Supplementary: Key Considerations for Cell Selection in Electric Vertical Take Off and Landing Vehicles: A Perspective

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Packing density

The energy density of a battery pack is significantly influenced by the number of cells it incorporates. For safety considerations, battery engineers intentionally maintain an optimal spacing between consecutive cells and between the outermost cell and the inner wall of the battery pack. This spacing plays a crucial role in preventing overheating and ensuring safe operational conditions. The packing density, defined as the ratio of cell volume to battery pack volume, is therefore not solely determined by the shape and size of the cells, but also by the relative spacing between consecutive cells and the gaps between the outer cells and the inner boundary of the battery pack. Consequently, a higher packing density signifies more efficient utilisation of space within the battery pack.

In the following section, we calculate the packing density for cylindrical and prismatic cell configurations.

Cylindrical cell

Fig. S1 schematically depicts two optimum configurations of cylindrical cells with radius 'r' and spacing 'd' within the battery pack. In the first arrangement (Fig. S1a) the cells are positioned in a head to head fashion, forming a 90° between adjacent cells ($\angle ABC = 90°$). This configuration corresponds to a coordination number of four. In contrast, the second arrangement (Fig. S1b), features the rows of cells titled at an angle ($\angle ABC = 60°$), resulting in a coordination number of six. To calculate the packing density (η) based on the configuration shown in Fig. S1, we consider the unit height, and proceed as follows,

Coordination number four:

$$\eta = \frac{cell\, area\, inside\, square\, ABCD}{area\, of\, square\, ABCD} = \frac{\pi r^2}{(2r+d)^2} = \frac{\pi}{(2+d/r)^2}$$

Coordination number six:

$$\eta = \frac{cell\, area\, inside\, equilateral\, triangle\, ABC}{area\, of\, equilateral\, triangle ABC} = \frac{0.5\pi r^2}{(\sqrt{3}/4)\times BC^2} = \frac{2\pi}{\sqrt{3}(2+d/r)^2}$$

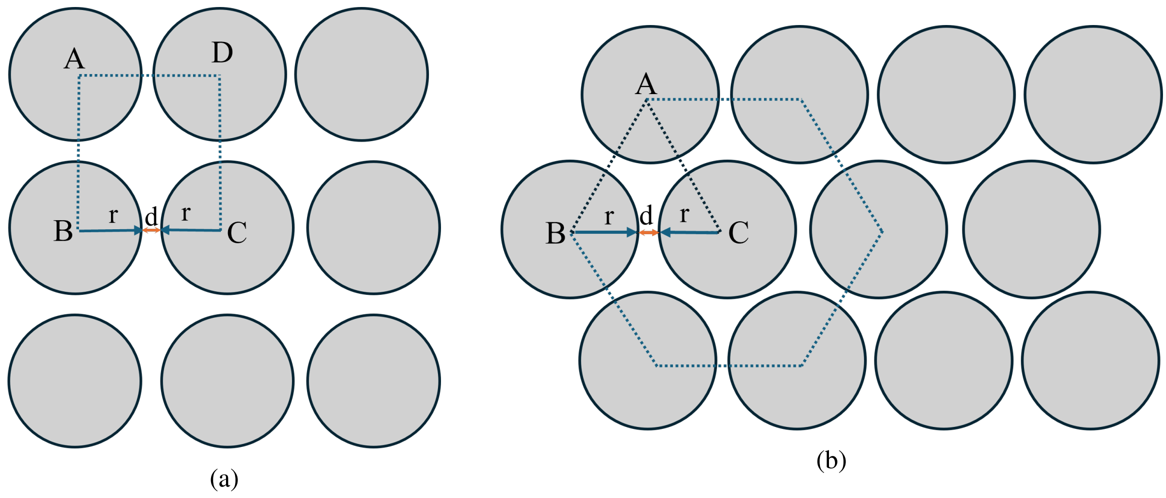

Figure S1: Schematic of two different cylindrical cell configurations with (a) coordination number 4, and (b) coordination number 6, where each cell (depicted as circles) has a radius r and is separated from its neighboring cells by spacing d.

Pouch cell/ Prismatic cell

Fig. S2 depicts the prismatic cell of cross-section $w \times h$ with spacing 'd' between two consecutive cells. We consider unit height and calculate the packing density (η) as,

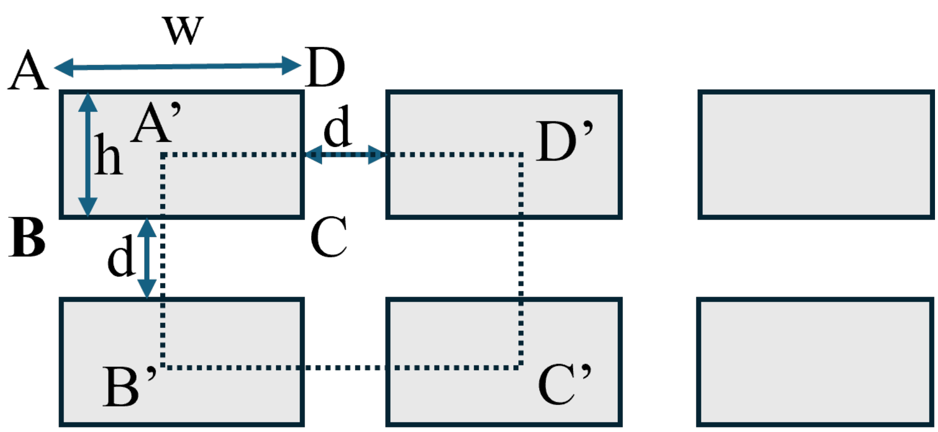

Figure S2: Schematic of prismatic cell arrangement with cross section $w \times h$ and spacing d.

$$\eta = \frac{cell\, area\, inside\, rectangle\, A'B'C'D'}{area\, of\, rectangle\, A'B'C'D'} = \frac{wh}{(w+d)(h+d)} = \frac{1}{(1+d/w)}\frac{1}{(1+d/h)}$$