

Transport as a design lever in the European battery supply chain

Jesper Frost Thomsen^{a,*} & Simon Lux^{a,b}

^a Institute of Business Administration at the Department of Chemistry and Pharmacy, University of Münster, Leonardo Campus 1, 48149 Münster, Germany.
^b Fraunhofer Research Institution for Battery Cell Production (FFB), Bergiusstrasse 8, 48165, Münster, Germany

Research question

How do **Complexity** and **Internationalization** in the battery supply chain influence **Transport distance** and the resulting **GHG emissions** and **Transport costs**?

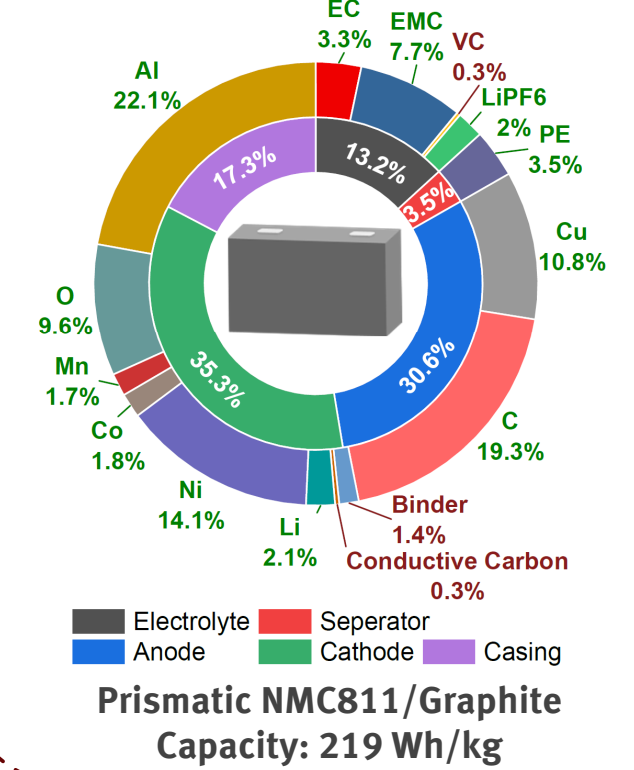
How do transport impacts differ between **Chinese** and **European** cell producers?

How does transport influence European automotive manufacturers' **cell procurement**?

These research questions originate from a much simpler one: "How far are my battery materials transported?" In answering this question, we have developed a reproducible and reliable approach to assessing the impact of transport, the results of which will be presented in this poster.

The Cell

Weight distribution of cell components used in this study.

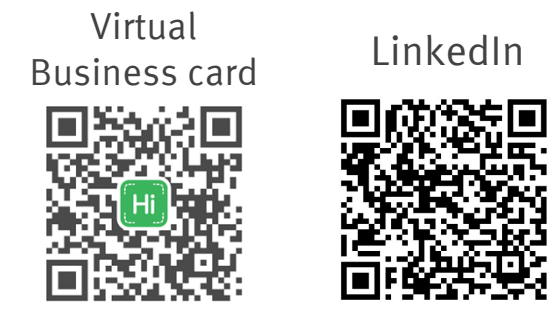


System boundary & assumptions

- Cell scope:** One representative cell type and chemistry.
- Boundary & coverage:** Transport modeled for 98 wt% of cell mass; materials traced at least one upstream process.
- Transport modeling:** Python shortest-path routing with multimodal ship/rail/truck combinations.
- Real-world basis:** Real-world locations and transport infrastructure are used to construct and route battery supply networks.
- Material handling:** Packaging and material losses are included across the supply network.
- Analysis:** A transport breakdown is done comparing a cell from China and Poland, and a Region comparison is done using 10 manufacturers from each region.



