Application Note

# Tesla 4680 vs. BYD Blade Cell – Design and Performance Analysis with SI-9300R

**Application Note: 2025**

## 1. Introduction

The rapid growth of the electric vehicle (EV) market has intensified the need for advanced lithium-ion battery technologies. In the research funded by the German Federal Ministry of Education and Research (grant no. 03XP0256), two leading designs, Tesla's 4680 cylindrical cell and BYD's Blade prismatic cell, represent distinct approaches to balancing performance, safety, and cost were analyzed. The Tesla 4680, with its high-nickel NMC811 chemistry, prioritizes energy density and range, while the BYD Blade, using lithium iron phosphate (LFP) chemistry, emphasizes safety, thermal stability, and cost-effectiveness.

This application note, based on finding published by Jonas Gorsch, Research Associate Battery Engineering & Safety at RWTH Aachen University and his team provides a comparative analysis of the Tesla 4680 cylindrical cell and the BYD Blade prismatic cell, focusing on their design features and performance characteristics. Leveraging data from the open-source article "Contrasting a BYD Blade prismatic cell and Tesla 4680 cylindrical cell with a teardown analysis of design and performance" from Gorsch *et al.*,[1] this note details how the AMETEK Solartron Analytical SI-9300R Battery Analyzer can be used to evaluate key parameters such as energy density, internal DC resistance, thermal management, and efficiency.

## 2. Cell Design Overview

### *2.1 Tesla 4680 Cylindrical Cell*

The Tesla 4680 cell is a large-format cylindrical cell with dimensions of 46 mm in diameter and 80 mm in height. It features a tabless design and a "jelly roll" configuration, where electrode layers are tightly wound inside a steel casing. Laser welding is used for electrode connections, reducing internal resistance and enhancing current collection efficiency.

The cathode uses NMC811 (nickel-manganese-cobalt in an 8:1:1 ratio), and the anode is graphite without silicon additives. Binders include polyacrylic acid (PAA) and polyethylene oxide (PEO).

### *2.2 BYD Blade Prismatic Cell*

The BYD Blade cell is a prismatic cell with dimensions of 965 mm in length, 90 mm in height, and 14 mm in thickness. It uses a Z-folded electrode stack and hybrid laser/ultrasonic welding for robust electrode connections, offering mechanical stability and simplified thermal management.

The cathode is lithium iron phosphate (LFP), known for thermal stability and lower cost, paired with a graphite anode. Binders include carboxymethyl cellulose (CMC) and styrene-butadiene rubber (SBR).


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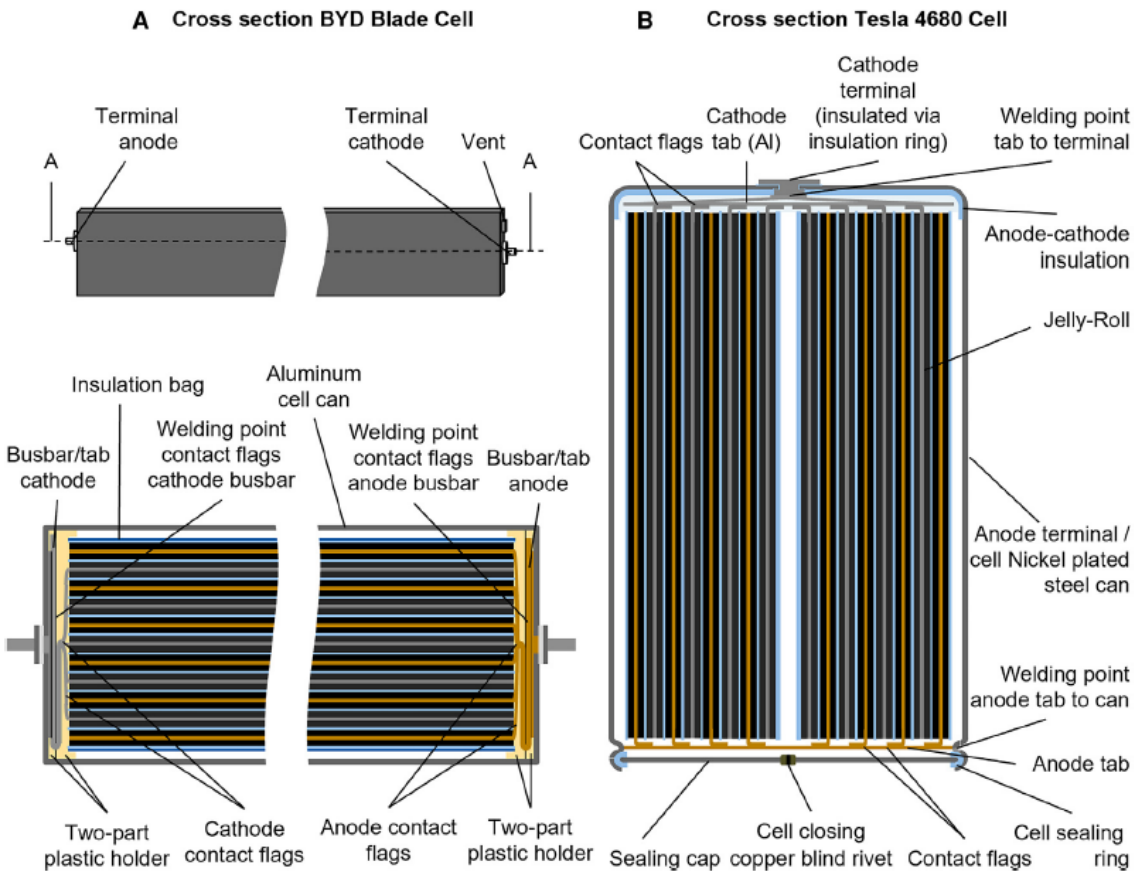



