Life-cycle greenhouse gas emissions of combustion engine and electric passenger cars in Europe

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Introduction

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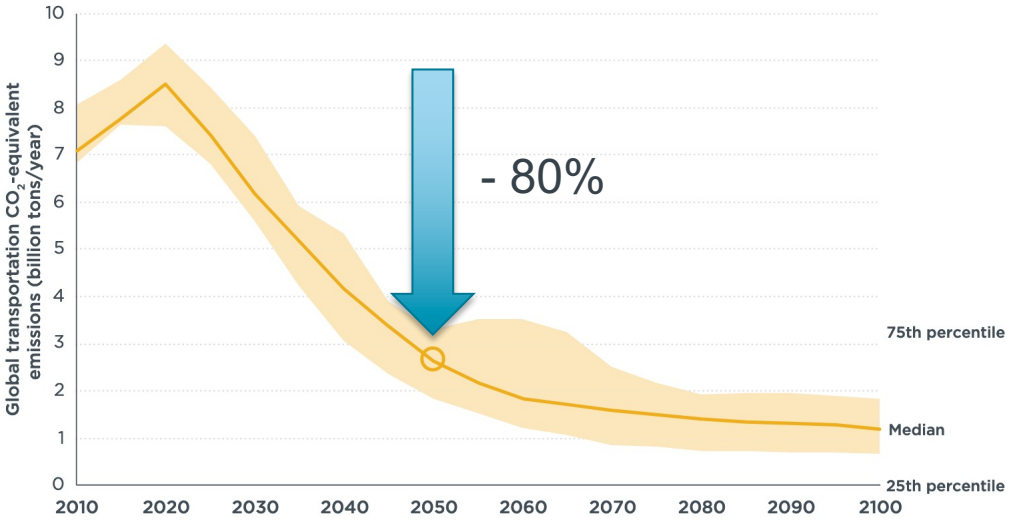
Transport: 80% lower GHG emissions by 2050

- To limit global warming to 1.5 °C, GHG emissions of **global transport** need to be **80% lower** by 2050
- **Which technologies** can deliver this deep reduction in the passenger car fleet despite a growing number of vehicles?

Global transport sector GHG emissions in the 1.5°C scenario



ICCT (2020). Vision 2050: A strategy to decarbonize the global transport sector by mid-century.

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Methodology

Scope: Life-cycle GHG emissions

- Life-cycle GHG emissions: CO_2, methane (CH_4), nitrous oxide (N_2O)
  - **Vehicle cycle**:
    - Vehicle and battery production (including raw material)
    - Maintenance
    - End-of-life, recycling
  - **Fuel cycle** (well-to-wheel):
    - Fuel and electricity production
    - Indirect land use change (ILUC)
    - Fuel combustion in vehicle

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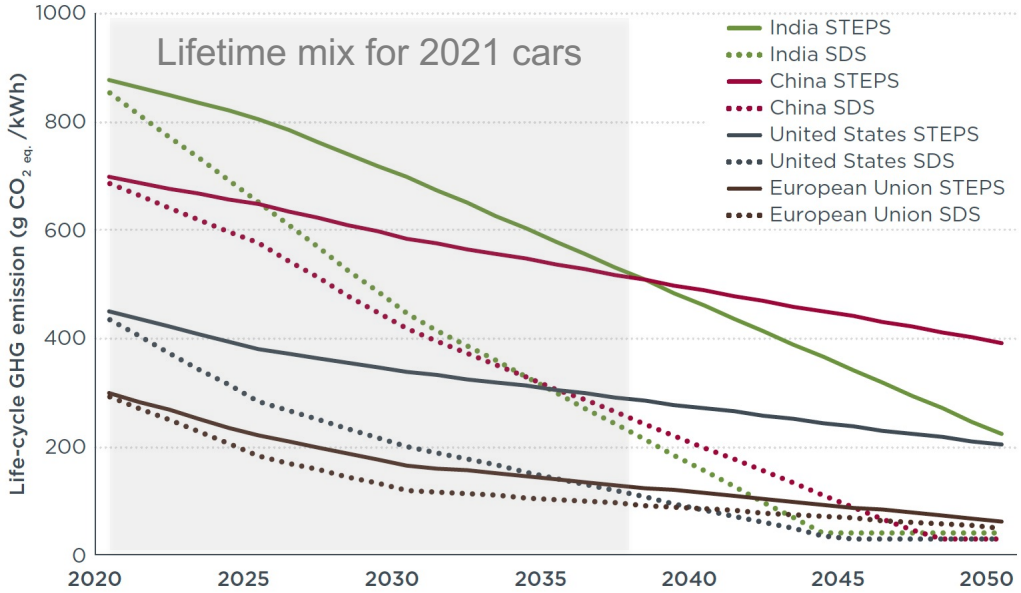
Methodology: Lifetime average electricity mix

1) **Vehicle lifetime average carbon intensity of fuel/electricity mix**:

   - EU average **biofuel and biogas blend**
   - EU average **electricity mix**
   - Projected future blend/mix based on current policies
   - Compared to Paris Agreement-aligned development

Life-cycle GHG emissions of electricity consumption



Bieker (2021). A global comparison of the life-cycle GHG emissions of combustion engine and electric passenger cars.