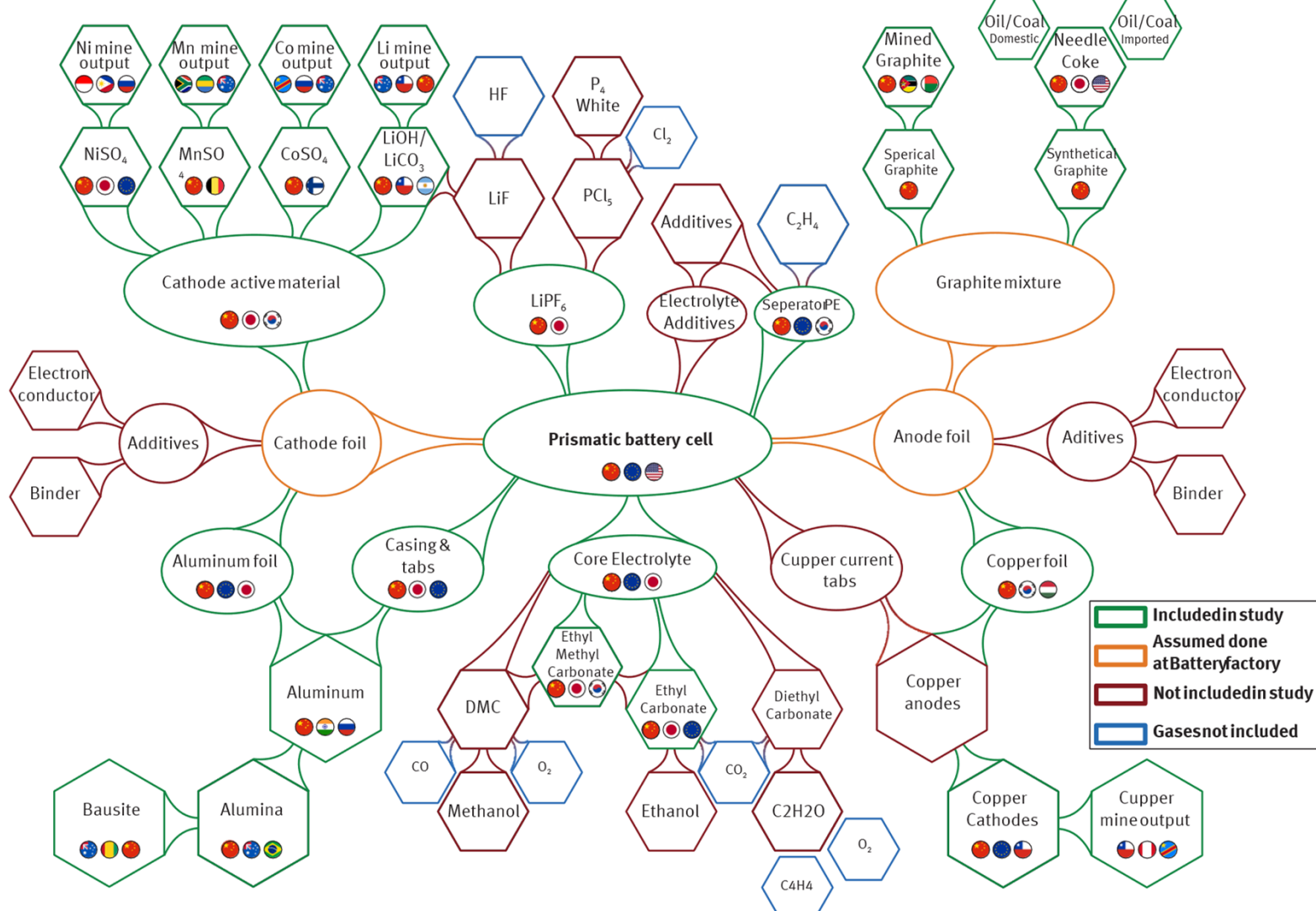
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Jesper.f.thomsen@uni-muenster.de

Complexity

Battery cell production requires 9+ chemicals and components, sourced through different supply chains, to converge at a single production site. Together, these supply chains form the complex network behind the battery supply chain.