*Figure 1. Simplified sketch of the cells' cross-sections displaying all internal components.*[1]

## 3. Performance Analysis with the SI-9300R Battery Analyzer

The SI-9300R Battery Analyzer is a versatile tool for characterizing battery cells, offering precise measurements of electrical, thermal, and mechanical properties. Below is how it can be applied to analyze the Tesla 4680 and BYD Blade cells based on the teardown data.

### *3.1 Energy Density and Capacity*

Measurement Method: The SI-9300R Battery Analyzer was used to measure the cells' capacity and nominal voltage at a C/10 rate. CCCV (constant current, constant voltage) charging and discharging cycles were performed with a CV cutoff at a C/20 current. The average capacities during charging and discharging were calculated (refer to Table 1). The efficiency behaviors of the cells were then compared to evaluate their electrical performance.

The Tesla 4680 achieves 241.01 Wh/kg and 643.3 Wh/L, significantly outperforming the BYD Blade's 160 Wh/kg and 355.26 Wh/L. This reflects the NMC811 cathode's higher material-level energy density (720 Wh/kg) compared to LFP (528 Wh/kg). However, cathode material utilization rates are close, at 33.45% for Tesla and 30.3% for BYD, indicating similar efficiency in active material use despite design differences.


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Table 1. Overview of general cell properties.[1]

| | *Tesla 4680 Cell* | *BYD Blade Cell* |
|---|---|---|
| *Nominal capacity, Ah* | 23.125 | 135 |
| *Nominal energy, Wh* | 85.56 | 432 |
| *Nominal voltage, V* | 3.7 | 3.2 |
| *Voltage window, V* | 2.5-4.3 | 2.6-3.65 |
| *Weight, g* | 355 | 2700 (±300) |
| *Volume, mL* | 133 | 1216 |
| *Energy density (gravimetric), Wh/kg* | 241.01 | 160 |
| *Energy density (volumetric), Wh/l* | 643.3 | 355.263 |
| *The areal capacity of the cathode (calculated), mAh/cm²* | 4.99 | 2.393 |

### *3.2 Thermal Management and Efficiency*

Measurement Method: Utilizing SI-9300R's electrochemical and synchronized temperature measurements capabilities to assess heat generation and internal resistance (DCIR) during operation at 1C and higher C-rates. Cell thermal efficiency was compared by measuring internal DC resistance at 10% SOC steps and 10°C, 20°C, and 40°C, per ISO 12405-4.29. Figure 2 shows 1C charge/discharge resistance. Resistance rises at lower temperatures for both cells. Tesla 4680 resistance increases at high SOC, especially in cold, while BYD Blade's decreases. This may reflect anode charge transfer resistance from high lithium levels, needing further study, as rising resistance at high SOC is atypical.

