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Greenhouse gas reduction pathways for EU road transport

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Study Objectives

- Compare pathways to decarbonize EU road transport
- What alternatives remain to reduce GHG emissions quickly enough?

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EU 2035 GHG Reduction Targets

Scientific Advice

77-87% reduced GHG/y from EU economy, vs. 1990

Current State

CO_2/year from road traffic ~20% above 1990

Current Ambition

100% reduced tailpipe CO_2 from new light-duty vehicles

65% reduced tailpipe CO_2 from new heavy-duty vehicles, vs. 2019

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Pathways Assessed

Powertrains	Energy supply
ICEVs – internal combustion engine vehicles	Fossil fuels Biofuels Electrofuels (e-fuels, RFNBOs)
BEVs – Battery electric vehicles • New vehicles • Retrofits of ICEVs	Plug-in ”slow” charging Plug-in ”fast” charging ERS – Electric Road System
FCEVs – Fuel-cell electric vehicles	Green hydrogen • Multiple production locations • Multiple transportation methods • Gaseous or liquid

Methodology

1. Levelized cost per kilometer
2. Levelized lifecycle greenhouse gas (GHG) emissions per kilometer
3. Maximum scalability by 2035
4. Expected change in total transport work, with “soft interventions”

Cite when possible, calculate when necessary

Road Transport Demand Reduction

- Urban interventions can have local impact
- Immature literature, cannot estimate EU impact
- Significant shift of road transport to rail and waterways is unlikely
- Price increase can reduce demand
- Electrification will reduce costs
- Still expect increasing road transport

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Biofuels

- In use today (~6% of energy)
- Cost-neutral with fossil fuels at expected cost of carbon (~100-250 €/t$CO_{2\text{-eq}}$)
- Challenging to increase supply without significantly increasing cost

Hydrogen and E-fuels

- **Green hydrogen** is not available today
- Supply still much less than proposed uses by 2035
- Road transport competes with better uses of hydrogen – no real GHG reduction
- Expensive through all pathways, some are also polluting and energy intensive inside Europe
- Insufficient potential for cost reductions, even at scale

- **E-fuels** are well suited for long-distance transportation and use in road vehicles
- Production requires green hydrogen and sustainable carbon supply, plus new refineries
- Competes with biofuels
- Poor energy efficiency
- High cost, slow to market, insufficient long-term demand to warrant investment

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Battery Electric

- The most scalable pathway
- Lowest cost
- Electricity supply is rapidly decarbonizing

- Embodied light-vehicle emissions must decrease, mainly from batteries
- Low uptake potential by 2035 through new sales outside light vehicles in North and Western Europe

Electric Road Systems

- Lowest cost charging
- ~50% smaller battery packs
  - Reduced BEV cost (heavy)
  - Reduced BEV emissions (light)

➔ Quicker to 100% BEV share of new vehicles

➔ ICEV to BEV conversions more likely

- Massive infrastructure project:
  50 000 – 130 000 km by 2030
- Insufficient political momentum today, not in AFIR, not promoted by vehicle OEMs
- Unclear if ERS is a realistic option for impact by 2035

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Electric Retrofits

	Light-duty vehicles	Heavy-duty vehicles
Static charging	Parts: **€8-17k** Savings over 50% BEV lifetime: **€3-6k**	Parts: **€100-180k** Savings over 50% BEV lifetime: **€40-100k**
Dynamic charging (ERS)	Parts: **€8-15k** Savings over 50% BEV lifetime: **€6-9k**	Parts: **€60-130k** Savings over 50% BEV lifetime: **€100-130k**

