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# Real-world usage of plug-in hybrid electric vehicles

Fuel consumption, electric driving, and CO<sub>2</sub> emissions

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Online presentation, 28 September 2020

# Plug-in hybrid electric vehicles (PHEVs) use electricity as well as conventional fuel for driving.

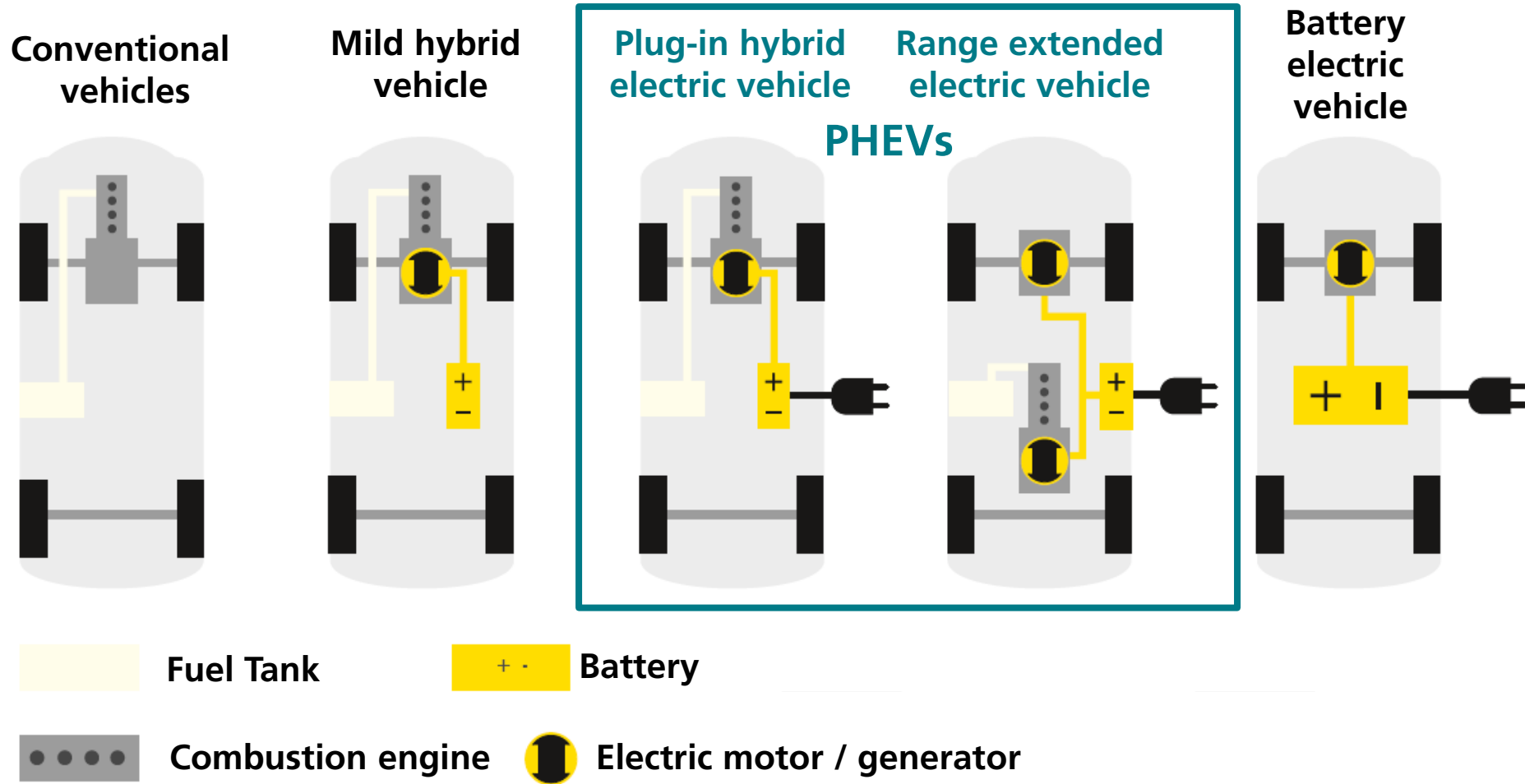


Figure source: e-mobil BW

# PHEVs are one third of the global electric vehicle fleet and contribute to CO<sub>2</sub> reduction targets worldwide.

- More than 2 million PHEV in stock globally
- One third of global electric vehicle stock are PHEV
- Sales shares 1<sup>st</sup> half 2020:
  - 3.5 % in Europe and growing
  - 1.1 % in China
- Most PHEV help manufacturers to reach CO<sub>2</sub> reduction sales targets

