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Rivian: Powering Up or Losing Charge in the EV Market?

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A Secretive Startup Emerges

For years, a shuttered Mitsubishi Motors factory sat dormant surrounded by cornfields in Normal, Illinois. In its glory days, the factory had once pumped out 200,000 vehicles a year and employed 3,000 workers,[1] but now weeds grew through the cracked pavement of its empty parking lot. The area had suffered from population declines and job losses, until one day in 2017 Normal's fortunes suddenly changed. A mysterious startup, Rivian Automotive, bought the Mitsubishi plant, which was just weeks away from being demolished. "The company's mystique was part of the excitement," a local radio station noted.[2] "Who was [RJ Scaringe] this MIT grad who wants to build electric vehicles here? What will the cars look like? Will it be like Tesla?"

Five years later, Rivian emerged from a deliberate period of secretiveness, internally dubbed "stealth mode," to one of the largest IPOs in American history. Backed by investments from Amazon and Ford, Rivian had delivered only 156 trucks at the time and had no immediate revenue stream, but investors didn't seem too worried.[3] They were seduced by the company's promise to revolutionize the auto industry with emissions-free, adventure-themed trucks and sport utility vehicles. Rivian's R1T pickup truck and R1S SUV featured a long battery range and a skateboard chassis that had earned praise from auto enthusiasts. Amid all this excitement, the local economy in Normal, Illinois reaped major benefits, with Rivian creating more than 6,000 local jobs.[4] [Exhibit 1] The housing market boomed, nearby small businesses rebounded and the local community college launched an electric-vehicle technical training program. Rivian was flush with cash from its IPO and spirits in Normal were high, but Scaringe knew challenging days lie ahead. "We've got a lot in front of us. We've got a big climb. There's a lot to do," he said, foreshadowing what would be an especially difficult year as the company ramped up production.[5]

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Fast forward to November 2022, and the heady days following the blockbuster IPO had given way to a difficult reality. Rivian's stock was down 70 percent from its debut on the Nasdaq. In its first year as a publicly-traded company, Rivian had burned through cash at an alarming rate (about $1.7 billion per quarter),[6] laid off hundreds of employees[7] and recalled 13,000 vehicles — nearly all the vehicles it had produced.[8]

Amid all the tumult, Scaringe warned that an even larger problem loomed. Electric-vehicle makers were facing a massive battery shortage, and the solution wasn't clear. Rivian was faced with three key choices: Should it build its own batteries in house, launch a joint-venture with an existing manufacturer, or continue buying batteries from a supplier?

Rivian's Origin Story

R.J. Scaringe was born in 1983 and grew up in an area of Florida dubbed the Space Coast for its proximity to the Kennedy Space Center and Cape Canaveral Space Force Station. The son of an engineer father who developed refrigeration units used on space shuttles, Scaringe loved to tinker and became a car enthusiast from an early age. "If you were to go in my bedroom as a kid, you'd find [car] hoods under the bed and windshields in the closet," he recounted years later as an adult.[9] Scaringe learned to restore Porsche 356s in a neighbor's garage, and he deeply embedded himself in learning automobile history. "It was funny, when I was growing up, I'd say to my parents, 'I wish I was born in 1890' because that was when all the excitement happened in the auto industry — when it was all formed," he told a journalist in 2022. "What's interesting today is that I'm so glad I was born in 1983 because I do think the changes are going to be larger over the next two decades." [10]

As a teenager, Scaringe knew he wanted to be an engineer and start a company, but he foresaw that raising capital would be difficult. So during summer breaks in high school in the late 1990s, he worked two full-time jobs: one as a machinist during the day and another at a restaurant on nights and weekends. At 17, he used his earnings to buy a house, which he rented out for income. He studied mechanical engineering and economics at Rensselaer Polytechnic Institute, and went on to earn a Ph.D. in mechanical engineering at the Massachusetts Institute of Technology, which boasted the renowned Sloan Automotive Lab. The day after graduating in 2009, he founded Mainstream Motors in Florida. It was a turbulent year for the auto industry (General Motors and Chrysler had filed for bankruptcy that year) and an especially tough time to raise money for an auto startup, but Scaringe hoped his MIT doctorate would brandish him with the credibility he needed to dazzle investors. In the meantime, he sold his house and used the proceeds, in addition to funds his father chipped in after refinancing his own home, to start the business.

Initially, Mainstream Motors worked on developing a fuel-efficient (not electric) car, but it never panned out. The company changed its name to Avera, then Rivian in 2011. Scaringe blogged at the time:

> The name pays homage in part to the Indian River Lagoon, which is walking distance from our facility in Rockledge, Florida. The name represents a blend of the words Indian and River – taking the first three letters of River and the last three of Indian. When we thought about the parallels between a river and our company, it felt perfect. Rivers are powerful enough to reshape their landscapes and we intend to dramatically reshape the way vehicles are designed and manufactured.[11]

At the end of 2011, Scaringe pivoted away from the sports car prototype and began working on electric vehicles. Although the company raised "hundreds of millions of dollars" from investors (according to Scaringe), it was an uncertain time for the company's direction and product strategy.[12]

Over the next few years, Rivian built research facilities in Silicon Valley and Michigan, and in 2017, it purchased the former Mitsubishi facility in Normal, Illinois to serve as its manufacturing hub. Scaringe described the moment like this: "This is like 1992 in the internet days. We are at the very, very beginning of a major transformation in how we look at the customer model with regards to the vehicle."[13] By the end of 2017, Rivian announced its two prototypes were complete, but the company continued to keep the designs under wraps.

