FACT SHEET EUROPE

SEPTEMBER 2020

REAL-WORLD USAGE OF PLUG-IN HYBRID ELECTRIC VEHICLES

BACKGROUND

Plug-in hybrid electric vehicles (PHEVs) combine an electric and a conventional combustion engine drivetrain. In the first half of 2020, they accounted for about 3.5% of all new passenger car registrations in Europe, 1.1% in China and 0.3% in the United States. As of 2019, PHEVs accounted for more than two million vehicles globally and their total fleet is expected to grow further over the next decade.

The potential of PHEVs to reduce local pollutant and global greenhouse gas emissions strongly depends on their real-world fuel consumption and the share of kilometers driven on electricity, referred to as the utility factor (UF). While official PHEV fuel consumption values are assessed in standardized testing procedures, or test cycles, such as the New European Driving Cycle (NEDC) or the Worldwide Harmonized Light-Duty Vehicles Test Procedure (WLTP), little is publicly known how these test cycle values relate to the fuel consumption, electric drive share and thus CO_2 emissions in their real-world usage.

This study provides a better understanding of the real-world usage of PHEVs in China, Europe, and North America, with a focus on Germany, the largest PHEV market in Europe.

METHODOLOGY

The study uses data on the real-world usage of PHEVs, such as real-world fuel consumption, annual vehicle kilometers traveled (VKT), and the UF. This data covers several countries and includes data from private and company cars (Table 1). In total, we collected data from primary and secondary sources of more than 100,000 PHEVs. Although the sample is dominated by North American vehicles, the sample sizes for individual countries are still sufficiently large to discern general patterns and draw conclusions. While most of the vehicles in the sample are private, a substantial number of more than 10,000 PHEVs are company cars, allowing significant analyses for this user group. In total, the data includes 66 models, among which 202 model variants can be differentiated.

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Table 1. Overview of PHEV Sample

User group	Country	Sample
Private	China	6,870
Private	Germany	1,385
Private	Norway	1,514
Private	US & Canada	84,068
Company car	Germany	72
Company car	Netherlands	10,800
TOTAL		**104,709**

KEY FINDINGS

PHEV fuel consumption and tail-pipe CO_2 emissions during real-world driving, on average, are approximately two to four times higher than type-approval values. The deviation from NEDC type-approval values spans much larger ranges than for conventional vehicles. Real-world values are two to four times higher for private cars and three to four times higher for company cars (Figure 1). Making use of the limited dataset of PHEVs that are type-approved to the newly introduced WLTP, the deviation found is about the same as for PHEVs type-approved to the NEDC.

The real-world share of electric driving for PHEVs, on average, is about half the share considered in the type-approval values. For private cars, the average UF is 69% for NEDC type approval but only around 37% for real-world driving. For company cars, an average UF of 63% for NEDC and approx. 20% for real-world driving was found. There are noteworthy differences between the markets, with the highest real-world UF found for Norway at 53% for private vehicles and the United States at 54% for private vehicles. The lowest UFs were for China at 26% for private vehicles, Germany with 18% for company cars and 43% for private vehicles, and the Netherlands with 24% for company cars (Figure 2).

