LCA of PV and Battery Systems for a Cloakroom and Club Building in Zurich

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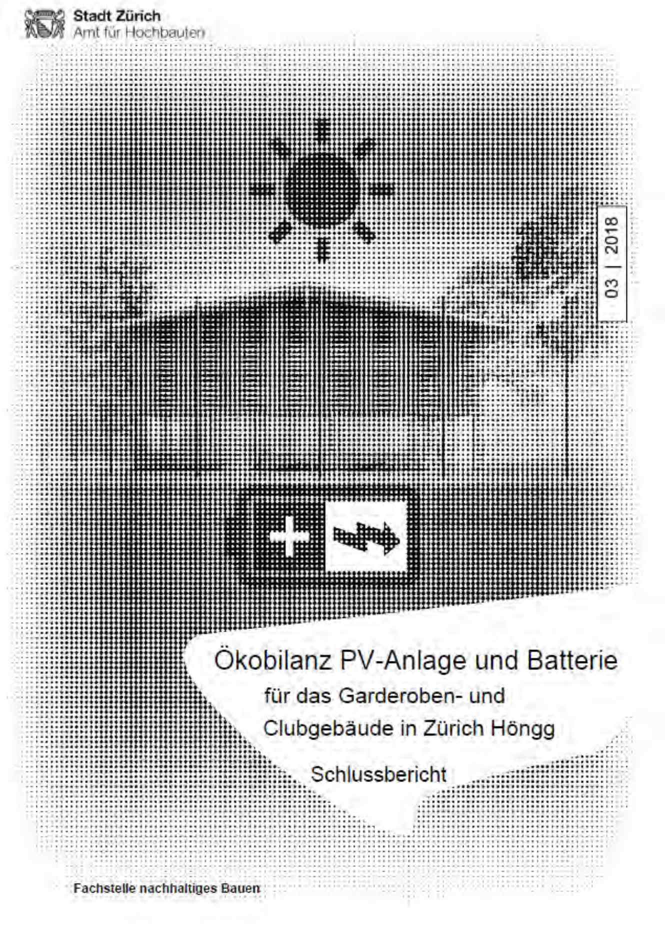
Overview

- Introduction and Goal
- Scope
- PV System
- Battery Systems
- Electricity GCGH
- Conclusions



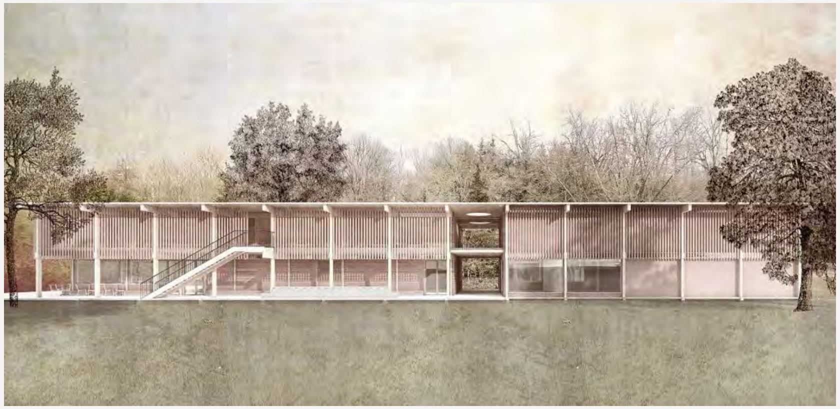
Download report *(in German)*:
www.stadt-zuerich.ch/pv-batterie

Introduction and Goal

treeze
fair life cycle thinking

- Office for Building Engineering of the City of Zurich currently plans the construction of a cloakroom and club building in Zurich (GCGH)
- Evaluation of a photovoltaic (PV) system in combination with a battery system (different types and capacities)

- Goal:
Calculation of the environ-mental footprint of the PV system and different battery systems with LCA



https://www.stadt-zuerich.ch/hbd/de/index/ueber_das_Departement/medien/medienmitteilungen/2017/170712a.html

Scope

- Roof-integrated PV system with multicrystalline silicon (multi-Si) modules
- Battery systems with current / future / second-life Lithium-ion batteries
- KBOB LCI data DQRv2:2016 (background database)
- Impact assessment methods
  - Eco-Points 2013 (UBP’13)
  - Cumulative energy demand (total)
  - Greenhouse gas emissions