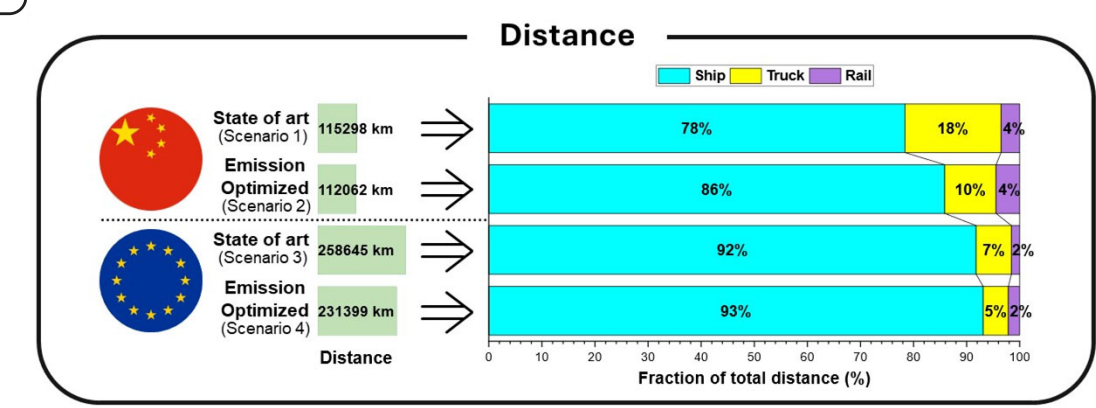


In this work, 24 production steps were modeled due to their significant contribution to the overall transport impact in the supply chain.

Transport distance, GHG emissions, & Cost

Supply-chain complexity and internationalization translate into long material transport distances—over 100,000 km for Chinese cells and 200,000 km for European cells.

The transport distances can be combined with supply chain information, such as material type, purity, packaging, and losses, to determine transport costs and emissions.



Total transport distance and the distribution of distance between modes.

Two types of supply chains: **state-of-the-art (SOA)** always choosing the leading producing country.

optimized the supply chain with the lowest transport cost or emission

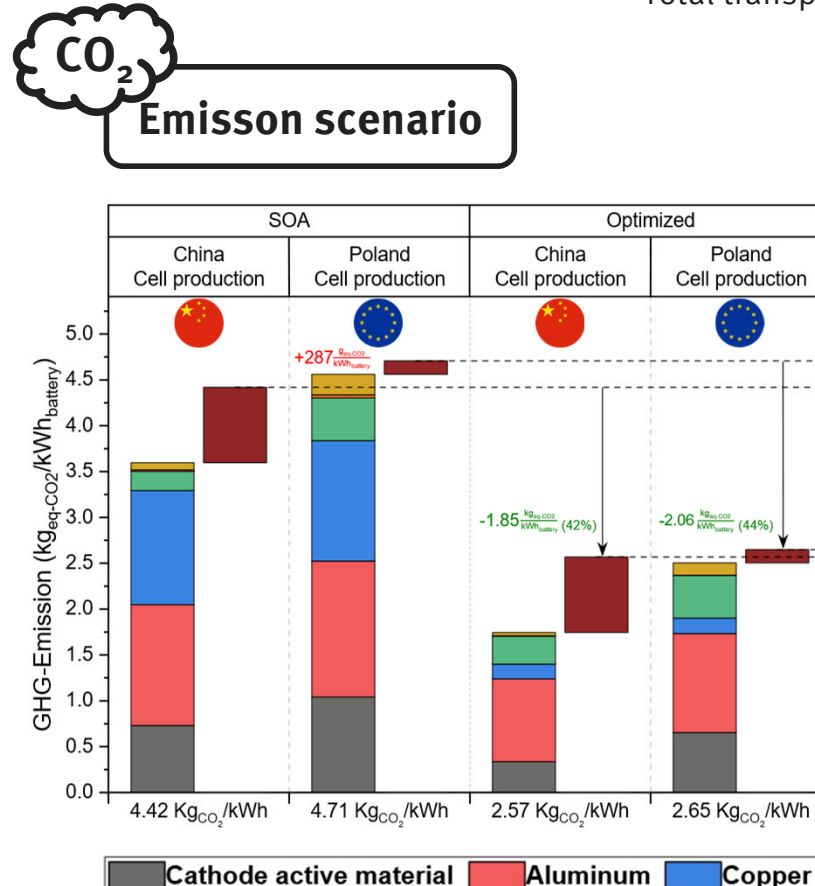
Emissions and costs are found to be similar across regions when final transport is accounted for.

