HOW CLEAN ARE ELECTRIC CARS IN EUROPE TODAY?

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

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Life-cycle greenhouse gas emissions from passenger cars in the European Union: A 2025 update and key factors to consider

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Methodology and input data
- Key results
- Summary

- Policy considerations

Methodology and input data

Scope of work

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- Vehicles registered in 2025
- EU average medium-sized passenger car
- Gasoline, diesel, CNG ICEVs; HEVs; PHEVs; BEVs; FCEVs

Key input parameters

- Real-world fuel and electricity consumption
- Lifetime mileage (240,000 km over 20 years)
- Dynamic change of electricity and fuel mix during the vehicle lifetime

Key vehicle input parameters

Power train types	Selected medium segment passenger car	Real-world fuel/energy consumption	Battery capacity
Gasoline ICEVs	2023 EU registrations-weighted average	6.9 L / 100 km	-
Diesel ICEVs	2023 EU registrations-weighted average	5.8 L / 100 km	-
Natural gas ICEVs	2023 EU registrations-weighted average	4.7 kg / 100 km	-
Hybrid EVs (HEVs)	Toyota Corolla (dominantes HEV sales in medium segment in EU)	5.3 L / 100 km	-
Plug-in hybrid EVs (PHEVs)	2023 EU registrations-weighted average	3.8 L / 100 km; 11.8 kWh / 100 km	13.3 kWh
Fuel cell EVs	Toyota Mirai (only FCEV model in the segment)	1.0 kg / 100 km	-
Battery EVs	2023 EU registrations-weighted average	20.2 kWh / 100 km	53.4 kWh

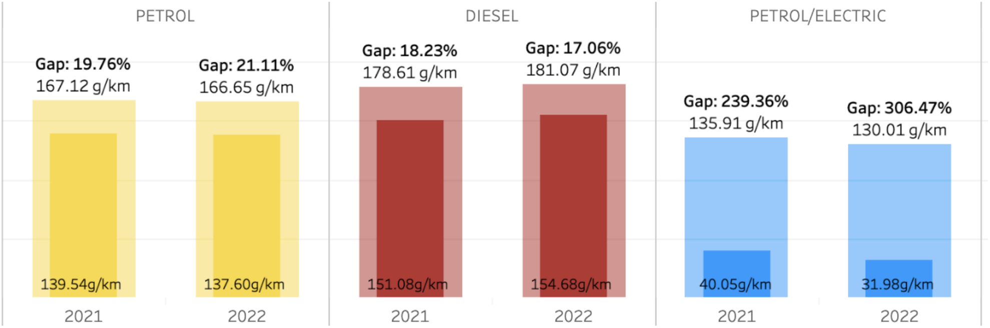
Real world vs WLTP fuel and electricity consumption

Fuel and electricity consumption:

a) Comparing apples and apples: **segment average** values

b) Average real-world usage
- **Conventional cars and BEVs:** +18% to +25% higher than WLTP
- **Plug-in hybrid vehicles:** +239% higher than WLTP

Real-world vs. WLTP fuel consumption of the fleet



- European Environment Agency (2025). Real world CO2 emissions from new cars and vans

Real world vs WLTP fuel and electricity consumption: BEVs

It becomes immediately clear that although WLTP energy consumption is roughly constant over the given period, real-world energy consumption is trending upwards. The following figure shows that the percentual gap between real-world and WLTP energy consumption has been trending upwards for a number of years from about 15% at the beginning of 2020 to roughly 25% at the beginning of 2023.

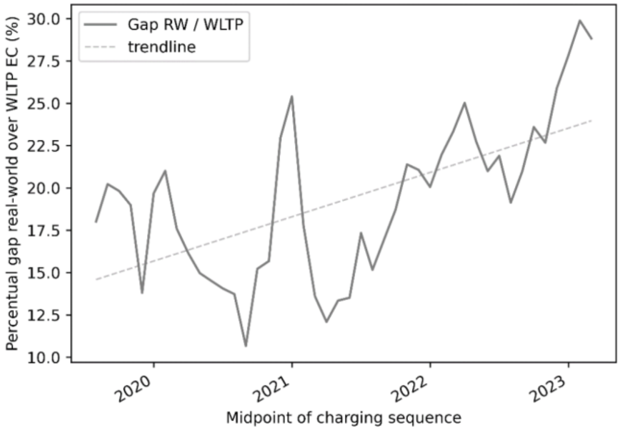


Figure 5-4: Monthly averages of gap between real-world energy consumption and WLTP energy consumption as a percentage of the WLTP value.