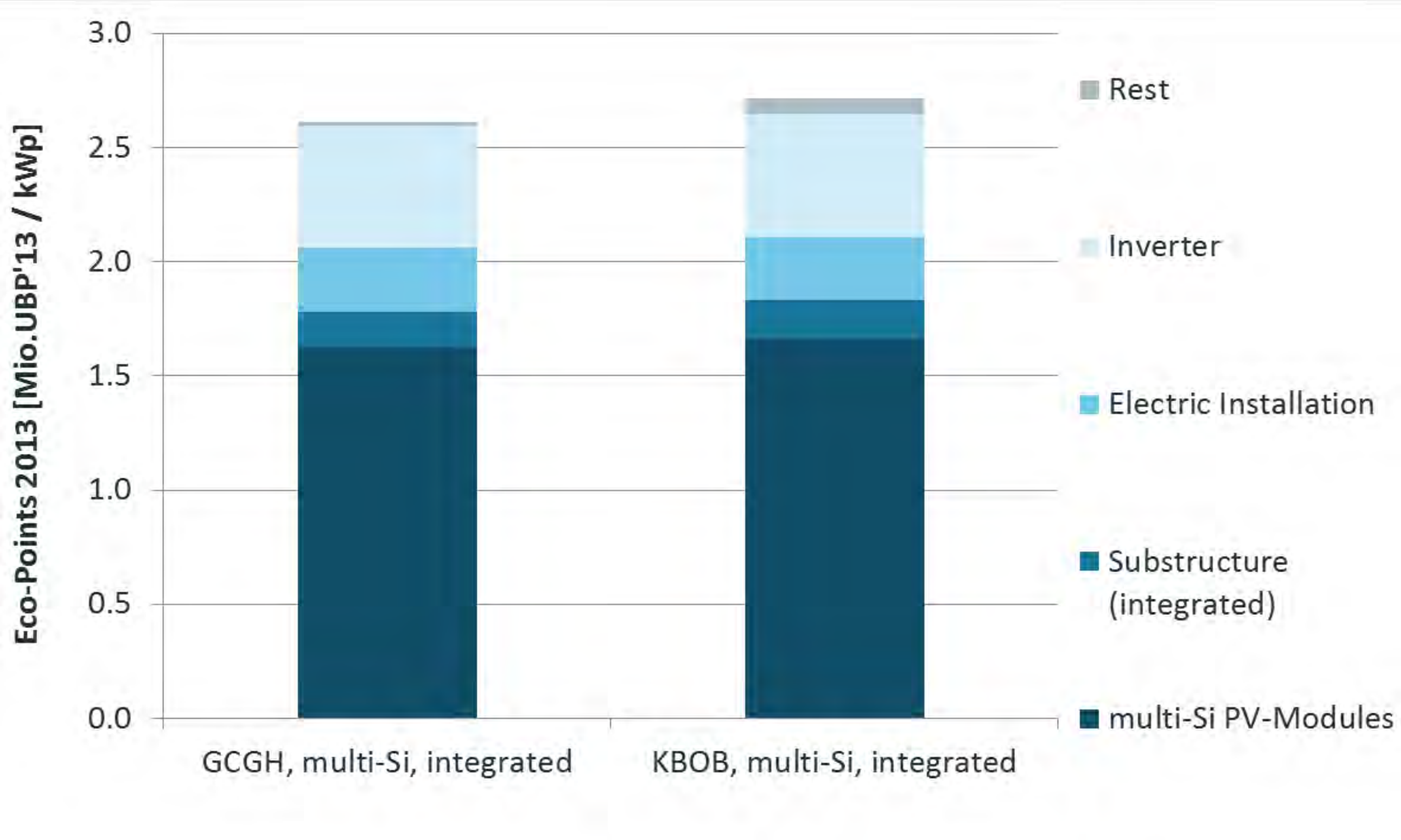
Life Cycle Inventories

PV System

- Reference unit: 1 kWp maximum power output
- System scope
  - According to PEFCR (modules, substructure, el. installation)
  - Inverter
- Maximum power output: 60 kWp
- 230 multi-Si modules
  - Specific power output: 161 Wp/m^2 (efficiency: 16.1%)
  - Standard measures (1.65 x 0.98 m^2), framed
- PV system is integrated in roof