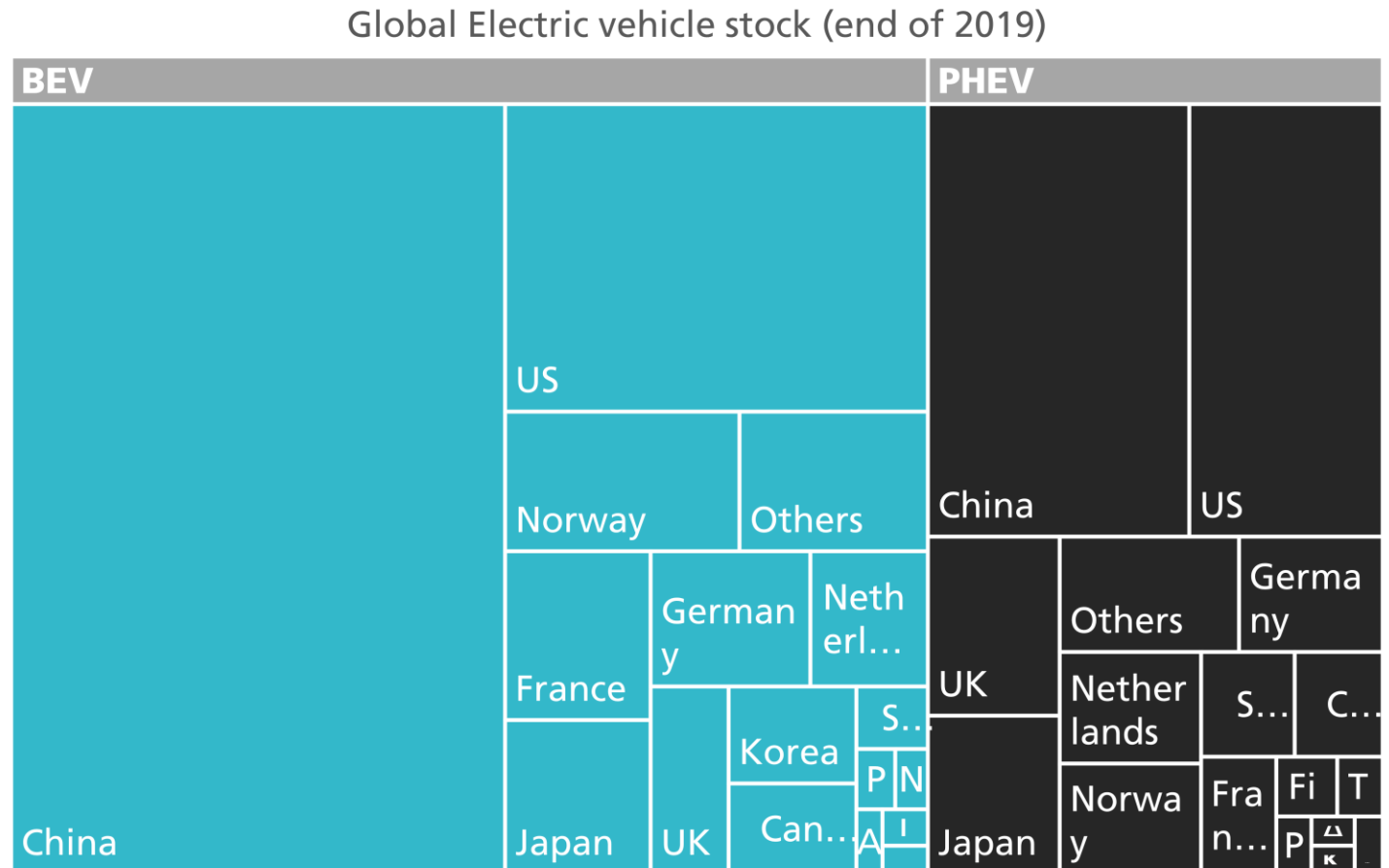


Figure based on IEA (2020): Global EV outlook 2020.

