Customized design of lithium-ion batteries for residential photovoltaic systems: Techno-economic analysis and optimization

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Compared to the electric vehicles, the cycling profiles of batteries employed in the residential storage, regardless of dispatch strategy, hold a low value of power/energy ratio. This feature theoretically allows to manufacture batteries for stationary storage applications at a lower cost thanks to less design constraints at the electrode and cell levels .[1] This inspires dedicated studies to be conducted in order to quantify the prospects of cost reduction in the behind-the-meter batteries using optimum and customized designs at electrode and cell levels.

In this work we present the result of a techno-economic analysis aiming to assess the profitability of adding battery packs composed of $LiNi_{0.33}Mn_{0.33}Co_{0.33}$/Graphite pouch cells to the residential PV systems. To do so, we couple a physics-based battery model[2] with a process-based manufacturing cost model[3] to optimize the return of investment for a series of typical prosumers, characterized by their local PV generation, demand, and installed battery size. The modeling framework enables determining the sensitivity of the cost advantage and the performance of batteries to a wide range of design characteristics including electrode thickness, electrode volume fraction, cell width, aging rate, electricity pricing, and manufacturing rates. Although different in the details, the common feature of the designs considered in this study is the higher mass loading of the electrochemically active materials in cells compared to the state-of-the-art batteries employed in the electric vehicles.

Our results suggest that the transition from the conventional EV battery design to a more specific design for the residential storage sector can lead to 30-70% lower investment costs with a minimum compromise on the system's power capability. Such a design transition translates into a higher return of investment by almost 50%, i.e. from 31% to 45% for an average Belgian residential household with PV peak power and battery size of 4 kW and 4kWh, respectively.

References

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