Results

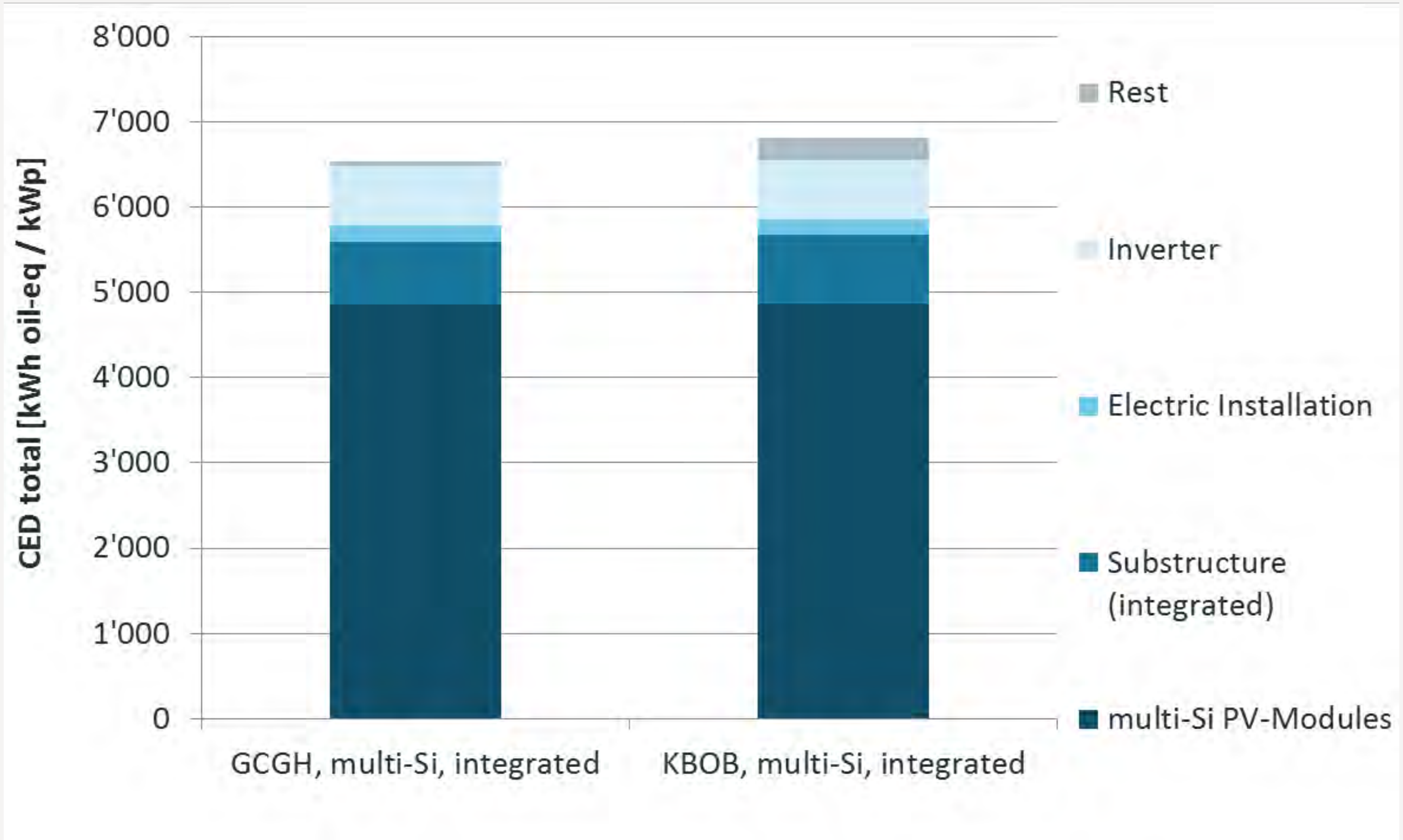
PV System: Eco-Points 2013



- Module efficiency GCGH is slightly higher than KBOB

Results

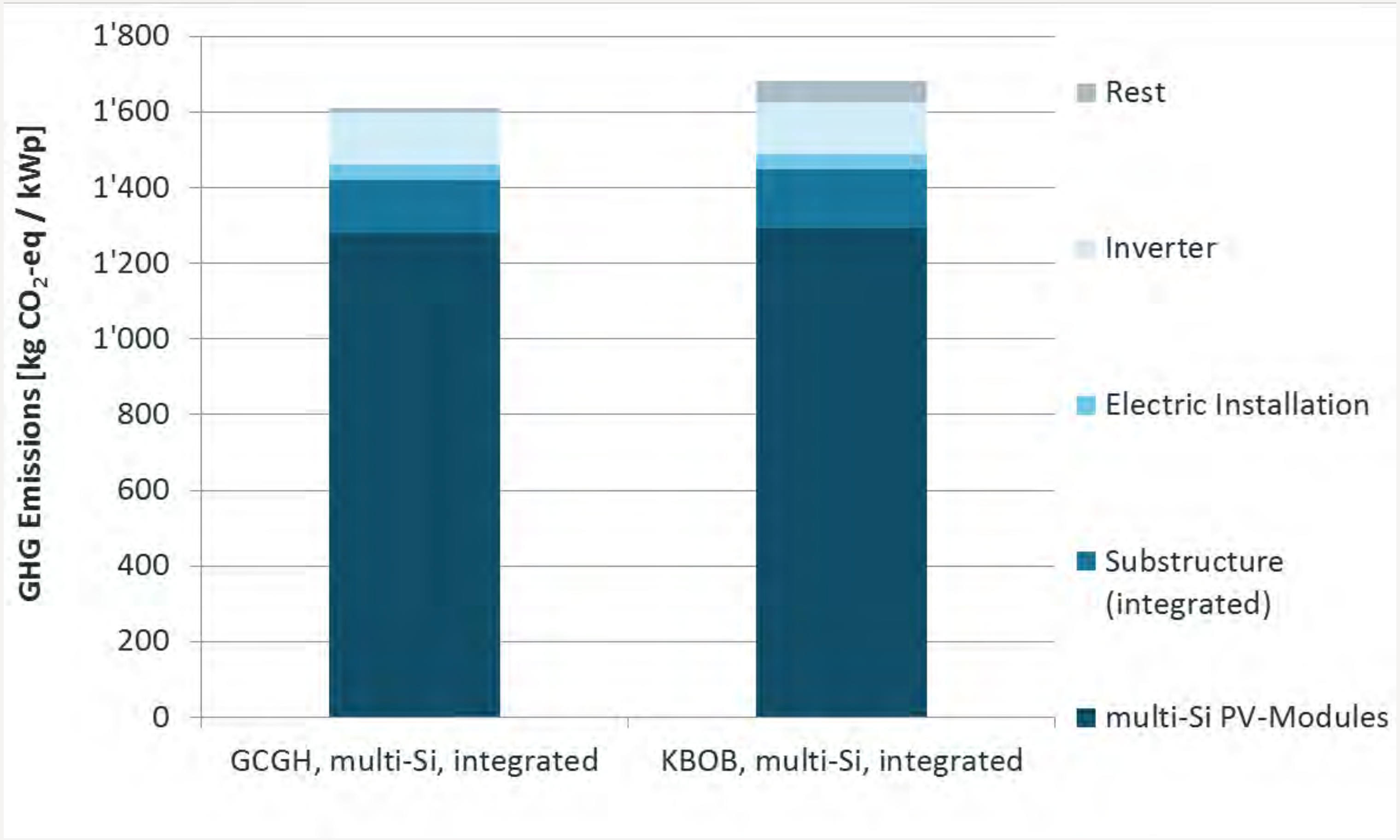
PV System: Cumulative Energy Demand



- Module production contributes 74% to the CED

Results

PV System: Greenhouse Gas Emissions



- Module production contributes 79% to GHG emissions

Life Cycle Inventories

Battery Systems

- Reference unit: 1 kWh storage capacity
- System scope
  - Manufacture of current / future Li-ion batteries (incl. battery management system, cooling system, battery cells, housing)
  - Repurposing of used Li-ion batteries
  - Electronics, cabling and system housing
  - Transports

Life Cycle Inventories

Current Li-Ion Batteries

- LCIs from Ellingsen et al. (2014)
- Energy density: 105 Wh/kg
- Battery cells (60% of battery weight)
  - Anode: Graphite on Copper
  - Cathode: Nickel Cobalt Manganese Oxide (NCM)
  - Electricity demand: 22.7 kWh/kg (Eastern Asian mix)
- Lifetime: 5’000 charge cycles / 15 years

Life Cycle Inventories

Future Li-Ion Batteries

- Basis: LCIs of current Li-ion batteries
- Assumptions
  - Doubling of the energy density: 210 Wh/kg
  - Electricity demand for cell production: 15.0 kWh/kg (produced in large-scale, open ground multi-Si PV systems)
  - Anode made from secondary Copper
- *Further developments, which are disregarded*
  - *Anode: Graphite-Silicon on Copper*
  - *Cathode: More Nickel relative to Cobalt and Manganese*
- Lifetime: 10’000 charge cycles / 20 years