Rivian finally emerged from secrecy during the L.A. Auto Show in 2018. In an evening under the stars at the Griffith Observatory, overlooking Los Angeles, Scaringe appeared beside popstar and businesswoman Rihanna, as he unveiled the Rivian R1T, an electric concept pickup truck.[14] The company touted the pickup could go from zero to 60 miles-per-hour in just three seconds, tow up to 11,000 pounds and travel 400 miles on a single charge in its longest-range version. Its batteries were embedded in the chassis, which had a so-called "skateboard" platform design that left ample space for a trunk in the front, where, in a gasoline-powered truck, the engine would normally be. The company said it would be sold at a starting price of $61,500 after a federal rebate.

That night, Rivian also unveiled its R1S, an SUV with the same powertrain, suspension and electronic features as the pickup truck, but with a cab seating five to seven people, with prices starting at $65,000 after a $7,000 federal rebate was applied. Orders for both vehicles immediately began pouring in.

In September 2019, a single moment accelerated Rivian's growth, immediately separating it from other rookie automakers. Amazon founder and then-CEO Jeff Bezos announced Amazon would go carbon neutral by 2040, a decade ahead of the Paris Accord's 2050 goal. As part of its efforts to reach that goal, Amazon had placed an order for 100,000 electric delivery vans made by Rivian, to be delivered by 2030. For Rivian, it was a game-changing moment. That big book of business, along with large investments from Amazon and Ford, sparked additional investments from T. Rowe Price, D1 Capital Partners and Fidelity.[15]

Source: Screenshot from video on Amazon's press website https://www.aboutamazon.com/news/sustainability/the-climate-pledge.

Initially, Rivian had planned to start delivering vehicles to customers by the end of 2020, but when the Covid-19 pandemic struck that year, the company temporarily shut down all its facilities and paused construction on its factory in Normal.[16] Even once the company resumed operations, supply-chain disruptions lingered, slowing down the company's plans to ramp up production quickly. Finally, in September 2021, Rivian rolled out its first R1T pickup trucks for customers.[17]

Source: RJ Scaringe, via Twitter https://twitter.com/RJScaringe/status/1437842808384233477/photo/1

Soon after in November 2021, Rivian had more reason to celebrate. Its initial public offering raised $11.9 billion,[18] the largest for a listing on a U.S. exchange since 2014 and the seventh-largest since 1995, according to Dealogic. In it first week of trading on the Nasdaq, Rivian's market cap surged to $140 billion, valuing it as the third largest car company in the world by market cap behind Tesla and Toyota.[19]

The company also started delivering its R1T and R1S vehicles to employees and customers, although the waitlist continued to expand. Exhibit 2 shows the different options and pricing that were available at the end of 2022, and Exhibit 3 shows the financial statements of the company. With plans for a second plant in Georgia that would be able to assemble 400,000 vehicles per year at a cost of $5 billion to build, the future of the company looked extremely bright.[20]

The U.S. Auto Market

When it comes to industries with high barriers to entry, the U.S. automobile industry is often highlighted as exhibit number one and for good reason. It's one of the most highly-concentrated industries in the world. From 1948 to the 1980s, one firm alone — General Motors — accounted for at least 40 percent of domestic sales each year.[21] Together with two other large manufacturers, Ford and Chrysler, these companies made up "The Big Three" automakers, dominating the U.S. auto market for decades. In the 1970s, Japanese competitors entered the U.S. market and started to gain market share — but no new U.S. firm successfully entered the industry with a mass-market product from World War II to the 2000s.

Several barriers to entry have made it especially difficult for startups to gain a foothold in the industry. Take high capital costs, for instance. Establishing a new automaker requires enormous upfront investments in research and design, as well as physical manufacturing plants. Meanwhile, startups find it hard to compete against the economies of scale long enjoyed by the existing automakers. Early in auto history, Henry Ford had pioneered a vertically-integrated business model, keeping everything from mining and manufacturing, to sales and distribution in-house, in order to drive down costs. In modern times, the existing automakers operate highly-complex, global supply chains to source raw materials and parts, and dealer networks to distribute and service their vehicles. General Motors, for example, sources about 133,000 different parts[22] from 3,100 primary suppliers and operates 4,000 dealerships in the U.S.[23] Ford sources parts from 1,200 primary suppliers and operates 3,000 dealerships in the U.S.[24]

In the U.S., passenger cars like sedans and station wagons long dominated auto sales. They made up 80 percent of the market in 1975.[25] But in recent years, the auto industry has gone through a massive shift away from passenger cars to SUVs, pickup trucks and crossover vehicles (also known as "car-like SUVs"). Sedans and wagons fell to 50 percent of the market in 2013 and just 26 percent of the market by 2021. Conversely, SUVs reached a record 58 percent of the market in 2021 and pickups increased to 16 percent in 2021.[26]

Since 1982, the Ford F-150 pickup truck has been the best-selling vehicle in the US.[27] In 2021, second and third place were also claimed by pickups, including the Ram and Chevrolet

Silverado.[28] Edmunds, which specializes in automotive research, attributes the surge in pickup sales to several factors including a relatively stable U.S. economy from 2010 to 2020 and an increase in North American crude oil production, which kept gas prices stable for many years.[29] Automakers also increased the features, technology and amenities in their pickups, expanding their appeal beyond their traditional working-class customer base, to include families and luxury buyers. As of 2019, 81% of pickups featured 4-door "crew cab" configurations which accommodate more passengers. The average pickup sold for around $50,000, 41 percent higher than a decade earlier.

Tesla's Playbook

In 2011, Elon Musk sat on stage at the TechCrunch Disrupt conference in Silicon Valley and shared some advice with aspiring entrepreneurs in the audience. Starting a company, he said, was a little like "staring into the face of death…If that sounds appealing, go ahead."[30] For those who wanted to tackle society's messiest problems — like he was attempting to do with electric cars and space exploration — Musk recommended starting by founding an internet company. Speaking from his own life experience, it was a viable way to raise money and credibility. In other fields (like auto manufacturing), the barriers to entry were just too high.