+25%

TNO (2024). Real-world fuel consumption and electricity consumption of passenger cars and light commercial vehicles - 2023

Lifetime fuel and electricity mix

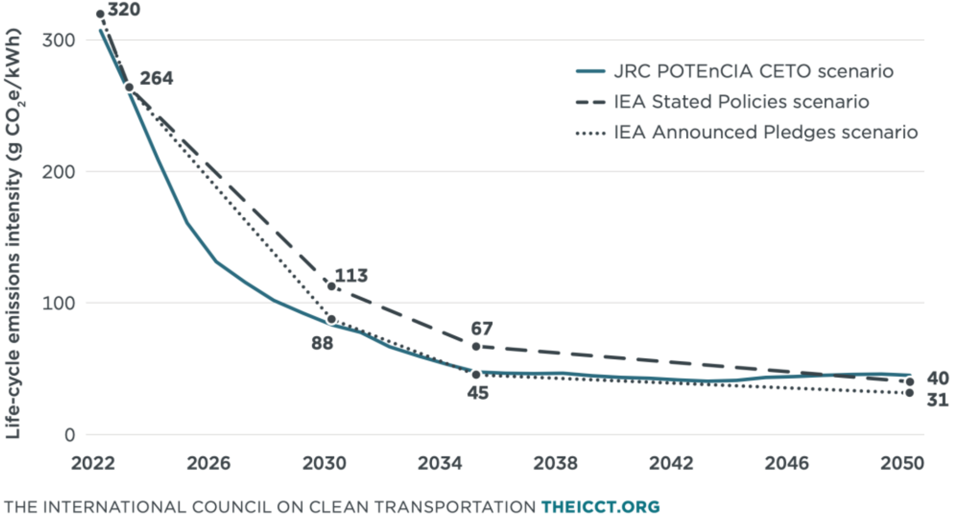
Electricity mix

- Baseline: JRC POTEnCIA CETO scenario
- Sensitivity: IEA Stated Policies Scenario

Fuels mix:

- Baseline: based on RED III requirements
- Sensitivity: optimistic advanced biofuels uptake scenario

EU electricity mix decarbonization over time



- JRC (2024). POTEnCIA CETO 2024 Scenario
- IEA (2024). World Energy Outlook 2024
- UNECE (2024). Life Cycle Assessment of Electricity Generation Options
- World Bank Group (2025). Electric power transmission and distribution losses

Full vehicle lifetime

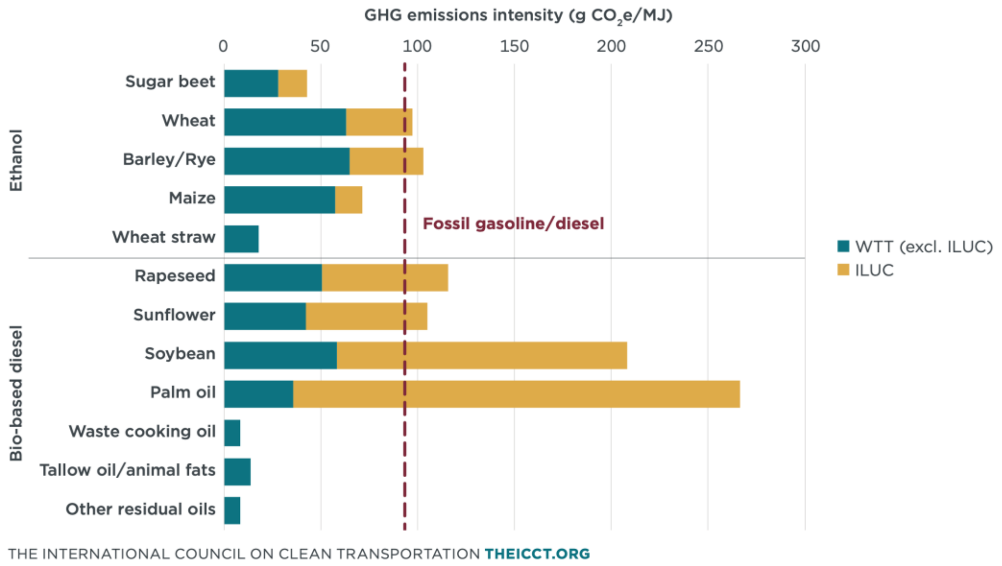
Country	Year	Age	Source
Belgium	2022	18.5	**Febelauto** (2023), rapport annuel 2023 *(Febelauto is the extended producer responsibility organization for vehicles in Belgium)*
Finland	2024	22.8	**Finnish Information Centre of Automobile Sector** (2025), based on Statistics Finland
France	2022	19.8	**Agence de l'environnement et de la maîtrise de l'énergie** (2024), Véhicules : données 2022
Germany	2022	18.6	**Federal Ministry for the Environment and Umweltbundesamt** (2024), Jahresbericht über die Altfahrzeug-Verwertungsquoten in Deutschland im Jahr 2022
Netherlands	2023	19.6	**Auto Recycling Nederland** (2024), Highlights of the Sustainability Report 2023 *(ARN covers 84% of vehicles recycled in the Netherlands)*
Portugal	2022	23.8	**Portuguese Environment Agency** (2024), Reporte de Qualidade VFV 2022
Spain	2023	21.1	**SIGRAUTO** *(Spanish Association for the Environmental Treatment of End-of-Life Vehicles)*