Life Cycle Inventories

Second-life Li-Ion Batteries

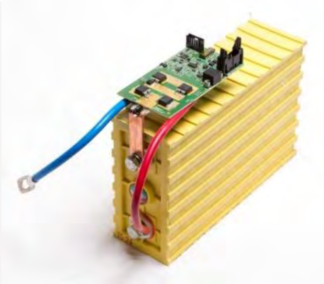
- Used batteries of electric vehicles may be suited for a second use in stationary storage systems
- Ongoing pilot project for the development of a storage system with used batteries from electric scooters of the Swiss Post
- LCI mainly based on data from Ökozentrum Langenbruck on this pilot project

Kyburz (2013)

Life Cycle Inventories

Second-life Li-Ion Batteries

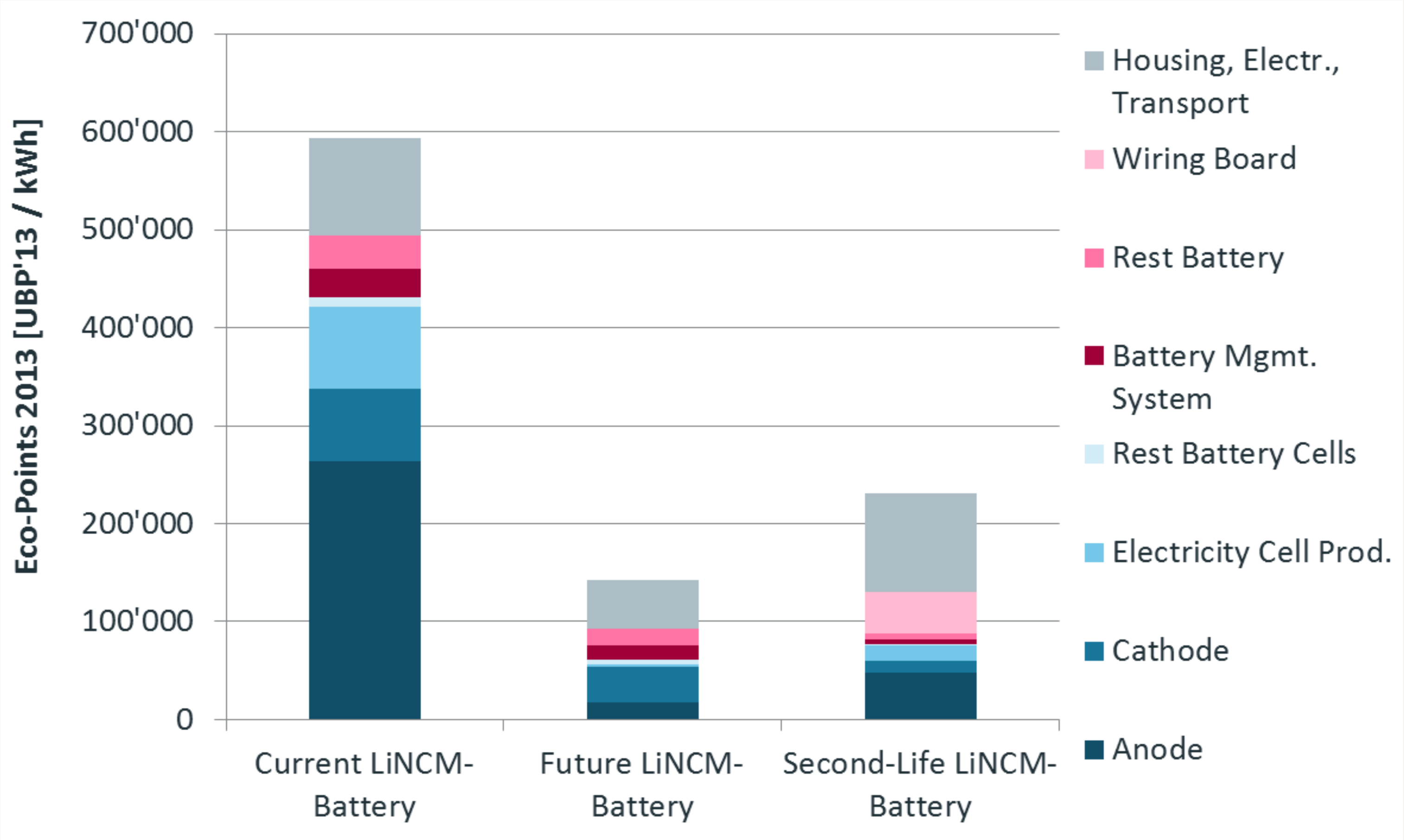
- Battery capacity
  - New: 300 Wh/Battery
  - Beginning of second use: 240 Wh/Battery (80% of initial capacity)
- Batteries have a residual value after first use
  - Price (new): 300 CHF/Battery
  - Price (used): 50 CHF/Battery
  - Economic allocation of production efforts of current batteries → 1/7 of the environmental impacts are allocated to 2^{nd} use
- Lifetime: not available until summer 2018 (assumption: 10 years)



Sattler et al. (2017)

