LCA OF AUTONOMOUS MINIBUSES IN PUBLIC TRANSPORTATION SYSTEMS

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RESEARCH INTEREST

Initial situation

- Unknown environmental effects of autonomous minibuses in public transportation and their implications for future mobility systems

Research objective

- Assessing environmental impacts of autonomous minibuses in public transportation systems

Background

- This research is one part of the EU Horizon 2020 project 'AVENUE'

METHODS & LIMITATIONS

Methods

- LCA using a mix of theoretical and primary data (see Fig.1)
- Considered guidelines:
  - DIN EN ISO 14040
  - International Reference Life Cycle Data System (ILCD) Handbook (IES, 2010)
  - eLCAr - Guidelines for the LCA of electric vehicles (Althaus et al. 2013)
- LCI database ecoinvent 3.5 in combination with Umberto LCA+ (see Fig. 6-8)

Limitations

- Data uncertainty (missing primary data, etc.)
- Usage data from early innovation stages

Procedure

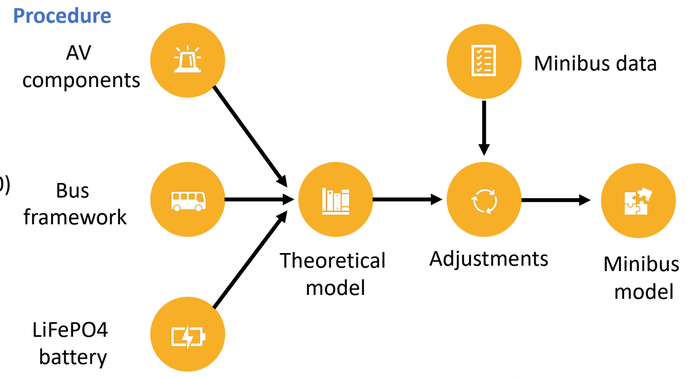


Figure 1: Procedure

GOAL & SCOPE

- one passenger kilometre in short-distance traffic
- production, assembly, use phase, EoL (cradle-to-grave)
- 21 most important components (> 92% of total weight)
- cut-off: 3% of autonomous components
- Europe
- 12-15 years of operation
- climate change, EP, AP, PODP, ADP, ecotoxicity (identified as most frequently used in this particular technology domain)

SYSTEM BOUNDARIES

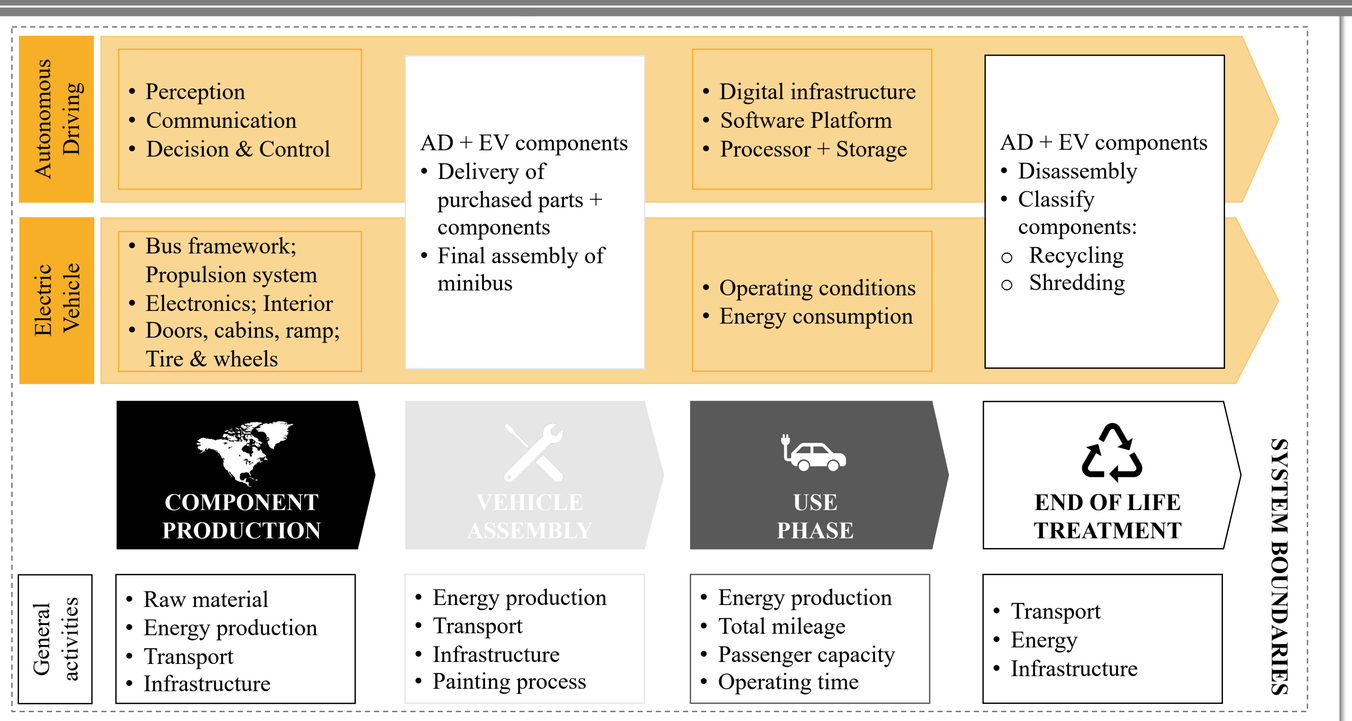
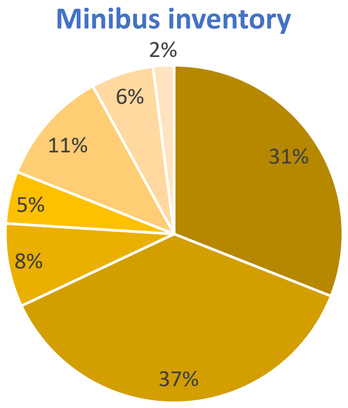


