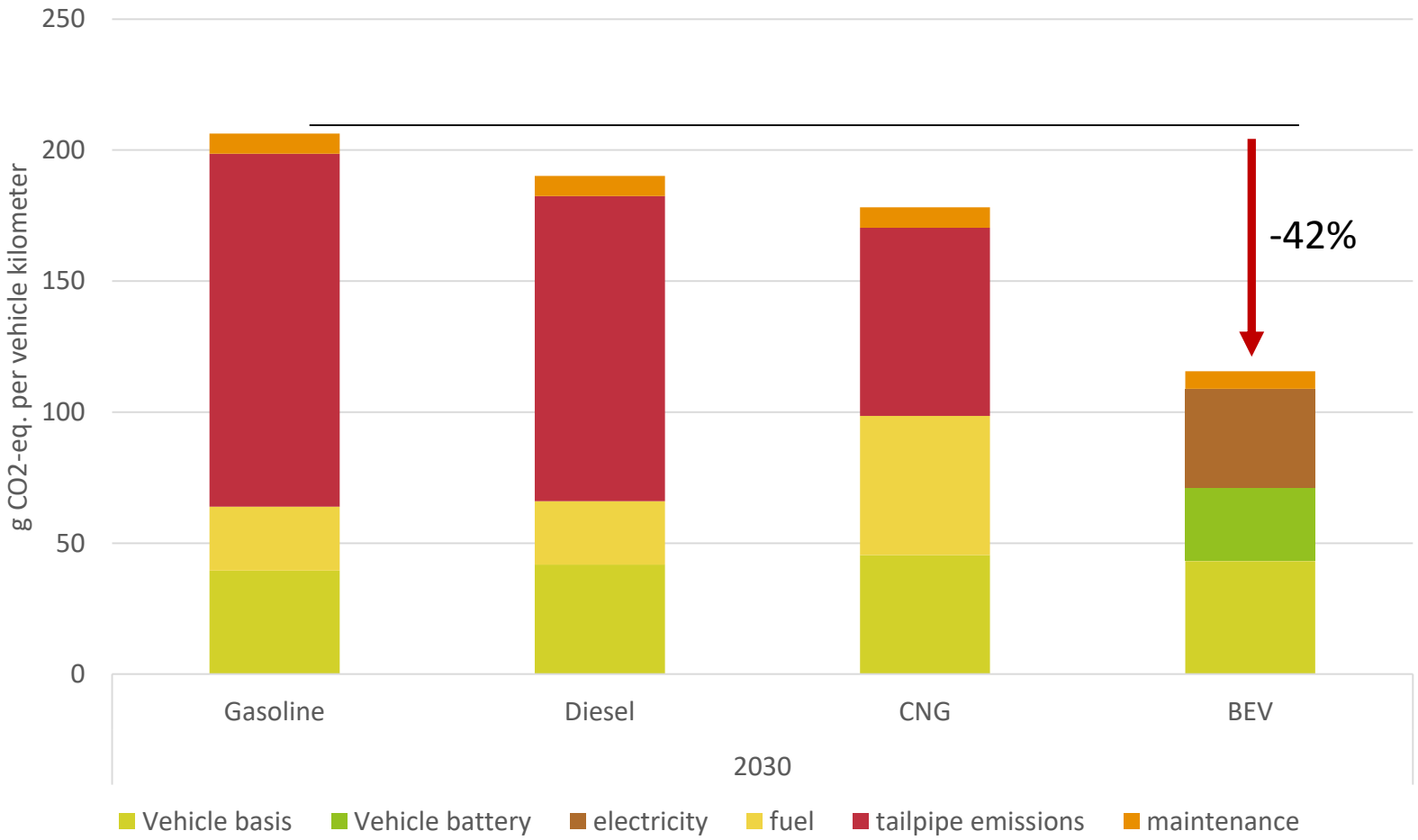
Further decarbonisation of the electricity mix

- More renewable energy is key!