Results

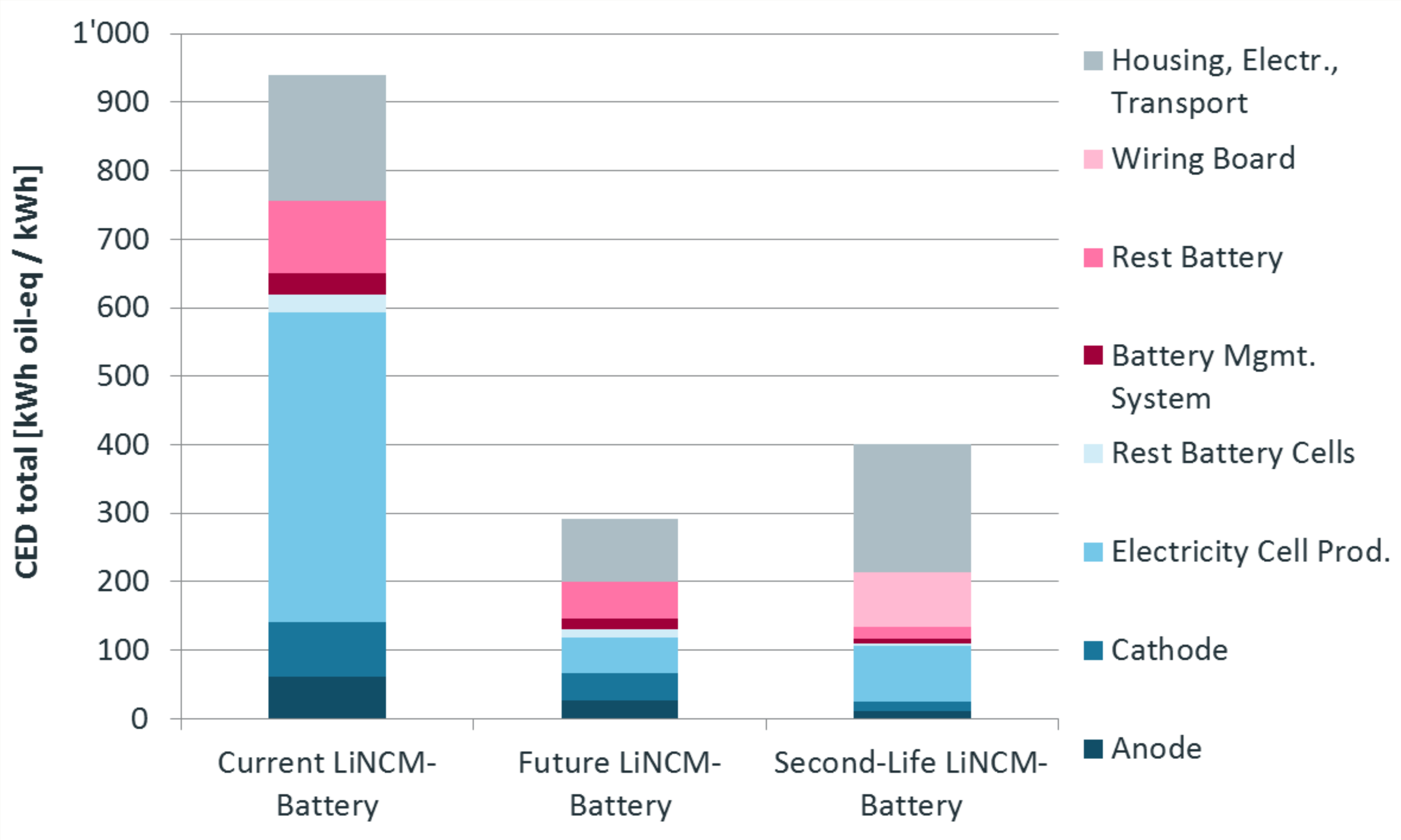
Batteries: Eco-Points 2013



- Share of battery cells in total impacts:
  current batteries: 70%, future batteries: 40%, second-life batteries: 30%

