JULY 2021

A new life-cycle assessment of the greenhouse gas emissions of combustion engine and electric passenger cars in major markets

If the transportation sector is to align with efforts supporting the best chance of achieving the Paris Agreement's goal of limiting global warming to below 2 °C, the greenhouse gas (GHG) emissions from global road transport in 2050 need to be dramatically lower than today's levels. It is therefore important for policymakers to understand which powertrain and fuel technologies are most capable of shrinking the carbon footprint of cars—and not only the emissions from the tailpipes, but also from fuel and electricity production and vehicle manufacturing.

A new ICCT study is a life-cycle assessment (LCA) that compares the GHG emissions of current and future passenger cars in China, Europe, India, and the United States, four markets that are home to the majority of global new passenger car sales and reflect much of the variety in the global vehicle market. The study considers the most relevant powertrain types—internal combustion engine vehicles (ICEVs), including hybrid electric vehicles (HEVs); plug-in hybrid electric vehicles (PHEVs); battery electric vehicles (BEVs); and fuel cell electric vehicles (FCEVs)—and a variety of fuel types and power sources including gasoline, diesel, natural gas, biofuels, e-fuels, hydrogen, and electricity.

An important finding is that for each of the four regions, the same trends are observed. Results show:

» Only BEVs and FCEVs are capable of a deep decarbonization of passenger cars. As shown for average new medium-size cars in Figure 1, the **life-cycle emissions over the lifetime of BEVs registered today are lower** than comparable gasoline cars in all four regions, by 66%–69% in Europe, 60%–68% in the United States, 37%–45% in China, and 19%–34% in India. For medium-size cars projected to be registered in 2030, as **the electricity mix continues to decarbonize**, the life-cycle emissions gap between BEVs and gasoline vehicles increases to 74%–77% in Europe, 62%–76% the United States, 48%–64% in China, and 30%–56% in India. BEVs entirely powered by renewable energy correspond to **81% lower** life-cycle GHG emissions than gasoline cars.

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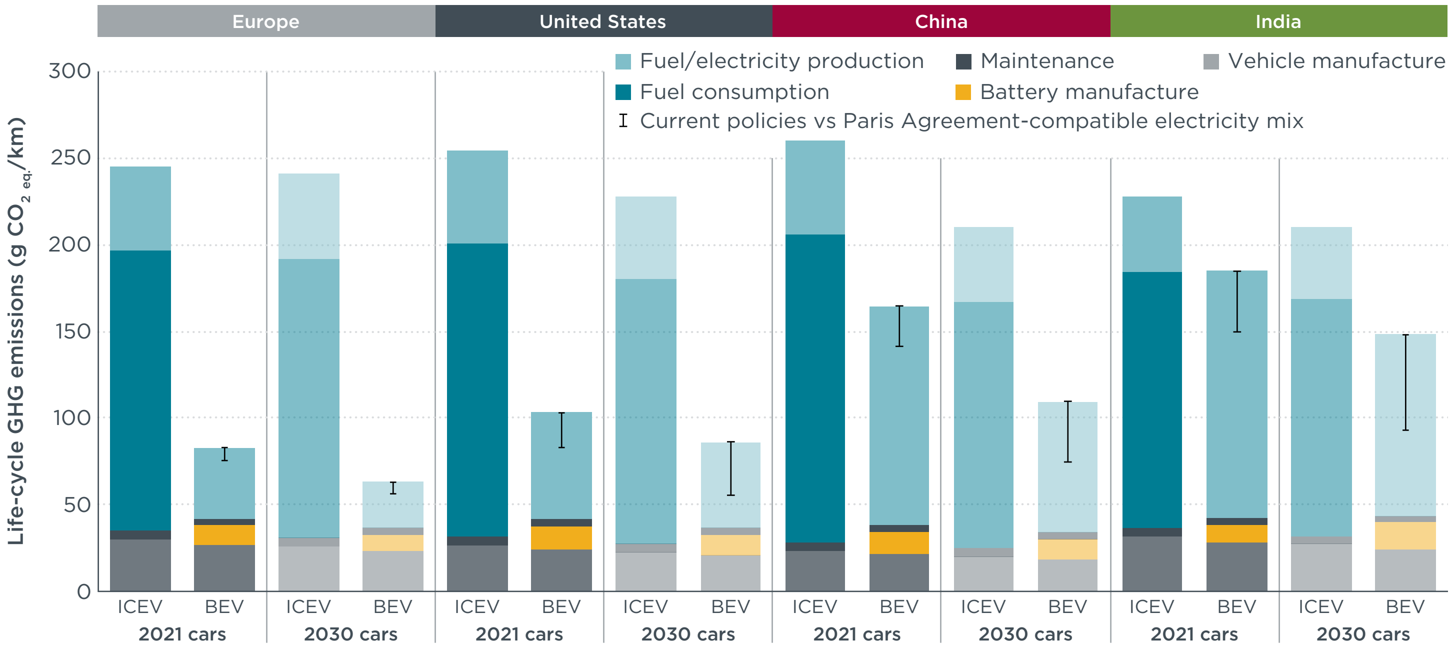