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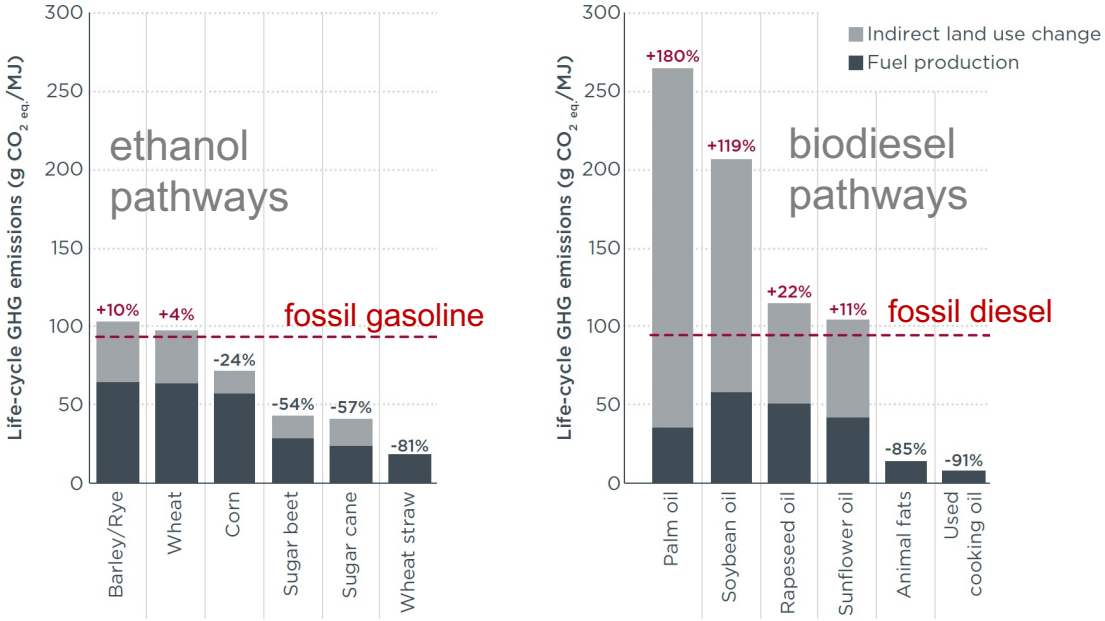
Methodology: Indirect land use change (ILUC)

2) **Life-cycle GHG emission of biofuels:**

- **Food-based biofuels:** high ILUC emissions
- **Residue- and waste-based biofuels:** low ILUC emissions

Study: EU average biofuel blend and future changes according to RED II.

Biofuel production and indirect land use change emissions



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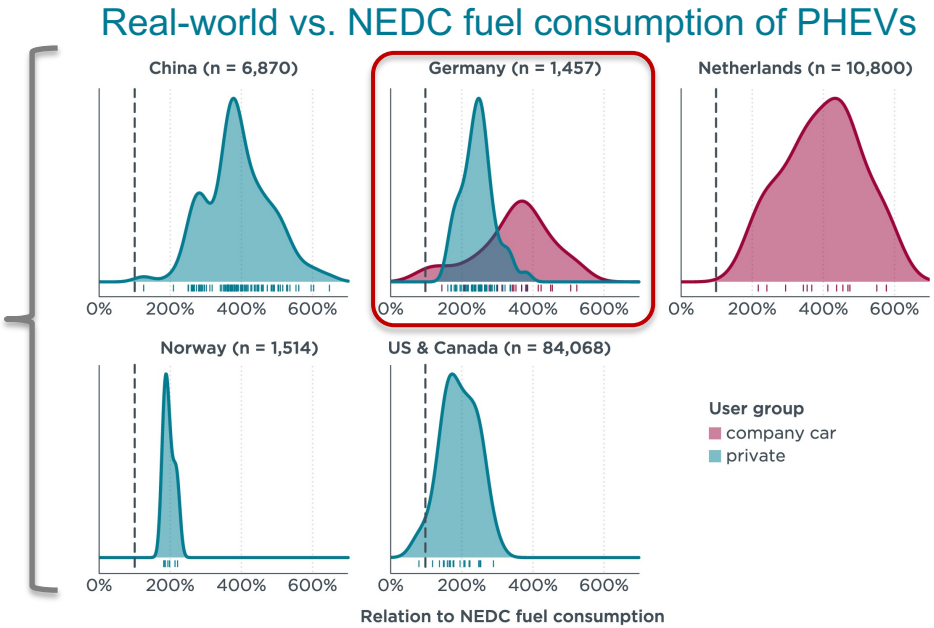
Methodology: Fuel and electricity consumption

