Environmental Saving Potential of Circular Approaches for Traction Batteries

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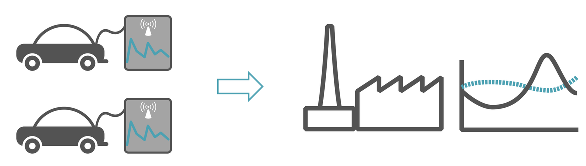


Introduction and Objectives

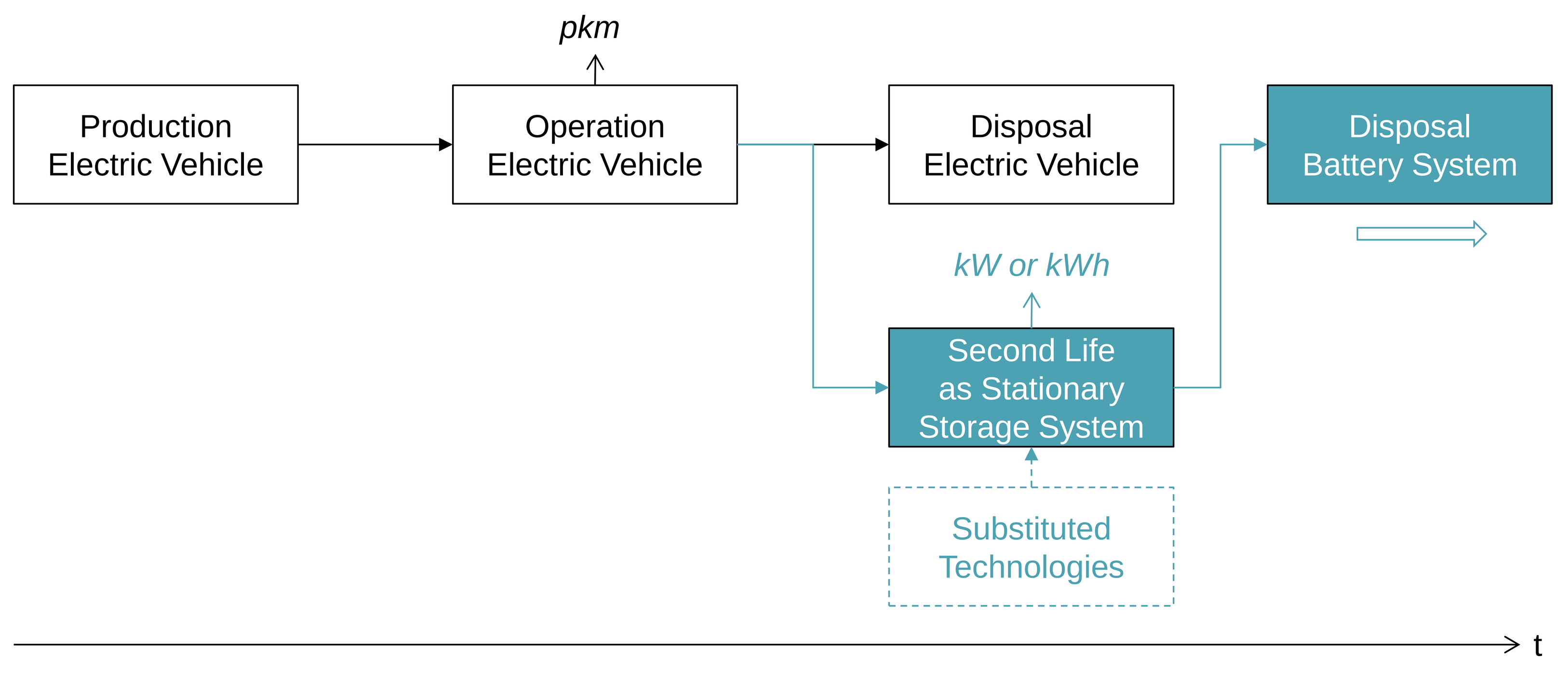
The energy transition - including the transformation of the mobility sector - requires new technologies, many of which come with an increasing demand for critical resources. Approaches from the circular economy, such as sharing and reuse, can lead to increasing resource productivity as well as new opportunities for value creation. In the following the methodological challenges of applying Life Cycle Assessment (LCA) methods to identify environmental saving potentials of circular approaches are illustrated using the example of lithium-ion traction batteries from electric vehicles.

