Design Project – SIE 2022

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Analysis and optimization of the use of electric vehicles in the distribution sector of the Swiss Post

Introduction

- To achieve carbon neutrality in the delivery sector, the Swiss Post changes from internal combustion engine vehicles (ICEVs) to battery electric vehicles (BEVs) for packaging delivery
- Objectives:
  - ➢ Life cycle assessment (LCA): comparison of current (ICEV) and future state (BEV)
  - ➢ Analysis and optimization of the charging process of BEVs
  - ➢ Case study of the distribution center of Geneva: data analysis and future electricity consumption

Life Cycle Assessment

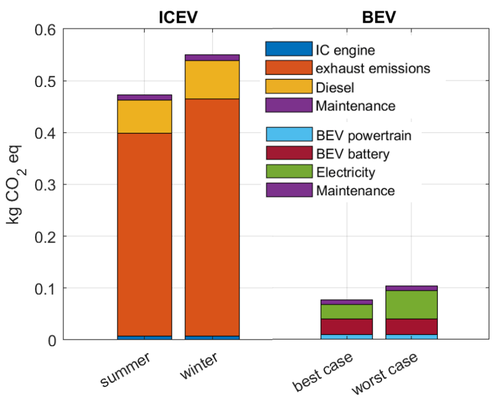
- Environmental impact assessment of BEV and ICEV
- Function: packaging delivery
- Functional unit: covering a distance of 1 km on a packaging delivery tour
- Software: SimaPro with Ecoinvent database
- Impact assessment: ILCD 2011 Midpoint+ method
- Scenario definition on consumption:
  - ➢ ICEV: differentiates between summer and winter based on real data
  - ➢ BEV: worst- and best-case scenarios give a range of electricity consumption (assumptions based on values defined by the WLTP)

Optimization

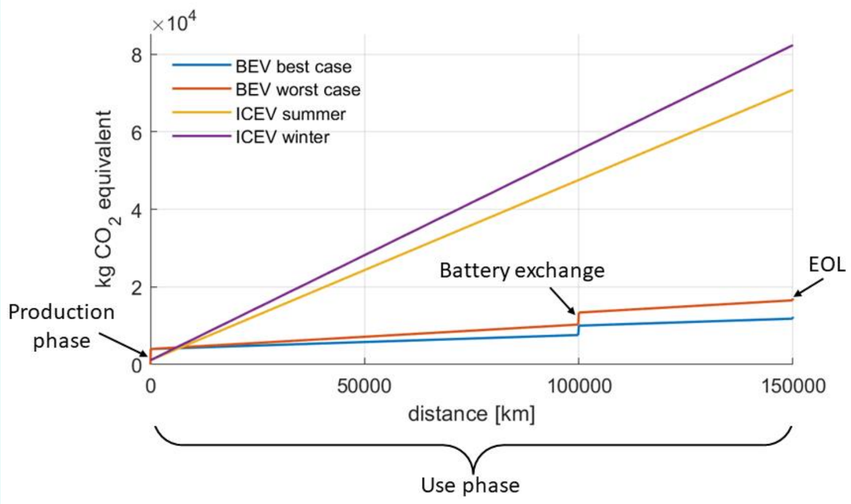
- Comparison between two scenarios: peak- vs. off-peak hours charging to assess potential savings
- Cost-effectiveness evaluation between three types of charging stations: AC Wallbox (normal), DC Wallbox (fast), DC Concrete Base (fast)
- Payback time of BEVs with respect to ICEVs
- Evaluation of increase in power consumption due to charging
- Optimized charging to minimize battery degradation

CO_2 equivalent emissions

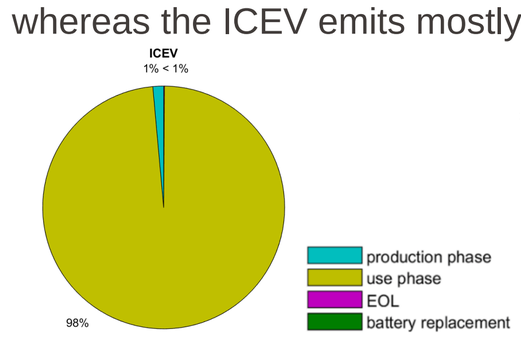
- BEV emits on average 0.42 kg less CO_2-eq/km than ICEV
- Swiss Post saves 1'940 kg CO_2-eq per vehicle in one year