"The higher the capital requirements, the higher the barriers to entry...When there are high barriers to entry, then you don't see new entrants, and you don't see innovation. It's really that new entrants are what drives innovation," he said. Musk admitted he wouldn't have been able to secure funding for either Tesla or SpaceX if he hadn't first enjoyed other success. Earlier in his career, he had founded an online bank called X.com that had merged with PayPal. The combined company was later acquired by eBay for $1.5 billion in 2002. Musk parlayed his windfall into a variety of ventures, including Tesla Motors and SpaceX. "It would have been impossible for me to do electric cars and rockets right from the start," he said.

At Tesla's beginning in 2003, the company sought to bring electric vehicles to the mass market — but as a first step, Musk set his sights on a more immediate goal: build a high-end electric vehicle produced in low volume.[31] Whereas existing automakers might spend four to five years and more than a billion dollars designing a new vehicle, Tesla didn't have the luxury of time and a huge amount of capital, so it borrowed a "move fast" mentality and iterative design principles from Silicon Valley. Its first car, the Tesla Roadster, served as a minimum viable product — a way to test the concept in the world before ramping up production to serve the mass market.

To achieve this, Tesla partnered with other companies, including Panasonic to supply batteries and Lotus, a British automaker known for making sports cars and race cars. Tesla designed the car's powertrain and took an unconventional approach. Rather than designing an entirely new battery to suit electric vehicles, it assembled a battery pack from 6,831 Panasonic lithium-ion batteries (the type commonly used in laptop computers). Meanwhile, the company collaborated with Lotus to co-design the body and chassis. Because the vehicles were electric, the design could avoid some of the complexities involved with internal combustion engine vehicles. (Electric vehicles contain about 80% fewer moving and wearing parts than gasoline-powered vehicles.)[32] Between 2008 and 2011, Lotus produced 2,500 of the cars in the UK. These partnerships saved Tesla time and money. Developing the Roadster cost Tesla about $140 million, in contrast to the $1 billion General Motors spent developing its first electric vehicle, the EV1, and the $1.2 billion it spent developing the Chevy Volt.[33]

The press widely praised the $109,000 Roadster for its ability to travel more than 200 miles on a single charge, as well as its ability to accelerate from a standstill to 60 miles-per-hour in just four seconds. Unlike other sports cars, which average 25 to 30 miles-per-gallon, the all-electric Tesla boasted an EPA fuel-economy rating equivalent to 105 miles per gallon. Its success made Tesla a household name and made it possible for Musk to take the company to the next stage.

For its next vehicle, the $70,000 Model S sedan, Tesla partnered with Daimler, Panasonic and Toyota. Tesla also bought and retooled a former General Motors and Toyota plant in Fremont, California, allowing it to ramp up production, in-house. Following the Model S, other lower-price models followed, a $35,000 Model 3 sedan in 2017 and the $40,000 Model Y crossover in 2020. Tesla also produced a $80,000 Model X SUV starting in 2015.

While other manufacturers struggled to keep production lines running due to chip shortages following the Covid-19 pandemic, Tesla was able to quickly rework its software to use alternative chip options, allowing the company to navigate the crisis relatively unscathed.[34] By the end of 2021, Tesla enjoyed a dominant position in the EV market with a 71% market share of new electric vehicles, and its market capitalization exceeding $1 trillion, eclipsing the total value of its top 5 competitors (Toyota Motor Corp, Volkswagen AG, Daimler AG, Ford Motor Co, and General Motors) combined. (See Exhibit 3 for the company's financials.)

However, 2022 proved to be a more challenging year for the company. While Q3 deliveries surpassed 343,000 vehicles, an increase of 42.5% compared to Q3 in 2021, an influx of new EV models from competitors and production issues at its factories abroad disappointed financial markets leading to a more than 69% drop in market value during 2022. The company's Cyber Truck, a light-duty truck competitor to Rivian's R1T with an announced starting price of just $39,900, was slated for production in 2021, but was pushed back multiple times and was not expected until mid-2023.

The Electric Vehicle Market

Electric vehicles have been around since the beginning of automobiles in the 1800s. In fact, by 1900, they accounted for about a third of all vehicles on U.S. roads.[35] New York City alone had a fleet of more than 60 electric taxis, and although steam and gasoline-powered vehicles were also popular, the future seemed bright for EVs.

That changed when Henry Ford's mass-produced Model T came on the market in 1908. Widely available and affordable, it dealt a death blow to the electric car. By 1912, the gasoline car cost only $650 (around $21,000 in 2022 dollars),[36] while an electric roadster sold for $1,750 (about $56,000 today). EVs entered a sort-of Dark Ages, giving way to the dominance of gasoline-powered cars.

A major turning point didn't come until nearly a century later when Toyota Prius, the world's first mass-produced hybrid electric vehicle, was released worldwide in 2000, and then the emergence of Tesla in 2003. In 2010, the Chevy Volt and the Nissan LEAF were released in the U.S. market. Hybrid and fully-electric vehicles continued to grow in popularity.

That said, as of 2022, EVs still accounted for just a drop in the bucket of the entire auto market. They made up less than 1 percent of the 250 million cars, SUVs and light-duty trucks on the road in the United States.[37] Increasing their share on the road is a long, slow process, as only about 17 million new cars are sold in the U.S. each year. IHS Markit analysts estimate that by 2035 about 45 percent of new car sales could be electric. At that rate, about half of the cars on U.S. roads would be electric by 2050.

