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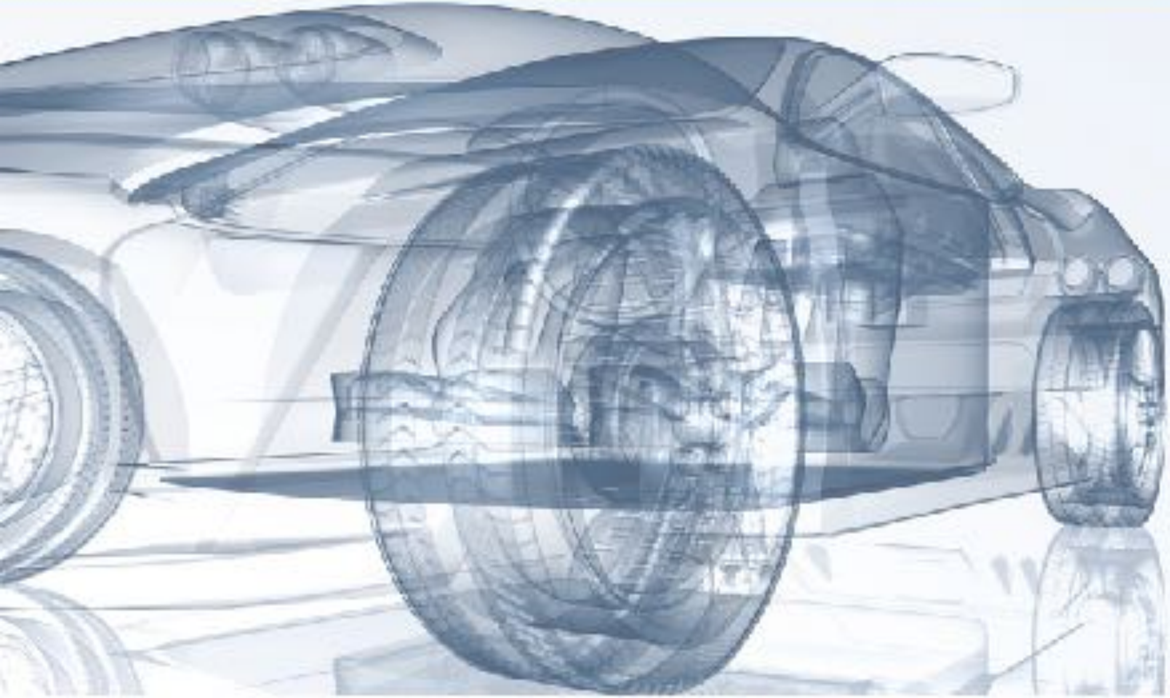

The 30th International Electric Vehicle Symposium & Exhibition

October 9–11, 2017

Messe Stuttgart, Germany

www.evs30.org

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Life cycle assessment of electric vehicles in commuter traffic - field test results of the project RheinMobil

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Content

- *Environmental aspects of E-Mobility: questions in public discussions*
- *Case study on commuter traffic: results from RheinMobil fleet testing*
- *Discussion and outlook*

Environmental performance EVs -Questions in public discussions

Are electric vehicles (EV) worse or environmentally friendlier than vehicles with combustion engine (ICEV)?

Environmental impacts of the production phase of EVs are higher than for ICEVs,

- ***but magnitude depends on vehicle model, concept, technology and sizing of power train components (e.g. battery system)***

Use phase compensates higher impacts of production,

- ***but this depends on specific boundary conditions, e.g. use context, user behavior, charging electricity mix, mileage, etc.***

Recycling in the end of life could support securing long-term supply of required materials,

- ***but take back systems and specific recycling / reuse schemes have to be applied and established in time. First estimates on recycling processes are available, but have to be validated in commercial scale.***

Environmental performance EVs -Questions in public discussions

Are electric vehicles (EV) worse or environmentally friendlier than vehicles with combustion engine (ICEV)?

