Feasibility of different electrification options
results from a Swiss case study

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Foundation of our analysis: LSVA

Leistungsabhängige Schwer-Verkehrs-Abgabe → EZV tracks all HDV on all Swiss roads

- 52'800 vehicles subject to LSVA
- 99% powered by Diesel
- 35'000 vkm / yr
- 233'266 tkm / yr (= 6.5 t)

Image sources: Eidgenössische Zollverwaltung, blick.ch
LSVA → daily traveling distance of every vehicle in the fleet on every day of the year (plus if and what kind of trailer it towed)

Daily fleet performance

Daily distance by vehicle type

Articulated truck = «Sattelschlepper»

Rigid trucks tend to be lighter than articulated trucks; lighter trucks are used on shorter distances

Usage of the Swiss Heavy Duty Trucks
→ goal: assess the sectorial Energy Demand

- Mobility demand
  - GTE (BFS survey)
    - Movements of goods (type, weight, distance)
   - LSVA (BFS survey)
     - Movements of vehicles (kind, capacity, distance)
  - Performance of vehicles (odometer at given times)
  - Vehicle trip reconstruction procedure

- Vehicle / fleet specs
  - MOFIS (veh. registry)
    - Categorization
    - Trailer specifications
  - Vehicle specifications
  - Vehicle specs

- Vehicle simulation
  - CO₂

- Driving cycle

- FE

- Payload [kg]
Feasibility → energy demand of alternative powertrains
Using heuristics to estimate powertrain configuration of battery electric and H₂ trucks

Glider: unchanged

Replace ICE & gearbox by electric motor of same power, on rear axle

Add batteries until tank volume occupied or total mass > 10% of original
Battery electricifation → cell energy density limiting?

100% electrification on 1 charge / day → outrageous densities + high charging power

With improving battery densities, most vehicles cannot be fully charged in a night with 50 kW.

Higher electrification \(\rightarrow\) recharge during the day

Batteries of many 100 kWh: «fast-charging» not really feasible \(\rightarrow\) swap the entire battery

Battery swapping technology developed for Mercedes LE 206 Buses - 1972\(^2\)

Caveat: influence of weight limitation

Electric trucks only require a maximum permissible weight exemption

Many more options to use this model
Currently under investigation @ ETHZ-LAV

- Hydrogen trucks
- Plug-in hybrid trucks
- Gas trucks (LNG, CNG)
- Electric road systems
- Infrastructure requirements
- Operational variants
- Design constraints
Conclusions

Our contribution: energy carrier substitution → technical feasibility

- Contrary to aviation & navigation → electrification technically feasible
- Several options, all of which require supporting energy infrastructures
- CO₂ reduction potential limited by:
  - severity of specific use cases (range, power, time)
  - technological constraints (e.g. battery cell energy density)
  - regulatory constraints (maximal permissible weight)
  - energy infrastructure constraints (e.g. charging power)
  - gray emissions in energy chain (electricity mix) and production (battery)

The core issue: should we do it?

- Chicken & egg → who finances what infrastructure / technology and why?
- Many alternatives → substitute e.g. to rail (electrification already complete, at least in CH)
- Relevance → international perspective (larger growth, international players, …)