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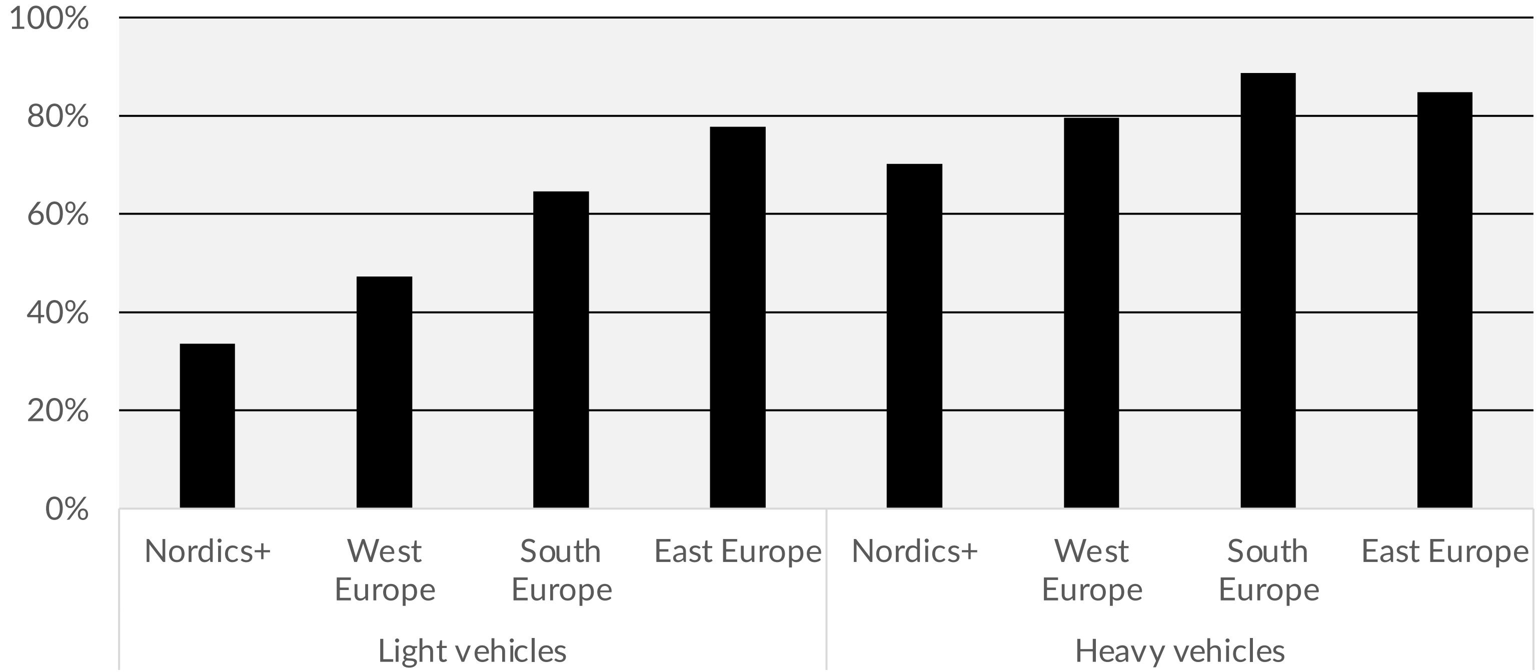
Maximum ERS-Adapted Share of the 2035 Rolling BEV Stock