- Total useful vehicle lifetime is > 20 years in the EU
- Average annual mileage of 12,000 km
- Resulting lifetime mileage: 240,000 km

Indirect land use change emissions

- Indirect land-use change emissions (ILUC) of biofuels refer to **expansion of land use in response to policies and market demand** for that fuel.
- In vehicle life-cycle assessments, including **ILUC emissions** allows a more comprehensive assessment of the climate impact, as they can **substantially increase** the overall carbon footprint of biofuels.

Contribution of ILUC to WTW emissions



ILUC values from: Ecofys, IIASA, E4tech (2015)

Electricity generation infrastructure emissions

UNECE's life-cycle emission factors for the EU28:

	Electricity generation technology	Life-cycle GHG emission intensity (g CO_2e/kWh)	Share of power plant construction and grid connection
Non-renewable	Coal	1023	<1%
	Natural gas	434	<1%
	Nuclear	5.1	~15%
Renewable	Photovoltaic (PV)	36.7	~98%
	Wind, offshore	14.2	100%
	Wind, onshore	12.4	~98%
	Hydropower	10.7	100%

UNECE (2022). Life Cycle Assessment of Electricity Generation Options

Key results

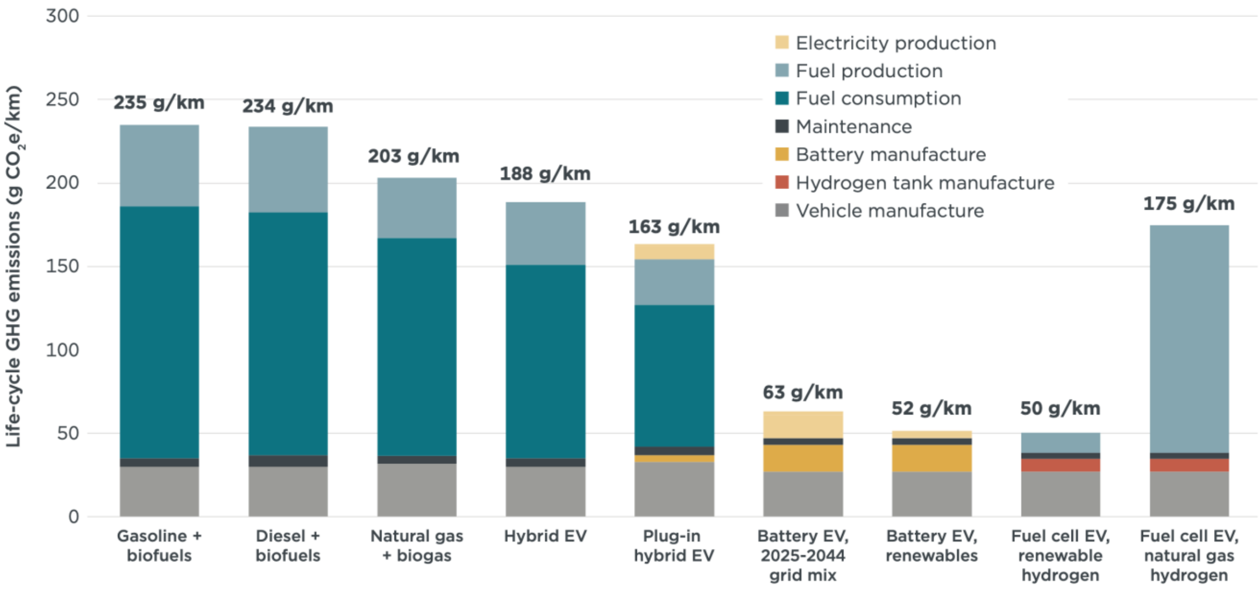
Baseline case results

- **Gasoline and diesel cars:** similar emissions
- **CNG cars**: -13%
- **Hybrids:** -20%
- **Plug-in hybrids:** -30%

