Potential of Light Electric Vehicles (LEVs) to Reduce Car Trips and Greenhouse Gas Emissions

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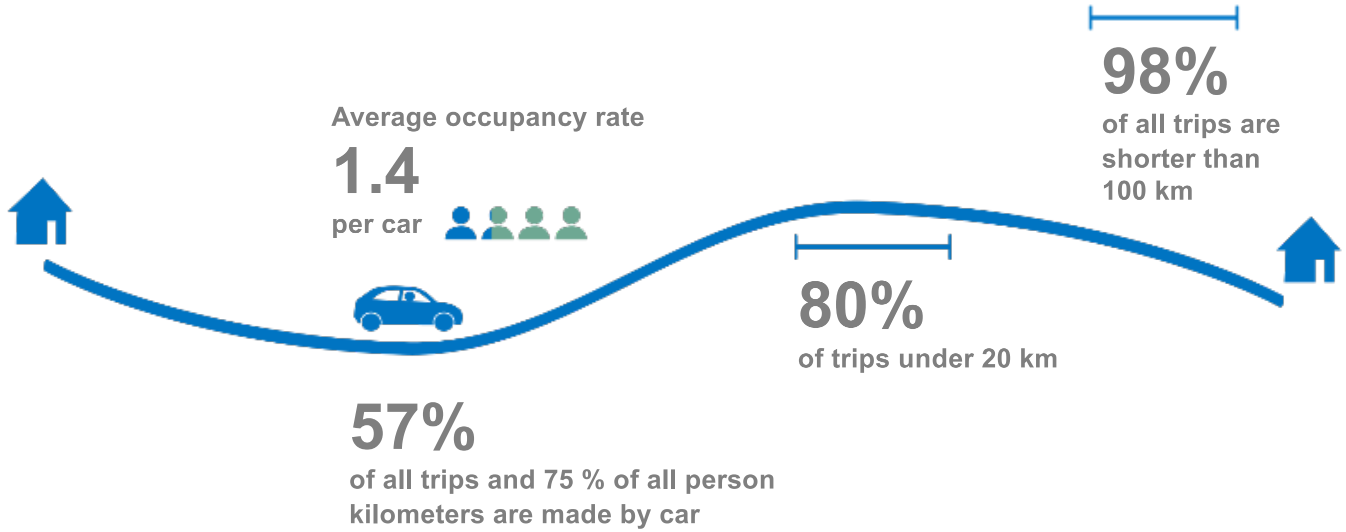
How do people move today - what are characteristics of today's car trips?

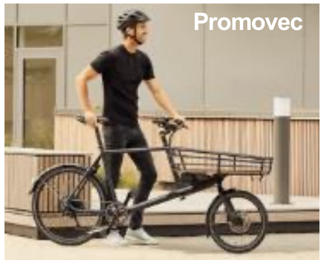
The **car is still the dominant means of transport** in the everyday lives of Germans. In most cases, only one or two persons are in the car and the **distances traveled are often short***:



* All Data: BMVI, n. d.

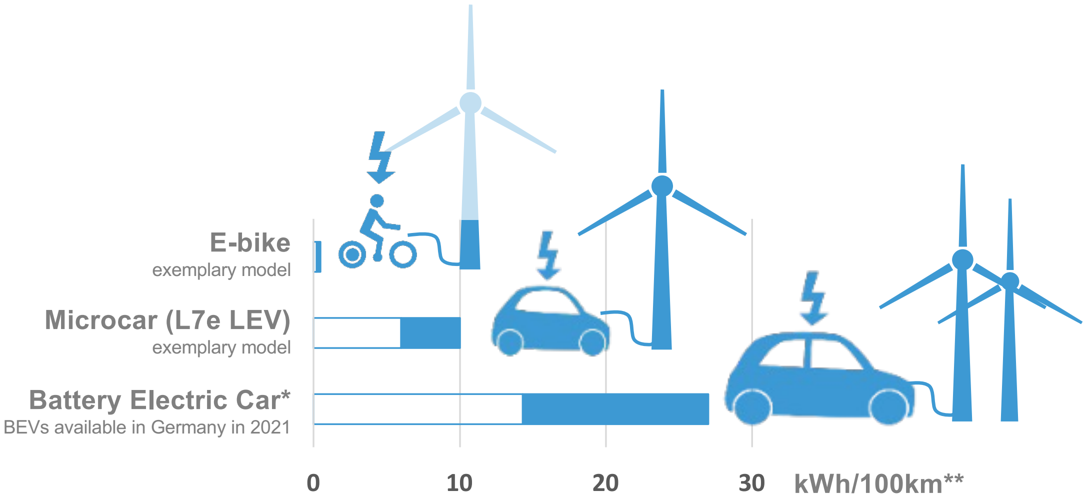
What is an LEV and what kind are available today or will be soon?

The market offers a wide range of Light Electric Vehicles (LEVs) - from electric scooters to 4-wheelers. There are models with and without cabin, with no, one, two or more seats, with top speeds over 100 km/h and with different requirements in terms of age and driver's license possession.

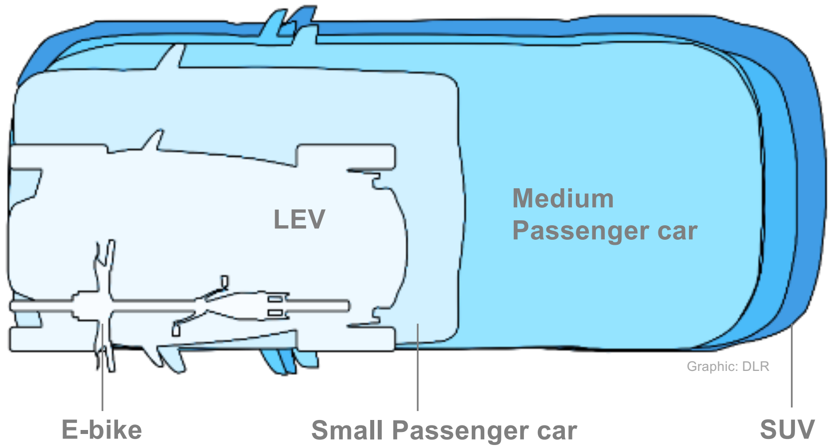


Sources: source in each case is the manufacturer indicated on the picture, except for Citroen: https://commons.wikimedia.org/wiki/File:Citro%C3%ABn_Ami_2020_(2).jpg
And Aixam: https://commons.wikimedia.org/wiki/File:Aixam_e-Coupe,_Paris_Motor_Show_2018,_IMG_0219.jpg

Why could trips with LEVs be more sustainable than with Passenger Cars?



