Will Tesla's thrust on expanding its in-house expertise pay off?

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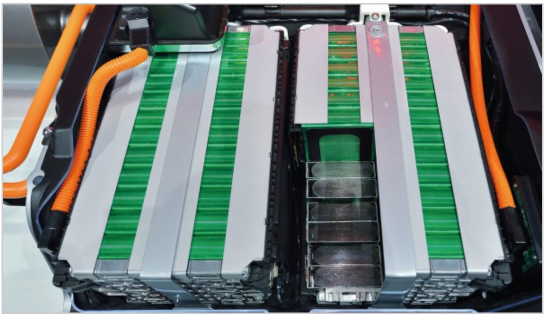

If Tesla is able to deliver the efficiencies in battery cell manufacturing and establish itself as a major battery producer, the impact on the overall electric vehicle industry will be significant

On 22 September, Tesla hosted an announcement-packed 'Battery Day", showcasing its vision on where it wants to be in terms of battery cell technology and production capacities within the next three years, as well as what some of the innovation in the works could mean for end customers of its electric vehicles (EV). The company announced evolutionary changes, right from the cell design, down to the manufacturing processes related to every cell component, that will not only improve the performance of the cell, but also reduce cost and complexity related to its manufacturing.

One of the key takeaways from the event was Tesla's push towards becoming increasingly self-reliant for battery cells. Being self-reliant is in the company's DNA; its EV charging network as well as its software development is testimony to that and among the key enablers of Tesla's success to date. However, establishing a captive and efficient battery production operation is going to be a different ball game altogether, considering the intricate supply chain dynamics involved in battery production. The fact that Tesla plans to manufacture cells in-house has been known for some time now, but the extent of it was revealed by Tesla's founder and CEO, Elon Musk during the event. Tesla is aiming to have a cell manufacturing capacity of 100GWh by 2022, which it plans will increase to 3TWh by 2030. This would require Tesla's business not only in the automobile industry but also in the energy storage system (ESS) industry to continue to grow rapidly. What is also clear is that this massive capacity scale up is not possible with the current manufacturing setup that Tesla has at its disposal, and that it would require a massive overhaul every step of the way to meet the envisioned battery cell capacity. It seems that once again, when faced with critical scaling or success-defining attributes, Tesla would err on the make side of the "make or buy" equation.

Another major takeaway of the Battery Day was in Tesla's claim that it has found a path to reduce battery cell costs by 56% (USD/kWh) thanks to

- bigger form factors,
- dry battery cell coating process,
- silicon anodes,
- a diversified cathode approach (iron for medium range and stationary energy storage, nickel-manganese for intermediate applications and high nickel cathodes for long range)
- revised battery integration approach.

Bigger and better

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A bigger and more powerful battery cell is at the center of all the changes Tesla wants to introduce. The company unveiled a 'tabless' 4680 cell which has a bigger form factor than the current 2170 cell with a tab. The new cells replace tabs and with a laser-patterned spirally-wound active material with dozens of connections. According to Tesla, this has reduced the electrical path length by 5 times from 250mm to just 50 mm, and has resulted in a cell with better power-to-weight ratio compared to smaller cells. It also has fewer parts, simplified winding and coating process, and improved thermal performance and alleviated safety concerns associated with bigger form factor cells. The end result is five times more energy, six times more power, enabling a 16% higher range, at a 14% USD/kWh cost reduction. More power could also involve better capture of regenerative braking energy during city driving.

To develop the new cells, Tesla is looking at transforming the entire cell manufacturing process. The biggest step-up is the move from wet process for electrode coating to dry process. This is a manufacturing capability that Tesla inherited with the acquisition of Maxwell Technologies in 2018. The dry process reduces manufacturing footprint by around 10 times, and thus the investments by eliminating the complex solvent mixing stage; it also cuts waste, especially waste water, which is a part of the conventional wet process, and is an environmental concern. Musk informed that the machines and processes from Maxwell have undergone four revisions to reach this pilot production stage, and that there will be a couple more generational changes before this new system is ready for mass-production.