- **BEV**:
  -73% for grid mix
  -78% for renewables

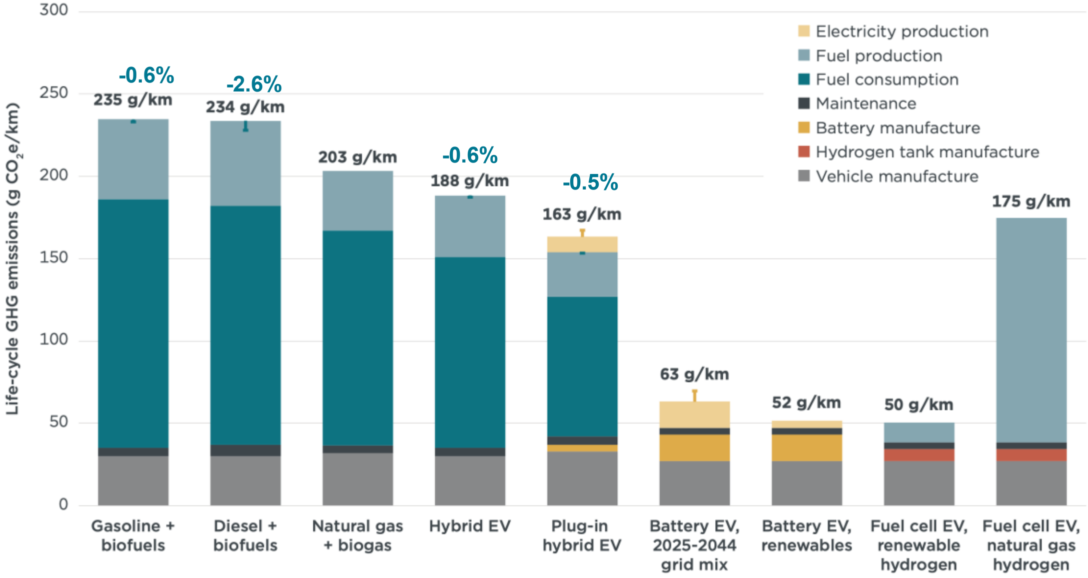
- **Fuel cell EVs:**
  -79% for green H2
  -26% for natural gas H2

Life-cycle GHG emissions of medium segment passenger cars sold in the EU in 2025



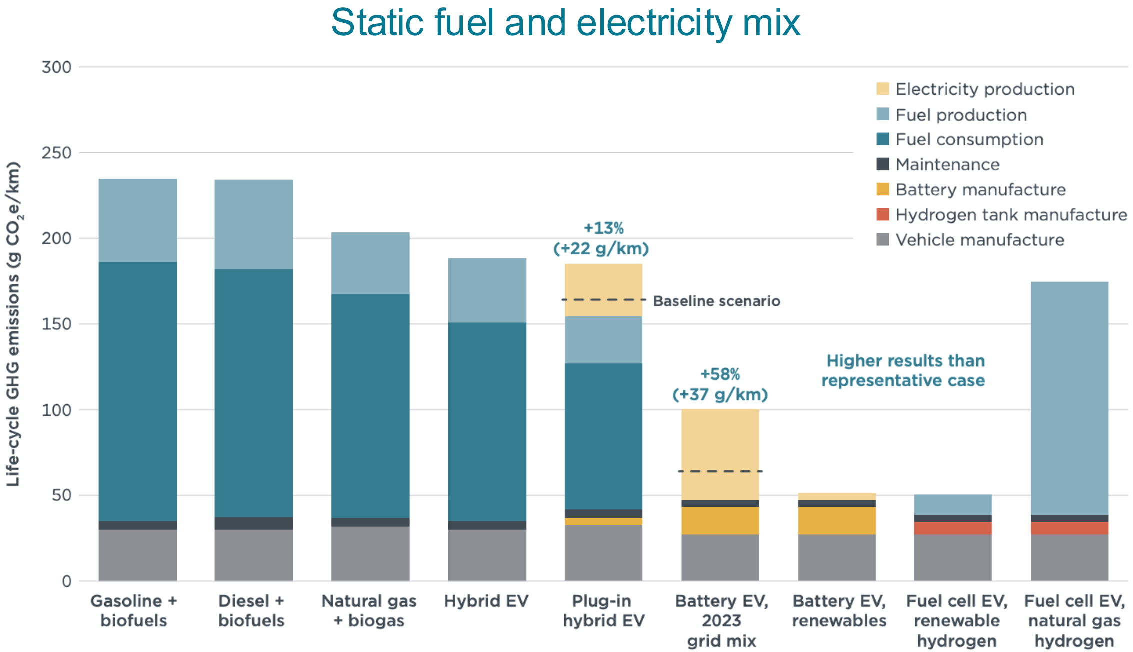
Sensitivity scenario: optimistic advanced biofuels uptake

- Illustrative scenario: the volume shares of biofuels in the diesel mix doubles by 2040 (14vol%); ethanol volume share in the gasoline mix increases until reaching the technical limit (10vol%).