Lower energy consumption – fewer power plants



Small footprint liberates space

** KBA 2021

Research Questions:

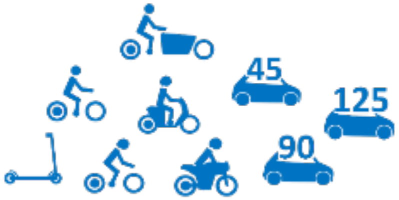
To what extent might LEVs substitute car trips?

How much CO_{2eq} might be saved with LEVs?

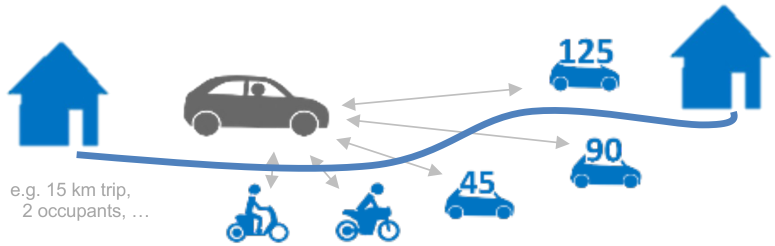
Study Approach

Graphic: DLR

Study Approach



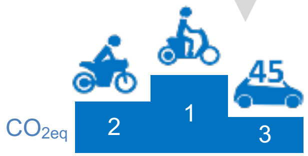
Which LEVs are considered?
Definition of exemplary set of LEVs and analysis criteria for trip substitution



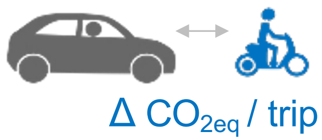
Which car trips can be substituted with which LEVs?
Analysis of car trips reported in a representative national travel survey on an average day regarding substitutability with LEVs (Germany)

How many trips / vehicle km can be substituted?
Amount of substitutable trips and according vehicle mileage

How much are the life cycle emissions per LEV type?
Determination of CO_{2eq} emissions of LEVs and cars



Which LEV suitable for trip substitution has the lowest emissions?
If several LEVs are suitable for trip: choice of the LEV with lowest CO_{2eq} emissions

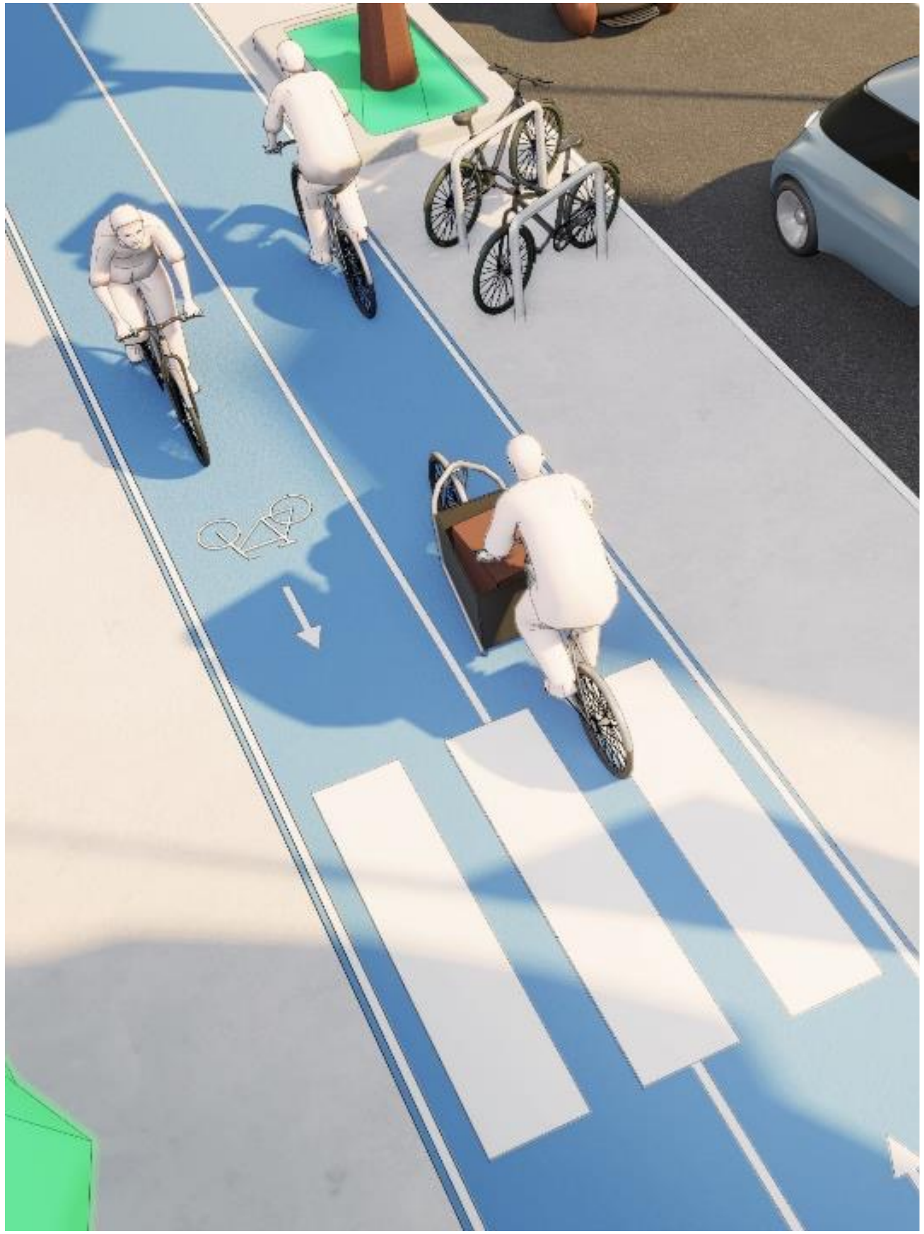


How many CO_{2eq} can be saved per trip?
Difference of CO_{2eq} emissions between a car and an LEV trip
(emissions per km times trip length, 2030 scenario, Germany)