Methods

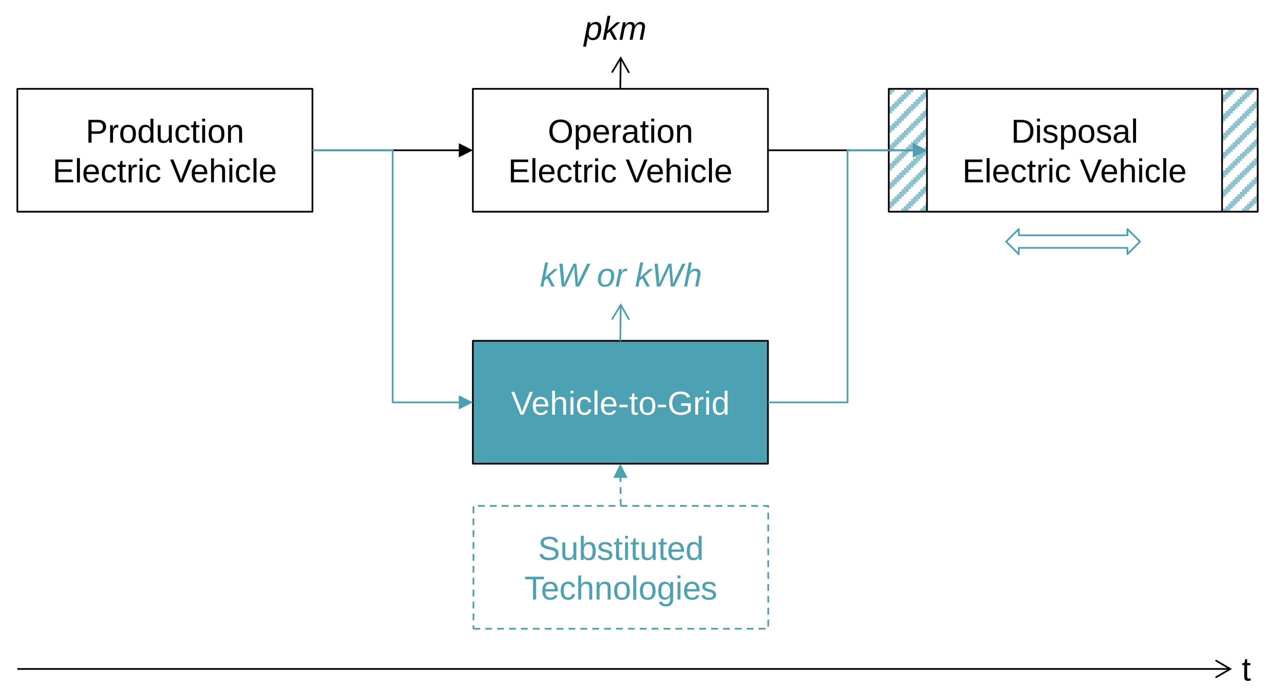
- Matching process: product architecture and quality vs. requirements of circular approaches → systematic identification of circular approaches for traction batteries
- Literature review: analysis of goal and scope definition based on ISO 14040/44 standards → methodological challenges of LCA of reuse and sharing concepts
- Case study: LCA of sharing concept “vehicle-to-grid for industrial peak shaving” → exemplary quantification of identified methodological challenges

Challenges for LCA of Reuse and Sharing of Traction Batteries

Reuse:



Sharing:



Challenges:

1. The delivered function and the life time of the storage system are dependent on the **battery ageing process** and thus the load profile and the state of charge
2. Due to a temporal delay the **future development of the disposal process** needs to be included
3. Allocation of emissions to **different functions**: mobility and energy system service
4. In case of system expansion: knowledge of the energy system needed in order to determine **substituted technologies**