Worldwide, the International Energy Agency predicts there will be 200 million electric vehicles by 2030, accounting for 10 percent of vehicles on the road.[38]

Electric Vehicle Batteries

If the internal combustion engine was the "heart" of the conventional car, the battery was equally, if not more, essential to the performance and viability of the electric vehicle. In fact, the battery is the single most expensive part of an electric vehicle, making up between 35 to 45 percent of the total cost.[39]

As electric vehicles gained popularity, automakers and the battery manufacturers poured billions into building out supply chains and improving battery technology. As a result, battery prices declined dramatically from $1,200 per kilowatt hour in 2010, to just $132 per kilowatt hour in 2021 — a stunning 89 percent drop.[40] The declines came to a pause in 2022, though, amid a shortage of lithium and other raw materials.[41] [Exhibits 5 and 6]

There are several criteria that can be used to compare different lithium-ion battery chemistries. Some of the most important criteria to consider include [Exhibit 7]:

- Capacity: The amount of energy that a battery can store. Batteries with higher capacity are able to store more energy, which means that they can power a device for a longer period of time before needing to be recharged.
- Energy density (Wh/L): The amount of energy that a battery can store per unit of weight. Batteries with high energy density are able to store a lot of energy in a small, lightweight package. Energy density is critical for determining EV range.
- Power cost ($/kW): The cost per unit of power output.

- Energy cost ($/kWh): The cost per unit of energy output. (Energy is the ability to do work, while power is the rate at which work is done. In other words, energy is the amount of work that can be done, while power is the speed at which the work is done.)
- Self-discharge rate: The rate at which a battery loses its charge when not in use. Batteries with low self-discharge rates are able to retain their charge for longer periods of time when not in use.
- Charge/discharge rate: The rate at which a battery can be charged or discharged. Batteries with high charge/discharge rates are able to be charged and discharged quickly, which can be useful for applications that require a lot of power.
- Cycle life: The number of times that a battery can be charged and discharged before it starts to lose capacity. Batteries with long cycle lives are able to be charged and discharged many times before they need to be replaced.
- Temperature range: The range of temperatures in which a battery can effectively operate.

While batteries have existed for centuries, recent improvements in battery chemistry and material science have led to a massive leap in performance, with multiple competing formats offering different performance tradeoffs:

Nickel-based, lithium-ion batteries: [Exhibit 8] The lithium-ion batteries that dominate in electric vehicles today began with technology developed by Nobel-Prize-winning Japanese chemist Akira Yoshino in the 1980s and commercialized by Sony Group in 1991.[42] First used widely in cell phones and laptops, these batteries rely on a liquid electrolyte passing between an anode (negative electrode) and a cathode (positive electrode) to generate an electrical charge. An insulating material, known as a separator, allows lithium ions to flow while keeping the anode and cathode from touching. The batteries are comprised of a mix of lithium, cobalt, manganese, nickel and graphite and other components. Two main types dominate today: NCM and NCA. (N stands for nickel, C for cobalt, M for manganese and A for aluminum). These nickel-based lithium-ion batteries dominate the EV market largely due to their high energy storage density and efficiency.

Early on, Japanese firms led lithium-ion battery production, but eventually they gave way to the rise of Chinese and Korean competitors. As of 2020, just six companies, Contemporary Amperex Technology Company (CATL), LEG Energy Solution, Panasonic, Samsung SDI, BYD and SK Innovation supplied 89 percent of batteries and battery metals in passenger EVs, according to The Institute of Electrical and Electronics Engineers.[43] [Exhibit 9]

When Tesla released its all-electric $109,000 Roadster in 2008, the sports car relied on more than 6,000 off-the-shelf, lithium-ion laptop batteries all mashed into one package. Tesla still relies heavily on lithium-ion batteries today, but like other EV makers, it has been trying to shift into other technologies.

As of 2021, nickel-based battery chemistries accounted for about 85 percent of EV battery demand.[44] That said, the rising cost of nickel, along with ethical concerns about cobalt mining practices including child labor, have led battery manufacturers to increasingly try to use chemistries with lower percentage of those materials. Russia is the world's largest supplier of Class 1 battery-grade nickel, producing around 20 percent of global supply, and the country's invasion of Ukraine has increased concerns around that supply chain. Meanwhile, about 70 percent of the global supply for cobalt comes from the Democratic Republic of Congo, which has a poor human rights track record.[45]

LFP batteries: LFP batteries (standing for lithium ferro-phosphate) are cobalt- and nickel-free and rely on relatively cheap iron and phosphate. Because they build off the existing technology of lithium-ion batteries, they're cheap and easy to manufacture. That said, they're lower in energy density, resulting in lower EV driving range. Tesla started using cobalt-free LFP batteries in its Model 3 sedans (its mid to lower-end vehicles) in 2021.

As of 2021, LFPs accounted for 15 percent of EV battery demand, mainly driven by an increased uptake of LFP-powered electric cars in China. [Exhibit 10] As of 2022, the International Energy Agency predicted LFPs are "set to surge globally."[46]

Solid-state batteries: Solid-state batteries, also known as SSBs, are not yet used in electric vehicles, but researchers are racing to develop the technology to replace the liquid components of lithium-ion batteries with a solid electrolyte. Considered the holy grail of car batteries, proponents claim SSBs could offer several advantages over lithium-ion batteries, including longer lifespans, lower risk of catching fire, shorter charging times, and larger capacities.