How many CO_{2eq} can be saved?
Calculation of overall CO_{2eq} emission saving potential per trip, aggregation of all trips, upscaling for one year for Germany

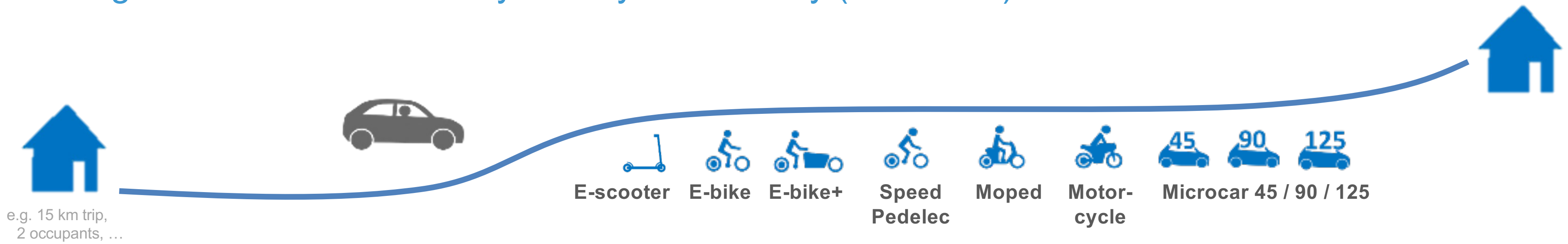
Changes in mobility behavior, social acceptance, as well as political measures are not modelled.

Trip Substitution Potential



Methodological approach to identify the LEV trip Substitution Potential

Basis: large-scale National Mobility Survey in Germany (MID 2017)



Criteria	Exemplary trip reported in the MID 2017	E-bike E-bike is used here to explain our methodological approach	check
Trip length	8 km (one-way)	Up to 15 km (single trip), up to 30 km round trip	✓
Trip purpose	Commuting	All trip purposes, excluding: • Accompaniment • Some shopping and professional trips	✓
Age (driver)	59	18 – 70 years	✓
Weather	Snowfall	Without heavy rain, snowfall, or icy roads	x
Impairments	None	Only people without any health or mobility impairments	✓
Number of persons	1	1	✓

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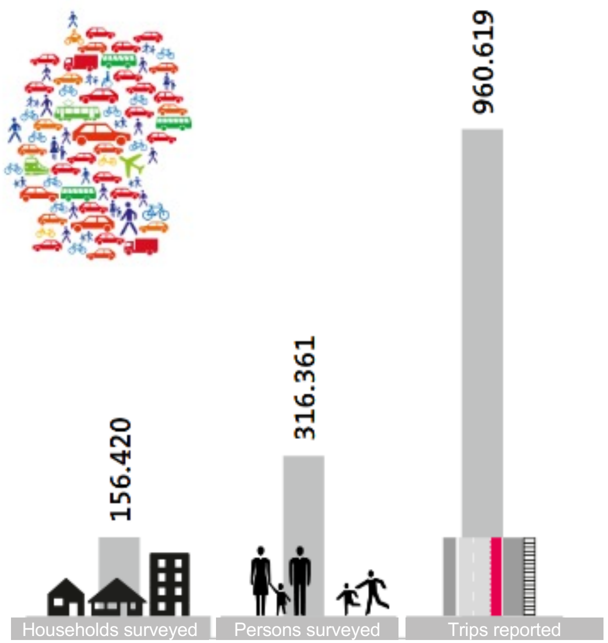
Data base to identify the substitution potential of current car trips



Studie Mobilität in Deutschland 2017, final report

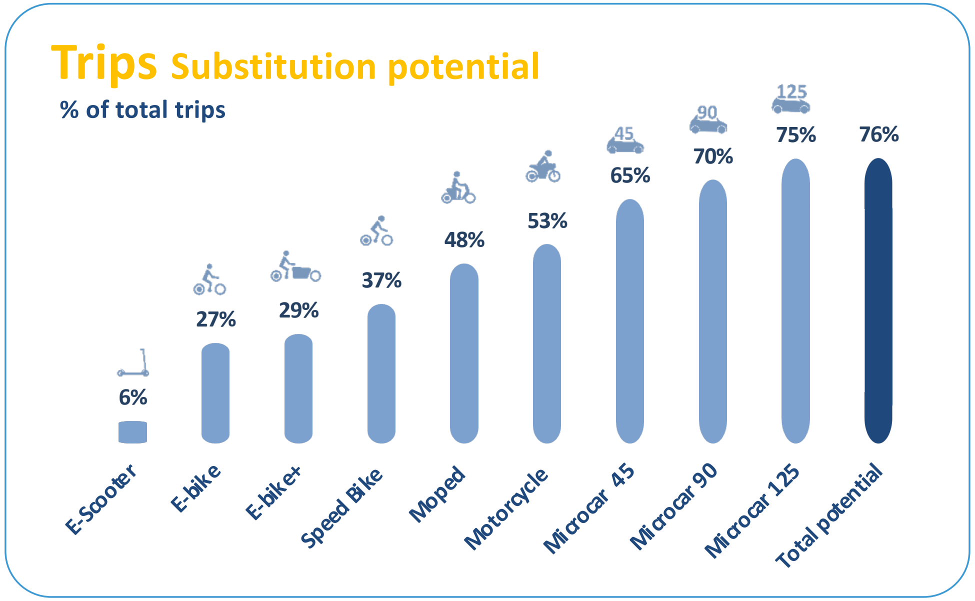
Mobility in Germany / „Mobilität in Deutschland“ (MiD)