Based on the literature, the estimated transport share of cell production emissions and costs, in the state-of-the-art (SOA) scenario, is:

7.3% of Emission

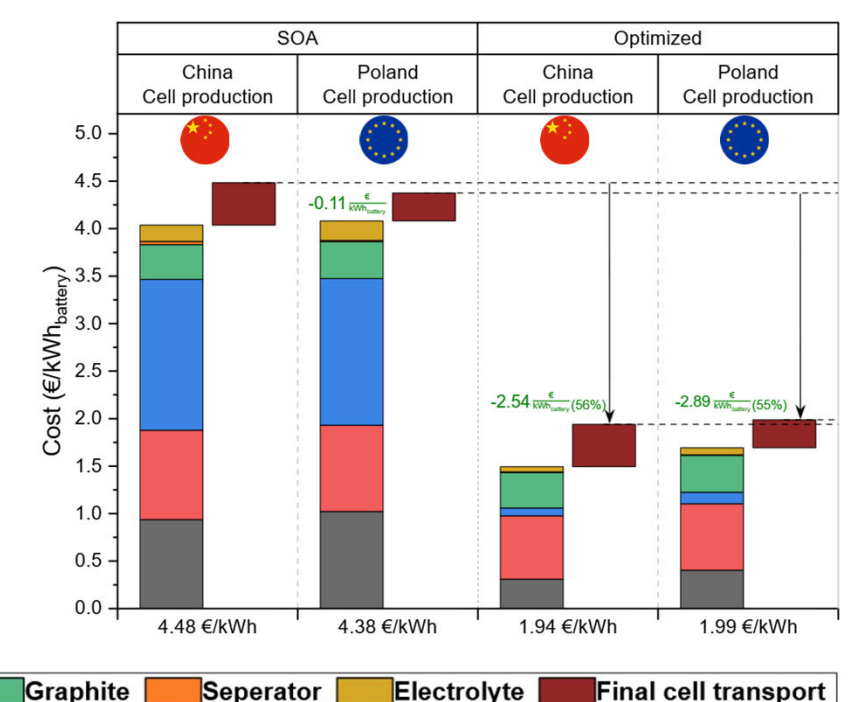
4.7% of cost

Emission scenario



Here are shown the cell breakdown for each major component and the final cell transport for a Chinese (CATL, Lichengzhen, China) and a European manufacturer (LG, Poland).