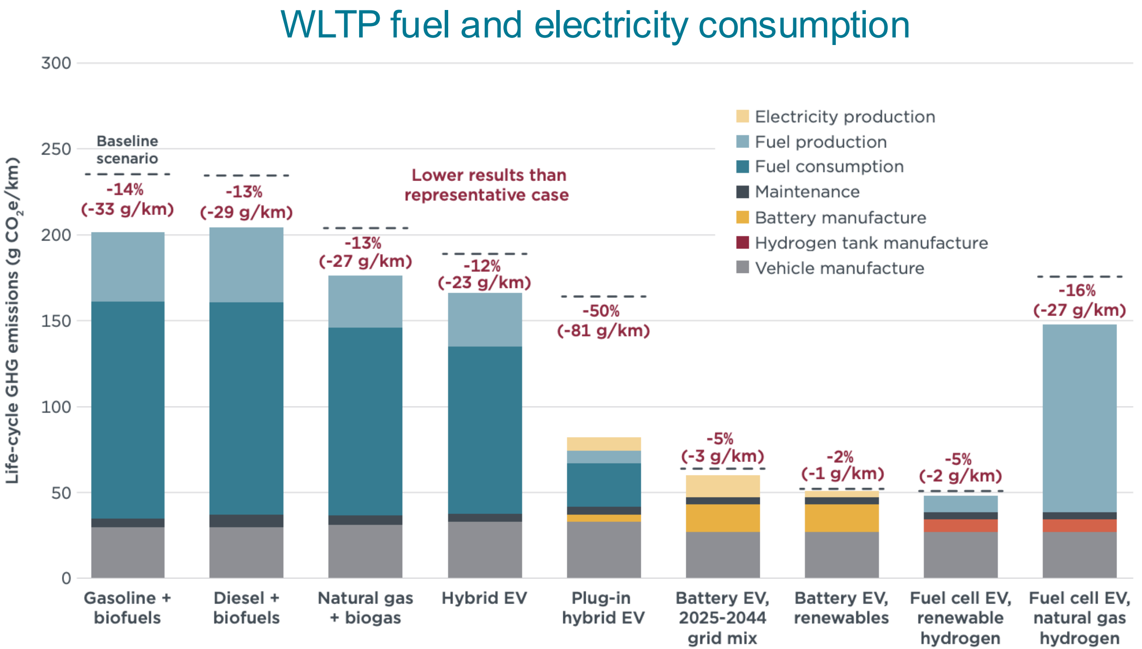
- Even with an optimistic advanced biofuels share in the blend, emissions are only 0.5%-2.6% lower

Factor 1. Lifetime fuel and electricity mix



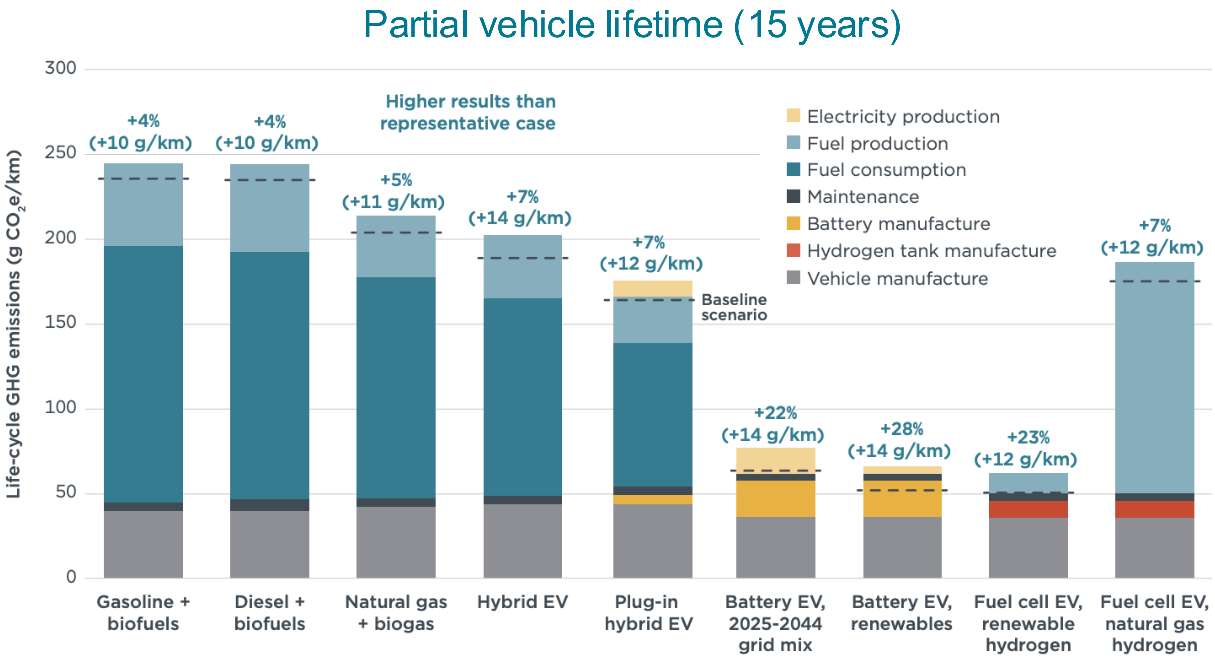
- The electricity mix becomes cleaner
- Assuming no change in the electricity mix largely overestimates the GHG emissions of BEVs