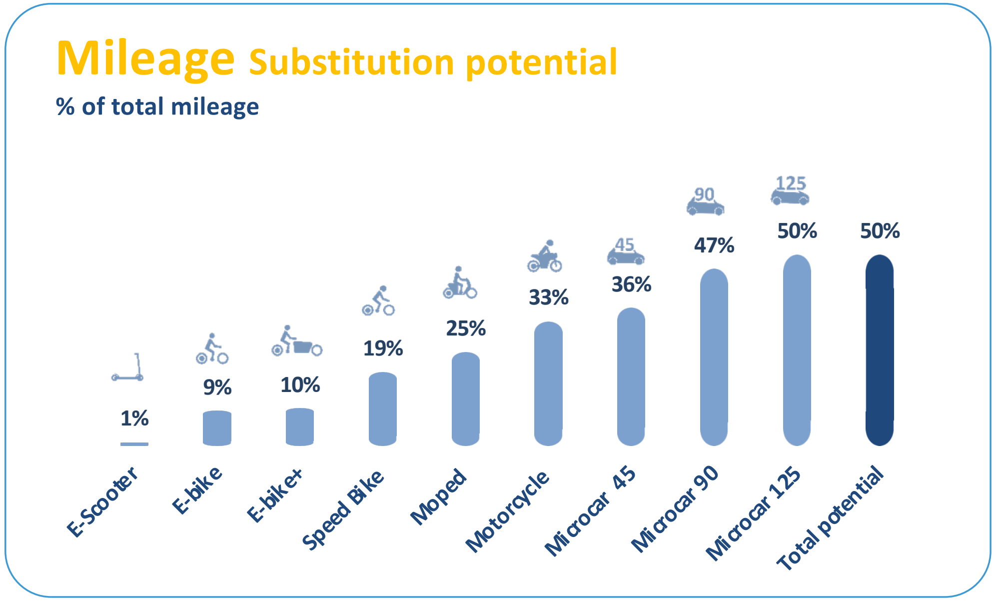
- German national travel survey
- Conducted 2002, 2008 and 2017; planned for 2023

MiD 2017

- Field phase: May 2016 – September 2017
- Surveyed approximately 960k trips by 316k people from 156k households
- Dataset also records household, personal, trip and car information
- Trip information includes e.g., trip length, trip purpose, modes used, weather, number of passengers, average speed, starting point
- Weighting and extrapolation factors available: enable calculation of representative figures for day-to-day mobility of German resident population during the survey period

Results: Substitution Potential (% of possible trips and mileage)

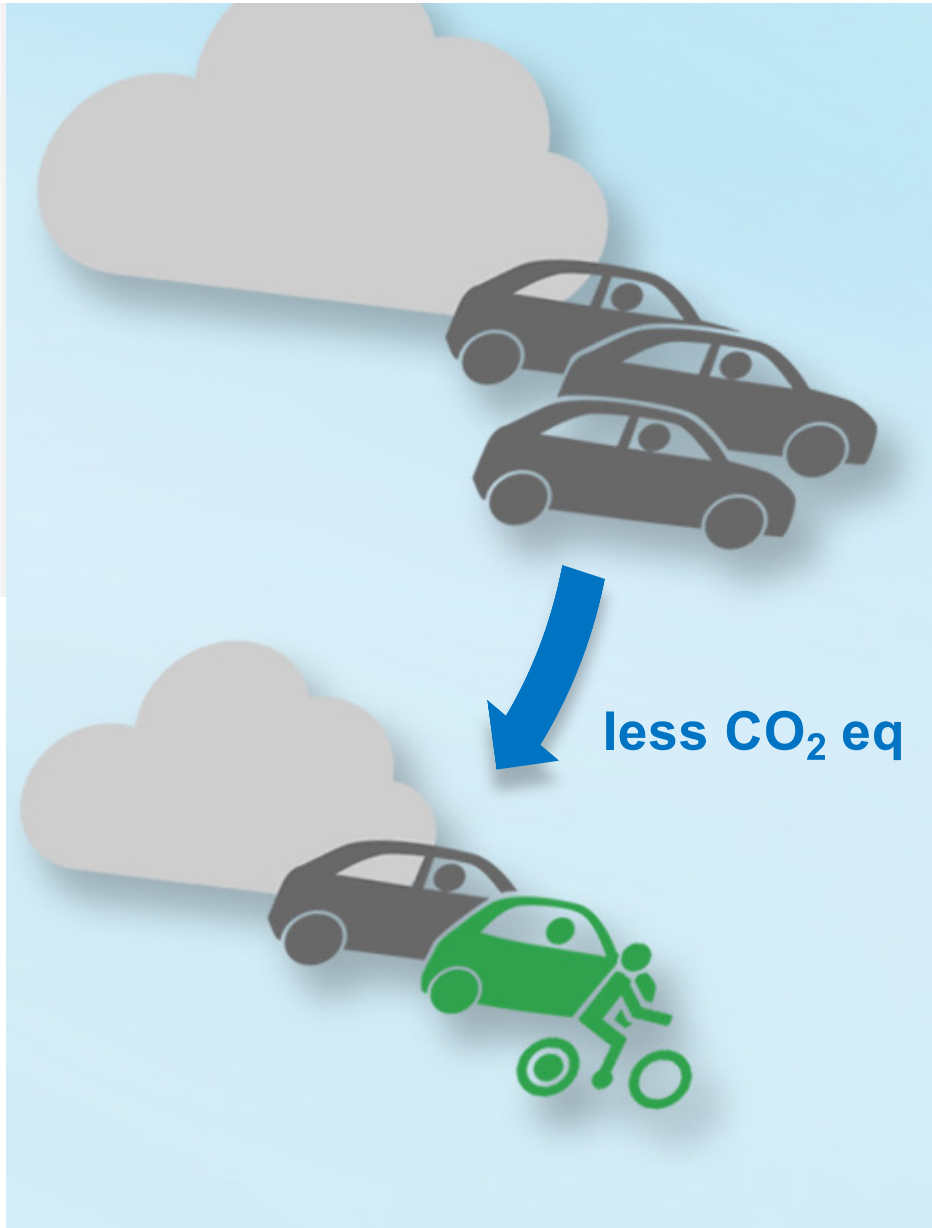




Note: In many cases, trips are not only substitutable with one LEV category, but with several.

