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PSI

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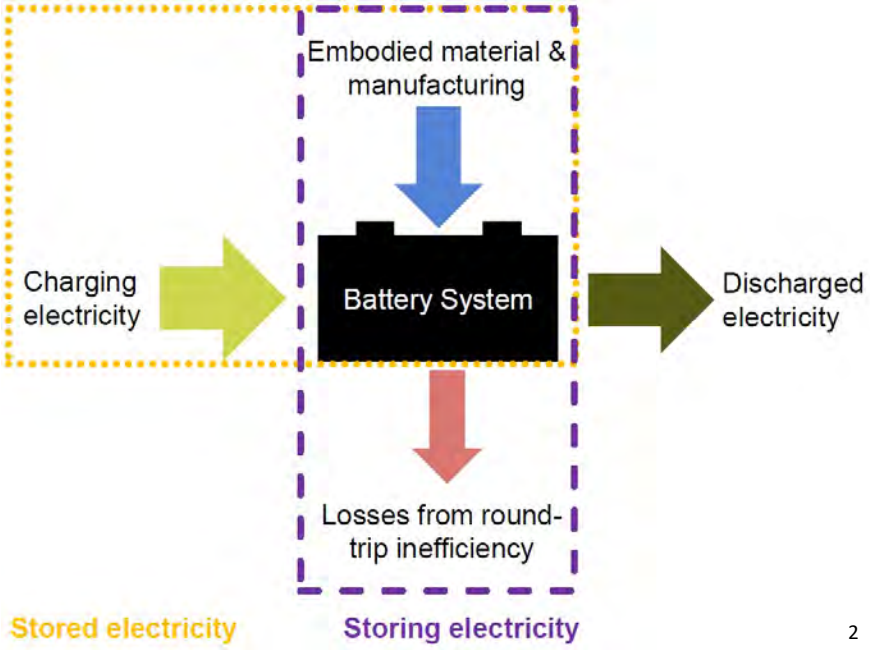
Techno-economic & environmental evaluation of batteries: technologies & applications

H2 Storage SCCER SoE

Batteries as enablers of low-carbon electricity supply systems

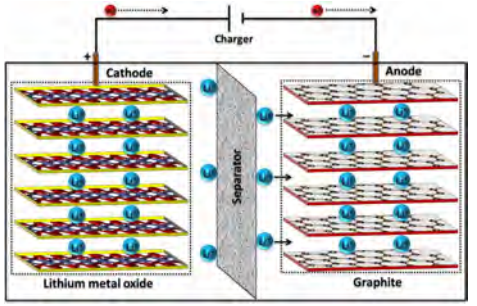
- Energy systems with high shares of intermittent, renewable electricity generation will need some sort of decentralized storage
- Most promising today: stationary batteries
- However: additional life-cycle costs (LCC) & emissions (LCE)
- RQ: "**What are the LCC & LCE of storing electricity with different battery technologies?**"
  - *different grid applications*
  - *different geographies*

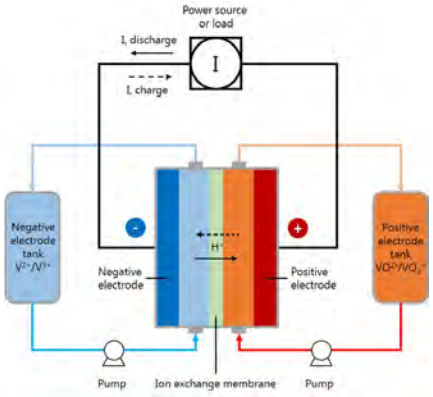


Scope

Six battery technologies:

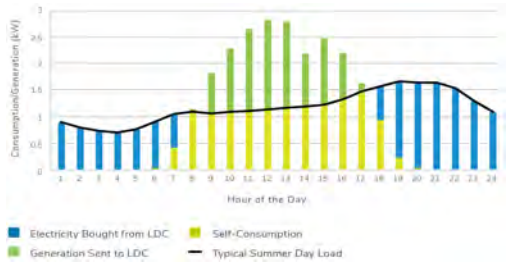
- Li-Ion
  - lithium iron phosphate (LFP)
  - lithium titanium oxide (LTO)
  - lithium nickel cobalt aluminum oxide (NCA)
  - lithium nickel manganese cobalt oxide (NMC)
- Lead-acid (VRF/PB)
- Vanadium-redox-flow (VRF)