3) Fuel and electricity consumption:

- **Average real-world usage**
  - Gasoline: +37% (NEDC)
  - Diesel: +44%
  - HEVs: +50%
  - **PHEVs: +100% to +300%**
  - BEVs: +19% (WLTP)
  - FCEVs: +33% (NEDC)



- Plötz et al. (2020). Real-world usage of plug-in hybrid electric vehicles.
- Dornoff et al. (2020). On the way to "real-world" CO_2 values.
- ADAC Ecotest

Methodology: Battery production

4) **Battery production:**

- Most recent data on **industrial-scale** battery production
- **Market average** mix of regional battery production

Battery production GHG emissions

kg $CO_{2\ eq.}$/kWh	Europe	United States	China	South Korea	Japan
NMC111-graphite	56	60	77	69	73
NMC622-graphite	**54**	**57**	**69**	**64**	**68**
NMC811-graphite	53	55	68	63	67
NCA-graphite	57	59	72	67	70
LFP-graphite	34–39	37–42	51–56	46–50	50–55

Based on Argonne National Laboratory's GREET Model (2020 version)

➡ **EU mix** of imported and locally produced batteries: **60 kg $CO_{2\ eq.}$/kWh**

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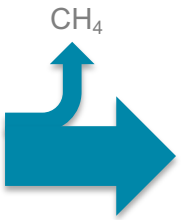
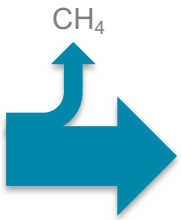
Methodology: 20-year GWP for methane

5) 20-year global warming potential (GWP) of methane leakage:

- Methane leakage for **natural gas** and for **grey and blue (CCS) hydrogen**



CNG cars:
- Natural gas extraction/processing
- Natural gas transport/distribution
- Methane slip from the vehicles



Grey and blue (CCS) hydrogen:
- Natural gas extraction/processing
- Natural gas transport
- Steam reforming

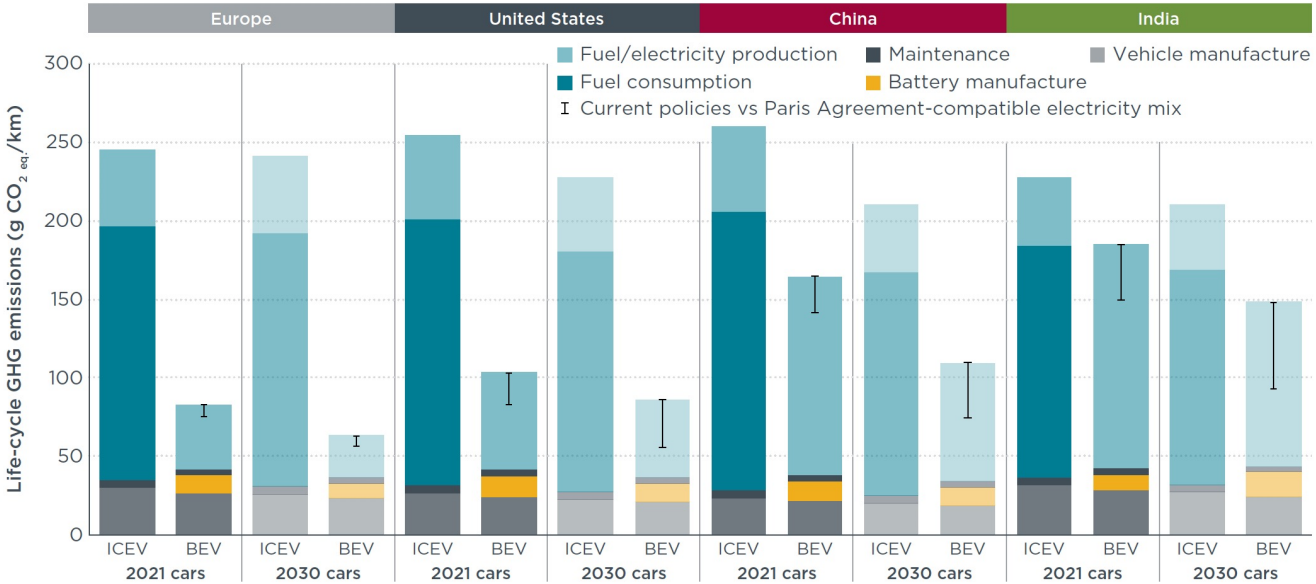
- 100-year timeframe: **30 times** higher GWP than CO_2
- 20-year timeframe: **85 times** higher GWP than CO_2