Trip substitution potential might seem high – but considering **80 % of the trips are less than 20 km**, **98 % less than 100 km (corresponds to 75 % of mileage)**, the result is plausible.

Emission Reduction Potential

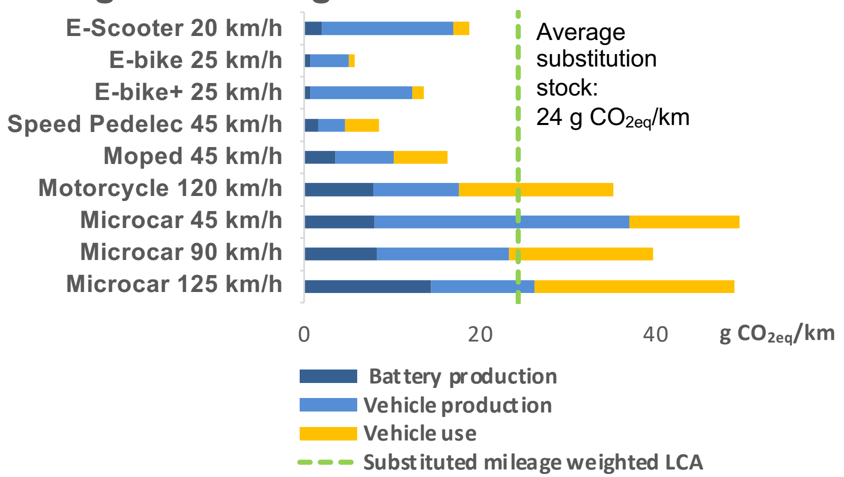


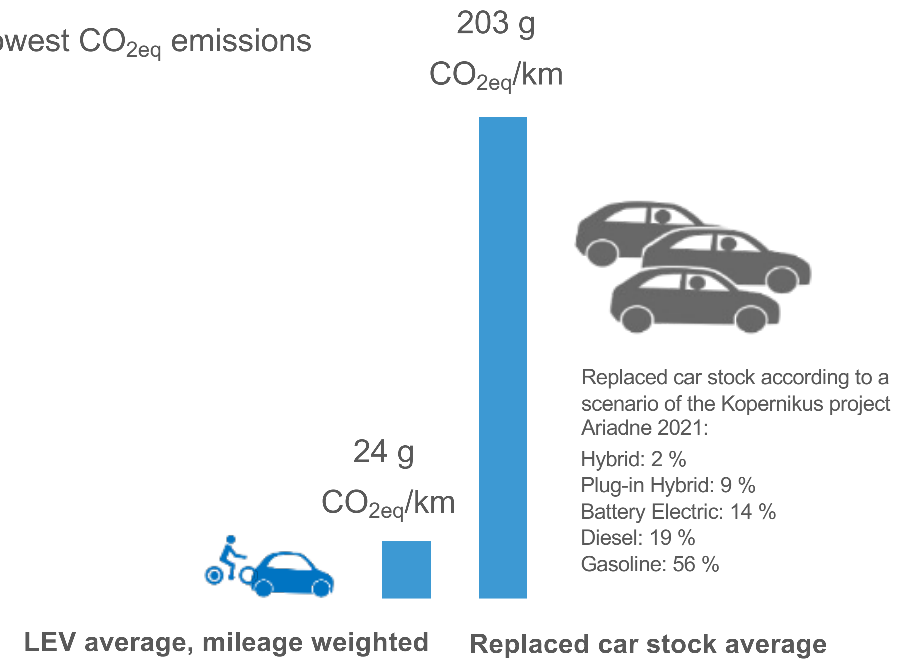
Life Cycle Emissions per kilometer – LEVs and replaced cars

Calculation of "well to wheel“ emissions for both LEVs and cars:

- ✓ Vehicle production emissions, including battery production
- ✓ Energy generation emissions* / Fuel production emissions
- ✓ Emissions of fuel combustion during operation (for the share of replaced passenger cars with combustion engines)
- ✓ If several LEVs are suitable for trip substitution: choice of the LEV with lowest CO_{2eq} emissions

LEV greenhouse gas emissions





*Scenario with 228 gCO_{2eq}/kWh (present day 450 gCO_{2eq}/kWh)

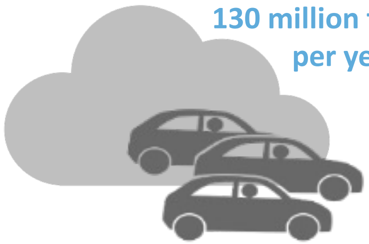
Greenhouse Gas Emission Reduction Potential by LEV Substitution

