Cylindrical vs. Prismatic Cells: Life, Safety, Cost
Does Shape Matter?
<table>
<thead>
<tr>
<th>Specific Energy1,2 (Wh/kg)</th>
<th>Energy Density (Wh/L)</th>
<th>Heat released in Thermal Runaway (kJ/cell)</th>
<th>Cost ($/kWh)</th>
<th>Cycle Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>18650</td>
<td>676</td>
<td>521</td>
<td>200</td>
<td>2000</td>
</tr>
<tr>
<td>Pouch</td>
<td>243</td>
<td>43</td>
<td>300</td>
<td>5000</td>
</tr>
</tbody>
</table>

1,2: Vs.
Practical Considerations

- Interchangeability – Samsung, Panasonic, LG, Sony, etc. offer virtually identical options

- Configurability – Could you do this with pouches?
Only a Niche Product?

- More assembly time, labor, and material

- More complex pack electrical design
The Big Reason for Large Format

Cycle Life Comparison

% Capacity Remaining

0  500  1000  1500  2000  2500  3000
# Cycles

% Capacity Remaining

What about calendar life?

Pouch Cell

18650
The Big Reason for Small Format

Single Cell failure
(large format)

Single Cell failure
(small format)
PCC Material (patented)
Hybrid and Electric Delivery Truck

- Customer makes hybrid and electric delivery trucks
- Battery systems are 60 and 120 kWh at 612V
- AllCell has brick configurable to 1s or 2s options

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurability</td>
<td>Less cycle life</td>
</tr>
<tr>
<td>Lack of reliance on one supplier</td>
<td>Slower charge</td>
</tr>
</tbody>
</table>
All Terrain Vehicle

- All electric off-road 4WD rec-utility vehicle
- System is 100V, 100Ah with 450A discharge peak
- AllCell provides 45 cell brick in unique shape

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<tbody>
<tr>
<td>Unique shape configurability</td>
<td>Less cycle life</td>
</tr>
<tr>
<td>Good power and energy to volume</td>
<td>High power+energy costs more</td>
</tr>
</tbody>
</table>
Material Handling

- Automated Material Handling Robots
- Systems 24 and 48V, 2-10 kWh
- AllCell has 70 cell brick configurable to 7.2V, 99Ah or 3.6V, 198Ah options

<table>
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<tbody>
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<td>Can efficiently make small packs</td>
<td>Less cycle life</td>
</tr>
<tr>
<td>Custom shapes</td>
<td>Slower charge</td>
</tr>
</tbody>
</table>
Stationary: Frequency Regulation

- Frequency Regulation battery-inverter systems perform continuous shallow cycle operation at power up to 2C
- Battery systems are typically 500-1000V and 125kWh-1MWh
- AllCell has 105-348 Ah bricks

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Comparable cycle life (theory)</td>
<td>Lower power</td>
</tr>
<tr>
<td>Safer</td>
<td>Higher cost (artificial?)</td>
</tr>
</tbody>
</table>
Is Frequency Regulation a Market Driver?

CAISO
- 300 TWh/yr delivered
- 265 MW frequency regulation (estimate)

PJM
- 791 TWh/yr delivered
- 700 MW frequency regulation

AB2514 → 1.3 GW energy storage mandate

1.3 GW >> 265 MW
If low power is the future...

VS.

VS.
Conclusion

- In a truly non-committal statement: Cylindrical cells and large format cells each have distinct advantages and disadvantages

- Slightly more specifically: Large format cells seem to have more theoretical advantages, but:
  - Need to prove that costs will drop as volumes increase
  - Harder to contain thermal runaway
  - Sometimes real world issues will override advantages
Thank You!

Greg Albright
galbright@allcelltech.com