Energy Storage – second in a five-part series

Lithium nickel manganese cobalt oxides (Li-NMC) is today's dominant battery chemistry, but its chemistry is not the cause. Li-NMC's dominance stems from being the battery chemistry driving transportation electrification. Although other chemistries competed, Li-NMC emerged because of its mobile suitability. Li-NMC dominated the market in less than a decade after it becomes commercial viability. As with most industrial solution ascendency, Li-NMC dominance resulted from compromises rather than clear technological supremacy. Li-NMC's commercial viability also coincided with the emergence of initial transportation electrification companies.

Battery market forecasts for the current decade show mobile energy storage consuming 90% of worldwide battery production. Meeting forecasted market demand will require rapidly scaling the battery supply chain. Although some existing and emerging chemistries may offer attractive advantages over Li-NMC, without raw material and manufacturing certainty at scale, these chemistries are not viable for consideration for transportation electrification. Battery component manufacturing mirrors semi-conductor production. Like semi-conductor fabrication, battery component manufacturing requires massive factory investments, long lead times to production, and resists changing chemistries and production processes, all of which complicate the supply chain's efficiency.

Of the rechargeable and commercially viable battery chemistries, Lithium- and Zinc-based ones bring higher energy density than Nickel Cadmium and Lead Acid. Transportation electrification competes with expectations on the range and re-energization – refueling or recharging – created by a hundred years' experience with reciprocating engines. The re-energization expectation is mitigated through the evolution of the recharging infrastructure. Higher voltage chargers delivering direct current to the batteries charge them faster. Energy density, however, represents a more daunting challenge.

Battery energy density measured by weight as watt-hours per kilogram (Wh/kg) and volume watt-hours per liter (Wh/l) remains the most significant consideration for mobile energy storage applications because larger and heavier batteries impact the vehicle's efficiency and design. Aside from larger ferries and ships, transportation electrification, including aircraft, faces battery size and weight restrictions regardless of the stored energy. Buses or heavy trucks require large and heavy batteries because they can consume two kWh per mile, creating opportunities for alternatives, such as compressed hydrogen fuel cells.

With both Lithium- and Zinc-based batteries as viable mobile solutions, other factors propelled Li-NMC to its leadership position. Longevity (charge/discharge cycles), reliability, recyclability, thermal flexibility, and safety were the other important considerations. Li-NMC mobile solutions have already reached or surpassed the equivalent longevity of internal combustion engines. Li-NMC battery components have greater elasticity, tolerating vibration better than other chemistries.

Battery recycling is advantageous for environmental and cost reasons. Most battery materials are toxic, and some are rare, making them more costly and their reuse more valuable. Within cost and practical limitations, engineering approaches mitigate thermal issues through battery heating or cooling and safety and environmental concerns by battery packaging.

Although based on compromises, Li-NMC's represented the best overall solution for today's dominant mobile battery solution, and mobile solutions drive the marketplace. But for stationary energy storage, is Li-NMC the dominant solution? Today, that answer is unclear.

For small-scale, less than 100kWh, energy storage, Li-NMC batteries dominate, the result of utilizing mobile battery technology. Further, Li-NMC addresses stationary applications' more demanding longevity requirements through monitoring and periodic component replacement. Still, the dominant chemistry for large-scale stationary energy storage remains unclear, and Li-NMC's competitors have emerged.

Although there are multiple Lithium-based battery technologies emerging in addition to Li-NMC, Lithium Iron Phosphate (Li-LFP) received serious consideration for mobile energy storage applications. Still, Li-NMC's reliability and energy density proved superior. Li-LFP will compete aggressively for stationary storage applications because it uses abundant materials with existing supply chains (e.g., iron) and is produced through processes like Li-NMC, resulting in lower cost. Further, Li-LFP delivers nearly 90% of Li-NMC's energy density in a slightly larger (10%) footprint.

Zinc-Air battery production focuses on the dry-cell battery market because it is cost-competitive, rechargeable, and recyclable, the latter a clear advantage. Further, Zinc-Air batteries possess greater energy density than Li-NMC. Zinc-Air battery components cost substantially less due to Zinc's abundance. Once produced at scale, Zinc-Air batteries will be a major competitor for stationary energy storage applications.

Flow batteries represent another storage technology competing for energy, not power, stationary applications. Flow batteries store energy via a liquid electrolyte; thus, storage-scaling requires expanding the electrolyte amount and increasing liquid throughput. The most common electrolyte, Vanadium Redux, raises environmental concerns, while others, such as Iron-Saltwater, do not. Flow batteries' lower energy density is mitigated by increasing the volume of electrolyte available, and the charge/discharge speed increased with higher volume pumps. Lastly, flow batteries cost substantially less than Li-NMC and bring unlimited recharging cycles at a lower cost.

Li-NMC batteries will remain the dominant mobile solution for both sound technical reasons and commercial inertia. For stationary applications, particularly above 100kw, however, the competition has just begun. Although Li-NMC brings market volume, stationary applications, which are less focused on size and weight, will select solutions based on lower cost and the number of charge/discharge cycles. Lastly, if Li-NMC demand exceeds supply, anticipated volume- and competition-related price declines will not appear, creating an opportunity for non-Li-NMC solutions in the stationary energy storage marketplace.