CO_{2eq} emissions before LEV substitution

50 % of mileage substituted with LEVs →

CO_{2eq} emissions after LEV substitution

130 million tonnes per year



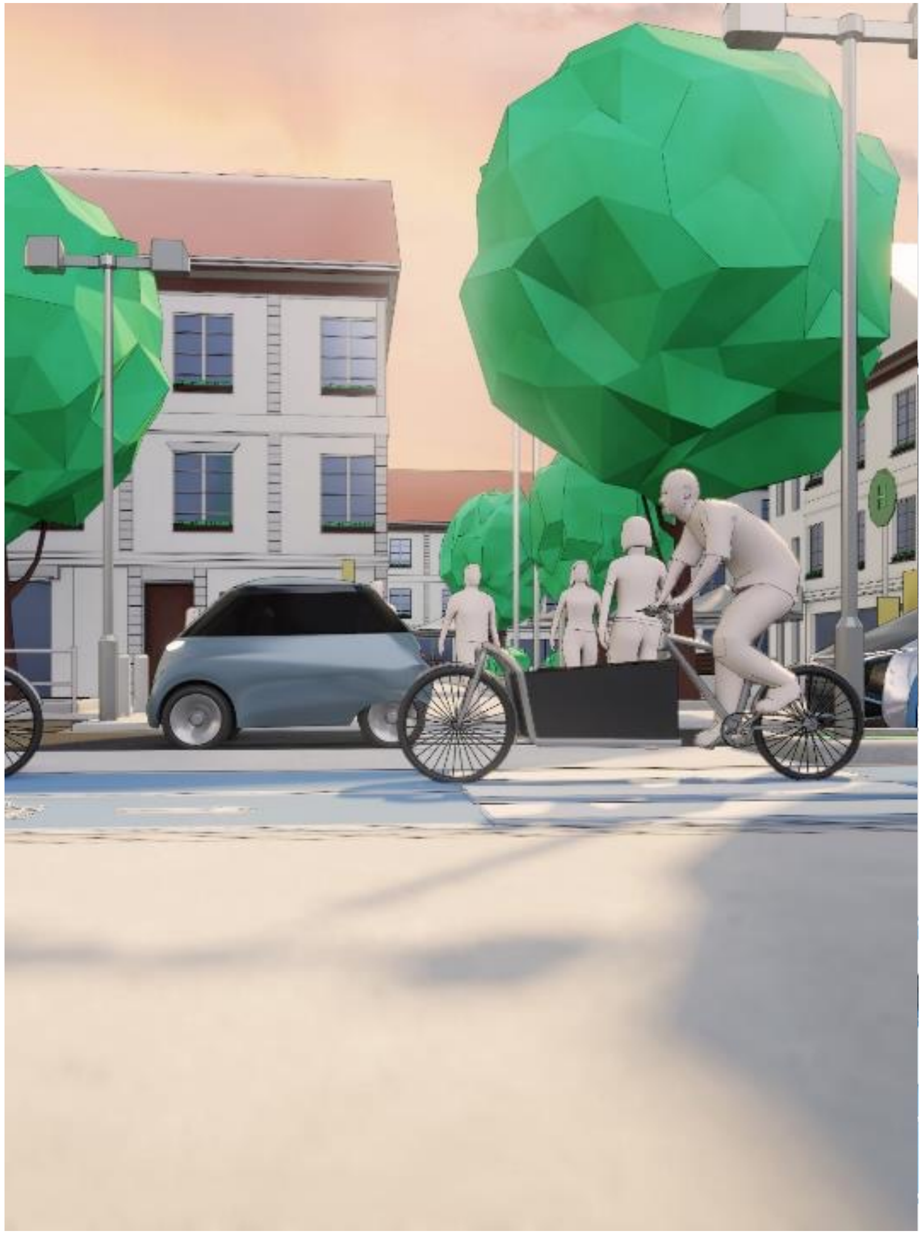
44%

Emission reduction potential, 57million tonnes CO_{2eq} per year

73 million tonnes per year

- **Changes in mobility behavior, social acceptance, as well as political measures are not modelled.**
- **Without profound changes in many fields, LEV's potential will not be extensively realised.**

Summary, Discussion, Conclusion



Conclusion

- LEVs are **a sustainable mobility option** with lower emissions in production and operation compared to cars
- Many car trips (76 %) and a high **share of car mileage (50 %)** could be substituted
- Car substitution offers a large emission **saving potential of up to 44 % less CO_{2eq}** (operation and vehicle production)
- Study shows a **theoretical potential – not considering LEV acceptance**. If it shall be realized, measures to promote LEV must follow: framework conditions for an attractive and safe use of LEVs, supported by detailed research on social aspects, acceptance issues and with technological development, etc. (not part of this study)
- A holistic approach for a sustainable mobility system is necessary: with LEVs, public transport, walking, cycling etc.

Graphic: DLR

The potential of LEVs to support climate change mitigation is significant.

Without profound changes in many fields, LEV's potential will not be extensively realised.

Need for further research / Questions for the discussion

- What factors and specific changes are necessary to realise a significant proportion of LEVs' emissions-reduction potential?
- What adjustments must be made and what obstacles removed to increase acceptance and use of LEVs?
- How can transport systems and vehicles be designed to maximise LEV safety?
- What opportunities would extensive LEV adoption offer in urban planning?
- How can adoption of LEVs be accelerated?

LEVs also promise considerable advantages beyond reducing emissions, for example increasing quality of urban life.