The battery startup QuantumScape became a stock market sensation in December 2020, after it revealed promising test results for a limited version of a solid-state battery.[47] It claimed the battery could be recharged to 80 percent in just 15 minutes and retain more than 80 percent of its capacity even after 800 charges. "Such numbers would make owning an electric vehicle much more similar to owning a gas-powered one today," The Wall Street Journal noted. The company, which is backed by Volkswagen and Bill Gates, soared to a more than $30 billion valuation (it was valued at $3.3 billion when it went public earlier in 2020), before the hype died down later in 2021. The company has remained secretive about the ceramic material at the heart of its design, making it impossible for scientists to verify the technology.[48]

Developing SSBs and retooling factories is an expensive proposition and high costs remain a barrier to scaling it as a technology. "There is no established process today, so it remains to be seen if it can be done in a cost-effective manner," an executive at Solid Power, a BMW and Ford-backed start-up specializing in sulfide SSB, said.[49]

Difficult Choices

Despite the huge cash infusion, Rivian continued to struggle to ramp up production and meet demand.[50] In its March 2022 earnings release, the company announced it had produced only

2,425 trucks to date, and overall, it would produce 25,000 vehicles in 2022, half number it said it could make if the supply chain were not a "fundamental limiting factor."[51] Additional missteps included announcing and then backtracking on a price increase for reservation holders after customers complained and in some cases, canceled their orders.[52] Scaringe apologized to customers.

2022 continued to be a challenging year. In July, Rivian laid off six percent of its workforce, with Scaringe citing "inflation reaching record highs, interest rates rapidly rising and commodity prices continuing to climb — all of which have contributed to the global capital markets tightening."[53] In August, Rivian reaffirmed its 25,000 vehicle production target for 2022 but predicted its losses would grow to $5.45 billion, up from previous projection of $4.75 billion. The company continued to cite inflation related to raw materials like lithium, as well as higher costs due to freight expenses, as weighing on its bottom line. Then, in September, Rivian announced a recall of 13,000 vehicles — nearly all its vehicles on the road — after it discovered a small part may have been incorrectly installed.[54] At this point, Rivian's stock was down 76 percent from its Nasdaq debut.

Not all was doom and gloom, though. In July, Amazon announced it was starting to roll out Rivian's delivery vans in a handful of cities throughout the U.S. and it expected to have "thousands" in more than 100 cities by the end of the year.[55] And in September, Mercedes-Benz announced it was teaming up with Rivian on a joint-venture to make large, commercial electric vans in Europe.[56]

Could the company push through its setbacks and deliver on its Scaringe's vision to dramatically reshape the auto industry?

That would depend on many factors, of course — but one challenge seemed to especially weigh on Scaringe. In interviews with journalists, he repeatedly warned of a major battery shortage. "This isn't speaking to Rivian — but as an industry — it's going to constrain how rapidly we go from a few million electric vehicles a year to 100 million electric vehicles a year," he said.[57]

In early 2022, Scaringe issued a warning while guiding journalists on a tour of Rivian's Normal, Illinois factory.[58] Automakers would soon face a shortage of battery supplies so dire, it would it hit manufacturers harder than the semiconductor shortage that had begun during the Covid-19 pandemic in 2020, he said. Demand for battery materials was already exceeding supply and production capabilities. "Put very simply, all the world's cell production combined represents well under 10 percent of what we will need in 10 years. Meaning, 90 percent to 95 percent of the supply chain does not exist" Scaringe said. As Tesla founder Elon Musk tweeted a couple months later, "lithium batteries are the new oil."[59]

Securing a long-term steady supply of batteries at an economically viable price has become the critical strategic issue for electric vehicle makers. Manufacturers essentially have three options: buy batteries from existing manufacturers, form a joint-venture with a battery manufacturer, or invest in battery R&D and eventually make the batteries in house.

Source from battery manufacturers: Aside from Tesla, U.S. based automakers initially were reluctant to invest in battery cell production. Instead, they've relied on suppliers, largely based in Asia, to build such parts. But when sourcing the batteries from an outside manufacturer, EV makers remain vulnerable to supply-chain disruptions – a reality automakers are keen to avoid after experiencing the semiconductor shortage, as well as global supply chain disruptions during the Covid-19 pandemic. Rivian currently sources its batteries from Samsung SDI.

Partner with a battery manufacturer: In 2014, Tesla signed an agreement with Panasonic, its largest battery supplier, to cooperate in constructing a large-scale battery manufacturing plant in Sparks, Nevada, known as the Gigafactory.[60] According to the agreement, Tesla would prepare, provide and manage the land, buildings and utilities, while Panasonic would manufacture and supply lithium-ion cells. Other automakers soon followed Tesla's lead, forming joint ventures with battery makers. General Motors partnered with LG Energy Solutions, Ford with SK Innovation and Honda with LG to open battery plants in the U.S.