Figure 2: System boundaries

Following: Althaus at al. (2013), Hauschild et al. (2018)

INVENTORIES

Minibus inventory



- Chassis, Bath, Arch
- Steering, Motor, Shock absorber, Variator, Battery
- Harness, AC, Lights, Calcul Unit
- Panels, Screens, Seats
- Doors, Cabins, Ramp
- Tires & Wheels
- Autonomous Components

Figure 3: Minibus inventory

Use phase data

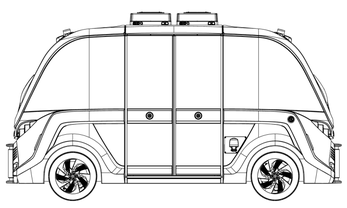


Figure 4: Minibus
33 kWh Li-FePO4 battery
Max. 15 passengers
2,400 kg

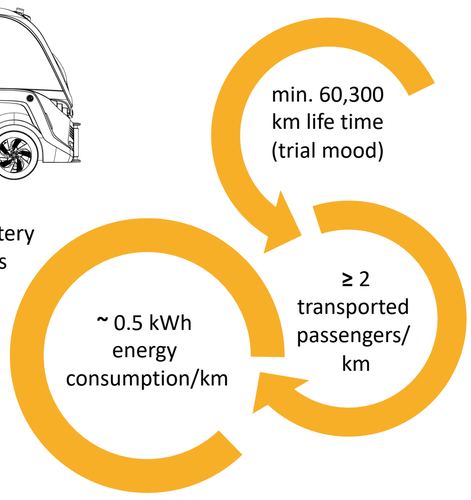


Figure 5: Influencing factors for operation

MINIBUS MODEL

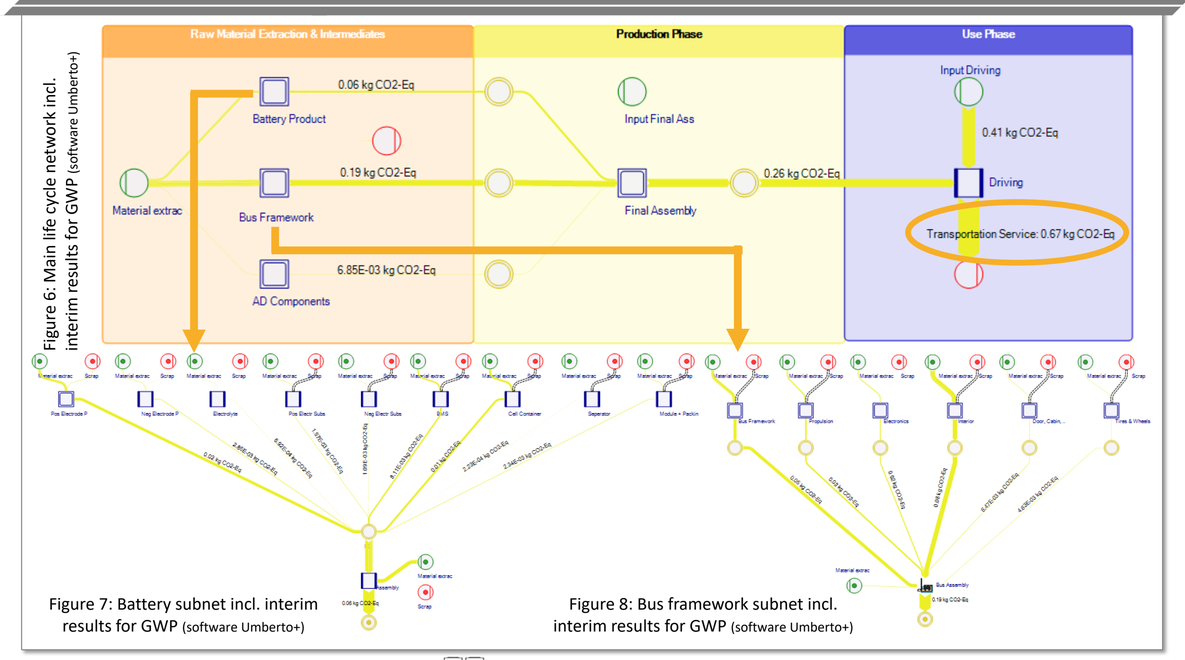


Figure 6: Main life cycle network incl. interim results for GWP (software Umberto+)

Figure 7: Battery subnet incl. interim results for GWP (software Umberto+)

Figure 8: Bus framework subnet incl. interim results for GWP (software Umberto+)

PRELIMINARY RESULTS

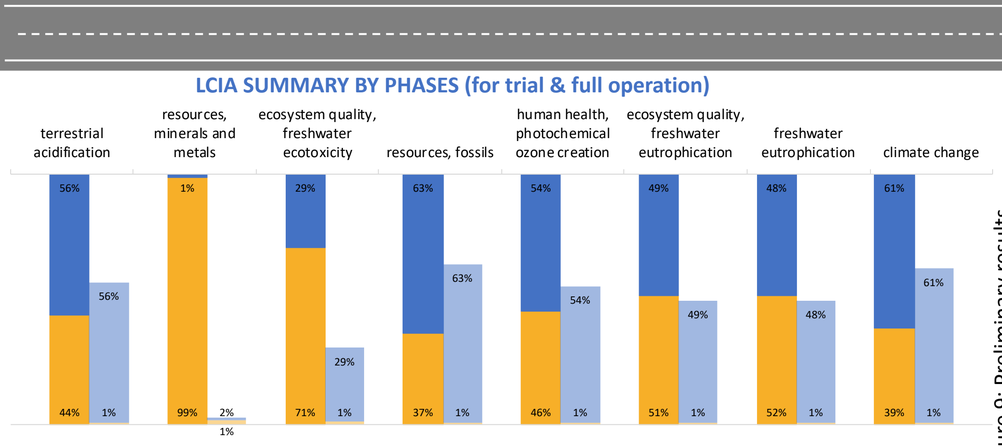


Figure 9: Preliminary results (life cycle phase distribution, trial phase = 100%)

- Major driver is electricity mix (expectable result in electric mobility context)
- Current modelling assumes minimal/trial usage of minibuses (early innovation stage)
- High capacity usage (alternative scenario) shows use phase as dominant life cycle stage and substantially reduced environmental impacts per pkm

CONCLUSIONS

- Contribution of AV technology to results is rather low, but further research still required (e.g., more detailed effects of data transmission).
- LCA challenges and results not too different compared to other electric vehicles (e.g., significance of electricity mix).
- Whether autonomous minibuses are environmentally beneficial depends on their ability to substitute individual motorized transportation.
- Hence, future work within the AVENUE project takes a whole system perspective on future mobility systems in which autonomous minibuses operate.
- Furthermore, results will be integrated into full sustainability assessment incl. economic, social, technical and environmental aspects.

LITERATURE

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