Case Study – Vehicle-to-Grid for Industrial Peak Shaving

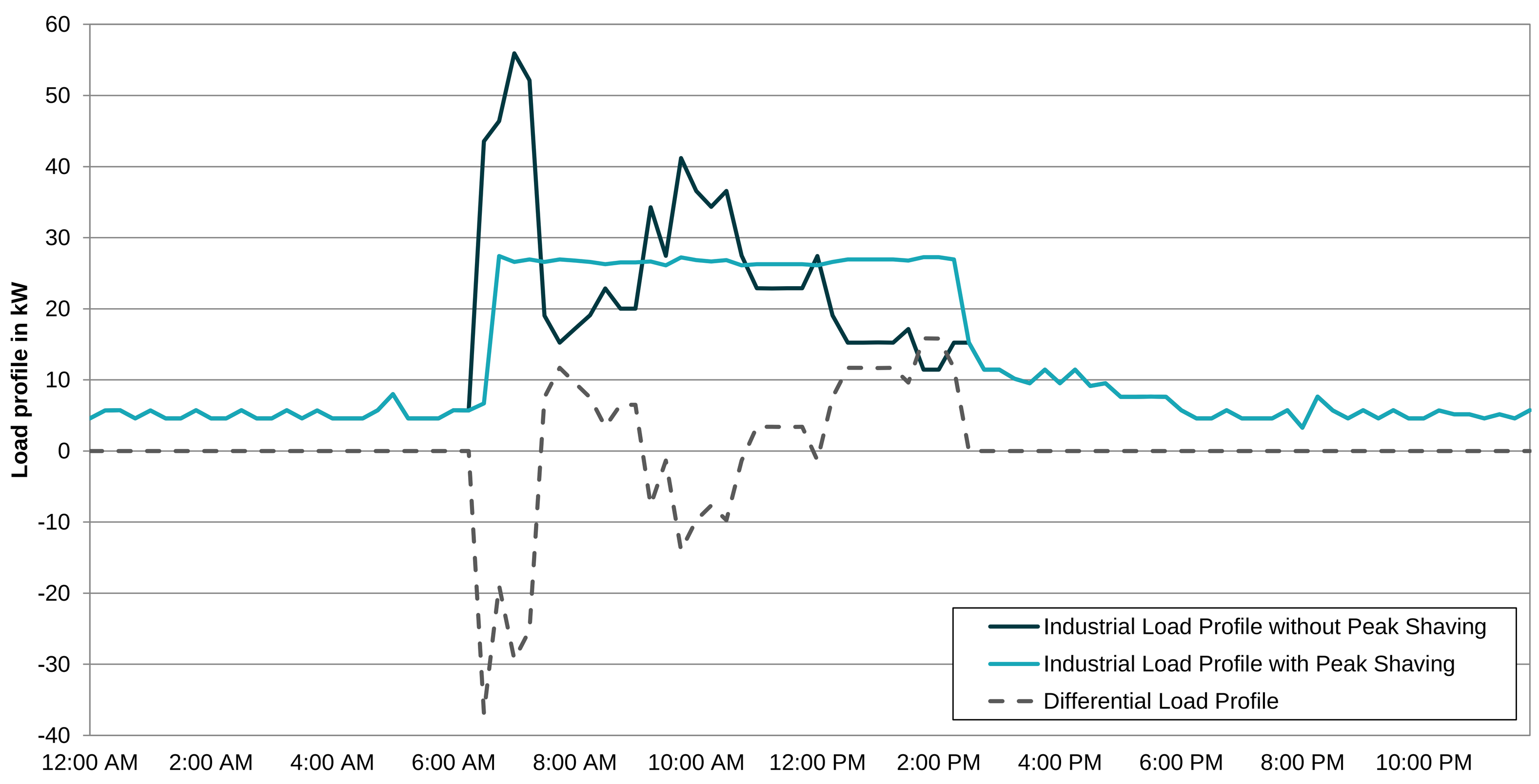
Description

Key facts:

Peak load	41 kW (without electric vehicles)
Number of electric vehicles	2
Usable capacity per vehicle	20 kWh
Charging power per vehicle	22 kW
Efficiency	85 %
Availability	Between 7 AM and 6 PM

Substituted technologies:

- Marginal power plants due to change of load profile
- Simulated power plant dispatch with energy system model “ISAaR”
- Scenario for year 2030 from project “Merit Order Netz-Ausbau (MONA)”
- Direct energy-related CO_2 emissions
- Calculation of resulting emission factors for electricity using two methods:
  1. Marginal Power Plant Method
  2. Electricity Mix Method



Results

Impact of Vehicle-to-Grid on emissions:

- In case of the marginal power plant method slight increase of emissions due to Vehicle-to-Grid

  Reasons:

  → Shift of marginal power plants from gas to coal

  → Additional battery storage losses, but low in comparison to total amount of electricity charged

Differences between marginal and mix approach:

- Specific emissions of marginal power plants larger than emissions of electricity mix