Cost scenario

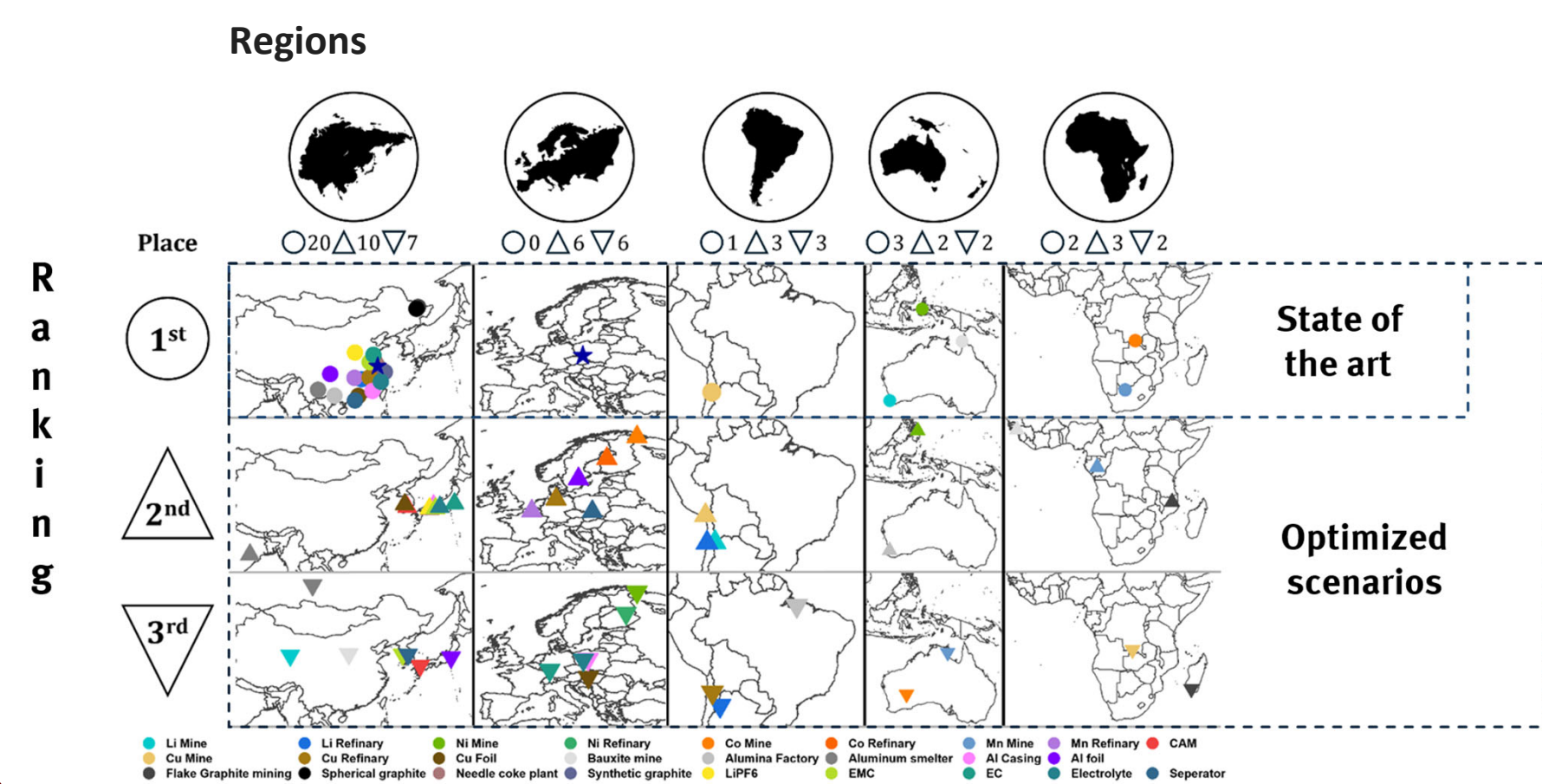


Internationalization

Raw material extraction is governed by the material's global contribution and abundance, resulting in a broad distribution of mining operations worldwide.

Refining and manufacturing capabilities are thought to be well established and dominated by China

The map below shows the locations of mines, refineries, and factories used in this study. For each production step, 1 real-world location was selected in each of the top 3 countries.

