Lithium ion battery 380 kWh

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Other studies1,2,4,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34 use bottom-up process-based cost models (PBCM) similar to the BatPac but increase the accuracy of the manufacturing cost calculation by including installation cost, machine downtimes, lead times, and individual scrap rates for each production step. Most authors have customized their models to address particular research topics (e.g., the comparison between cylindrical and prismatic cells26) and have not publicly shared their models. As a result, these models are not readily applicable as universal tools for estimating the costs of various battery cells and production methods.

The presented model comprises six distinct stages (cf. Fig. 1): (1) and (2) establish the cell design, properties, and process chain, along with the overall production volume. (3) calculates the required material throughput for each selected process based on individual scrap rates. (4) determines the resource requirements. (5) calculates the individual process costs followed by the calculation of full, marginal, and levelized costs in (6).

Calculation procedure of the model to determine the production costs.

We investigate two cell types due to the availability of data and relevance within the automotive sector: cylindrical cells of modern dimensions (4680) and standard prismatic hard case cells (PHEV2) with a flat cell winding, both as used by Tesla (cf. Fig. 2).

Considered cell types including the type of jelly roll: cylindrical 4680 cells with round core winding (a) and the prismatic PHEV2 cell with prismatic core winding (b).

The case study assumes a yearly production volume of 10 GWh. The factory is located in Germany and operates 360 days a year, with a 3-shift operation lasting 8 h each (including a 1-h break). The modeled plant incorporates an excess capacity of 25%40, providing a buffer against potential production interruptions. This allows the machines to deliver a theoretical 25% higher throughput. Table 3 presents the general production parameters used in the case study.

The fabrication of LIB cells is a series of sequential and interrelated process steps38. The process chain design for this case study, chosen in consultation with experts, is shown schematically in Fig. 3. The figure illustrates both the actual material and by-products flow sequence during the process steps (light blue path) and the anterograde calculation of material flow that includes generated scrap (dark blue path).

Production processes for the prismatic hardcase PHEV2 and cylindrical 4680 cells.

Battery production cost can be measured by full, levelized, and marginal costs. Several studies analyze the full costs, but the components are not clearly defined. For example, capital costs and taxes are omitted by most authors. For comparability and since there is no consistent calculation method used by the other authors, this paper omits both factors in the full cost calculation.

Levelized costs are a more complete and more clearly defined metric. They describe the average price an investor needs to realize from selling a product to achieve a zero net present value (NPV). This includes covering all operating expenses, payment of debt, and imputed capital cost on the initial project expenses, as well as an acceptable return to the investor41,42. This paper follows the formal definition of levelized cost from Reichelstein and Rohlfing-Bastian43, but adapts the calculation logic to include recurring investments for the periodic replacement of machines.

Another important cost measure is the marginal unit cost which reflects the costs to produce another unit of output. They are used for short-term production decisions44. In the case of battery cells, marginal costs include all material, energy, and direct labor necessary to produce another kWh of battery capacity but neglect fixed costs like investments in the production facility. It is possible that reports of very low battery production costs5 refer to marginal costs instead of the full costs. This paper reports all three measures to ensure comparability.