Key results

Global: Battery EVs have lowest emissions

- **Battery EVs** have the **lowest emissions** for cars registered in 2021 **in all four regions**
- The GHG emission benefit increases for future BEVs

Life-cycle GHG emissions of medium-size cars registered in **2021** and in **2030**



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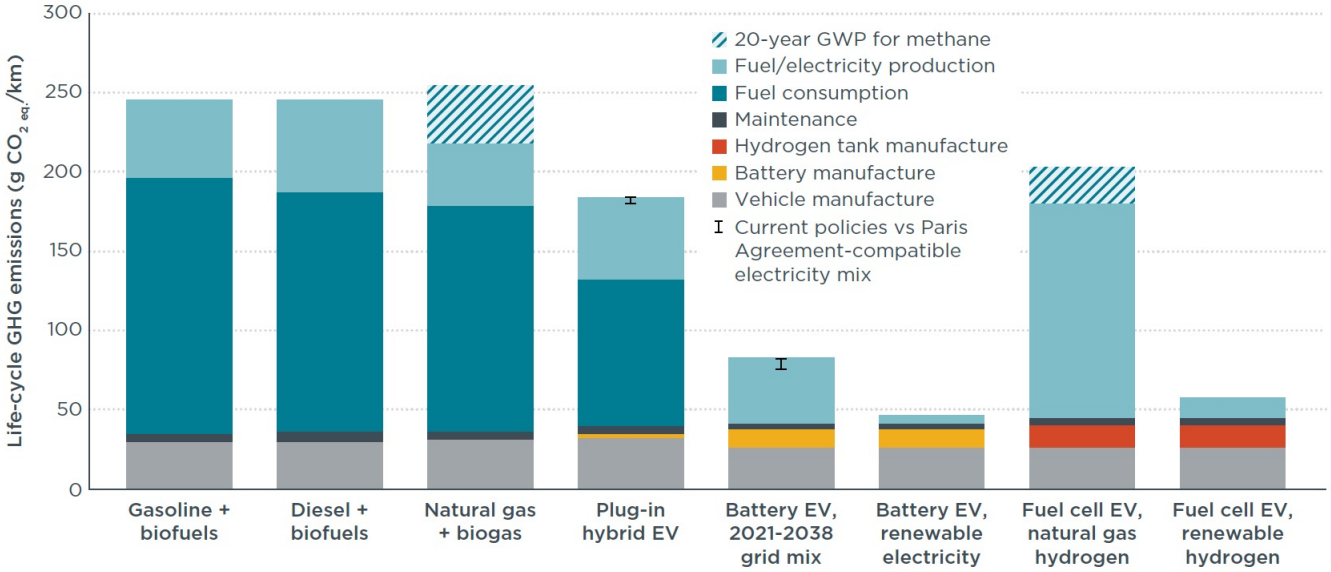
Europe: Lower medium segment

- **Gasoline cars** include hybrid electric vehicles
- **Diesel and CNG cars:** no GHG emissions benefit
- **Plug-in hybrid EVs:** 25%–27% lower emissions
- **Battery EVs:** 66%–69% lower emissions
- **Fuel cell EVs:** emissions vary with hydrogen source