Results

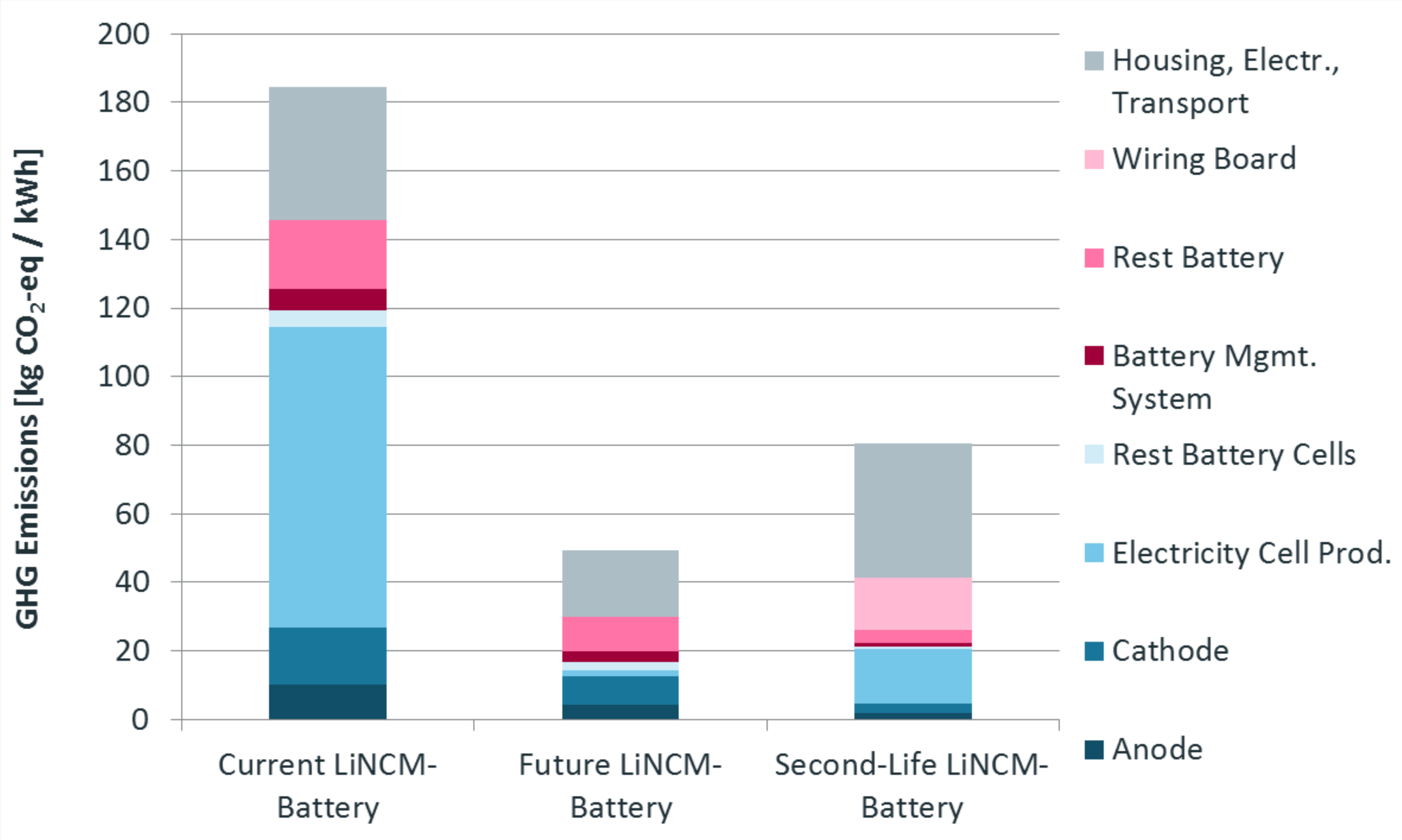
Batteries: Cumulative Energy Demand



- Electricity demand of cell production contributes about 50% to CED of current batteries

Results

Batteries: Greenhouse Gas Emissions



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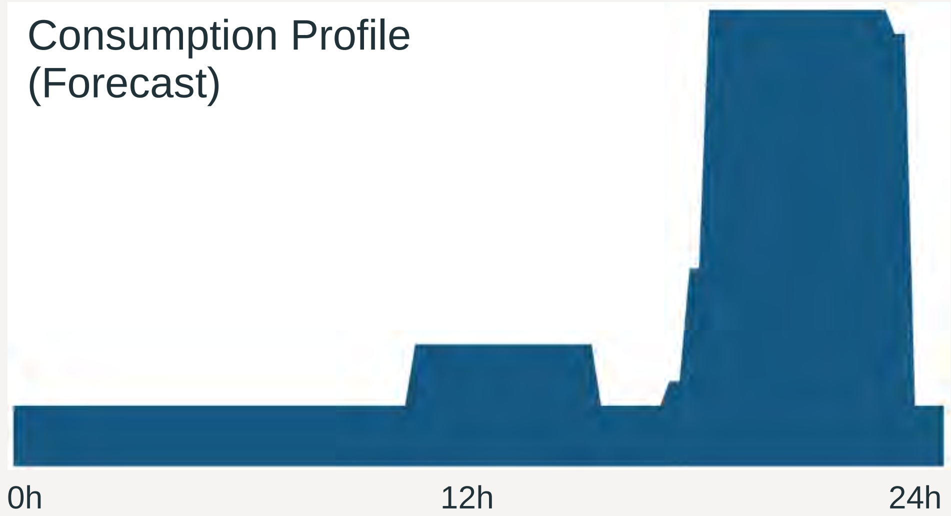
Electricity GCGH

Configuration and Key Parameters



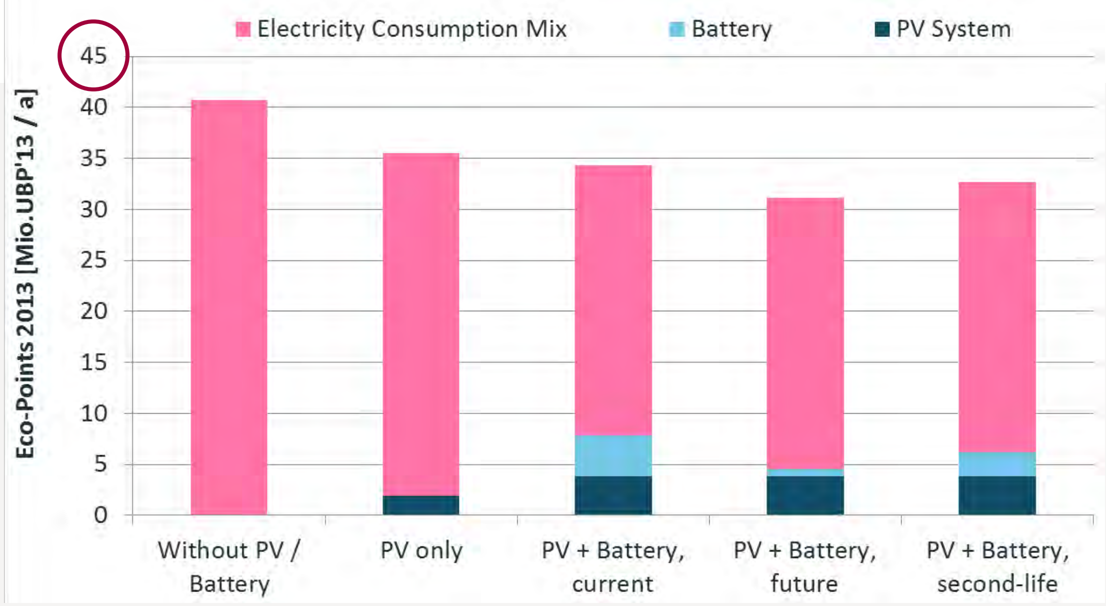
AHB Zurich

- Reference unit:
  1 a electricity consumption
- System configuration
  - PV system: 60 kWp
  - Battery storage: 100 kWh
- Annual electricity consumption: 106 MWh

	PV + Battery	*PV only*
• Self-consumption share	62%	31%
• Self-sufficiency share	35%	18%