Study available: https://www.dlr.de/content/de/downloads/2022/lev-studie.pdf?__blob=publicationFile&v=1
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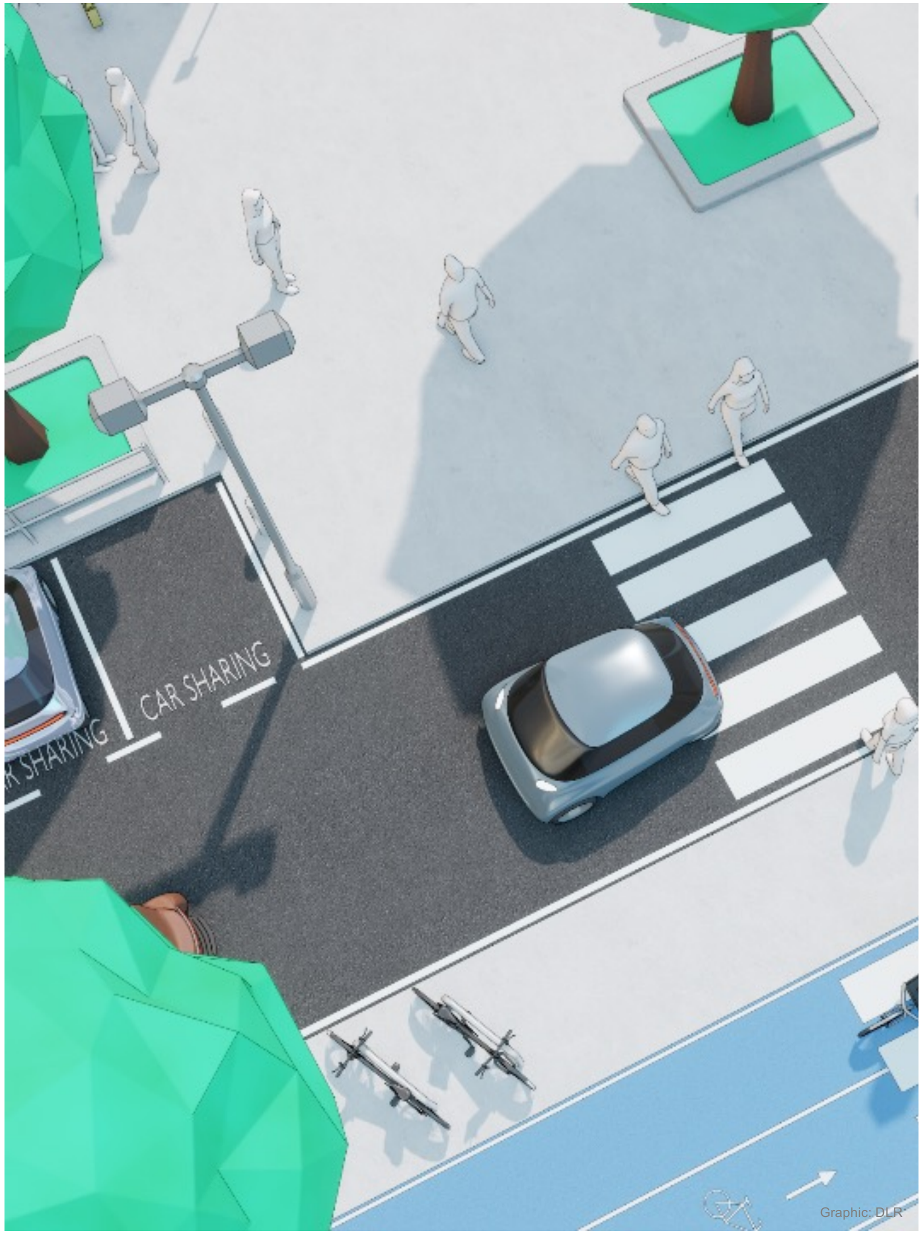

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LEV Categories for the Analysis

Regulation (EU) No 168/2013*

E-scooter	E-bike	E-bike+	Speed Pedelec	Moped	Motorcycle	Microcar 125	Microcar 45	Microcar 90
			L1e	L1e	L3e	L5e	L6e	L7e

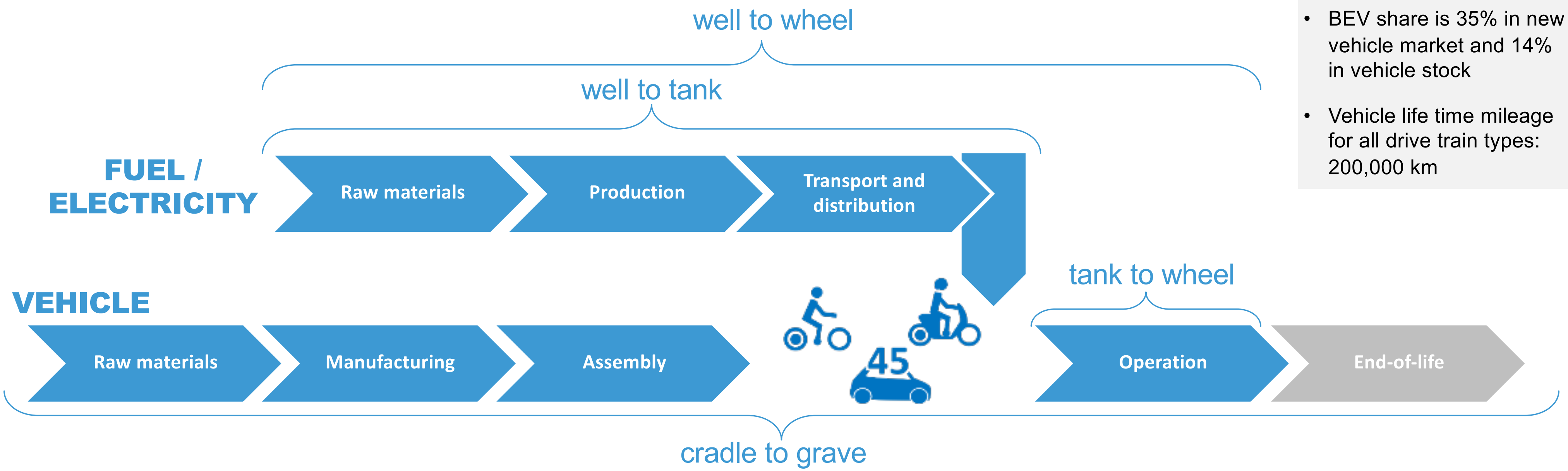
The number behind the name indicates the top speed of the exemplary model. The maximum design speed is limited by law to 45 km/h for category L6e, to 90 km/h for category L7-e** and is not limited for category L5e.

For each category, an exemplary LEV model that is (soon) available on the market serves as basis for definition of technical parameters. These parameters are needed for evaluation of trip substitution potential and emission reduction.