# Aim of the study: Empirical overview of real-world PHEVs usage and CO<sub>2</sub> emissions.

## Background

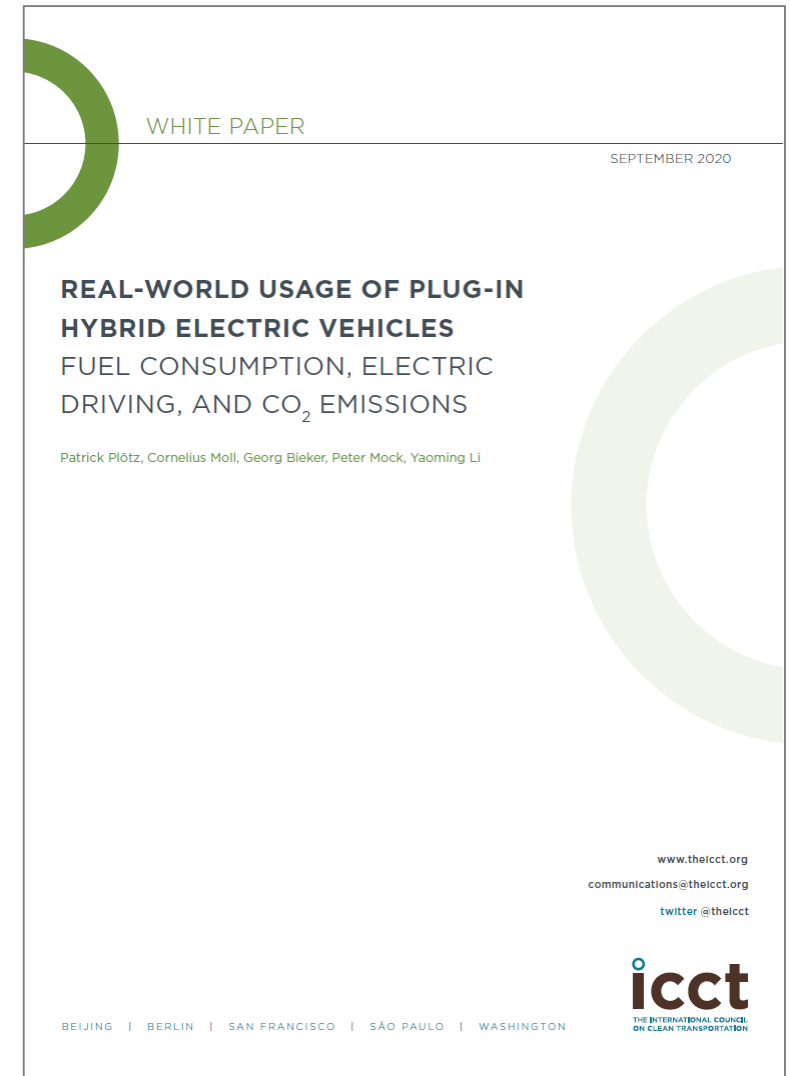
- Potential to reduce local and global emissions depends on real-world usage and real-world utility factor (UF)
- No systematic investigation of PHEV usage compared to test cycles

## Aim of the present study

- Better understanding of real-world usage, electric driving and CO<sub>2</sub> emissions of PHEVs in China, Europe, and North America.
- Focus on Germany, the largest PHEV market in Europe.
- Identify policy recommendations

## Presentation of full study today!

- Full study: <https://theicct.org/publications/phev-real-world-usage-sept2020>
- English and German summaries here: <https://s.fhg.de/plug-in-hybrid>



# The data base covers usage of more than 100'000 PHEVs globally from primary and secondary sources.

## Data base

- Primary sources: online fuel consumption tools (e.g. Spritmonitor.de)
- Secondary sources: published reports and scientific studies
- Comparison to simulation of PHEV from trip data of conventional vehicles
- Robustness of results: consistent findings across sources
- Meta-analysis of new and existing data