Factor 2. Real world vs WLTP fuel and electricity consumption



- The gap between real-world and official WLTP values is higher for PHEVs
- Assuming official test values distorts the comparison

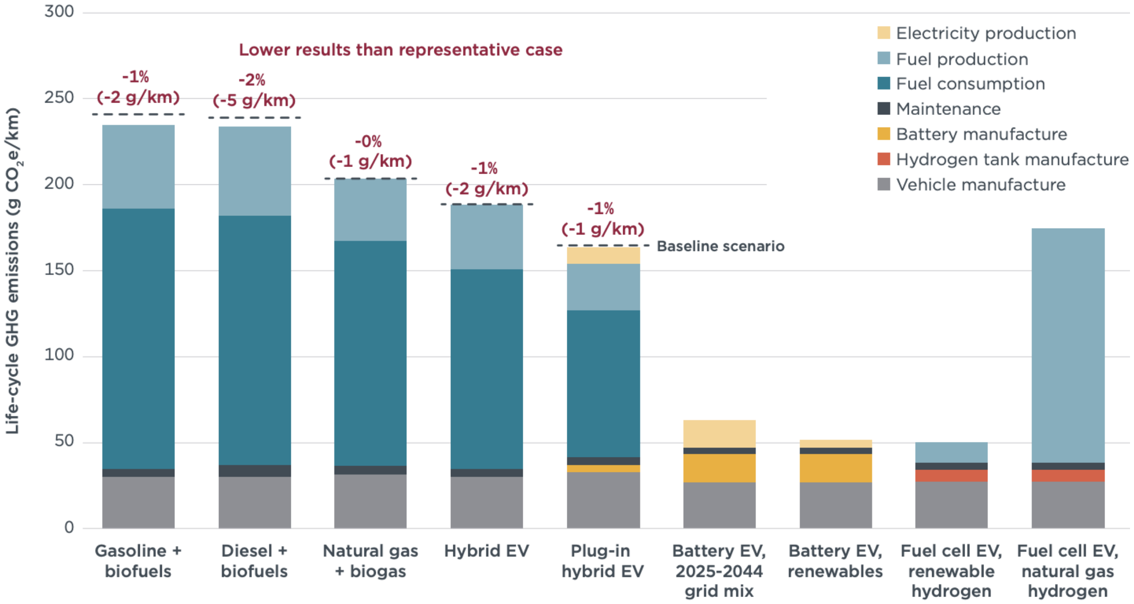
Factor 3. Full vehicle lifetime



- The relative contribution of production emissions is higher for BEVs
- Assuming a shorter lifetime distorts the comparison