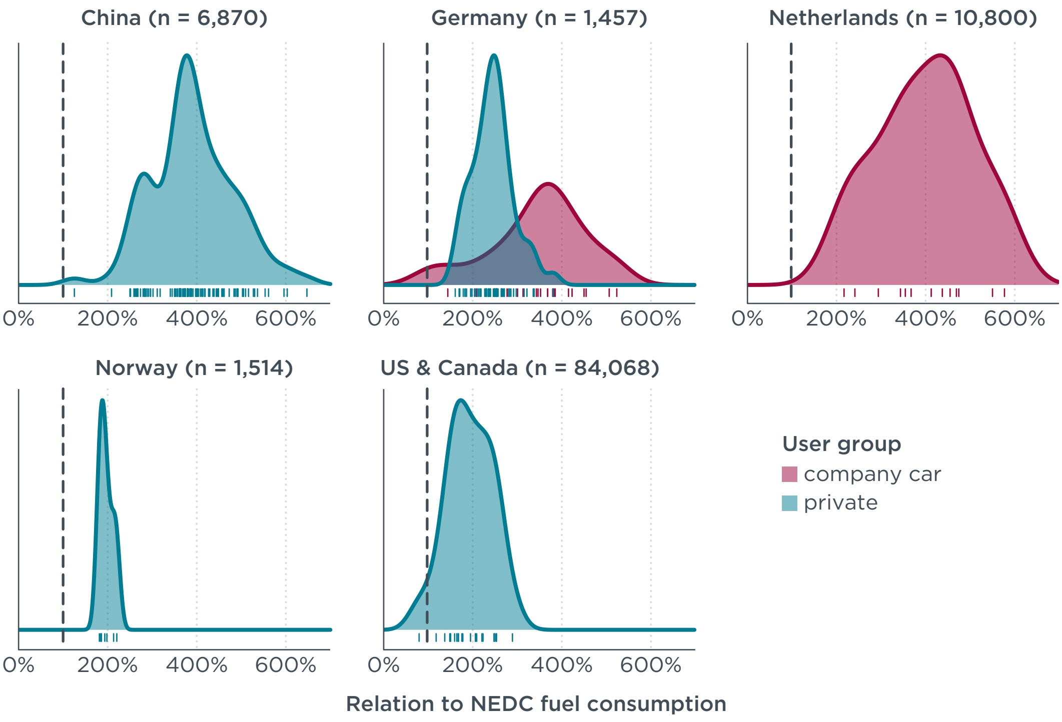

Figure 1. Distribution of real-world fuel consumption in relation to NEDC test cycle. Shown is the distribution by country. The vertical dashed line at 100% corresponds to real = test cycle. Private users in blue and company car users in red. Small rugs next to the x-axis indicate individual observations at PHEV model variant level.