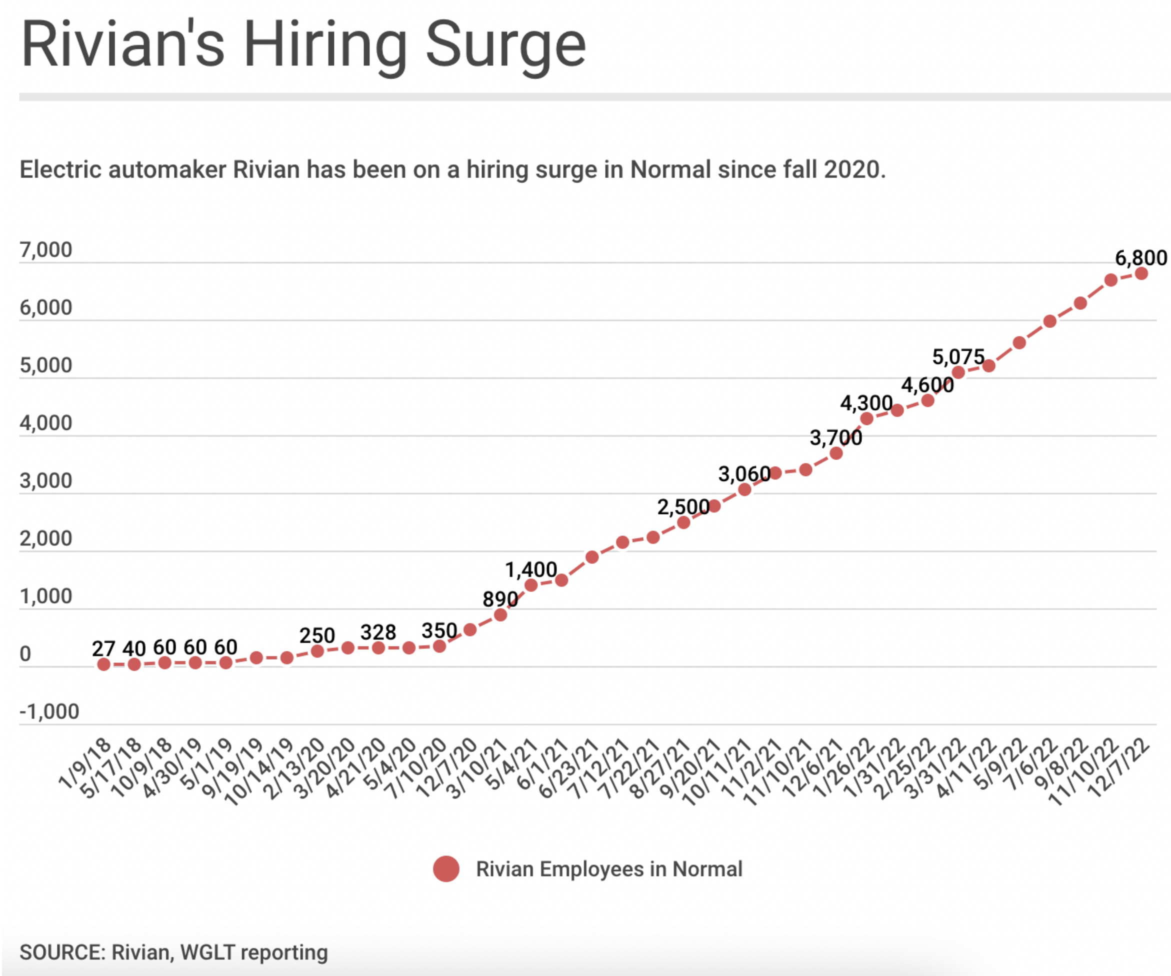
Rivian was in talks to create a joint venture with Samsung SDI but reports indicate the talks broke down after Rivian demanded access to Samsung's battery making technology and the right to inspect the interior of its factories.[61] And Samsung asked for a commitment from Rivian to purchase a certain amount of batteries.

Manufacture batteries in house: In late 2020, Musk announced that Tesla aimed to halve the costs of its batteries by producing some of its own.[62] The company launched a test battery factory in Fremont, California. But as a young company, could Rivian stomach the same risk? This is obviously an expensive move, and not just because of the costs of building out another facility. Staffing enough engineering talent is a key challenge when it comes to making batteries. Median salaries for U.S. battery engineers have been climbing for years, and in 2021, they ranged from around $100,000 for a junior engineer to nearly $200,000 for a director, according to a report from the Volta Foundation, which compiled data using H-1B visa applications. C-suite-level battery executives reported salaries close to $400,000.[63]

In addition to how Rivian secures batteries for the future, there is also the question of what battery technology to bet on for the future. Should the company focus on established and proven battery chemistries such as LFP, or should it invest in exploring more advanced (but uncertain) technologies such as solid-state batteries or non-lithium chemistries involving zinc or sodium that offer radically improved performance and cost profiles? How should Scaringe balance between the short and long-term battery needs?

Exhibits

Exhibit 1: Rivian Hiring Trend 2019 – 2022



Source: Ryan Denham, "Rivian Begins Trading on NASDAQ after Massive IPO," WGLT. November 11, 2021, https://www.wglt.org/local-news/2021-11-10/rivian-to-begin-trading-today-on-nasdaq-after-massive-ipo.

Exhibit 2: Rivian Model Comparison

							
Model	R1T				R1S		
Drive	Dual	Dual	Dual	Quad	Dual	Dual	Quad
Battery Pack Capacity	105 kWh	135 kWh	180 kWh	135 kWh	105 kWh	135 kWh	135 kWh
Range	231 mi	314 mi	410 mi	328 mi	249 mi	316 mi	321 mi
Price	$73,000	$79,000	$89,000	$87,000	$78,000	$84,000	$92,000

Source: Case writer, based on publicly available information.

Exhibit 3: Rivian Income Statements 2019 – 2021

	2021	2020	2019
Revenue	$55		
Cost Of Goods Sold	$520		
Gross Profit	($465)		
Research And Development Expenses	$1,850	$766	$301
SG&A Expenses	$1,242	$255	$108
Other Operating Income Or Expenses	($663)		
Operating Expenses	$3,755		
Operating Income	($4,220)	($1,021)	($409)
Total Non-Operating Income/Expense	($468)	$3	($17)
Pre-Tax Income	($4,688)	($1,018)	($426)
Income Taxes	$0	$0	$0
Income After Taxes	($4,688)	($1,018)	($426)
Net Income	($4,688)	($1,019)	($426)
EBITDA	($4,023)	($992)	($402)
EBIT	($4,220)	($1,021)	($409)
Basic Shares Outstanding	204	101	98
Shares Outstanding	204	101	98
Basic EPS	($22.98)	($10.09)	($4.35)
EPS - Earnings Per Share	($22.98)	($10.09)	($4.35)

Source: Company disclosure.

