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Sodium-Zinc solid electrolyte batteries - the enabler of low-cost energy storage?

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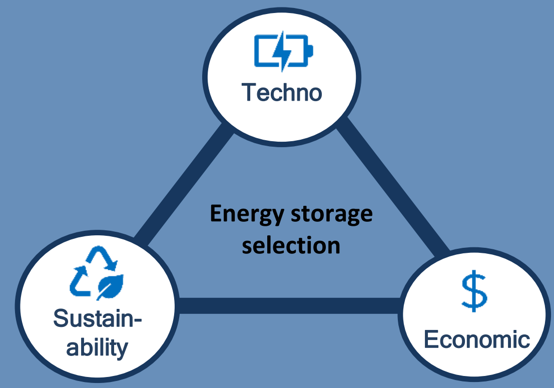

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Aims & objectives

1. Determine the possible capital cost (CAPEX) and the Levelized cost of storage (LCOS) of Na-Zn solid electrolyte battery, inspired by ZEBRA technology
2. Alter the overall design architecture of this novel battery to achieve the low-cost objective of this battery energy storage system (BESS)

Background

The utility-scale energy storage system is a viable solution for the high penetration of intermittent renewable energy in electricity generation. The widespread use of Li-ion batteries is inhibited for utility-scale energy storage because of the high cost, availability of raw materials and recycling issues. Therefore, many battery developers try to develop alternative cheap and sustainable solutions, including Na-Zn batteries. This novel solid electrolyte battery technology, inspired by the well-known ZEBRA battery for fast-track development, is still in the laboratory stage and requires cost analysis to determine the potential cost breakthrough.

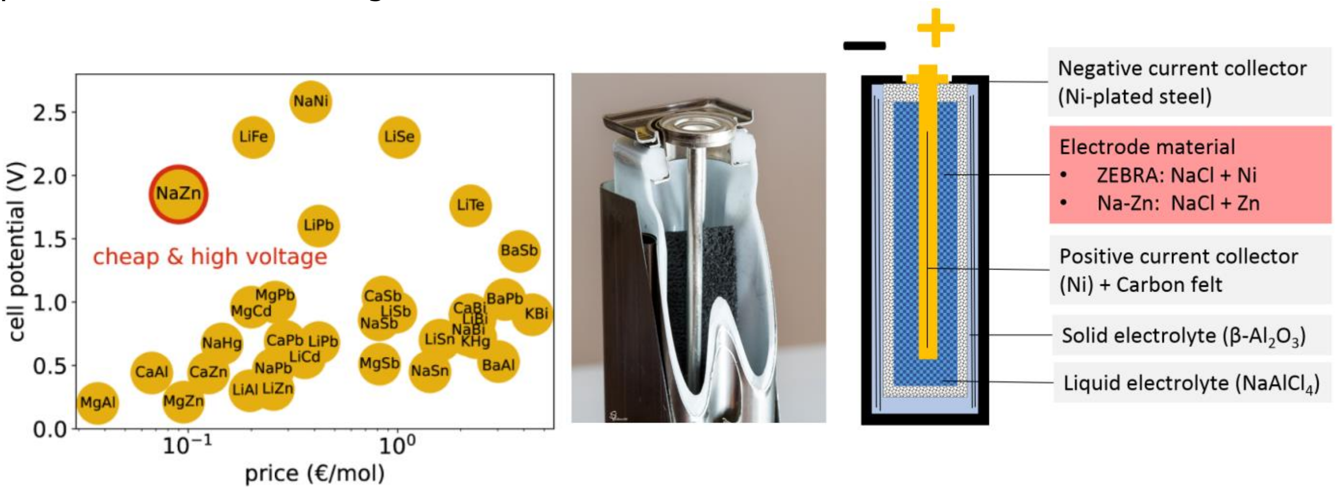

Figure 1: Price vs cell potential [1], ZEBRA cell cross-sectional view [2] and Na-Zn solid electrolyte cell elements, inspired by ZEBRA battery

Methodology

The methodology for the cost establishment is the bottom-up cost engineering technique combined with the data from the experts' interview, considering all associated costs to reach the cell energy capacity and battery energy storage system's specification. The techno-economic model was created based on the cost breakdown structure of the BESS project's CAPEX down to the single cell element. The data was collected from interviews with the R&D team of Na-Zn solid electrolyte battery and combined with secondary data sources to forecast the CAPEX from cell to BESS. Since this technology is in the laboratory stage (TRL 3), the dynamic model's insights from the Monte-Carlo and sensitivity analysis can alter the parameters to achieve the low-cost target.