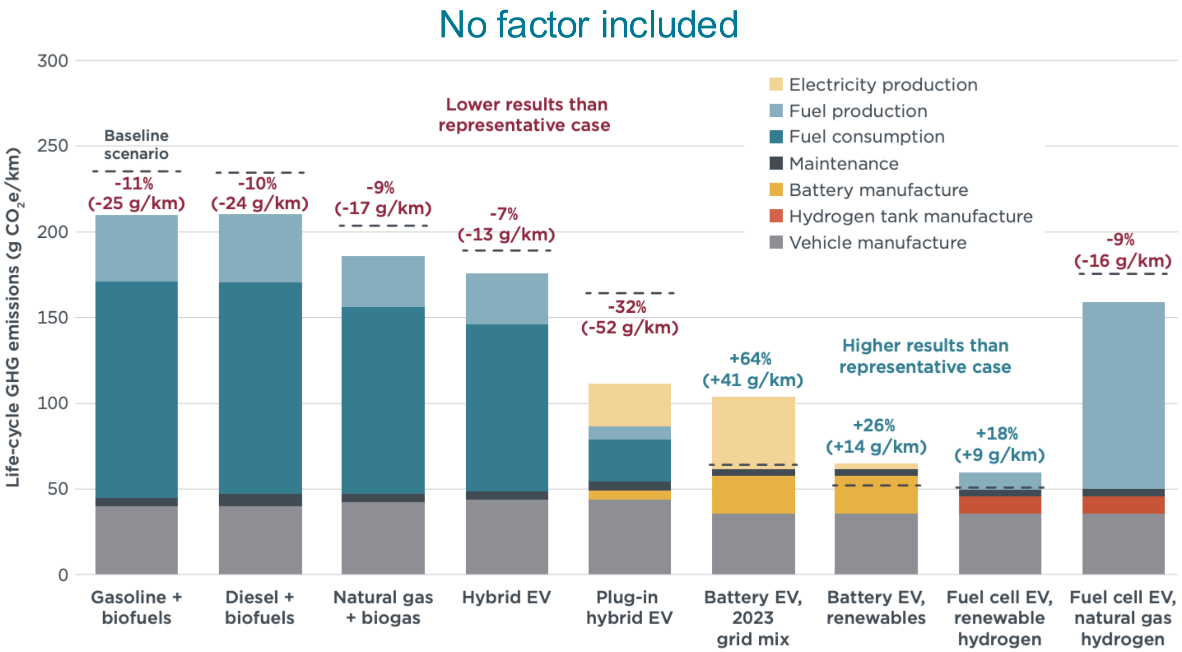
Factor 4. Indirect land use change emissions

No ILUC included



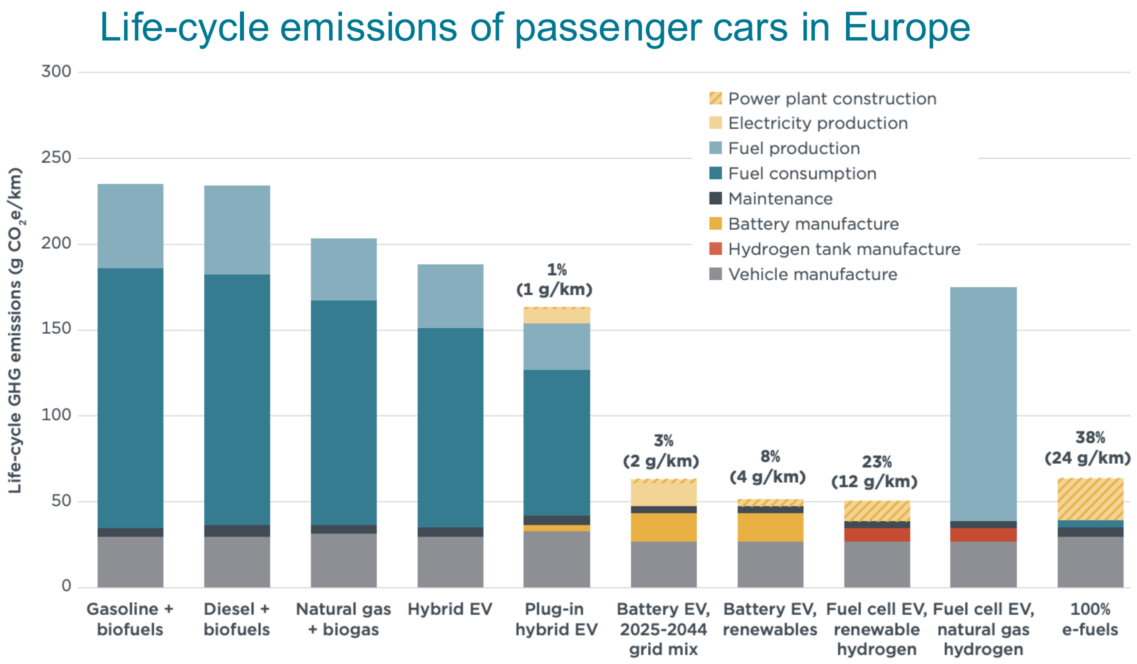
- ILUC emissions do not make a large impact for the EU (no high ILUC risk biofuels)
- In other regions (Indonesia and Brazil), the impact of ILUC is substantial