Life-cycle GHG emissions of average lower medium segment cars registered in 2021



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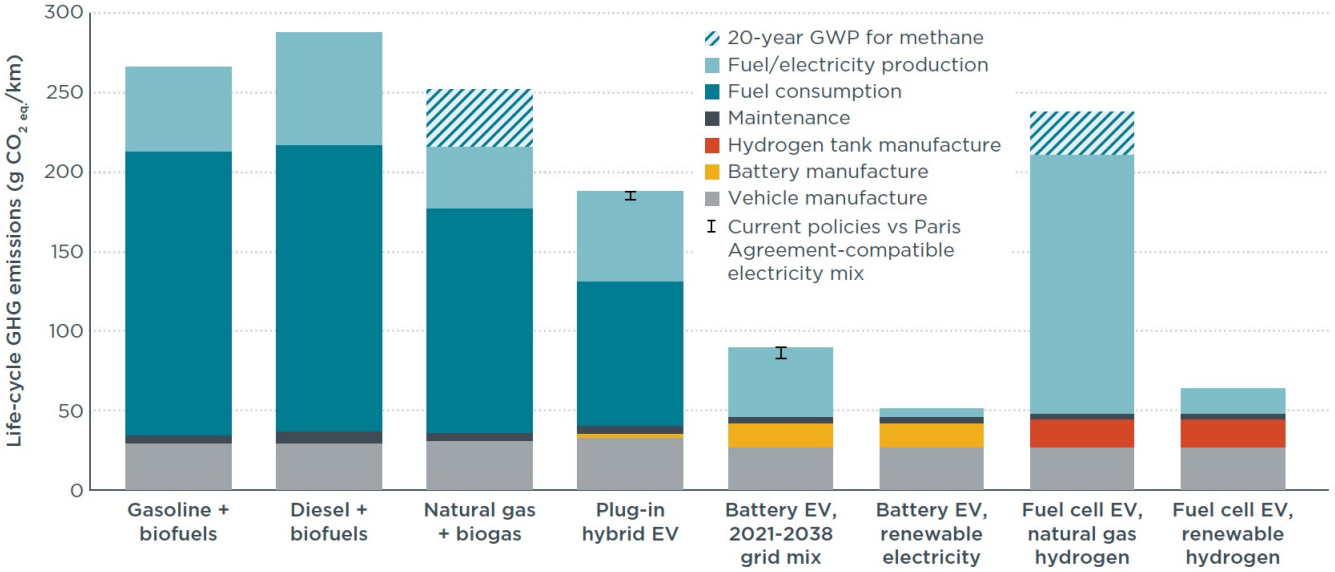
Europe: SUV segment

- **Gasoline cars** include hybrid electric vehicles
- **Diesel and CNG cars:** no GHG emissions benefit
- **Plug-in hybrid EVs:** 30%–32% lower emissions
- **Battery EVs:** 66%–69% lower emissions
- **Fuel cell EVs:** emissions vary with hydrogen source

Life-cycle GHG emissions of average SUV segment cars registered in 2021



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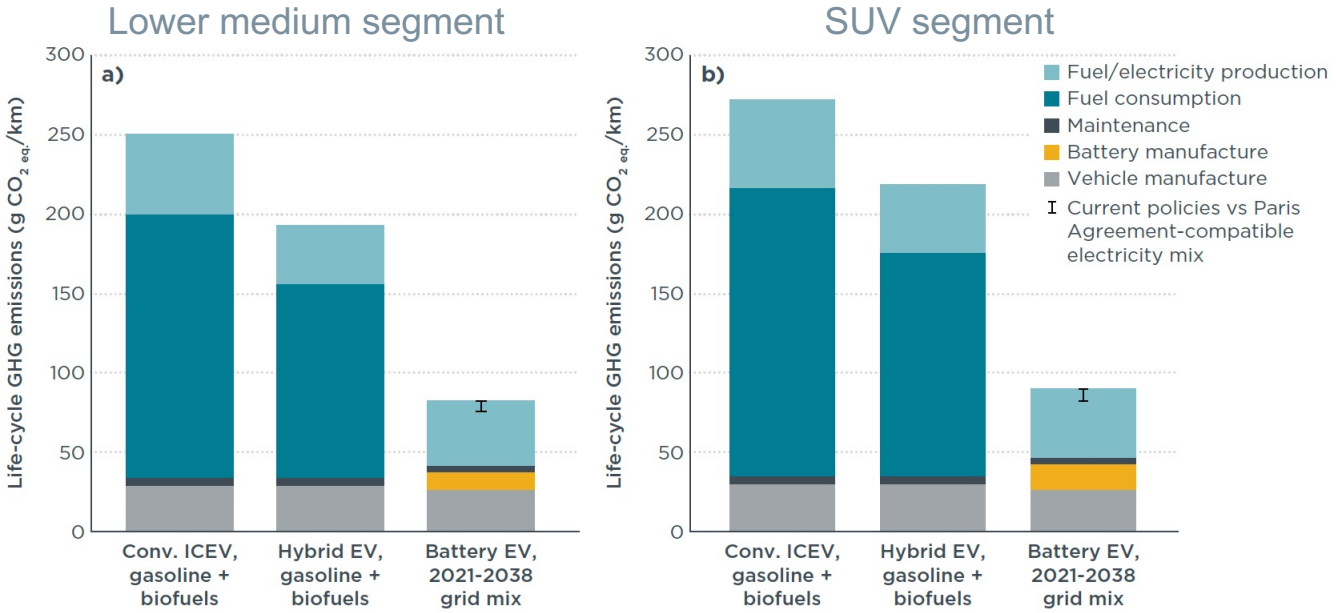
Europe: Hybrid electric vehicles (HEVs)

