**ENERGY & POWER BALANCE**

- Conflict requirements pose a layer optimisation problem
- Desires trading of energy & power in equally-dimensioned cells
- Layer reconfiguration trades fraction of active material mass with surface area available for redox reaction
- Maximum usable energy is available for neither the most rate capable nor the most energy density large layer configuration
- Empirical determination of optimal layer count is slow, costly & may not provide energy-density maximising result
- We propose a rapid & inexpensive model-based alternative

**LAYER OPTIMISATION**

- Stack thickness & active & inactive material quantities are recalculated for each new layer count (n) using derived expressions
- The optimal (i.e., range-maximising) layer configuration is the minimum number of layers that meets EV acceleration and fast charging targets
- Initially, we gain a lot of rate capability for little energy density loss since power density per layer decreases faster than cell nominal capacity
- At higher layer counts, it becomes increasingly expensive, in terms of energy density sacrificed, to accommodate higher powers
- Efficient designs employ < half the maximum possible number of layers

### Layer Configuration

<table>
<thead>
<tr>
<th>Layer Count</th>
<th>Rate Capable</th>
<th>Acceleration</th>
<th>Fast Charging</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
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</tr>
<tr>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**P2D SIMULATION**

- Custom, efficient binary search screens layer configurations
- Open-source electrochemical P2D model directly accepts power input, solves for current & converges rapidly owing to Jacobian
- Each new layer configuration requires model updates
- Vector of layer State-of-Function is produced; lowest layer count with a unity SoF is the optimal

**TAILORED CELL DESIGN MAPS**

- Repeat for new coolant (ambient) & cell temperatures to generate cell design maps precisely tailored to vehicle fast charge targets
- Values in coloured cells are optimal layer configurations/counts
- Map colour is usable capacity; charge added, 30 - 80% SOC window
- Black colours indicate unsuitable cell materials & thermal management system limit highlighted
- Method can offer xEV range extension over empirical cell designs by producing energy-density optimised layer configurations

**COMMON MODULE DESIGN FOR EV PACKS**

- New layer configurations generated for a different vehicle platform, using a cell with identical external dimensions
- Produces energy-density maximising designs for this new vehicle...

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See the paper: Ian D. Campbell*, Krishnakumar Gopalakrishnan, Dr. Monica Marinescu, Dr. Marcello Torchio, Dr. Gregory J. Offer, Prof. Davide Raimondo.