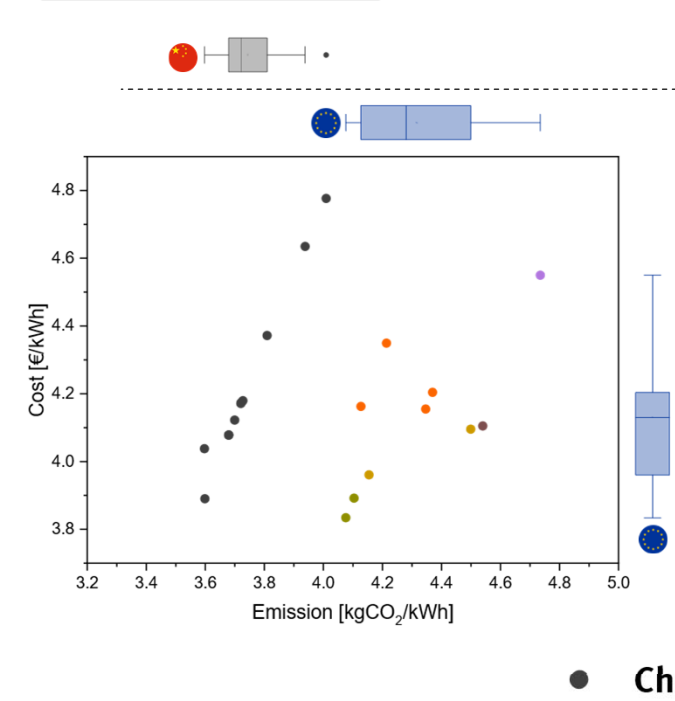


Europe vs China

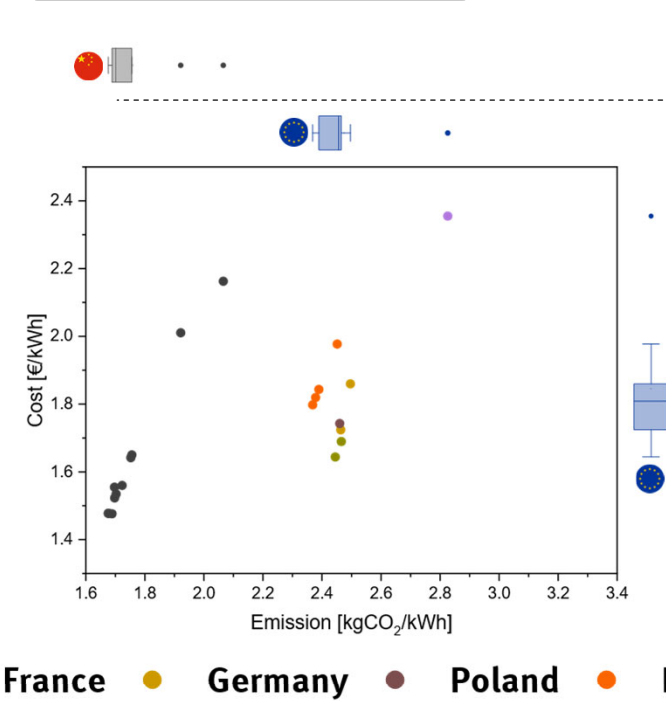
Europe currently has 10 battery cell plants between the late construction stage and fully operational.

These 10 plants are located in 5 countries and are distributed across the EU. In the figures below, the transport costs and emissions for the supply chains of the 10 European plants are compared with those of 10 real-world Chinese cell plants from different manufacturers.