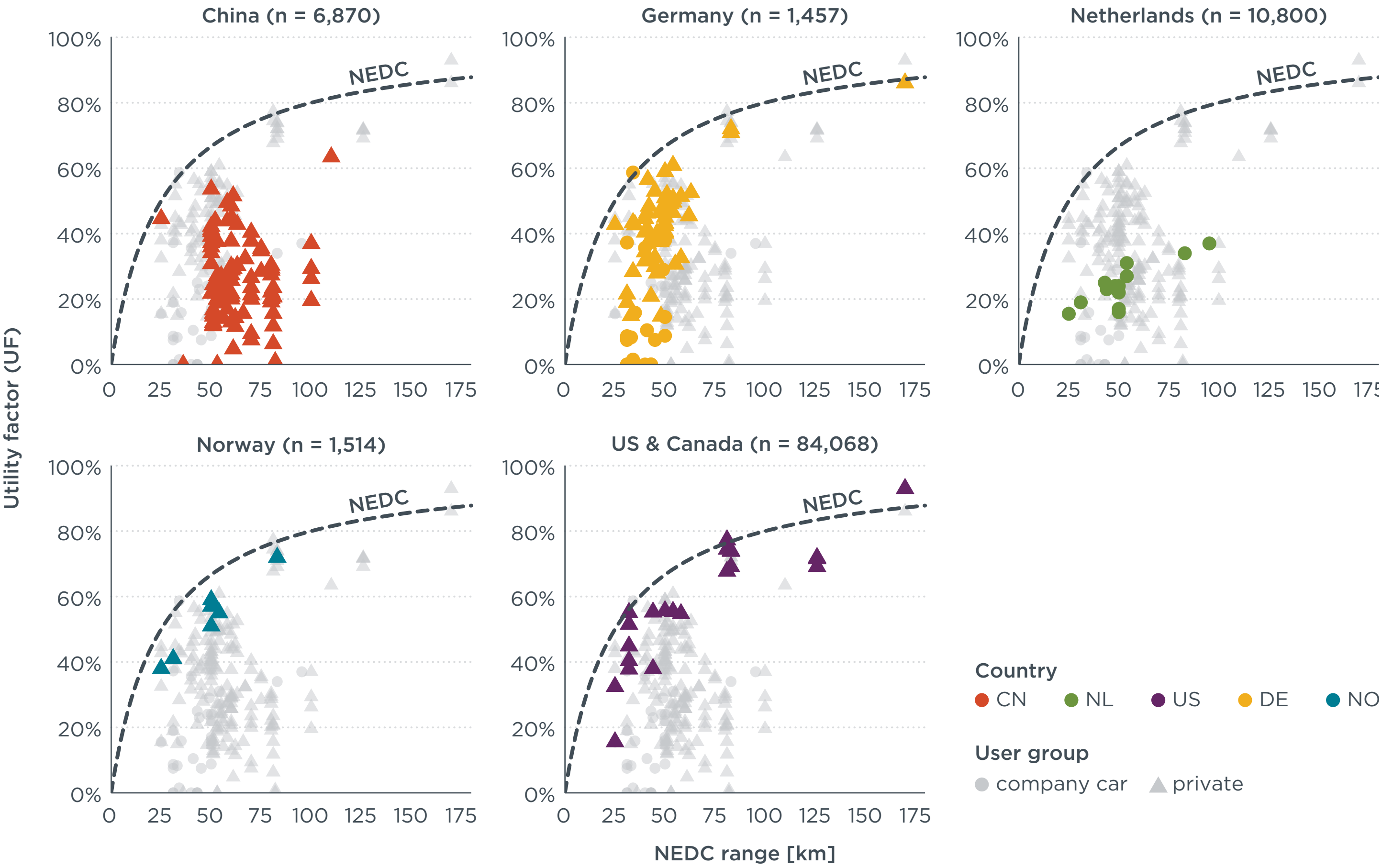

Figure 2. Utility factor of PHEVs with different all-electric range by country. The average specific utility factors (UFs) of individual PHEV model-variants are shown as observed in our sample for private vehicles (triangles) and company cars (circles) with the NEDC UF (dashed). The grey dots are the full sample and each plot shows data from one country by color.

PHEVs are not charged every day. Private users in Germany charge their PHEVs an average of three out of four driving days. For company cars, charging takes place only about every second driving day. The low charging frequency clearly reduces the share of kilometers driven on electricity. The very low UF for PHEVs in China also indicates low charging frequency, whereas PHEVs in Norway and the United States appear to be charged more often than in Germany or China.

PHEVs electrify many kilometers per year. Most PHEVs have type-approval all-electric ranges of 30 km–60 km (NEDC) and electrify 5,000 km–10,000 km a year, increasing with range. PHEVs with high all-electric ranges of 80 km or more achieve 12,000 km–20,000 km mean annual electric mileages, which are values comparable to the mean total annual mileage of the car fleet in Germany and the United States. The high mean annual number of electric kilometers reflects high annual mileages of PHEVs despite low UFs.

RECOMMENDATIONS

At **the European Union level**, the CO_2 emission threshold for super credits should be lowered, or the qualification of a specific PHEV model should be demonstrated by using real-world usage data, for example collected from on-board fuel consumption meters. Similarly, the threshold for providing Zero- and Low Emission Vehicle (ZLEV) credits should be adapted to real-world data and the current multiplier of 0.7 should be removed to avoid any incentive for PHEVs with a low electric range. In parallel, the testing procedures for PHEVs, and in particular the UF assumptions of the WLTP, should be updated to better reflect real driving and usage patterns.

At **the national level**, fiscal and other incentives should prefer PHEVs with a high all-electric range and a high ratio of electric motor power to combustion engine power. Whenever possible, incentives should be tied to demonstrating the proper real-world performance of the vehicles, for example by using UF data collected from on-board fuel consumption meters or during regular technical inspections. Furthermore, the legal and financial barriers for the installation of home charging points should be reduced. Company-car PHEV incentives could be issued only to companies that provide a sufficient workplace charging infrastructure or support employees in home or public charging. The attractiveness of driving on conventional fuel should be reduced by lowering charging costs, raising fuel prices, or limiting tax deductibility of costs for conventional fuels for organizations.

Vehicle manufacturers should increase the all-electric range of their PHEVs from an average of about 50 km today to a level of about 90 km in future years. This would be sufficient to cover the full daily distance electrically on about 85% of driving days or approximately 70% of total distances driven by German private car owners if charged every day. Some PHEV models on the market today provide an all-electric range of this order and show mean UFs greater than 50%. Furthermore, manufacturers should limit the power of PHEV combustion engines.

Fleet managers should carefully assess which of their company car users' driving and usage behavior is appropriate for PHEVs. They should incentivize frequent charging of PHEVs, for example by allowing unlimited charging while limiting the budget for gasoline or diesel on a fuel card provided by the company.

PUBLICATION DETAILS

Title: Real-world usage of plug-in hybrid electric vehicles - Fuel consumption, electric driving, and CO_2 emissions

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Download: https://theicct.org/publications/phev-real-world-usage-sept2020

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