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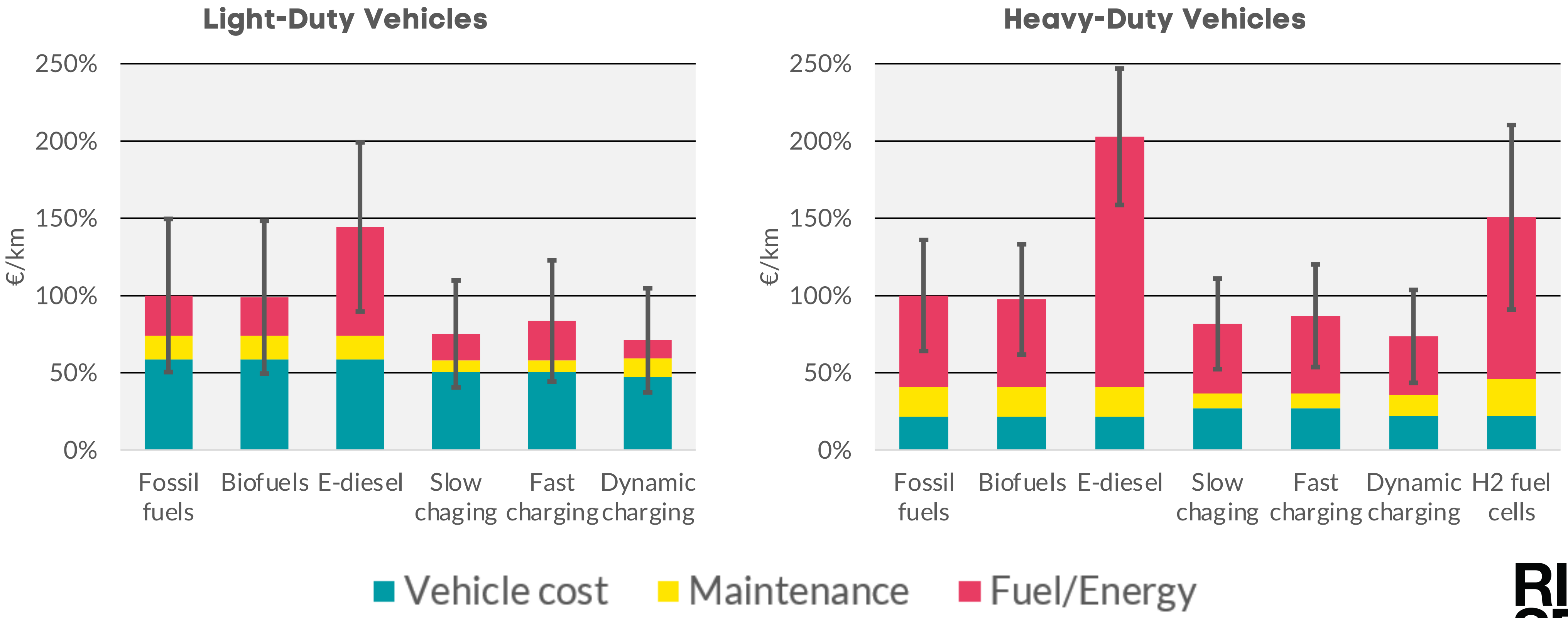