Five applications:

- Wholesale Arbitrage (WA)
- Area & Frequency Regulation (AF)
- Transmission & Distribution Grid Upgrade Deferral (TD)
- Demand Peak Shaving (PS)
- Increase of PV electricity Self-Consumption (SC)

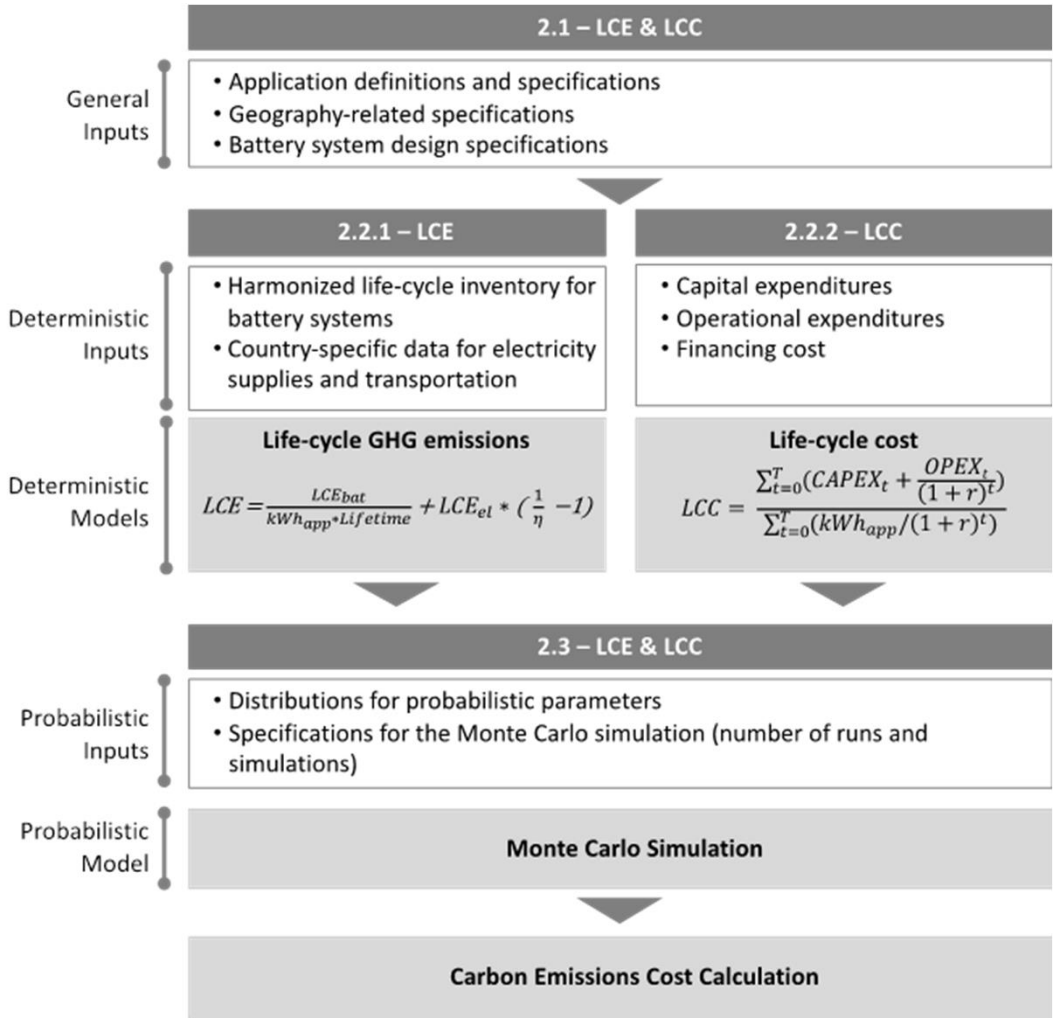


Three geographies:

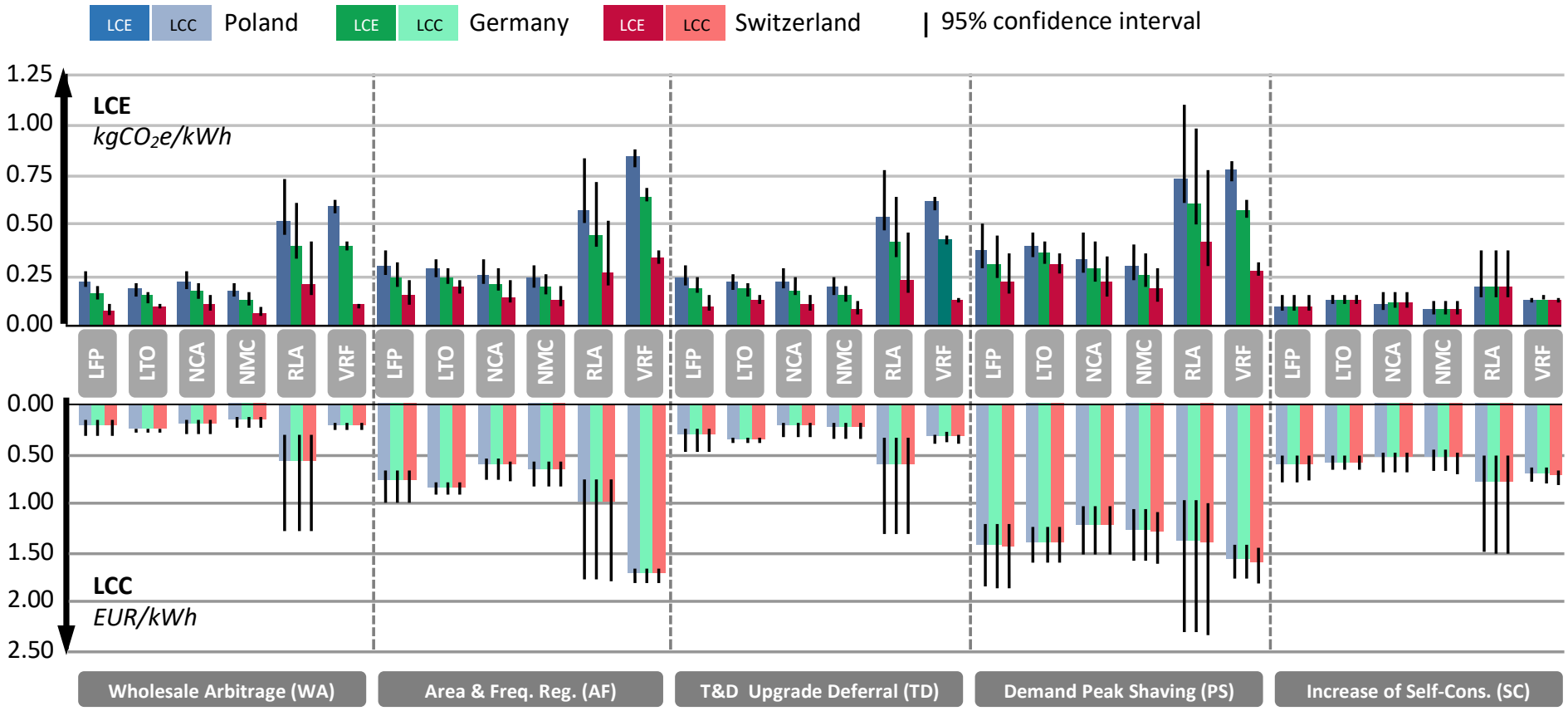
- Switzerland
- Germany
- Poland

Methodology

- Consistent quantification of life cycle costs (LCC) and life cycle GHG emissions (LCE) due to storage of electricity