## Available Information and sample

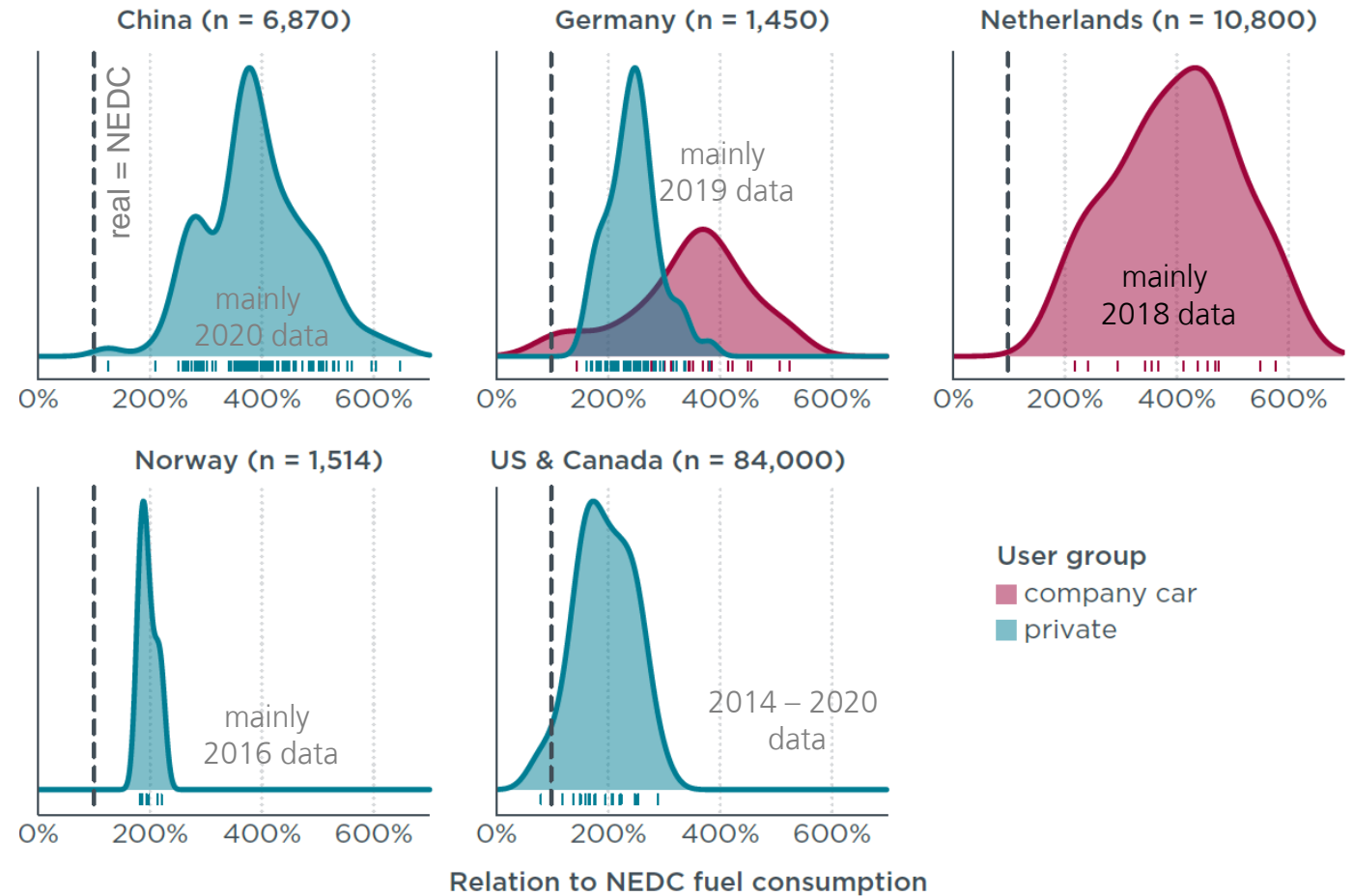
- Fuel consumption, annual vehicle kilometers traveled, UF
- Several countries; private and company cars
- 66 PHEV models and 202 PHEV model variants covered

## ➤ Sufficient & broad sample for all countries & user groups

User group	Country	Sample
Private	China	6'870
Private	Germany	1'385
Private	Norway	1'514
Private	US	84'068
Company car	Germany	72
Company car	Netherlands	10'800
<b>TOTAL</b>		<b>104'709</b>