- **Hybrid electric vehicles:** 23%–27% lower fuel consumption than conventional gasoline

  = **20%–23%** lower life-cycle GHG emissions

Life-cycle GHG emissions of average new hybrid electric vehicles



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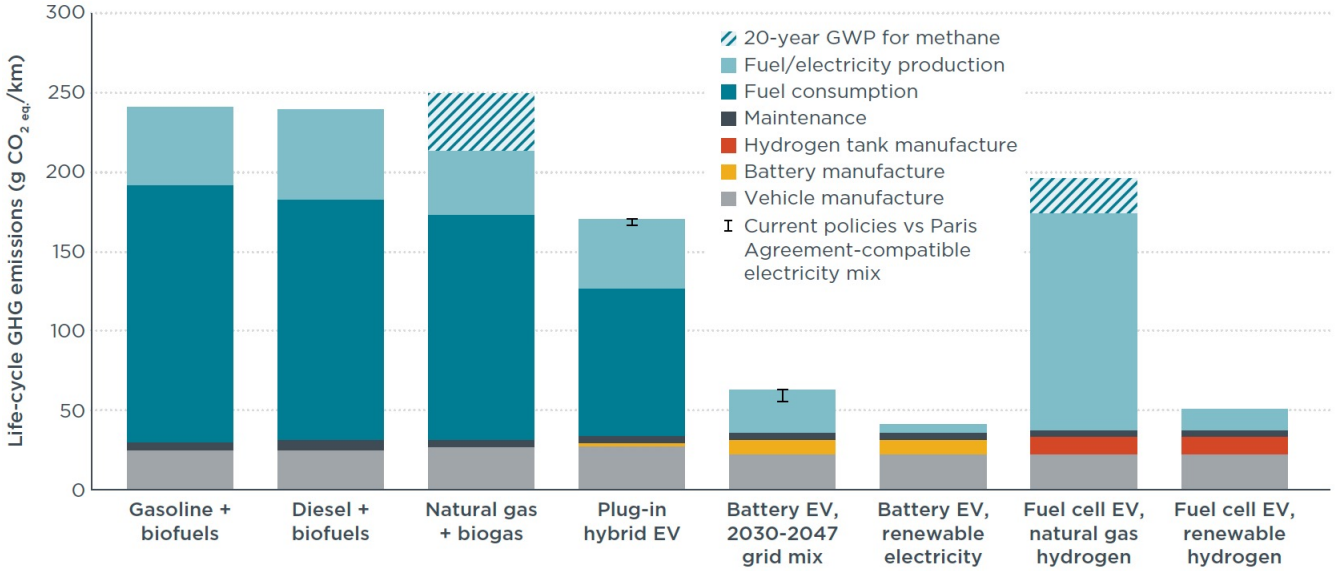
Europe: Cars registered in 2030

- **Gasoline cars** include hybrid electric vehicles
- **Diesel and CNG cars:** no GHG emissions benefit
- **Plug-in hybrid EVs:** 29%–31% lower emissions
- **Battery EVs:** 74%–77% lower emissions
- **Fuel cell EVs:** emissions vary with hydrogen source

Life-cycle GHG emissions of average lower medium segment cars registered **in 2030**



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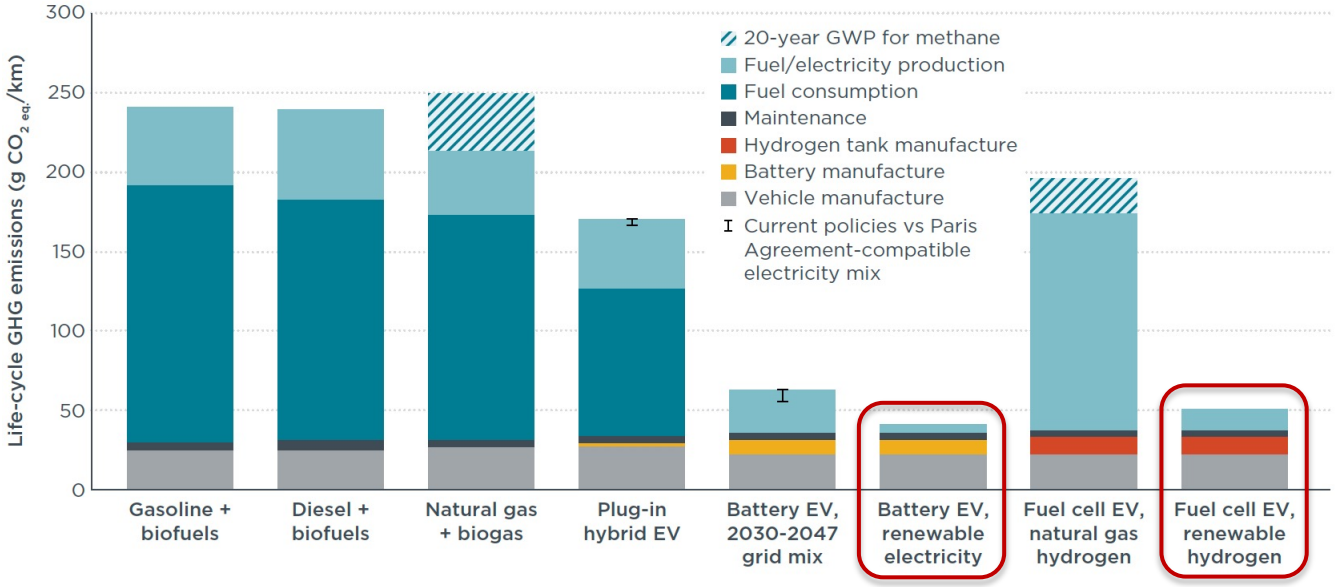
Europe: Cars registered in 2030