Exhibit 4: Tesla Income Statements 2009 – 2021

	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Revenue	$53,823	$31,536	$24,578	$21,461	$11,759	$7,000.13	$4,046.03	$3,198.36	$2,013.50	$413.26	$204.24	$116.74	$111.94
Cost Of Goods Sold	$40,217	$24,906	$20,509	$17,419	$9,536	$5,400.88	$3,122.52	$2,316.69	$1,557.23	$383.19	$142.65	$86.01	$102.41
Gross Profit	$13,606	$6,630	$4,069	$4,042	$2,223	$1,599.26	$923.50	$881.67	$456.26	$30.07	$61.60	$30.73	$9.54
R&D Expenses	$2,593	$1,491	$1,343	$1,460	$1,378	$834.41	$717.90	$464.70	$231.98	$273.98	$208.98	$93.00	$19.28
SG&A Expenses	$4,517	$3,145	$2,646	$2,835	$2,477	$1,432.19	$922.23	$603.66	$285.57	$150.37	$104.10	$84.57	$42.15
Operating Expenses	$7,083	$4,636	$4,138	$4,430	$3,855	$2,266.60	$1,640.13	$1,068.36	$517.55	$424.35	$313.08	$177.57	$61.43
Operating Income	$6,523	$1,994	($69)	($388)	($1,632)	($667.34)	($716.63)	($186.69)	($61.28)	($394.28)	($251.49)	($146.84)	($51.90)
Total Non-Operating Expense	($180)	($840)	($596)	($617)	($577)	($79.01)	($159.00)	($97.95)	($10.14)	($1.79)	($2.43)	($7.32)	($3.82)
Pre-Tax Income	$6,343	$1,154	($665)	($1,005)	($2,209)	($746.35)	($875.62)	($284.64)	($71.43)	($396.08)	($253.92)	($154.16)	($55.71)
Income Taxes	$699	$292	$110	$58	$32	$26.70	$13.04	$9.40	$2.59	$0.14	$0.49	$0.17	$0.03
Income After Taxes	$5,644	$862	($775)	($1,063)	($2,241)	($773.05)	($888.66)	($294.04)	($74.01)	($396.21)	($254.41)	($154.33)	($55.74)
Net income (loss) attributable to noncontrolling interests	$125	$141	$87	($87)	($279)	($98)	$0	($294.04)	($74.01)	($396.21)	($254.41)	($154.33)	($55.74)

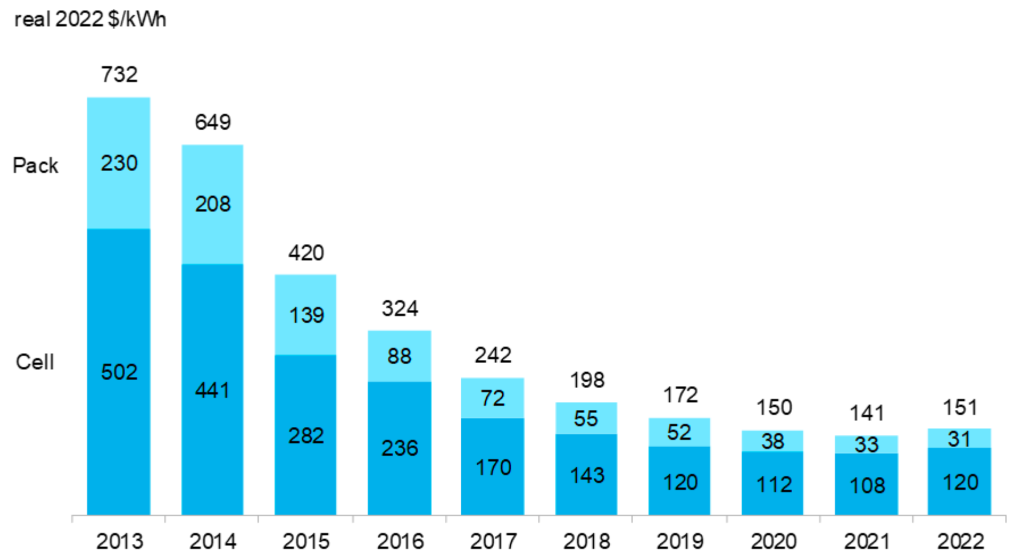
Exhibit 4: Tesla Income Statements 2009 – 2021 (cont.)

Net Income	$5,519	$721	($862)	($976)	($1,962)	($674.91)	($888.66)	($294.04)	($74.01)	($396.21)	($254.41)	($154.33)	($55.74)
Net Income	$5,519	$721	($862)	($976)	($1,962)	($674.91)	($888.66)	($294.04)	($74.01)	($396.21)	($254.41)	($154.33)	($55.74)
EBITDA	$9,434	$4,316	$2,085	$1,672	$95	$374.45	($215.99)	$114.98	$59.50	($365.46)	($234.57)	($136.22)	($44.96)
EBIT	$6,523	$1,994	($69)	($388)	($1,632)	($667.34)	($716.63)	($186.69)	($61.28)	($394.28)	($251.49)	($146.84)	($51.90)
Basic Shares Outstanding	2,958	2,799	2,661	2,559	2,490	2,163	1,923	1,868	1,791	1,610	1,506	761	105
Shares Outstanding	3,387	3,249	2,661	2,559	2,490	2,163	1,923	1,868	1,791	1,610	1,506	761	105
Basic EPS	$1.87	$0.25	($0.33)	($0.38)	($0.79)	($0.31)	($0.46)	($0.16)	($0.04)	($0.25)	($0.17)	($0.20)	($0.53)
EPS	$1.63	$0.21	($0.33)	($0.38)	($0.79)	($0.31)	($0.46)	($0.16)	($0.04)	($0.25)	($0.17)	($0.20)	($0.53)

Source: Company disclosure.