Dynamic developement in battery technologies

- Less energy- intensive cell manufacturing in countries with higher shares of renewables
- New cell technologies (e.g. cobalt reduction for NMC)
- Higher energy densities
- Stabilisation of car ranges at 350 km (real driving range for medium-sized cars)
  - 60 kWh battery capacity in 2030

Carbon footprint of medium-sized cars in Germany 2030



Source: „Wie klimafreundlich sind Elektroautos?“ (ifeu 2020)

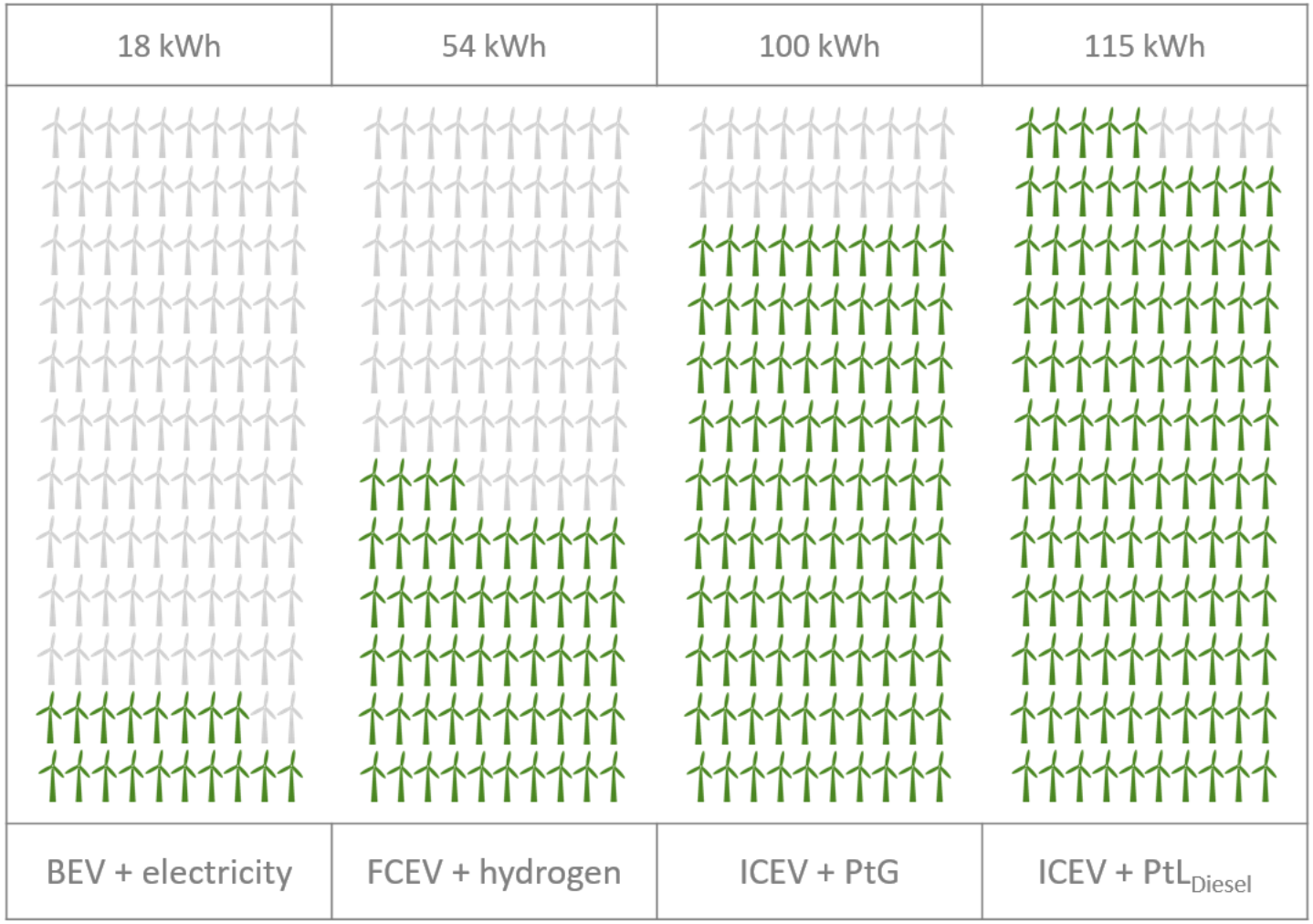
Conclusions - Carbon footprint of medium-sized cars

- Carbon footprint still dominated by the use phase
  - Decarbonisation of the electricity mix is key!
- High lifetime mileage is beneficial (especially for electric cars because of the additional impacts from battery manufacturing)
- Battery size should be as small as possible while still being acceptable for users
- Battery market is highly dynamic and improvements are being made

→ Battery-electric cars are the least energy-intensive way to use renewable electricity

Carbon footprint of different e-fuels (in Germany)