- **Battery EVs with renewable electricity:** 83% lower life-cycle GHG emissions
- **Fuel cell EVs with green hydrogen:** 79% lower life-cycle GHG emissions

Life-cycle GHG emissions of average lower medium segment cars registered **in 2030**



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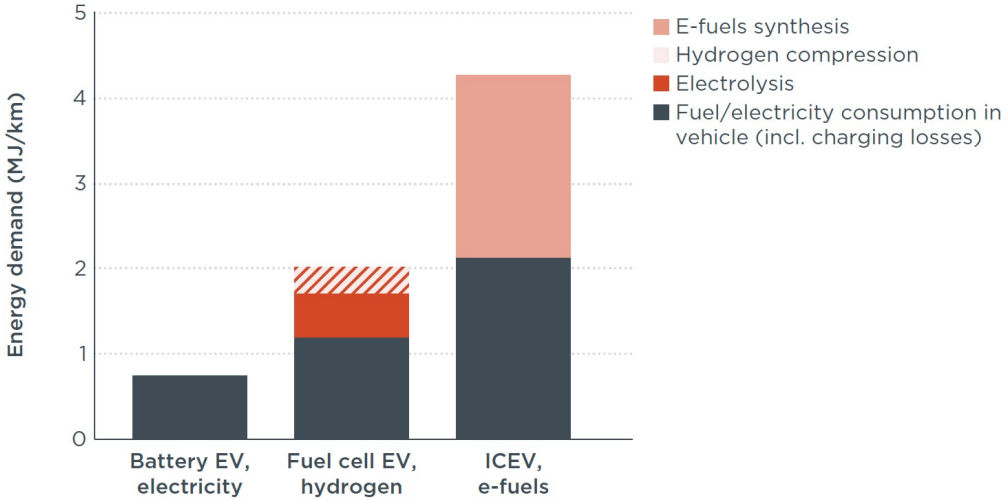
Electricity, green hydrogen and e-fuels

- Driving on **renewable hydrogen** is **three times** more energy intensive than battery EVs
- Driving on **e-fuels** is **six times** more energy intensive than battery EVs
- E-fuels are **too expensive** and **too limited** to contribute to the decarbonization of road transport

Energy demand of driving medium size cars with electricity, renewable hydrogen, and e-fuels



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Key messages

- For cars registered today, battery EVs already show the **lowest life-cycle GHG** emissions of all available options
- Only **battery EVs** and **hydrogen fuel cell EVs** have the potential to be **near zero-carbon** on a life-cycle basis
- There is **no realistic pathway to decarbonize combustion engine vehicles**: the availability of e-fuels and low carbon biofuels is too limited to substantially reduce the emissions of the fuel mix
- To limit global warming to 1.5 °C, the **global passenger car fleet** needs to be **electric by 2050**
- With a vehicle lifetime of 18 years, this requires that the registration of new **combustion engine vehicles is phased out by 2030–2035**

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Thank you!