➢ ***Life Cycle Assessment is an appropriate tool to address this issue***

Reliable statements require

- ***Documentation: Transparency of explicit boundary conditions***
- ***Case studies for validation of realistic and suitable fields of use for EV***

RheinMobil Project

Results of the
Life Cycle Assessment

RheinMobil – Project introduction

Goal:

- ***Demonstrating the feasibility of substituting ICEV with BEV in commercial applications with a high annual mileage in a long-term field-test between France and Germany***

Applications (fixed routes, mostly inter-urban)

- ***Commuting of shift workers***
- ***Business trips between two production sites***

Project Duration:

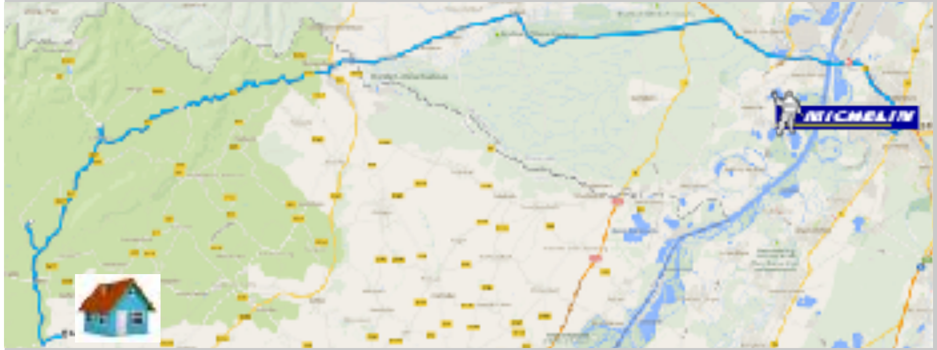
- ***2013–2015 (First BEVs on the road since April 2013)***

Key Figures:

- ***7 BEV (e-Wolf Delta 2 / Delta 2 (EVO), 1 Nissan Leaf)***
- ***Average monthly mileage per BEV > 3,000 km***
- ***Regular use of DC fast charging***

Sources: Michelin Karlsruhe Public Relations, Siemens Karlsruhe Public Relations

Commuting traffic (example route)



BEV	Delta 2
Number of people	≤ 7
Average speed	56 km/h
Distance (one-way)	65-80 km
Max. elevation difference	361 m

RheinMobil – LCA Results of commuting traffic

Production Phase

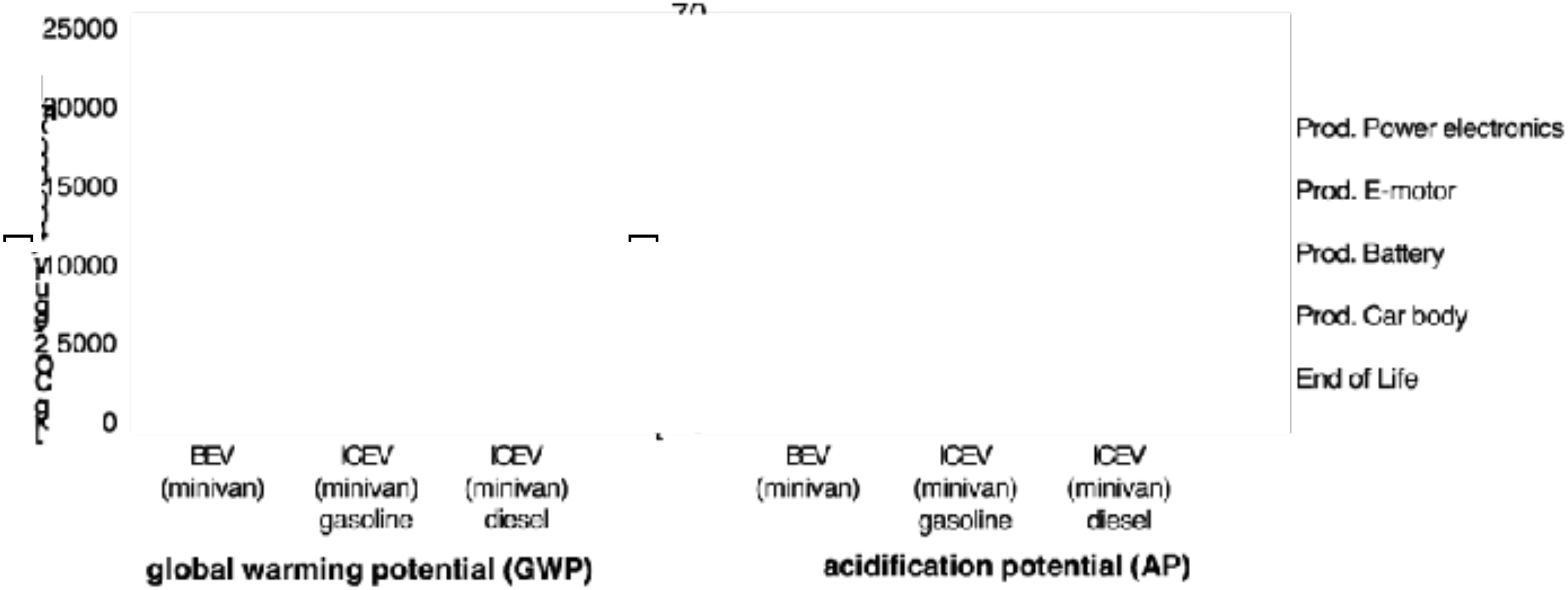
Analyzed vehicles (minivans)	
Battery electric vehicle (BEV):	*~1,700kg, 24.2kWh Li-NMC battery (~250kg)*
Gasoline vehicle (ICEV, gas):	*~1,360kg*
Diesel vehicle (ICEV, diesel):	*~1,400kg (based on estimate of comparable model)*
Vehicle LCA	
• *Based on internal LCA-Screening model of vehicles and power train concepts*	
• *Parameterization allows specific adjustment of material mixes according to technical specifications of vehicle platform and power train components*	
• *GaBi ts Software and databases*	