Results: LCE/LCC by battery & application

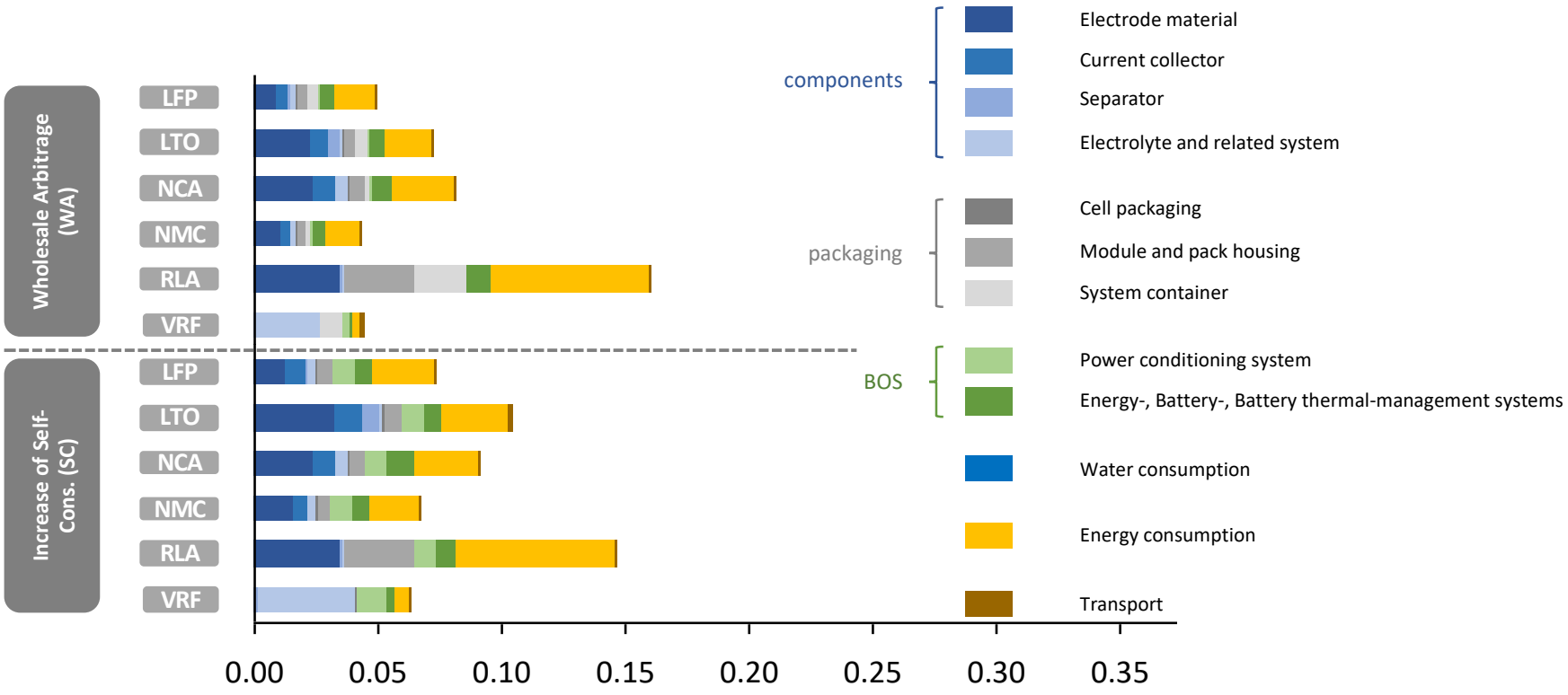


- LCE & LCC: Major differences between applications
- LCE: Major differences between countries
- LCC: Major differences between technologies

Results: Contributions of manufacturing vs use

- LCC: Manufacturing most important
- LCE: Major differences between countries & applications