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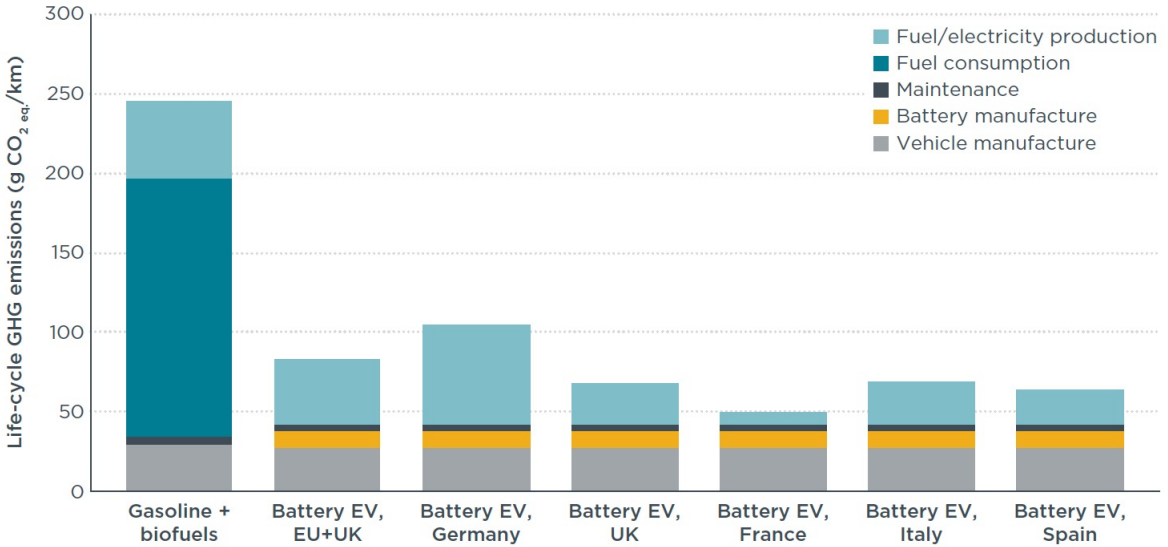
Europe: Variation between countries

- **Battery EVs:** lowest emissions in all European countries

Life-cycle GHG emissions of average lower medium segment cars



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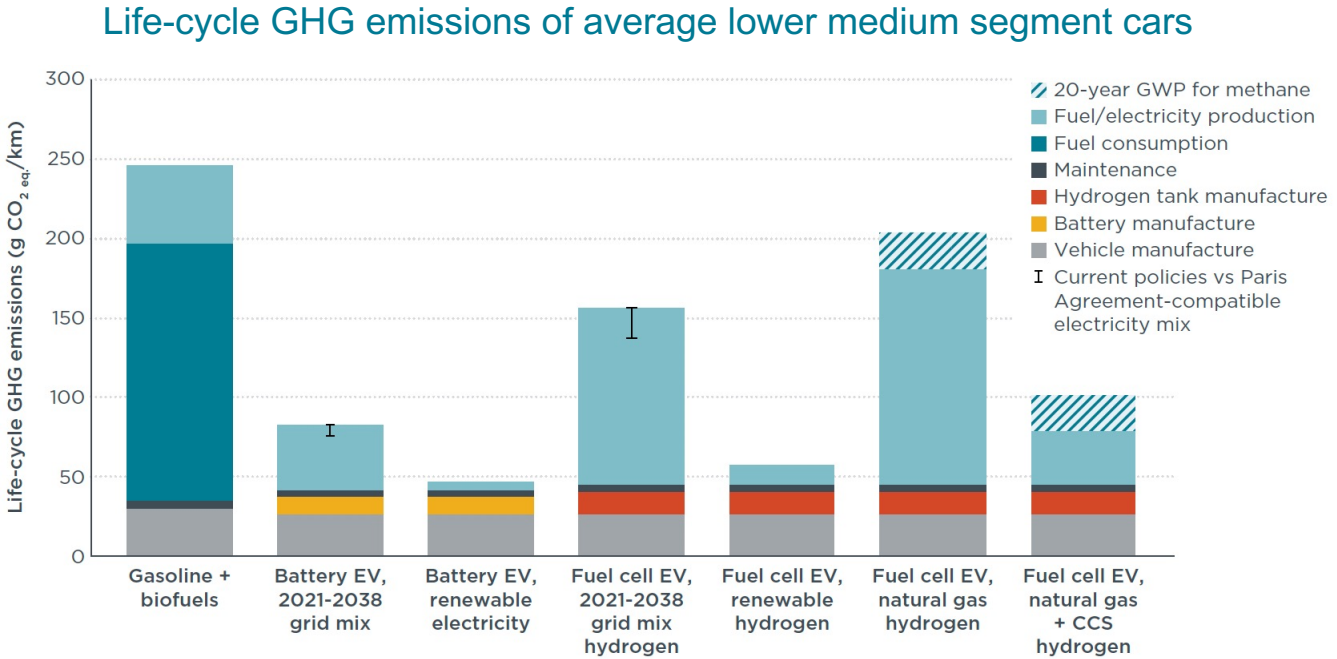
Europe: Hydrogen pathways

- **Fuel cell EVs:** only hydrogen from additional renewable energy is low-carbon



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