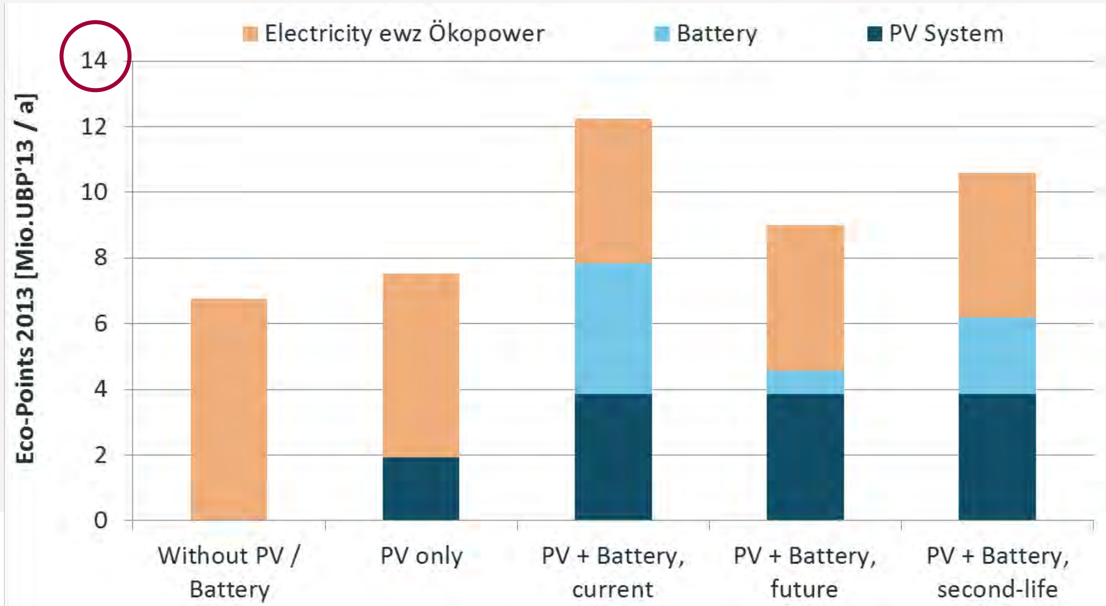
Electricity GCGH: Eco-Points 2013

Swiss Consumption Mix



Note the different axis scale!

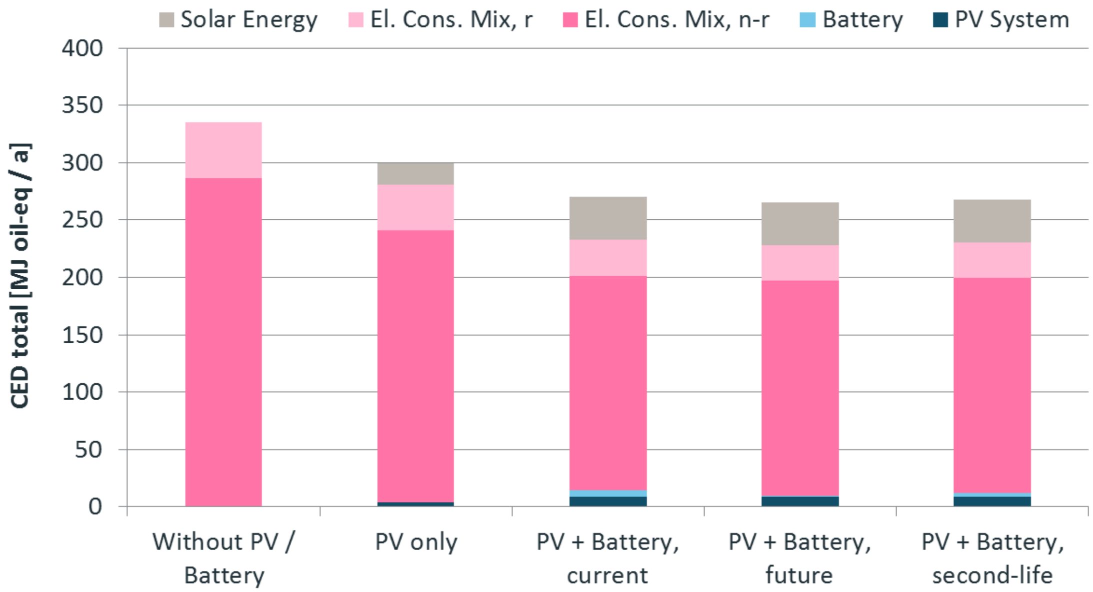
Renewable Electricity Mix



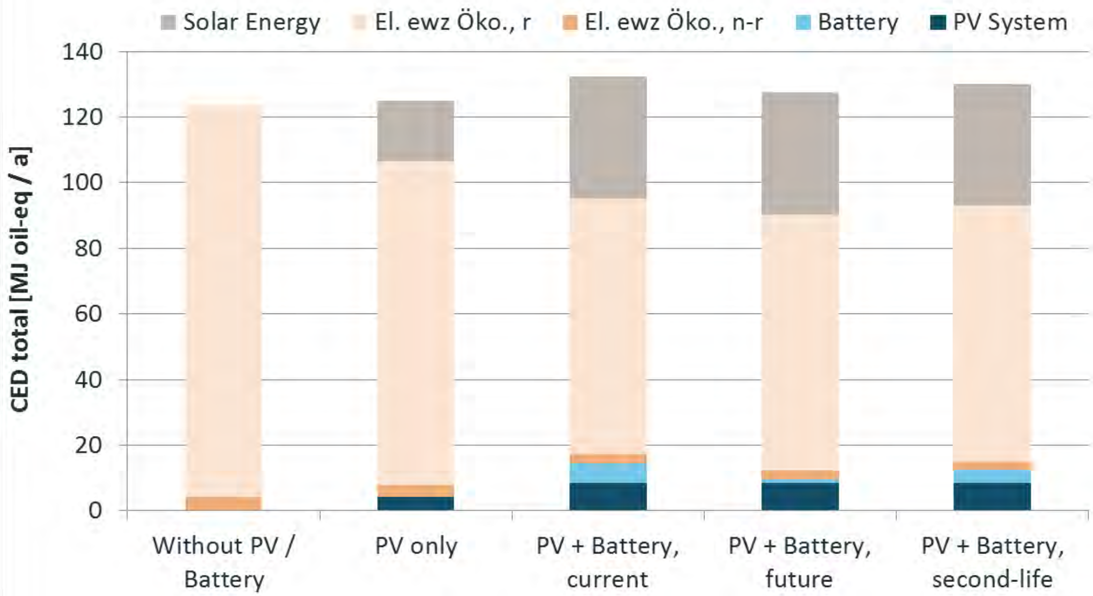
Results calculated by Thomas Kessler, AHB Zurich