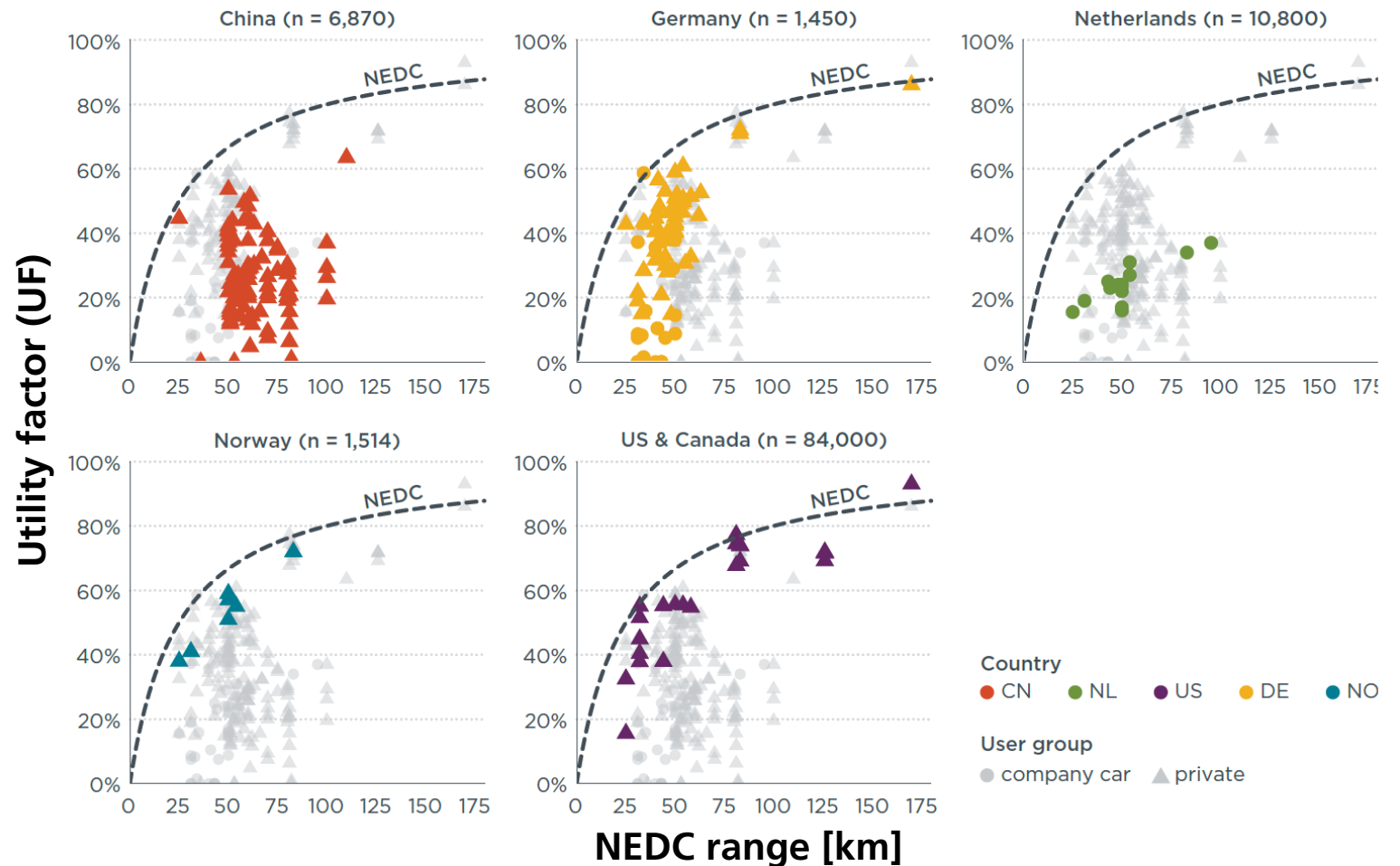
# PHEV fuel consumption and tail-pipe CO<sub>2</sub> emissions are two to four times higher than type-approval values.

- Deviation from type-approval values spans much larger ranges than for conventional vehicles
- Mean relation of **real-world fuel consumption** to type-approval values:
  - **2 – 3 times higher for private cars**
  - **3 – 4 times higher for company cars**
- Similar deviation for WLTP vehicles
- Most recent data for Germany & China
- US data mainly Volt, Prius, BMW i3