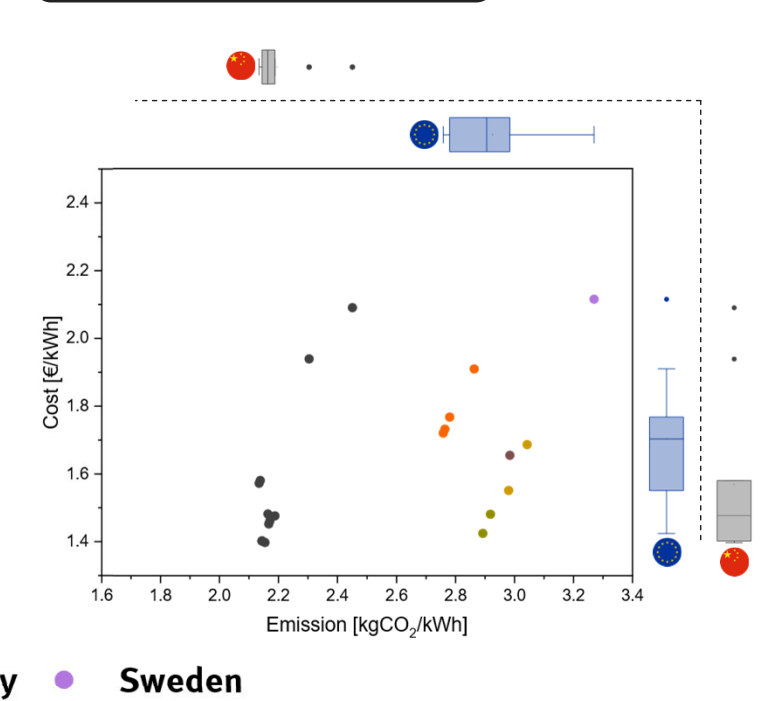
State of the art



Emission optimized



Cost optimized

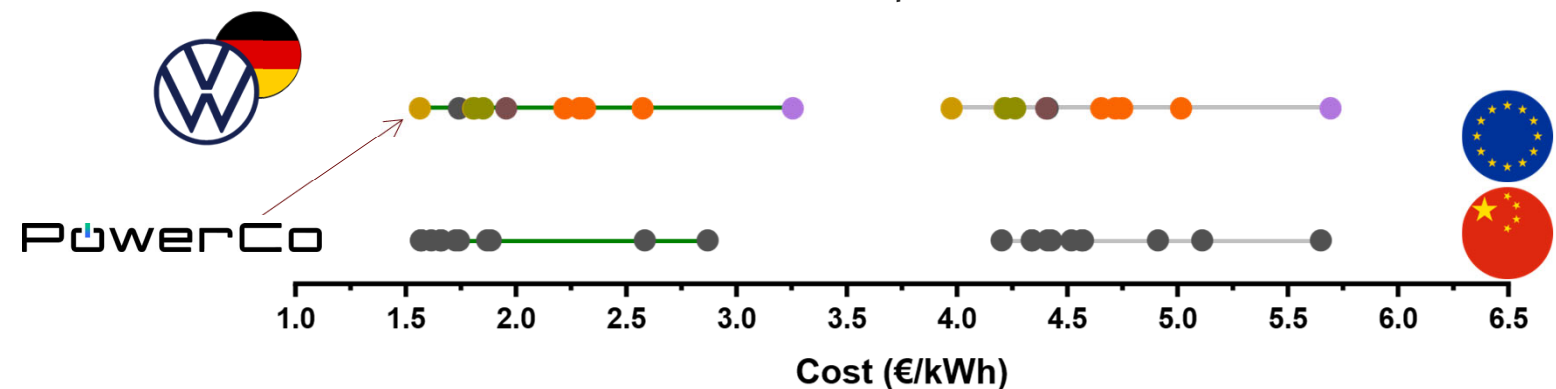


Each dot represents the transport emission and cost for a real-world cell manufacturer in Europe or China. For the state-of-the-art, emission-optimized, and cost-optimized supply chain. The data shows that China has lower transport emissions in all scenarios and, on average, a better cost case in the optimized scenarios.