- CO_2-eq emissions throughout the life cycle:

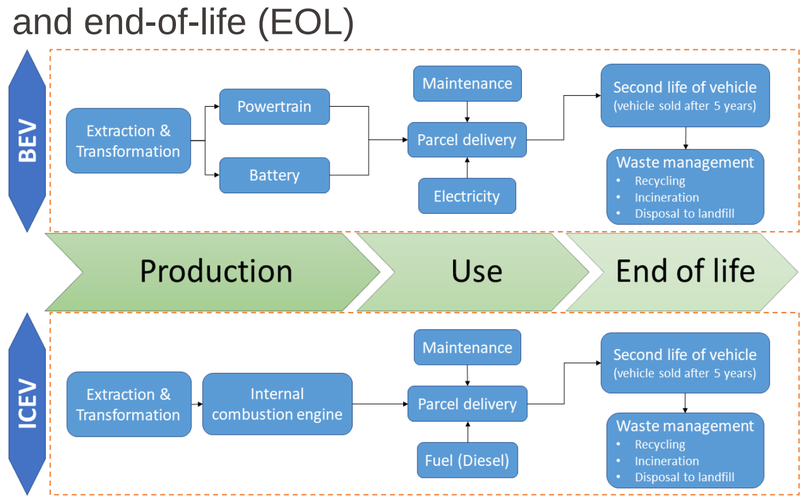


- Carbon payback time: 1.3 – 1.5 years
- BEV is strongly impacted by the production phase, whereas the ICEV emits mostly in use phase



System boundaries

- Life cycle divided into 3 phases: production, use and end-of-life (EOL)



- Glider* and transportation** are excluded (have equal impact on both systems)

*Vehicle without powertrain/battery

**From production site to Geneva and back to a disposal site

Results of data analysis

- Average travel distance of a vehicle per day: 18.1 km

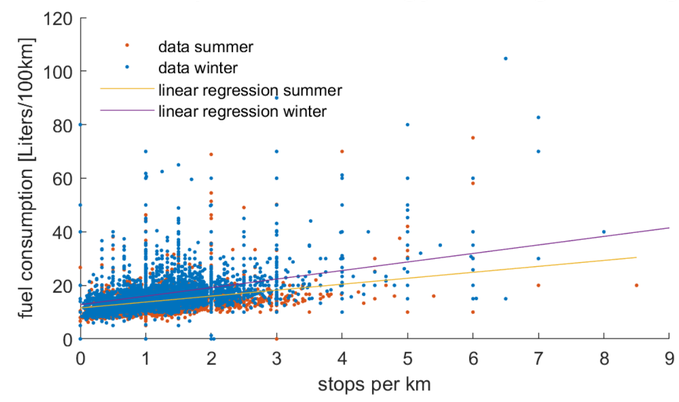
→ No BEV charging needed during the day

- Average maximum speed: 52 km/h

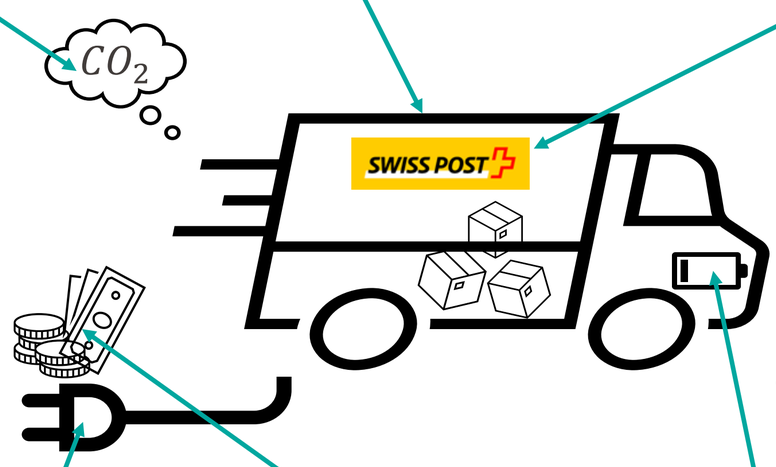
→ Low average speed favors a low power consumption