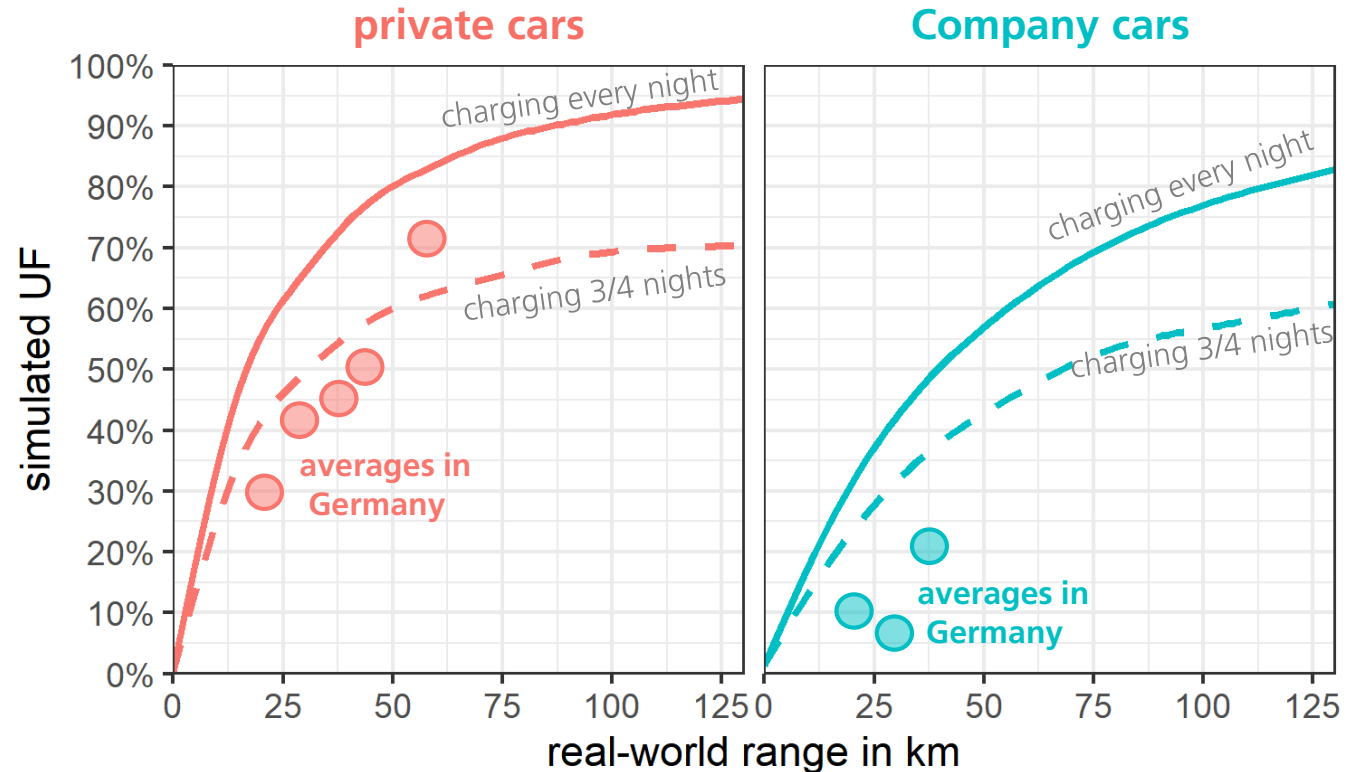
# Real-world share of electric driving of PHEVs is about half the share considered in type-approval.

- **Utility factor (UF):** portion of kilometers driven on electricity
- **Private cars:**
  - Mean UF in NEDC is 69%
  - Real-world mean UF is 37%
  - Only about half the expected
- **Company cars:** 63 % in NEDC but only 20% in real-world
- Similar deviations for WLTP
- Noteworthy country differences
- UF increases by 2 – 6 percentage points with every 10 km of range



# PHEVs are not charged every driving day.

- **Private users** in Germany **charge** their PHEVs on average on **three out of four driving days**
- **Company cars charge only about every second driving day**
  - economic disincentives for company cars
  - more long-distance trips
- **The average charging among all user groups is less than once per day**
- Low charging frequency reduces the share of kilometers driven on electricity
- Very low UF in China indicates low charging
- PHEVs in Norway and the United States appear to be charged more often