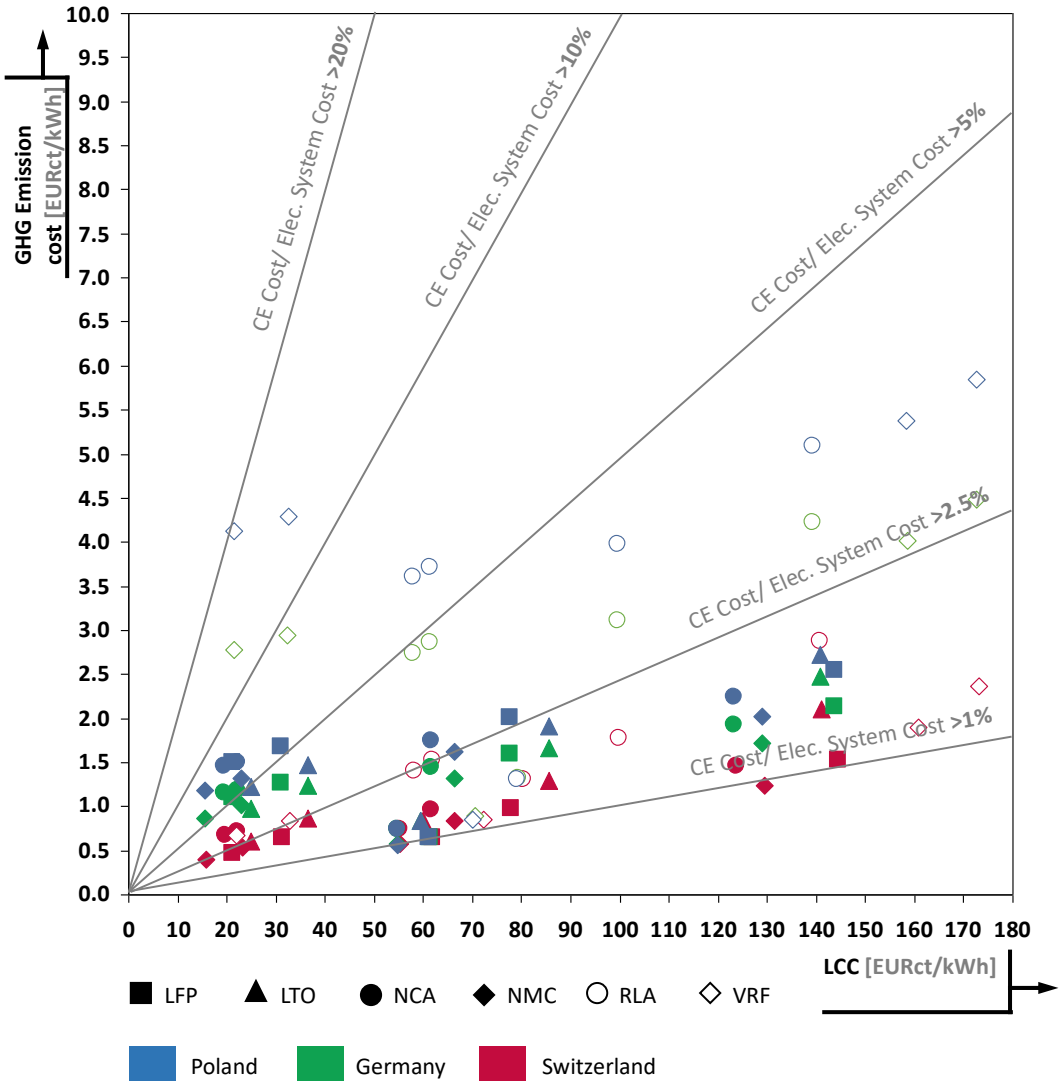
Results: Manufacturing related LCE



kg CO2 e of battery system manufacturing associated with storing 1 kWh of electricity