Some surprise emerged also on Tesla’s material research during the Battery Day. Tesla has been devoting more attention to material research in body, having hired in 2016 Apple’s alloy specialist Charles Kuehmann. Tesla has also developed its own aluminum alloy that does not require coating or heat treatment, to manufacture single-piece casting for the rear and front body using a large casting press, so called “Gigapress” sourced from Italy’s Idra Srl. During Battery Day Musk revealed this was part of a bigger plan to make the battery pack become a structural component of the vehicle, enabling elimination of intermediate structures, reducing mass and freeing up space for more cells. “This is supposed to help Tesla achieve reduce cost weight and thus improve range, however it does come with some concerns around battery pack serviceability,” according to Edwin Pope, Principal Analyst, Materials and Lightweighting at IHS Markit. “Tesla’s approach of integrating traditionally stamped sheet metal parts into singular castings goes beyond and will continue to grow in presence both inside and outside of battery pack. The integration of large cast sections into future vehicles will continue to help Tesla reduce weight, complexity, and cost as part of their manufacturing strategy.”

Tesla's path to reducing battery cost is as much about the manufacturing process overhaul itself, if not more, as it is about "breakthrough" technologies such as the 'tabless' cell. This is more evident in light of the past acquisitions Tesla has made, like Hibar Systems, Maxwell Technologies, Grohmann Engineering in 2016, a German engineering company that specializes in automated manufacturing, or commissioning of one of the biggest casting machines in any industry to support innovative body panel production. This manufacturing efficiency is what Tesla wants to leverage moving forward. “Basically, Tesla is aiming to be the best at manufacturing of any company on earth. This is the most important thing in the long run of long-term competitiveness. Eventually, every company will have long-range electric cars, every company will have autonomy. But not every company will be great at manufacturing. Tesla will be absolutely head and shoulders above anyone else in manufacturing and that is our goal,” Musk said at the event.

Choice of chemistry

Efficient, sustainable and yet cost-effective cathode and anode technologies is the goal that the battery industry is moving towards, and will be among the main factors that will determine competitiveness of EVs. Automakers are

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looking at using materials that are cheap and easier to procure sustainably, which is the reason why cobalt-free cathode technology is a significant research focus. Cobalt supply is highly concentrated geographically and is prone to supply and cost fluctuations. Tesla too has announced that it would have zero cobalt in its new cell and instead use a high amount of nickel, especially in batteries that are meant for heavy-duty applications such as its Semi truck and Cybertruck. For low-range, Tesla will rely on iron-based cathodes, which are cheaper than nickel and cobalt-based batteries while retaining some decent performance. Tesla also recently received an approval from the Mainland Chinese government to use lithium iron phosphate (LFP) batteries in Model 3 in Mainland China. The Model 3 Standard Plus variant with a 55-kWh LFP cathode-based battery is expected to have a range of nearly 468 km (291 miles).

“Cathode materials’ performance differs in output, lifespan, thermal stability, price, and weight depending on the composition, coating and doping material. Therefore, it is considered a good strategy to use a cathode material suitable for the purpose. Efforts to remove cobalt have come in many forms. Excluding LFP and lithium manganese oxide (LMO), which are already widely known in the market, there are other technologies such as lithium manganese nickel oxide (LMNO) and lithium nickel dioxide (LNO). According to what Tesla announced at the Battery Day event, LFP will be considered for long cycle life cars, LMNO for long range cars, and lithium nickel cobalt aluminum oxide (NCA) for commercial cars. Excluding cobalt adversely affects the cell's thermal stability and longevity. This is a field where cathode material manufacturers are actively engaged in research and development rather than cell manufacturers. Even if LMNO is used as the main cathode material, a trace amount of aluminium or cobalt doping will still be required,” said Richard Kim, Principal Analyst, IHS Markit.

For anode too, Tesla is planning to use basic silicon with elastic ion conducting polymer coating, instead of highly engineered silicon solutions such as silicon structured in graphite or silicon nanowires, to reduce the cost of anode to around USD1.2/kWh and contribute to increase range by 20% according to Tesla.