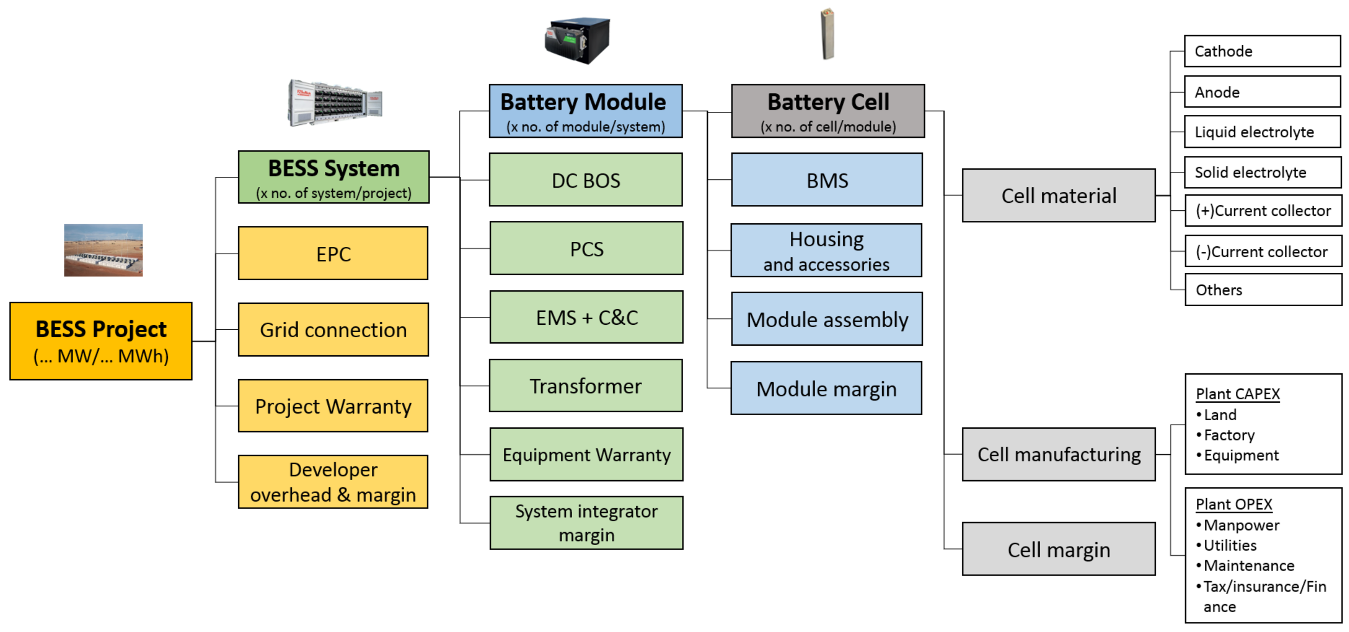

Figure 2: CAPEX classification and cost breakdown structure [3][4][5]