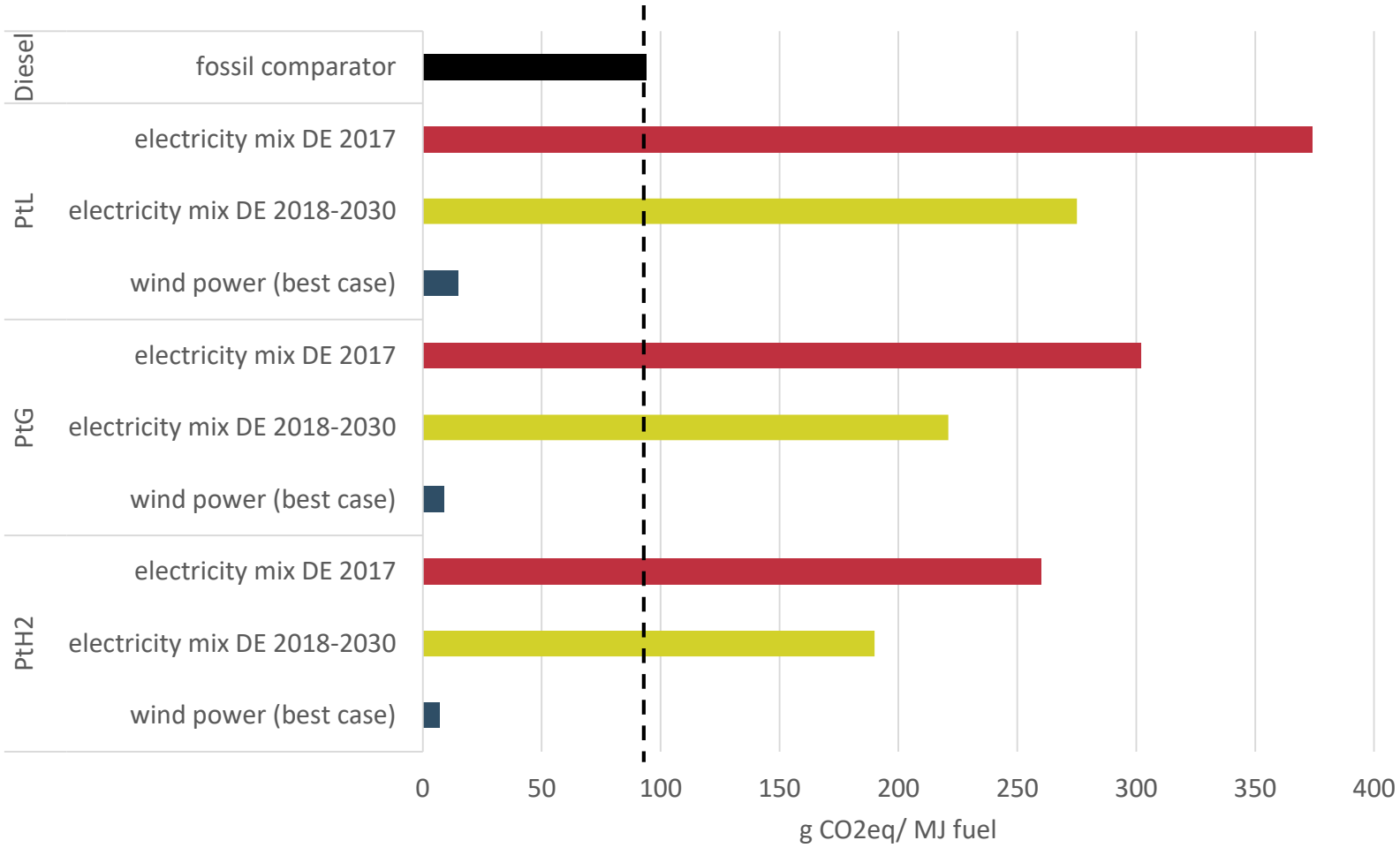
How much electricity is needed to power a medium-sized car for 100 km?



Direct usage of electricity needs 3 to 5 times less energy!

Source: Wie klimafreundlich sind Elektroautos? (ifeu 2020)

Carbon footprint of different e-fuels (in Germany)



- Hydrogen supply from electricity mix with no climate benefits today
- PtL and PtG perform a lot worse when using the German electricity mix than even the conventional variants!
- Open question: Where should the (additional) renewable electricty for Germanys e-fuels come from?

Source: Klimabilanz von strombasierten Antrieben und Kraftstoffen (ifeu 2019)

Conclusions on carbon footprint of e-fuels

E-fuels are only as green as the electricity used to produce them!

- Current e-fuels using the (German) electricity mix are MORE carbon intensive than fossil fuels
- E-fuels are only feasible when using renewable electricity

E-fuels will probably be imported from regions with higher renewable electricity potentials (e.g. MENA or Patagonia)

- „Fair share“ of renewable energy from those regions may be an issue

→ e-fuels will be needed to decarbonize air, water transport and long-distance street transport (where no other concepts are feasible) but for cars electric mobility might be the better solution