Aiming to be a battery supplier?

Tesla has had issues with battery cell supply chain in the past, especially when it was looking to scale up the production of Model 3. Musk has pointed out several times that Tesla was constrained by cell supply from its cell sourcing partner Panasonic. The new announcements at the Battery Day clearly suggest that Tesla wants to eliminate the possibility of a recurrence of a similar event in the future. Tesla is looking at a complete vertical integration of the battery value chain within the company, starting from mining of lithium, all the way to the recycling of cells. Tesla has announced that it will set up a cathode manufacturing facility and a lithium processing facility in North America, which will be part of the Gigafactory. The new facility is expected to follow significantly more efficient processing operations, which will reduce operations cost by 76% and investment by 66%, according to Tesla. In fact, Tesla informed that it now also has rights to a 10,000 acre lithium clay deposit in Nevada for lithium mining. However it is not clear when Tesla will start local lithium mining in the region. For now, the company will continue to depend on third-party suppliers for sourcing battery grade nickel, and has urged nickel mining companies to increase the production to cater to the proposed upcoming growth from the battery industry. Tesla is even looking at extracting nickel, lithium and cobalt from spent batteries at its new recycling plant. Tesla is planning to start the pilot full-scale recycling plant next quarter.

If Tesla is to reach the 3TWh goal by 2030, it would certainly need to have a lot more control over raw materials and production processes, which entails a significant investment. In terms of financing, it is predicted that about USD100 billion will be required to equip 3TWh facilities with the assumption of Tesla's 69% investment reduction it has claimed will be achieved through all the new innovations it will implement in the coming years.

The proposed capacity is unquestionably significant from an industry standpoint. According to IHS Markit, the total

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global demand for lithium-ion batteries from the light vehicle segment in 2030 is expected to be about 1.5TWh. It remains to be seen if Tesla, having developed this capacity level, intends to become a cell supplier itself, or if it eventually decides to spin-off the battery business as a subsidiary. However, Musk also informed that Tesla will continue to source cells from old partners Panasonic, LG Chem and CATL and may even expand its supplier panel depending on the need.

Details awaited

With a heavily revised manufacturing strategy and design for battery cell, Tesla is claiming massive efficiency gains, performance boost at less than half the investment. According to Tesla, the cumulative gains from all the technological innovations would result in 54% increase in range, 56% reduction in USD/kWh cost of the cell, and 69% reduction in investment per GWh. “By 2025, IHS Markit predicts that there will be a 25% drop in prices for battery cells and 30% for packs. Tesla's claimed 56% cost reduction will make a major difference at a pack level if it materializes. IHS Markit expects an 18% reduction in manufacturing cost by applying the dry electrode process to cell production. If the 56% cost reduction level is achieved, there will be major impacts for this sector. However, since there is no clear evidence about how close Tesla is in securing a high yield rate, it’s difficult to evaluate the achievability of the claimed cost reduction.” said Kim.

Among Tesla’s current lineup, the Model S has the longest estimated range of 402 miles, which means that if Tesla is able to achieve the claimed improvement of 54% in range, the vehicle could have a range well in excess of 600 miles, nearly 100 miles more than recently unveiled Lucid Air and twice as many as the Porsche Taycan. We will potentially start seeing the impact of some of these advancements next year when Tesla launches the Model S Plaid variant. The car will be the first to use Tesla’ tabless 4680 cells and is expected to have a range of 520 miles. The company also announced that it would launch a USD25,000 electric car, which may reflect the full extent of these innovations, in the next three years.

Despite the ambitious targets announced, markets reacted cautiously to the vision shared by Musk, possibly due to the three-year time gap for the longer-range battery to hit the market. Nevertheless, if Tesla is able to meet the targets, or even come in touching distance of them, it will raise the bar even further in the emerging EV segment.

Srikant Jayanthan, Senior Research Analyst, E-mobility, IHS Markit
Srikant.jayanthan@ihsmarkit.com

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