Cylindrical vs. Prismatic Cells: Life, Safety, Cost
Does Shape Matter?
VS.

- Specific Energy1,2 (Wh/kg): 243 (18650), 215 (Pouch)
- Energy Density (Wh/L): 676 (18650), 364 (Pouch)
- Heat released in Thermal Runaway (kJ/cell): 521 (18650), 43 (Pouch)
- Cost ($/kWh): 200 (18650), 300 (Pouch)
- Cycle Life: 50 (18650), 20 (Pouch)

1. Specific Energy is the energy available from a battery per unit of weight.
2. Energy Density is the energy available from a battery per unit of volume.
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

# Cycles

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

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<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>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<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>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</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...
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