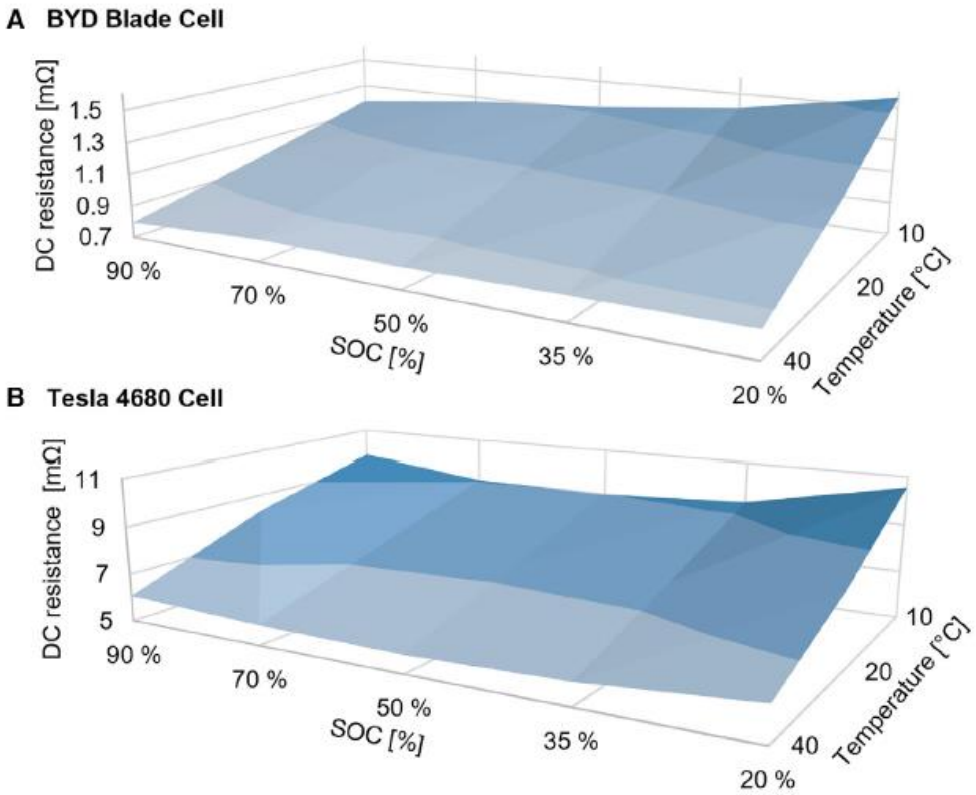



*Figure 2. Average direct current resistance (DCIR) at 1 C 18 s charging and discharging pulses at 20 °C: (A) BYD Blade cell. (B) Tesla 4680 cell.[1]*


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Specific heating was calculated as:

$$\text{Heating/Volume} = (I_{1C})^2 \times R_{average} / V_{cell}$$

Where, I = current; R = internal resistance; and V = volume.
The Tesla 4680 cell generates about 2 times more heat per volume than the BYD Blade cell at a 1C load (Figure 3). Consequently, cooling systems for Tesla 4680 cells must handle roughly 2 times more heat per volume compared to BYD cells under identical power demands. Thus, the LFP electrode design of the BYD cell offers a more advantageous cooling strategy for fast charging.

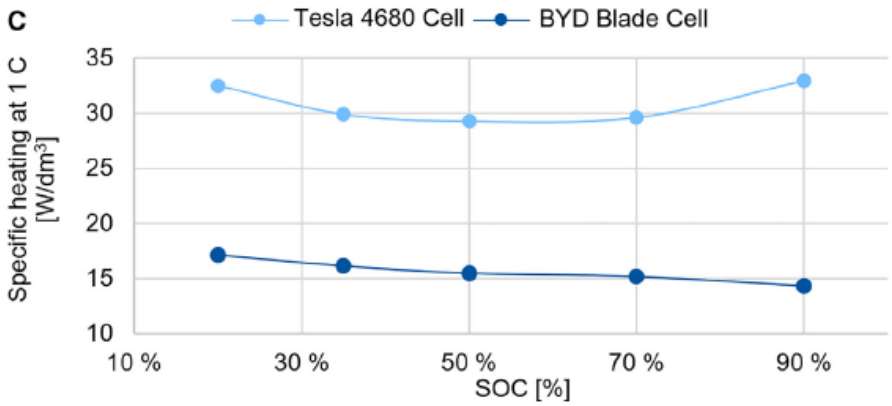



*Figure 3. Volume-specific heating of both cells at 1 C.*[1]

**Conclusion**

The Tesla 4680 and BYD Blade cells represent complementary approaches to EV battery design, with the former prioritizing energy density and performance, and the latter emphasizing safety and cost. The SI-9300R Battery Analyzer provides a robust platform for evaluating these differences, enabling engineers to make data-driven decisions for next-generation battery systems. Users can simulate real-world operating conditions such as urban profiling, leveraging from the arbitrary waveform tool of the Aspire Energy® software, to optimize thermal management systems, ensuring safety and longevity for each cell type.

For further information on the SI-9300R and SI-9300R-SA and their capabilities, please refer to our website- www.ameteksi.com.

**References**

1. J. Gorsch, J. Schneiders, M. Frieges, N. Kisseler, D. Klohs, H. Heimes, A. Kampker, M.M. Castro, E. Siebecke, Contrasting a BYD Blade prismatic cell and Tesla 4680 cylindrical cell with a teardown analysis of design and performance, Cell Reports Physical Sciences 6, 310245, March 19, 2025. https://doi.org/10.1016/j.xcrp.2025.102453


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