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Results

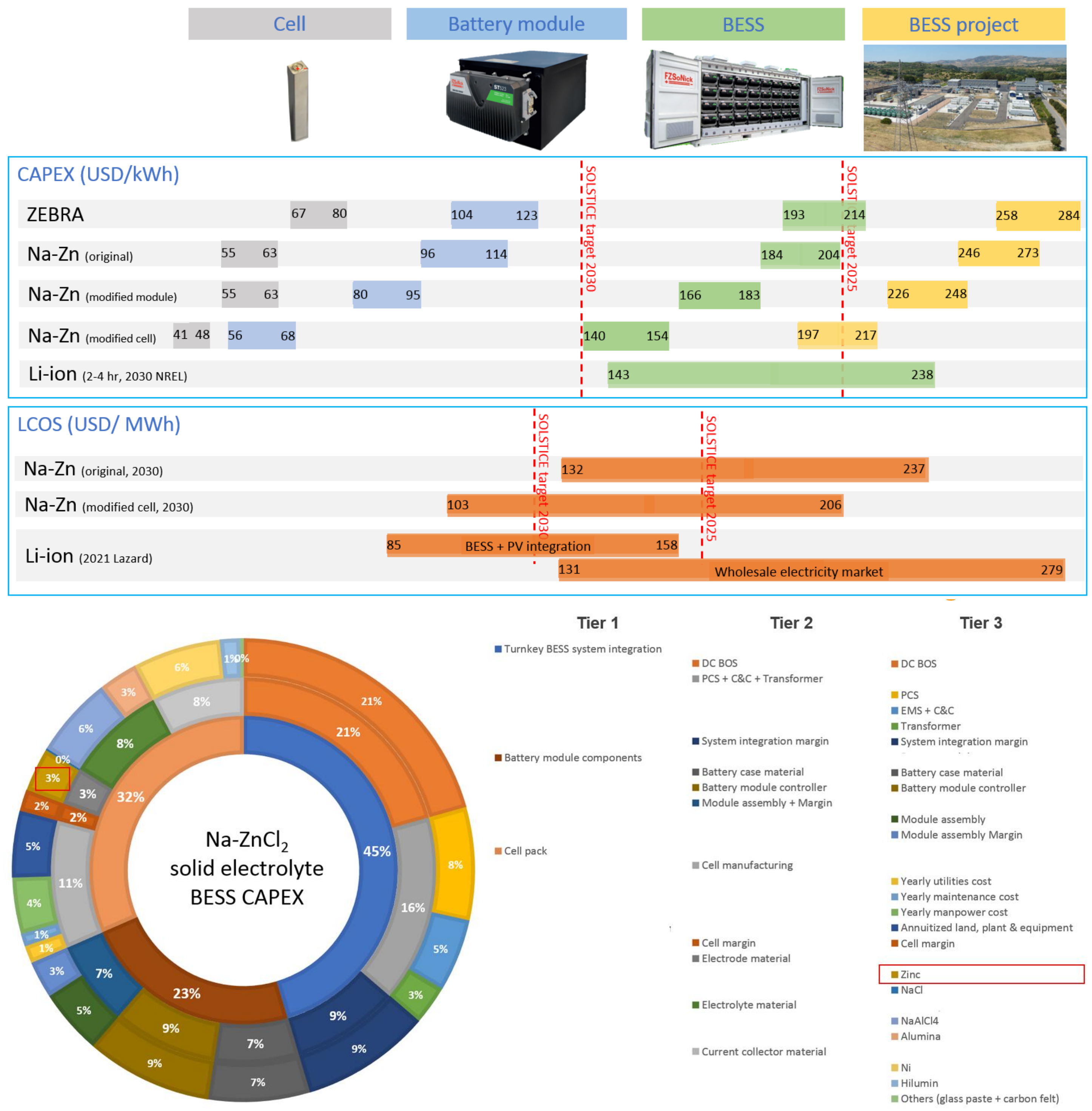

Figure 3: CAPEX, LCOS and cost breakdown of Na-Zn solid electrolyte batteries [6]

The techno-economic bottom-up cost engineering model shows the CAPEX and cost breakdown element of a cell, battery module, and BESS. The BESS project is the input for the Levelized cost of storage (USD/MWh) of the Na-Zn solid electrolyte battery technology.

Although replacing Ni-positive electrode material with Zn would reduce the energy capacity by 22% due to the lower cell voltage. However, the cell CAPEX could be 21% lower than the ZEBRA battery. The probable range of CAPEX is estimated between 55 – 63 USD/ kWh and 184 – 204 USD/ kWh at cell and BESS levels. Zinc material represents 3% of the BESS CAPEX, and the Na-Zn solid electrolyte battery rack accounts for 55% of the BESS CAPEX.

Regarding this forecasting BESS, the LCOS of the Na-Zn battery project is expected to reach 132 – 237 USD/MWh in 2030.

Conclusion

The battery energy storage system made with low-cost Na-Zn solid electrolyte technology inspired by the ZEBRA battery has the potential to compete with the existing Li-ion batteries for utility-scale storage applications.

Recommendation

This forecasting Na-Zn BESS project CAPEX could be further reduced by increasing the number of cells per module and the cell energy capacity. Both methodologies increase the gravimetric specific energy of the battery significantly. The increasing number of cells per module from 240 to more than 1,920 cells/module could reduce 8% of CAPEX. Increasing cell energy capacity similar to Na-S battery to 1.1 kWh could provide an 18% CAPEX saving. This cost reduction possibility could even make this novel Na-Zn solid electrolyte battery achieve the LCOS target of 122 USD/MWh in 2030.

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