RheinMobil – LCA Results of commuting traffic

Use phase assumptions

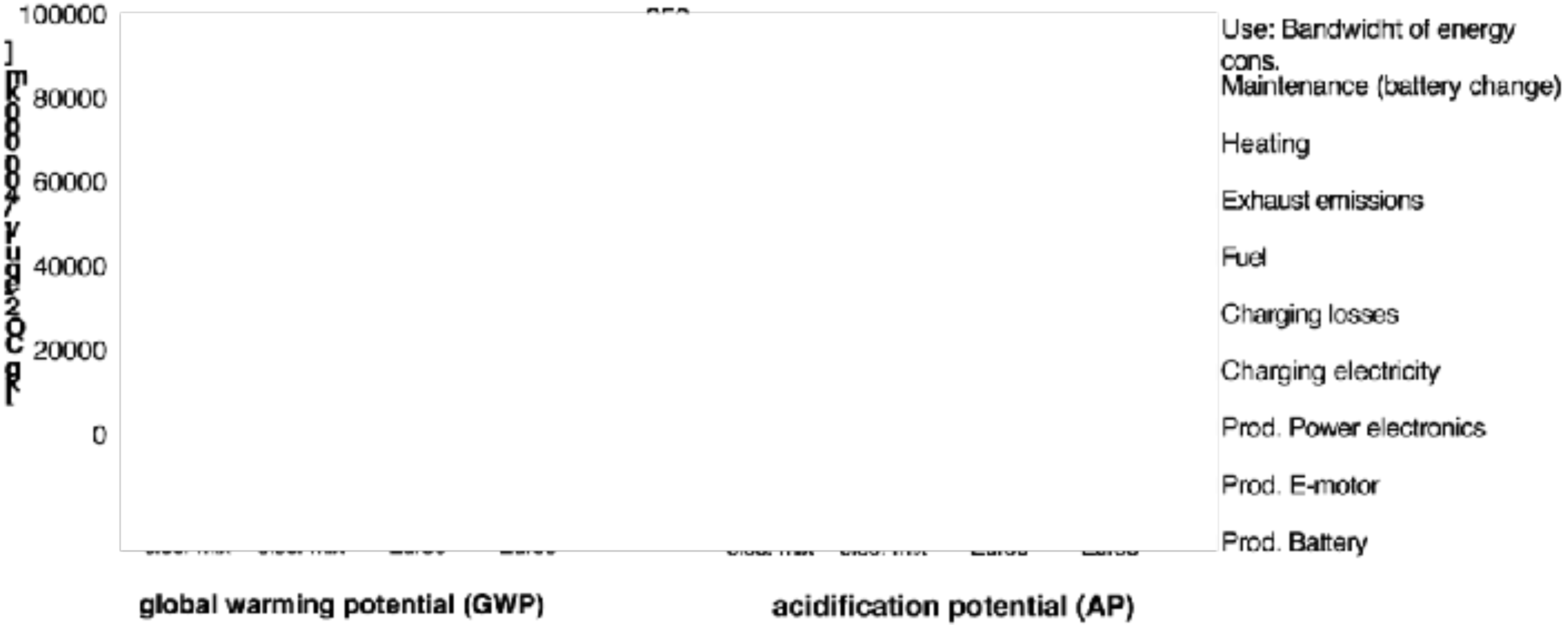
Use profile (minivan in commuter traffic)	
Monthly mileage	~3,000km
Total mileage (12 years lifetime)	~400,000km
BEV	
Energy consumption	23.1kWh/100km (average value, rage from 19.6- 27.1 kWh/100km)
Charging losses	15%
Battery life / maintenance	Change after 200,000km
RheinMobil electricity mix	50%/50% German / French electricity grid mix
ICEVs for comparison	
Gasoline:	8.13 l/100km (measured on field test)
Diesel:	5.5 l/100km (estimate)
Tailpipe emissions: Calculation based on fuel consumption and HBEFA3.2 emission factors	