*Regulation (EU) No 168/2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles
See attachment

Methodological Approach: Assessment of Carbon Footprint

- Assessment of greenhouse gas emissions from production and use of different vehicles
- Definition of typical vehicle characteristics in terms of:
  lifetime mileage, electricity consumption, battery capacity, vehicle weight, electricity mix, material mix
- Basis for calculation of overall potential of emission reduction by substituting trips with LEVs using results of the trip analysis

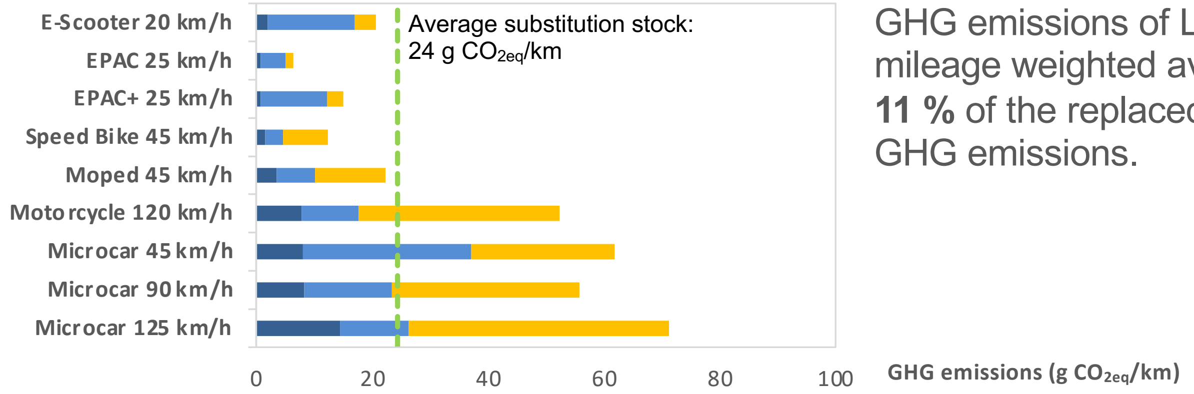


Passenger Cars

- Passenger car market: Trend scenario for 2030*
- ICE vehicles still dominate vehicle stock
- BEV share is 35% in new vehicle market and 14% in vehicle stock
- Vehicle life time mileage for all drive train types: 200,000 km

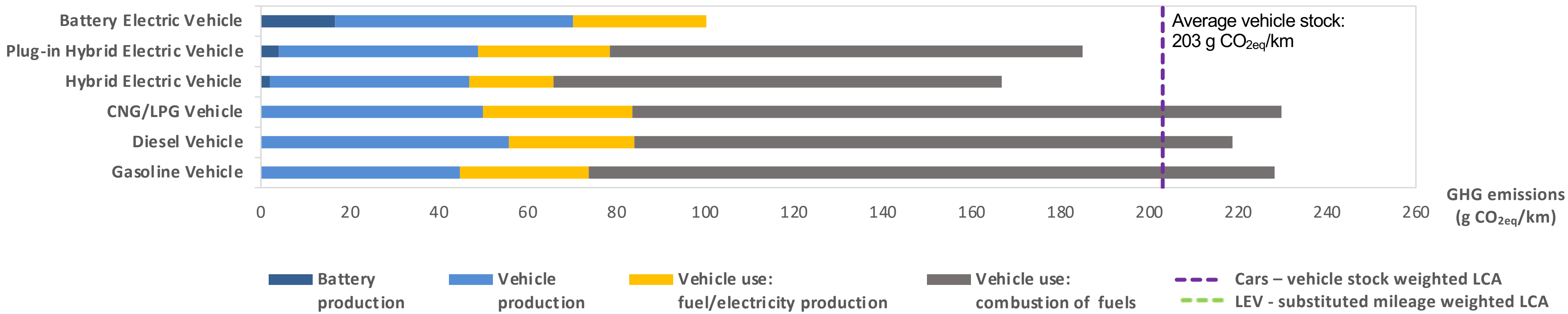
Results: Life Cycle Emissions per Kilometer

LEVs



GHG emissions of LEVs (substituted mileage weighted average) are only **11 %** of the replaced passenger car GHG emissions.

Passenger cars



Results: Greenhouse Gas Emission Reduction Potential by LEV Substitution

CO_{2eq} emissions before LEV substitution

130 million tonnes per year

CO_{2eq} emissions after LEV substitution

73 million tonnes per year

44% Emission reduction potential contributed by

- Overall saving is **44%** of entire passenger car emissions before substitution
- Achieved with **50 %** of mileage substitution

In absolute numbers:

- 157 kilo tonnes CO_{2eq} per day reduced from 356 kilo tonnes CO_{2eq} per day without substitution
- This is equivalent to a reduction of 57 Mio tonnes CO_{2eq} per year

Summary and Discussion

- **44 % less CO_{2eq}** could in theory be emitted by replacing three quarters of German trips and half of miles currently driven in conventional motor vehicles, saving 57m tonnes CO_{2eq} per year.
- This represents just over 1/4 of the sector emissions reduction target and, for each substituted trip, in average a 96 % emissions saving.
- This figure is sufficiently high to suggest that further research into LEV potential is likely to be worth pursuing.
- This does not take into account any social, political, LEV acceptance or mobility behaviour changes.

Graphic: DLR

Discussion

- **Plausibility:** 75 % trip substitution potential might seem high first glance, but considering that 80% of the trips are less than 20 km, the result is plausible.
- **Realisation of potential:** achieving even part of this potential will require fundamental changes to encourage a switch away from long-standing mobility habits, including push and pull measures.
- **Private car replacement:** the study does not examine possible changes of the vehicle stock and whether individuals would be willing to replace their car, further research is needed.
- **LEVs and other paths to sustainable mobility:** many approaches must work together, LEVs as one building block in the approach

Avoid – Shift - Improve

Conclusion and Outlook

The potential of LEVs to support climate change mitigation is significant. This promise suggests further investigation of their wider social, ecological, economic, safety and planning implications is urgently called for.

Need for research:

- What factors and specific changes are necessary to realise a significant proportion of LEVs' emissions-reduction potential?
- What adjustments must be made and what obstacles removed to increase acceptance and use of LEVs?
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