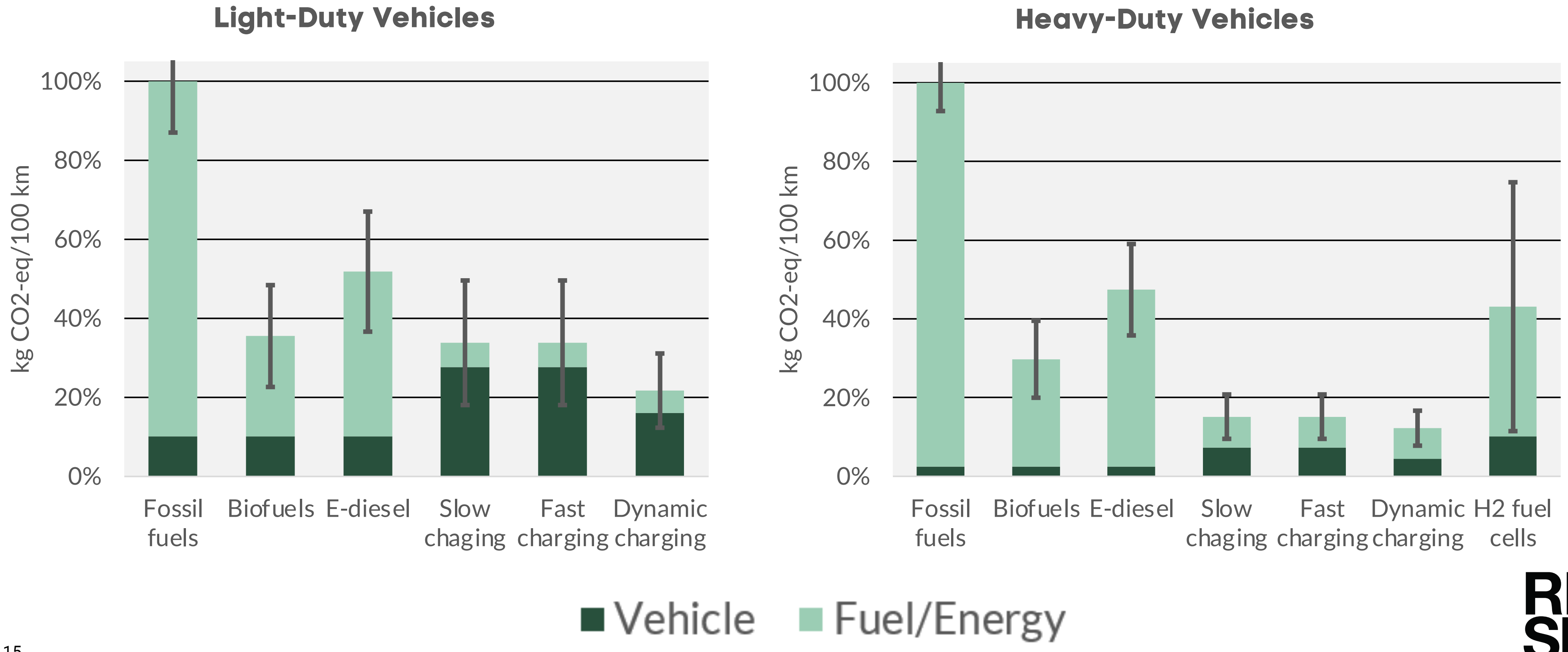
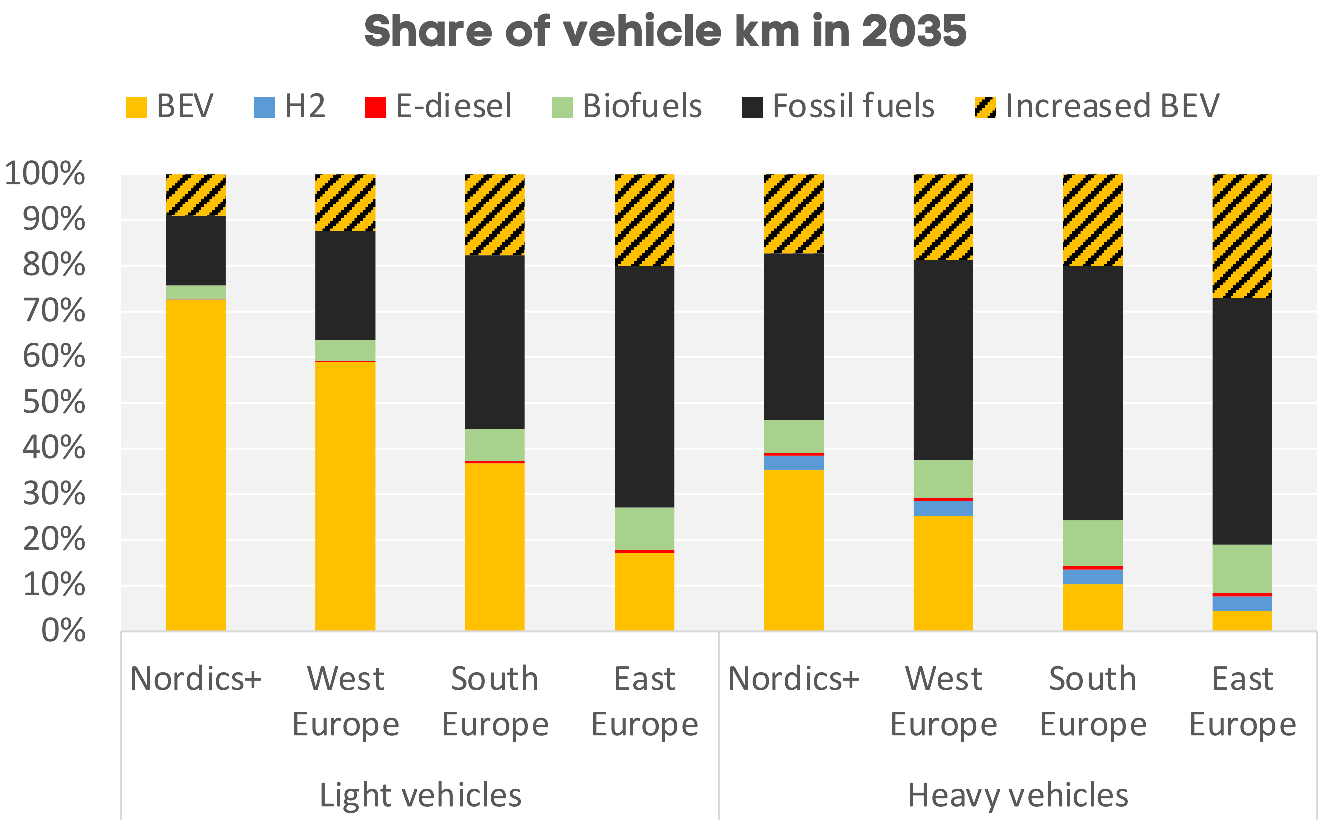
Cost Savings Potential by 2035