Production Phase



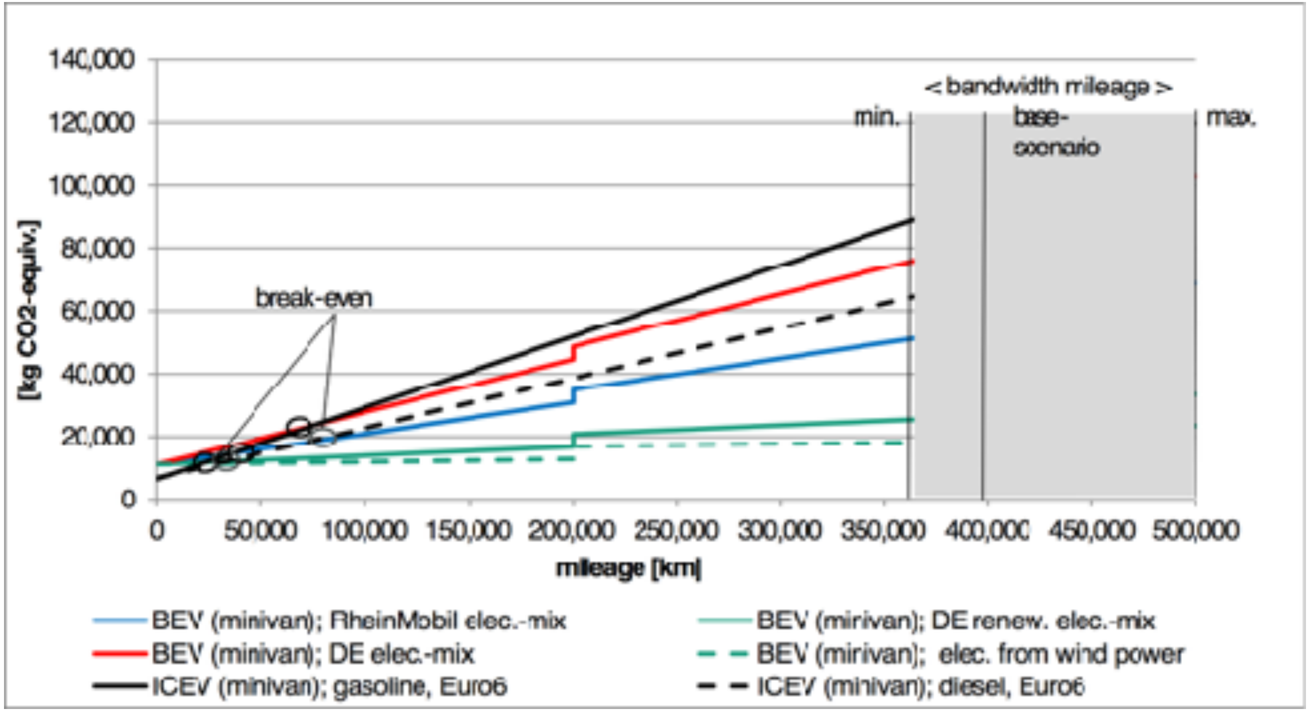
RheinMobil – LCA Results of commuting traffic

Life Cycle: GWP and AP under RheinMobil conditions



RheinMobil – LCA Results of commuting traffic

Use phase: Dependency of electricity mix and mileage (GWP)



Outlook – Future needs to deploy the full potential of e-mobility

Mobility and user behavior will change in the future:

- Requirements for higher flexibility of transportation systems and integration into intermodal mobility
- Reasonable integration of electric vehicles into new mobility instead of „just" substituting conventional vehicles with combustion engine

Requirements

- Decision support of users: Choose vehicles accordingly that fit to their individual utilization profile to avoid over-dimensioning of the battery system (e.g. electrical range, mileage)
- Market offers tailored EVs to satisfy users demands
- Electricity supply for e-mobility contains a high share of renewable power generation from additional installed power plants (avoid a shift of burden)
- Reduce environmental impacts where they occur to avoid a shift of burdens (e.g. rare or critical materials), e.g. recycling systems to increase secondary material shares