Impact of factors 1-4 combined



- When combined, the effects of the critical factors change the results significantly
- The emissions of BEVs are overestimated, and appear comparable to PHEVs

Bonus factor: including electricity generation infrastructure emissions



Additional LCA studies from ICCT in other regions for light duty vehicles

- Bieker (2021). A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars
- Mera et al. (2023). Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars in Brazil
- Mera and Bieker (2023). Comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars and two-wheelers in Indonesia
- Yadav et al. (2024). A comparison of the life-cycle greenhouse gas emissions from combustion and electric heavy-duty vehicles in India
- O'Malley and Slowik (2024). Life-cycle greenhouse gas emissions of U.S. sedans and SUVs with different powertrains and fuel sources

Summary

Summary – 5 key factors for the methodology

1) The **electricity mix is getting cleaner**. Vehicle LCAs should represent the expected decrease in emissions intensity.
2) There is a gap between WLTP and **real-world fuel and electricity consumption**. This gap is particularly wide for PHEVs. Real-world values should be preferred.
3) Vehicles in the EU are driven for >20 years. The **full vehicle lifetime** should be considered, to account for the long-term benefit of a cleaner grid and not to overestimate the relevance of production emissions.

4) **ILUC emissions** can substantially increase the climate impact of biofuels, and should therefore be included in the analysis.

5) **Electricity generation infrastructure emissions** should be considered. Especially for e-fuels they can represent a significant share of life-cycle emissions.

Summary – Results

When considering all of this:

- **Battery EVs** on average have **-73%** lower life-cycle GHG emissions than gasoline cars. The higher production emissions of the battery are compensated for already after 1-2 years.

- **Hybrids and plug-in hybrids** only have **-20% and -30%** lower emissions than gasoline cars: Their life-cycle emissions are three to four times higher than for battery EVs!

- **Fuel cell electric vehicles** allow a similar reduction in GHG emissions as battery EVs (-79%), but only when using renewable electricity-based (green) hydrogen, which is not widely available in the EU. When using natural gas-based hydrogen, their emissions are only -26% lower than for gasoline cars.

Policy considerations

Policy considerations

The phaseout of new ICEV, HEV, and PHEV registrations by 2035 would allow to align the transport sector emissions with EU climate targets.

- When running on the EU average electricity mix, only BEVs offer a large-scale reduction in life-cycle GHG emissions.
- FCEVs would need to be restricted to the use of renewable electricity-based hydrogen to achieve similar reduction levels.
- For ICEVs, HEVs, and PHEVs, the development of the average mix of fossil fuels and biofuels that can be expected from current policies and market developments would not allow vehicles of these powertrain types to meet EU climate targets.
- Vehicles running solely on e-fuels could, in theory, achieve life-cycle GHG emissions similar to BEVs, the future availability of e-fuel for the road sector is uncertain while costs are expected to remain high.

Policy considerations

Decarbonizing all components of the life-cycle emissions of passenger cars could be achieved by complementary policies.

Examples include:

- battery production carbon footprint provisions in the EU Battery Regulation,
- sustainability criteria for vehicle purchase subsidies,
- improvements in the energy efficiency of BEVs through energy efficiency standards,
- decarbonization of the EU power sector can be achieved with the Emissions Trading System

Policy considerations

Emission regulations based on life-cycle emissions could be effective in the long term but come with high uncertainties and administrative burdens and take several years to develop.

- This analysis shows: comparing the life-cycle GHG emissions of vehicles with different powertrain types is **highly sensitive to methodological choices**. Basing vehicle regulations on life-cycle emissions thus risks disproportionally benefiting powertrain types that do not offer a sufficient long-term decarbonization potential.
- It would require **extensive administrative effort** for companies and governments to trace, report, and verify emissions for each step of vehicle production, as well as time to build sufficient capacities and effective cross-industry data sharing platforms.
- Introducing LCA-based regulations would require **several years of reporting and negotiation** to establish both a baseline and an emissions threshold curve that decreases over time.

Policy considerations

There is a need to harmonize methodological guidelines towards using representative input factors on

1) projected changes in the fuel/electricity mix during the lifetime of the vehicles,
2) representative fuel and electricity consumption in real-world driving conditions,
3) a full vehicle lifetime of passenger cars.

For a most comprehensive assessment of the climate impact, it is further important to

4) include indirect land use change emissions of biofuels production,
5) electricity generation infrastructure emissions (e.g., for producing a solar panel)

Thank you!

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