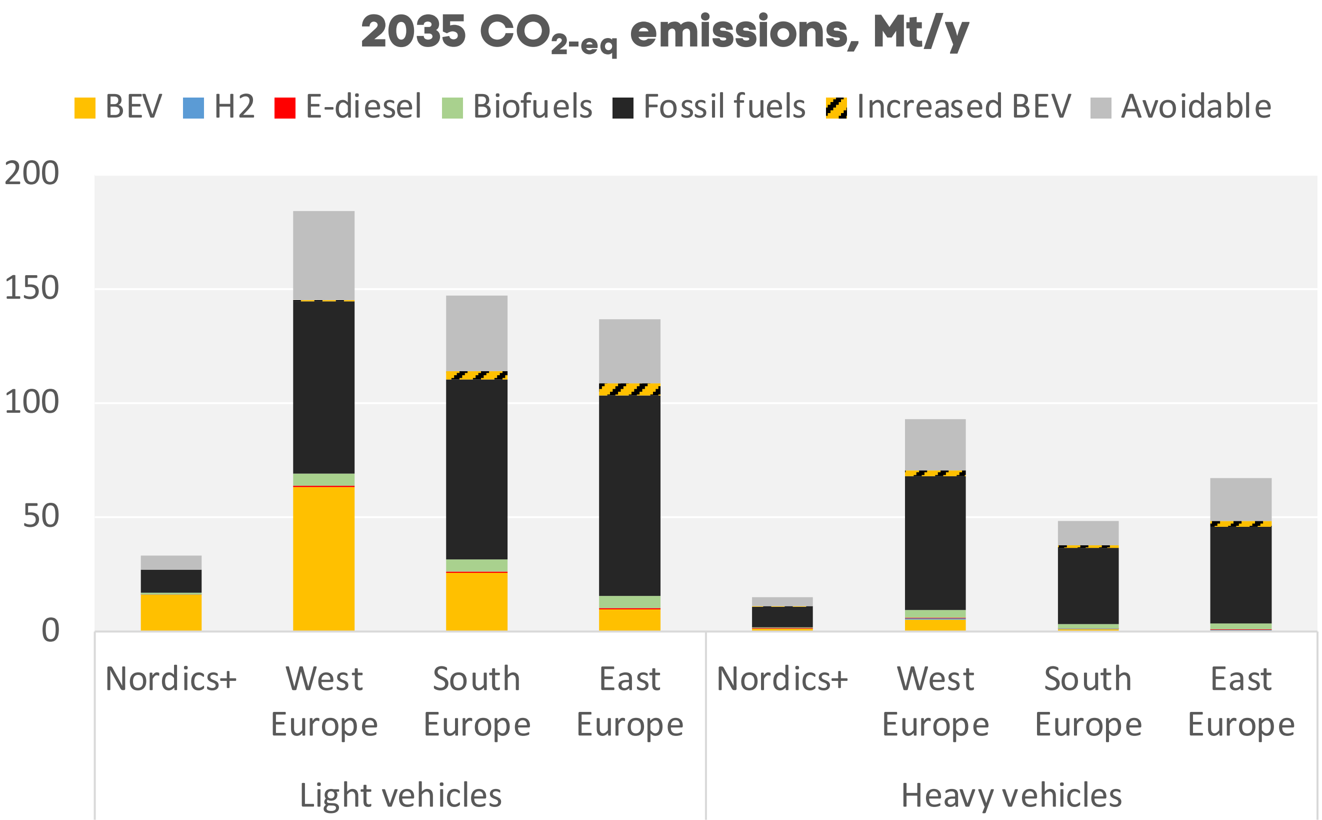
GHG intensity by 2035



Combined Impact Potential by 2035



GHG Emission Sources in 2035



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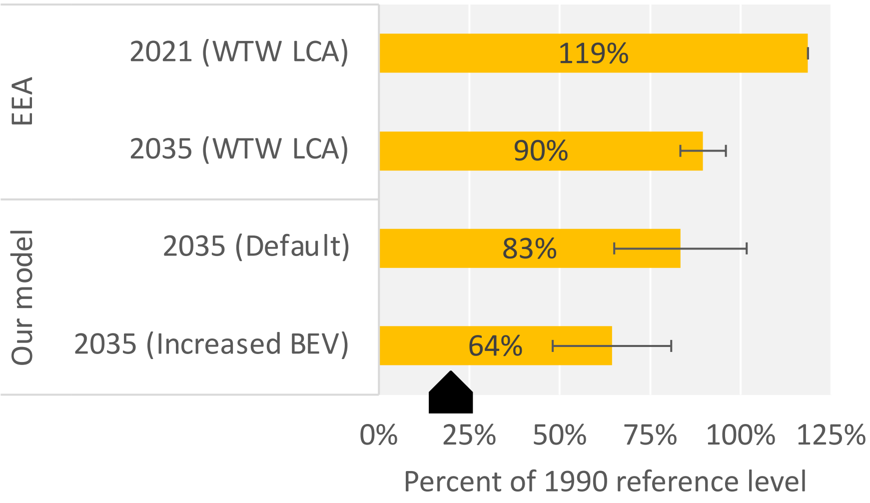
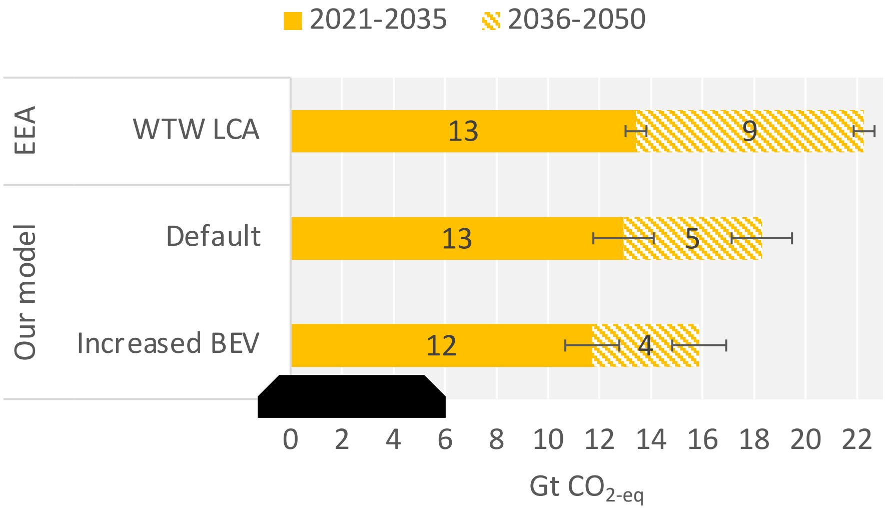
Total GHG Emissions

Annual GHG emissions from EU-27 road transport



Remaining cumulative GHG emissions from EU-27 road transport



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Summary

- Expect no additional GHG reductions by 2035 from biofuels, hydrogen or e-fuels
- Expect GHG and cost reductions from direct electrification
- Light-duty batteries pose a challenge
- ERS would increase electrification, and further reduce BEV emissions (light-duty) and cost (heavy-duty)
- We need ICEV to BEV conversions – requires ERS?

- ERS by 2030 is very challenging, due to political resistance and bureaucratic inertia
- Transport demand reduction is very difficult
- Reaching 2035 annual GHG reduction target would require 100% ERS BEV in all EU regions
- No way to stay within remaining cumulative GHG budget

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