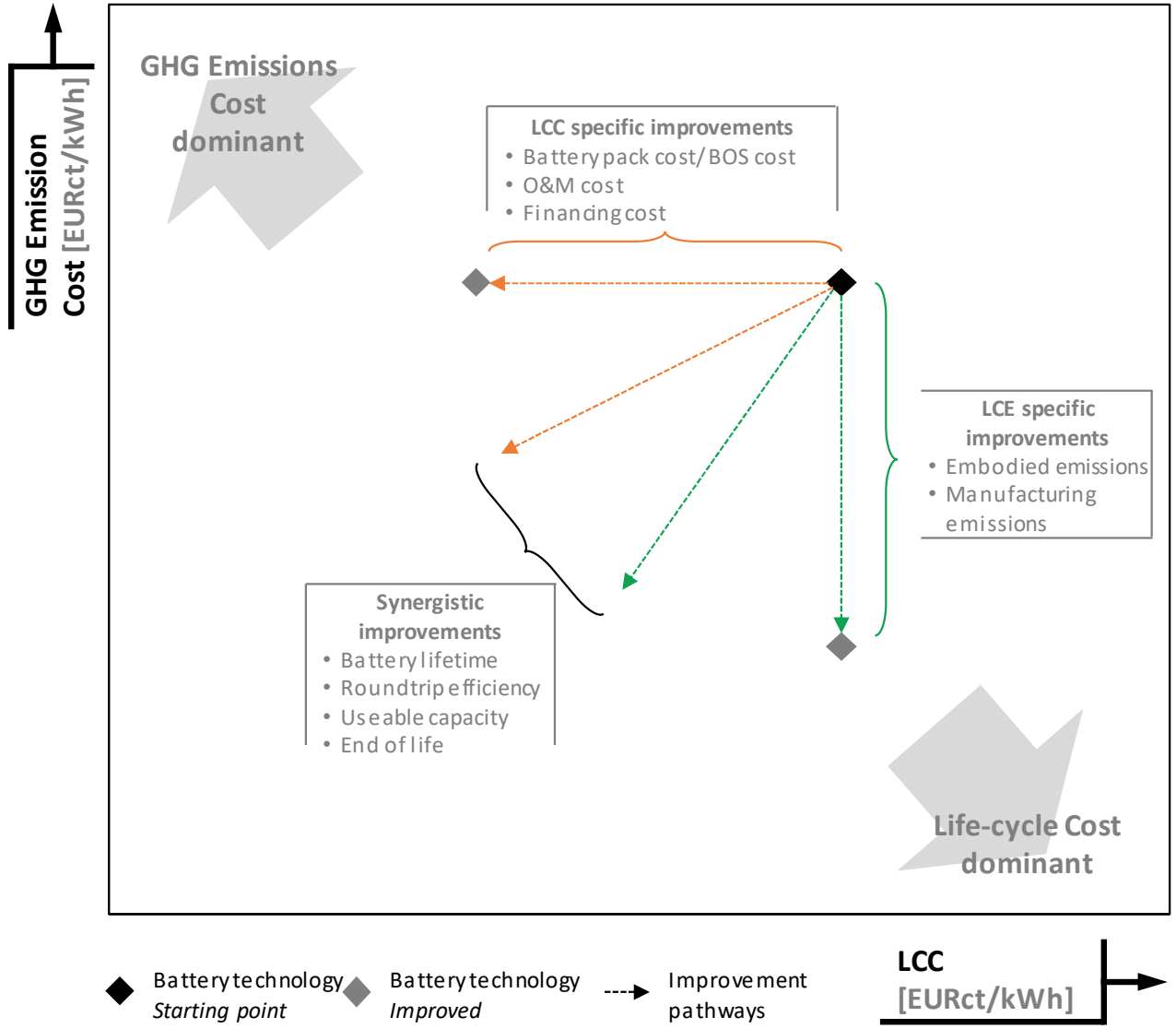
- Electrode materials & energy consumption are most important

Results: LCC vs carbon emission costs



- Direct costs >> C emission related costs (@70 €/t_{CO2})

Discussion:
Key parameters for reduction of LCC & LCE



Conclusions

- No major trade-offs between:
  - economic and environmental dimensions
  - battery technology and application
- Lithium-ion technology seems to be the least cost- and the least emission-intensive
- LCC are determined by the battery system cost
- LCE are determined by manufacturing emissions (and emissions associated with electricity losses)

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