Electricity GCGH: CED total

Swiss Consumption Mix



Renewable Electricity Mix



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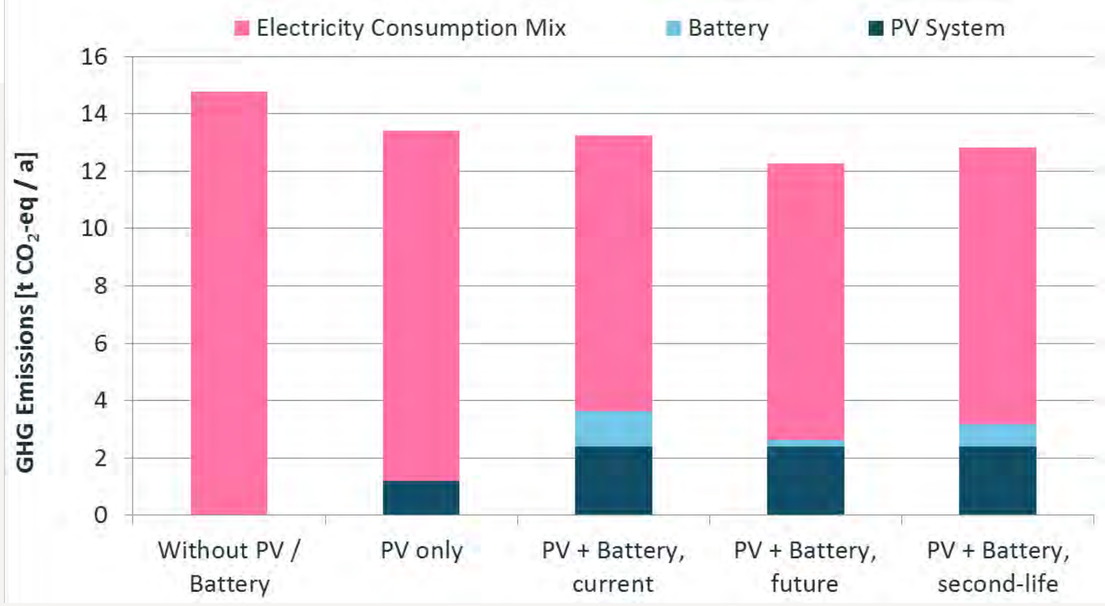
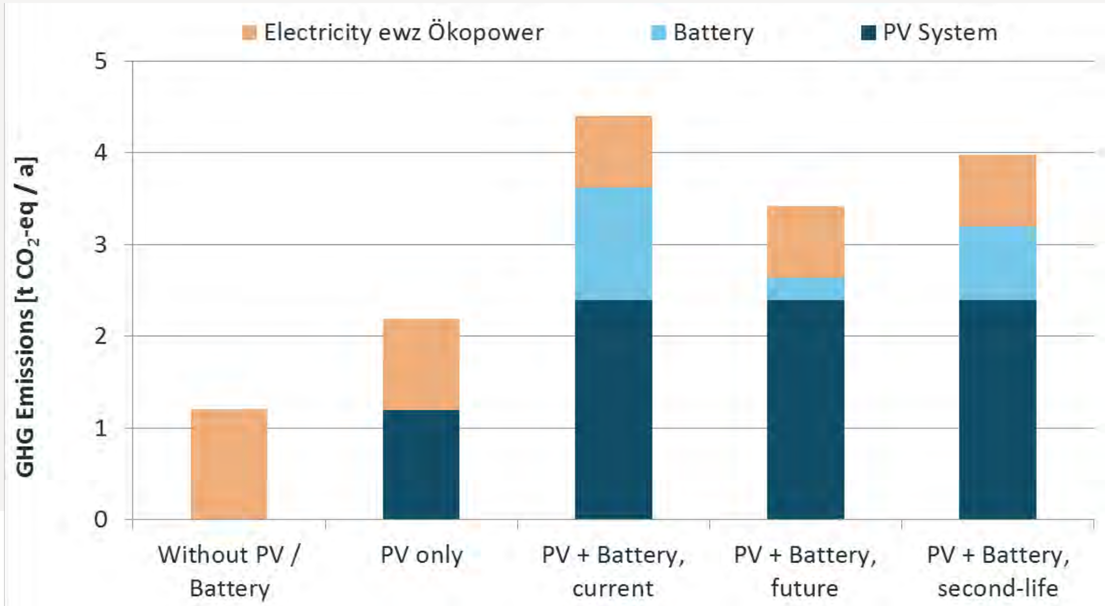
Electricity GCGH: GHG Emissions

Swiss Consumption Mix



Renewable Electricity Mix



Results calculated by Thomas Kessler, AHB Zurich

Conclusions

- Battery storage significantly increases the self-consumption share of PV electricity (electricity consumption mainly in the evening)

- The ranking of different options strongly depends on the grid mix
  - *Swiss consumption mix*
    PV and battery system results in the lowest environmental impacts of the electricity consumed by the GCGH
  - *Renewable electricity mix of the Zurich City Administration*
    PV system leads to higher environmental impacts in any case

- Production optimisations and second-life Li-ion batteries bear a significant potential to reduce the environmental impacts