Figure 1. Life-cycle GHG emissions of average medium-size gasoline internal combustion engine (ICEVs) and battery electric vehicles (BEVs) registered in Europe, the United States, China, and India in 2021 and projected to be registered in 2030. The error bars indicate the difference between the development of the electricity mix according to stated policies (the higher values) and what is required to align with the Paris Agreement.

- Life-cycle emissions of **FCEVs** are **only about 26%–40% less** than for average new gasoline vehicles registered in 2021 in the respective regions, if they are powered by hydrogen produced through reforming methane from natural gas ("grey hydrogen"). Utilizing hydrogen produced from renewable electricity ("green hydrogen"), instead, would result in **76%–80% lower** life-cycle GHG emissions for FCEVs. Renewable energy powered FCEVs show slightly higher life-cycle emissions than BEVs powered by the same renewable electricity, though; this is because the electricity-based FCEV pathway is approximately **three times as energy intensive** as the BEV pathway, and as such, emissions from the construction of additional renewable electricity installations were taken into account.
- Average gasoline and diesel cars correspond to very similar, and relatively high, life-cycle GHG emissions levels. **HEVs** are found to reduce life-cycle GHG emissions **by only about 20%** compared to conventional gasoline cars. The GHG emissions of **compressed natural gas (CNG) cars can even exceed** those of gasoline and diesel cars.
- The life-cycle GHG emissions of medium-size **PHEVs** registered today are 42%–46% lower than gasoline cars in the United States, only 25%–27% lower in Europe, and 6%–12% lower in China.
- The impact of **future changes in the biofuel blends** driven by current policies range from a **negligible influence** to a reduction of the life-cycle GHG emissions of gasoline, diesel, or natural gas vehicles by a maximum of 9%. Due to a number of factors, including competing demand from other sectors and high cost of production, it is **not feasible to supply enough low-carbon biofuels** such as residues- and waste-based biodiesel, ethanol, or biomethane to substantially displace fossil fuels in combustion engine cars. The very high production cost of **e-fuels** means they are **not likely to contribute substantially to decarbonization** of the fuel mix within the lifetimes of 2021 or 2030 cars.

Flowing from the analysis, ICCT recommends considering the following policy action:

- » The **registration of new combustion engine vehicles** should be **phased out in the 2030–2035 time frame**. Given average vehicle lifetimes of 15–18 years, only those technologies that can achieve a deep decarbonization of the global car fleet by 2050 should be produced and registered by about 2030–2035. BEVs powered by renewable electricity and FCEVs fueled by green hydrogen are the only two technology pathways that qualify. Hybridization can be utilized to reduce the fuel consumption of new internal combustion engine vehicles registered over the next decade, but neither HEVs nor PHEVs provide the magnitude of reduction in GHG emissions needed in the long term.

PUBLICATION DETAILS

Title: *A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars*

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Download: https://theicct.org/publications/global-LCA-passenger-cars-Jul2021

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