# PHEVs show high annual mileage and many long-distance trips.

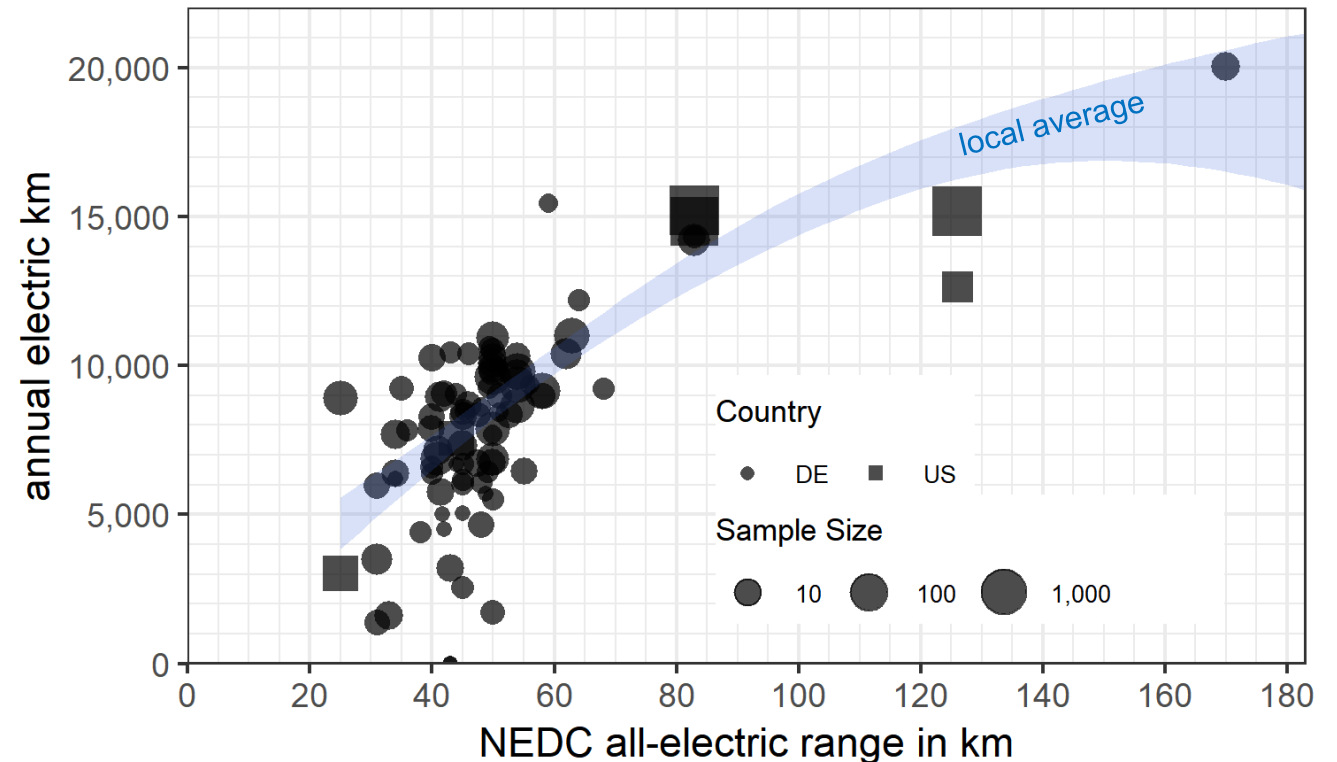
- **Germany: average annual mileage of PHEVs is significantly higher than** the car stock **average** (21'000 km for PHEV vs. 14'000 km in car stock)
- **US: annual mileage of PHEVs is similar to national car average** (21'700 km)
- Higher mileage means more long-distance trips
- Due to the limited all-electric range of PHEVs, this reduces the share of kilometers driven on electricity
- Long-distance driving >100 km only **5 – 10% of days** per year, but **25 – 30% of annual km** for private vehicles (and higher for company cars)
- **Even daily charging does not imply 100% electric driving**

Country	User group	Mean annual km
Germany	Private	21'000
Germany	Company car	30'000
US	Private	22'000

German Mobility Panel Data	private (N = 5'812)	company cars (N = 212)
share of days	7 %	24 %
share of driving days	9 %	28 %
share of annual mileage	19 %	47 %

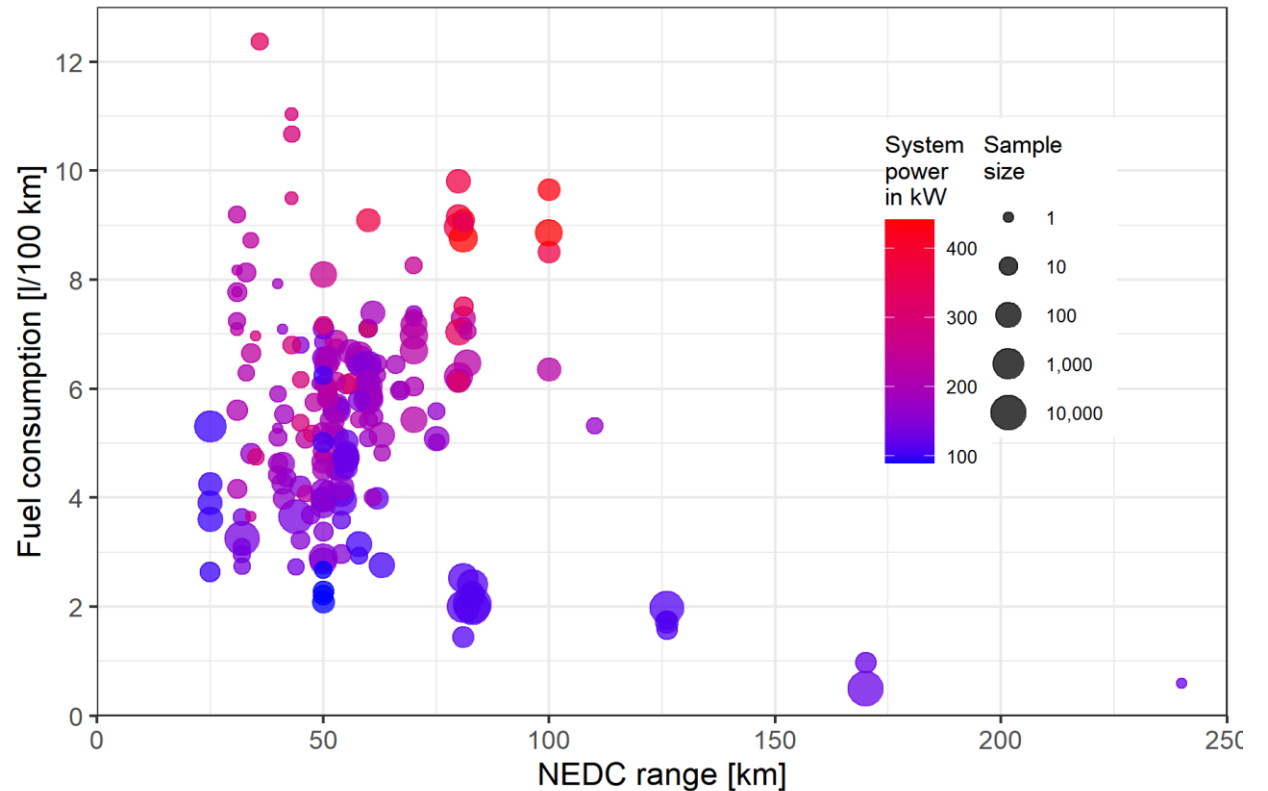
# PHEVs electrify many kilometers per year.