- Diesel consumption: higher in winter than summer, and increases with number of stops (see figure below)

→ BEV recuperates energy during braking

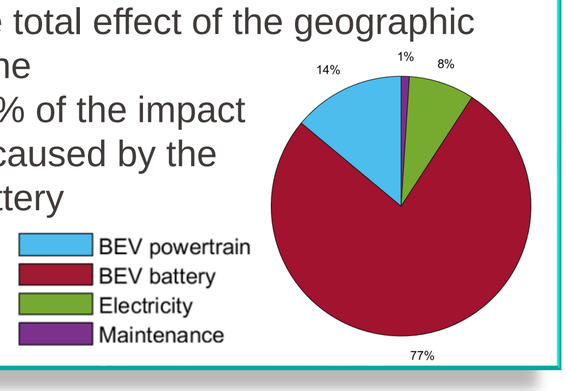


→ Yes, the BEV a viable alternative to the ICEV for the Swiss Post



Freshwater ecotoxicity

- Significant high relative contribution of the impact caused by the BEV on the total effect of the geographic zone
- 77% of the impact is caused by the battery

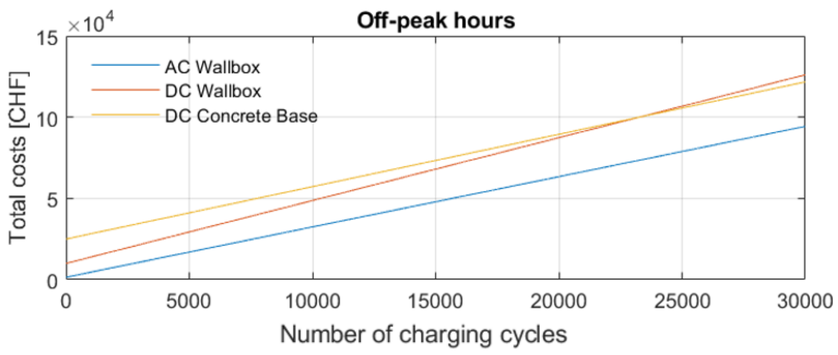


Vehicle to Grid

- Potential revenue of 1.27 CHF per day and per vehicle by giving electricity back to the power grid at the end of the day

Charging optimization

- By considering investment and utilization costs:
  AC Wallbox: cheaper than quick chargers,
  DC Wallbox: least expensive quick charger



- Charging 100 BEVs from 20 to 80% with a normal charger (4h) would cost 309 CHF/day against 520 CHF/day for 100 ICEVs consuming 2.87 L/day
- But including investment costs, payback time of BEV compared to ICEV is bigger than vehicle lifetime of 150'000 km

Sensitivity analysis on battery

- Battery causes most environmental damage

→ improve its performance in two ways:

N°1: smaller battery (33kWh instead of 52kWh)

N°2: extension of its lifetime from 100'000 km to 150'000 km

Percentage reduction of impact on a category compared to the base scenario

	Climate change	Freshwater ecotoxicity
N° 1	13.0%	27.9%
N° 2	12.0%	25.6%

Conclusion

- BEVs perform significantly better than the ICEVs regarding CO_2 equivalent emissions
- BEVs have indeed a bigger environmental impact than ICEVs on other categories, e.g., freshwater ecotoxicity → impacts mostly associated with battery production and end-of-life
- Careful handling of the battery can extend its lifetime and thus, reduce environmental damage
- Charging during off-peak hours allows significant savings → but BEVs still remain more expensive than ICEVs during their entire lifetime
- Higher costs of BEVs compared to ICEVs can be potentially offset by the deployment of the vehicle to grid technology