Cell procurement

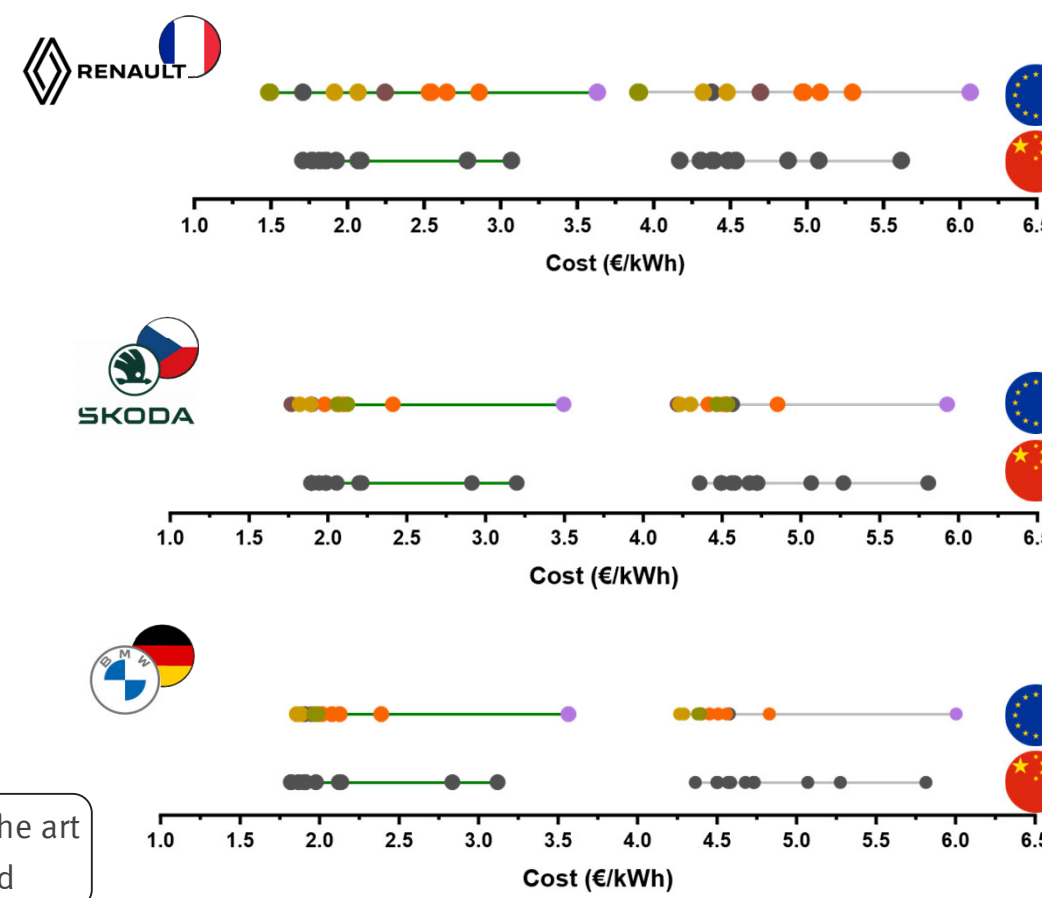
Many factors shape cell procurement in the automotive industry, including transport costs and supply chain security.

While Chinese manufacturers exhibit lower transport costs and emissions at the cell level, evaluating total supply-chain transport costs for European EV manufacturers indicates that European cell manufacturers can be the better choice when selecting based on total transport costs.



The figure shows the distribution of total transport costs across cell manufacturers when cells are delivered to the automotive plant under a state-of-the-art (grey) and an optimized (green) supply chain.

— State of the art
— Optimized



Perspective

Impact: The increased complexity and internationalization of the battery supply chain result in a significant share of total cell production costs and emissions attributable to transport.

Cell production: China's dominance in the battery supply chain results in lower transport emissions and costs, especially in the optimized scenarios.

European module manufacturing: We find that cell plants built in collaboration with, or for, a specific automotive partner incur the lowest transport costs in the supply chain.

Considerations: Material properties, such as material type, purity, packaging, and losses, are key when evaluating transport impacts in the battery supply chain.

Learning: The work shows transport can be a key lever in designing the future European battery supply chain, and underscores the importance of considering both input materials and products.