  Reasons:

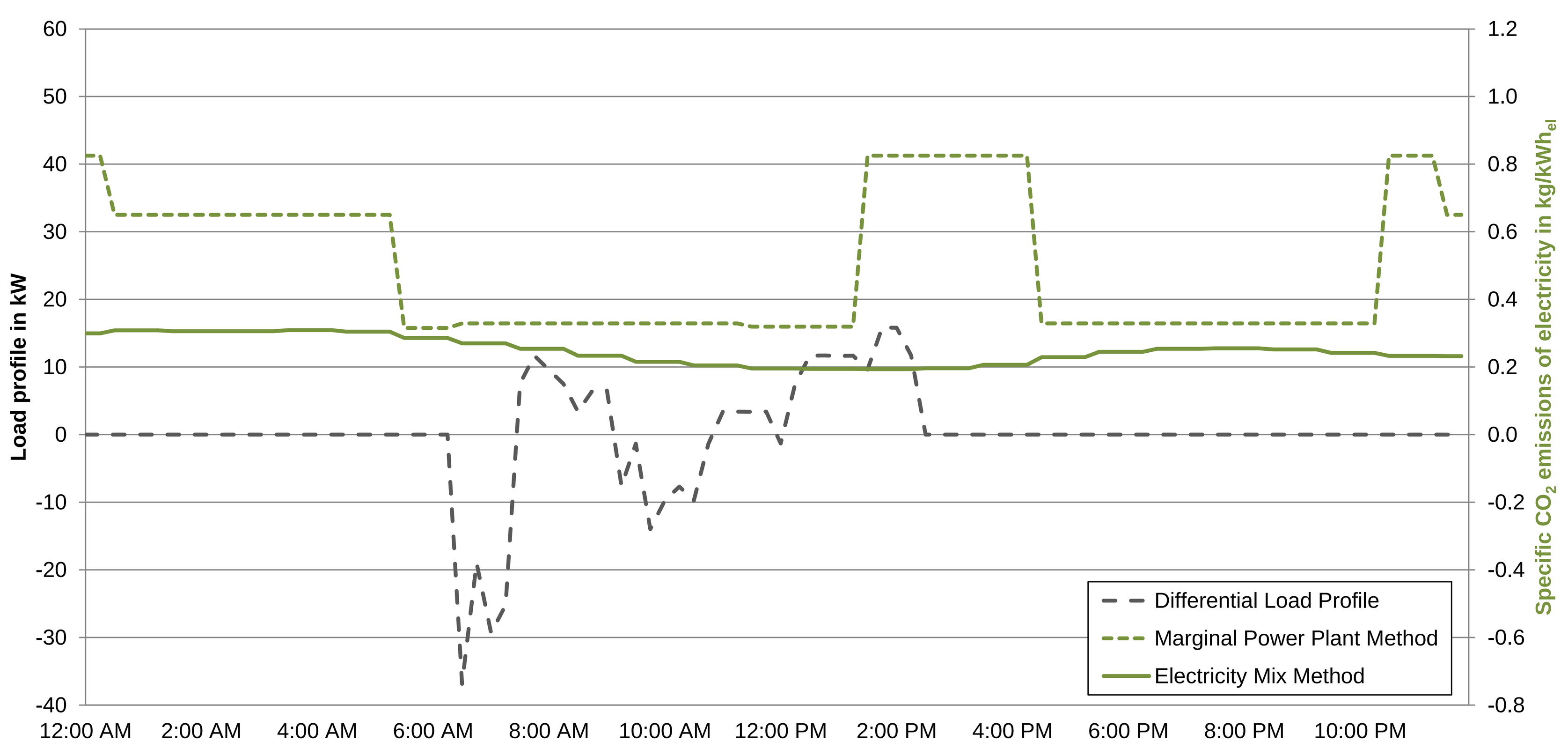
  → Feed-in priority of renewable electricity

  → Merit order effect

- In contrast to the marginal approach the electricity mix method results in a decrease of emissions

  Reasons:

  → The charging process is postponed into times with more renewable electricity production



Conclusion and Outlook

- Due to the temporal delay a prospective approach is needed for LCA of circular economy approaches
- The impact of Vehicle-to-Grid on CO_2 emissions is relatively low, but strongly dependent on the accounting method
- In case of consequential LCA of energy technologies system effects can be accounted for by energy system modelling

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