- **Most PHEVs** have ranges of 30 – 60 km (NEDC) and **electrify 5,000–10,000 km/year**
- Annual electric distance increases with range
- **PHEVs with high electric ranges  $\geq 80$  km achieve 12,000–20,000 km mean annual electric mileages** (comparable to mean annual driving of conventional vehicles)
- **Electric driving implies 15%–55% less tailpipe CO<sub>2</sub> emissions compared to conventional cars**
  - If fuel consumption of PHEVs at empty battery is similar to fuel consumption of conventional cars
  - Much lower CO<sub>2</sub> savings than expected from type-approval values



# Decrease engine power and increase range to improve real-world fuel consumption & CO<sub>2</sub> emissions of PHEVs.

- **Real-world fuel consumption and CO<sub>2</sub> emission**
  - -8% to -14% with each 10 km of all-electric range (NEDC) increase
  - +2% to +4% with each 10 kW of system power increase
- **Mean share of electric driving (UF)**
  - +3 to +5 percentage points with each 10 km of all-electric range increase
  - -1 to -3 percentage points with each 10 kW of system power increase
- Vehicle properties impact real-world fuel consumption and CO<sub>2</sub> emissions



# Summary: Analysis of 100,000 PHEVs confirms high deviation from official fuel efficiency and CO<sub>2</sub> values.

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## Background and study

- Plug-in hybrid electric vehicles (PHEVs) use electricity as well as conventional fuel for driving.
- They offer environmental benefits if they are mainly driven on electricity.
- The present study is the first large international and systematic study of real-world usage of PHEVs.

## Findings

- PHEV **fuel consumption & tail-pipe CO<sub>2</sub> emissions are two to four times higher than type-approval.**
- Real-world **share of electric driving** of PHEVs **is about half the share in type-approval** values.
- PHEVs are **not charged every day.**
- PHEVs show **high annual mileage and many long-distance trips.**
- PHEVs **electrify many kilometers** per year.
- **Decrease engine power and increase range** to improve real-world fuel consumption & CO<sub>2</sub> emissions of PHEVs.

# Thank you.



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The cover of a white paper titled "REAL-WORLD USAGE OF PLUG-IN HYBRID ELECTRIC VEHICLES: FUEL CONSUMPTION, ELECTRIC DRIVING, AND CO<sub>2</sub> EMISSIONS". The cover features a green circular graphic on the left and a light green circular graphic on the right. The text is in a clean, sans-serif font. At the bottom, it lists the authors and provides contact information for the International Council on Clean Transportation (icct).

WHITE PAPER

SEPTEMBER 2020

**REAL-WORLD USAGE OF PLUG-IN  
HYBRID ELECTRIC VEHICLES**  
FUEL CONSUMPTION, ELECTRIC  
DRIVING, AND CO<sub>2</sub> EMISSIONS

Patrick Plötz, Cornelius Moll, Georg Bieker, Peter Mock, Yaoming Li

Full study available online:  
<https://theicct.org/publications/phev-real-world-usage-sept2020>

English and German summaries:  
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