Exhibit 5: Lithium Ion Battery Pricing

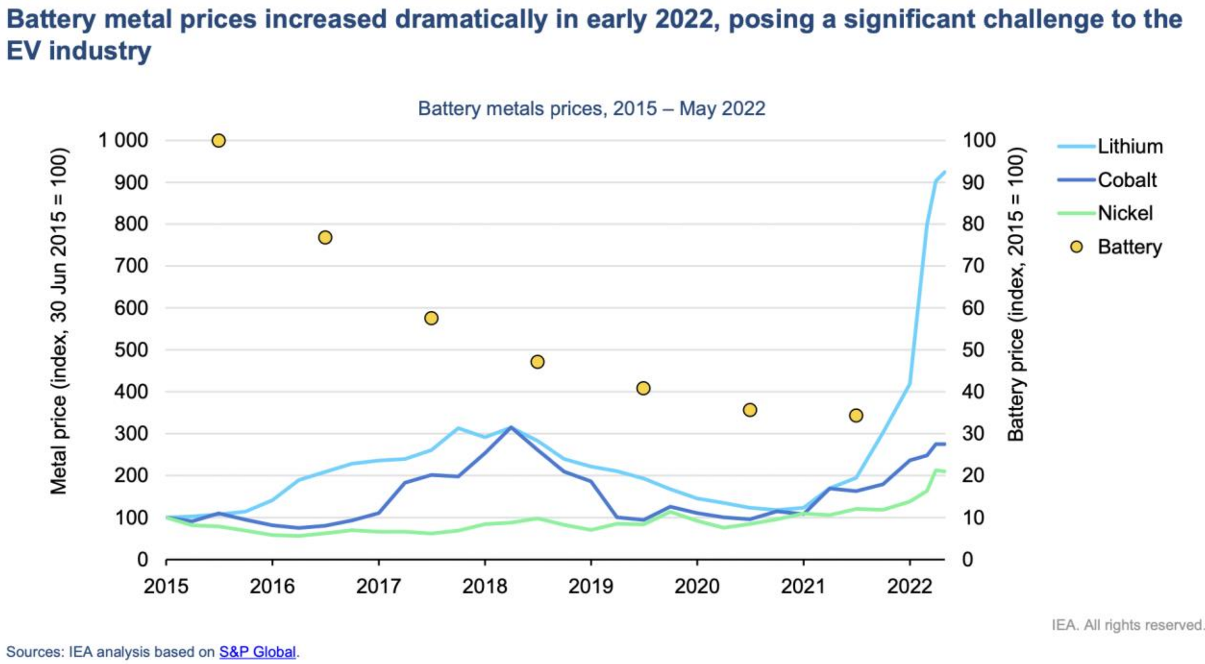
Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2022



Source: BloombergNEF. All values in real 2022 dollars. Weighted average survey value includes 178 data points from passenger cars, buses, commercial vehicles and stationary storage.

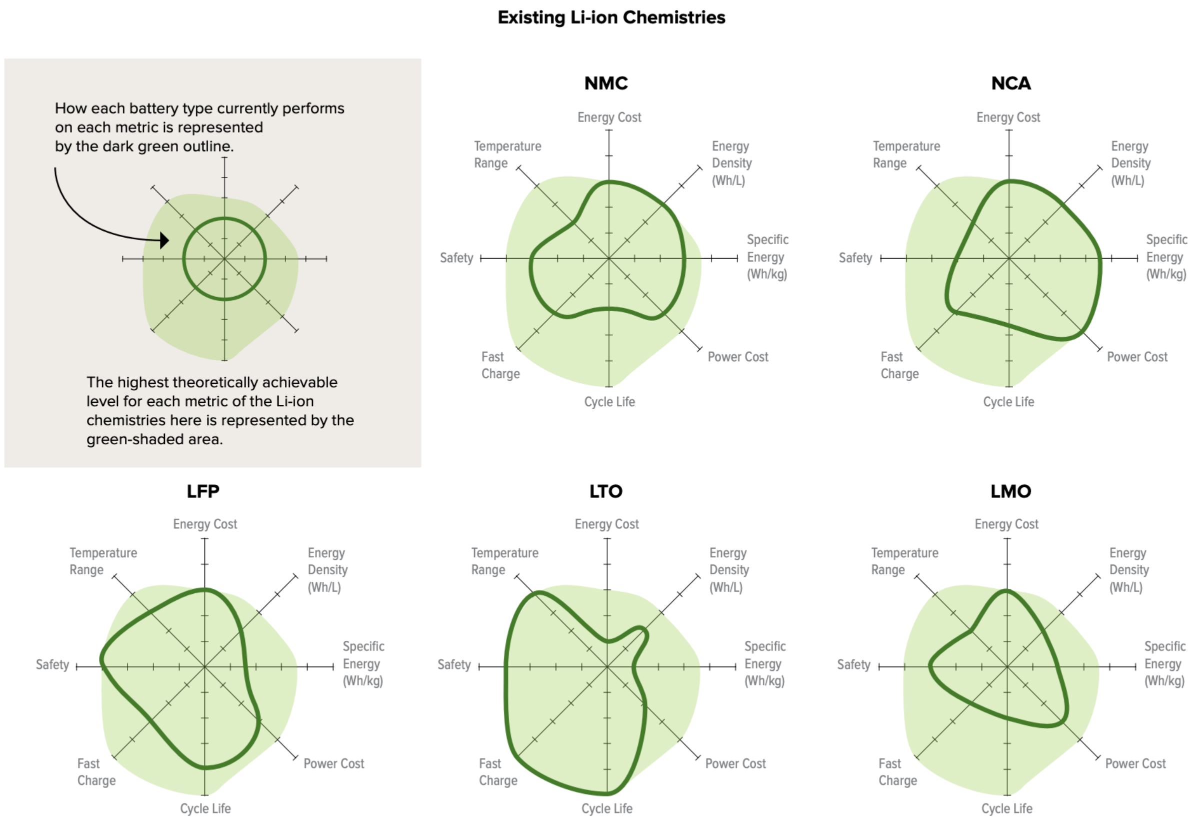
Source: Bloomberg NEF, "Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh" December 6, 2022, https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average -of-151-kwh/.

Exhibit 6: Battery Metal Prices



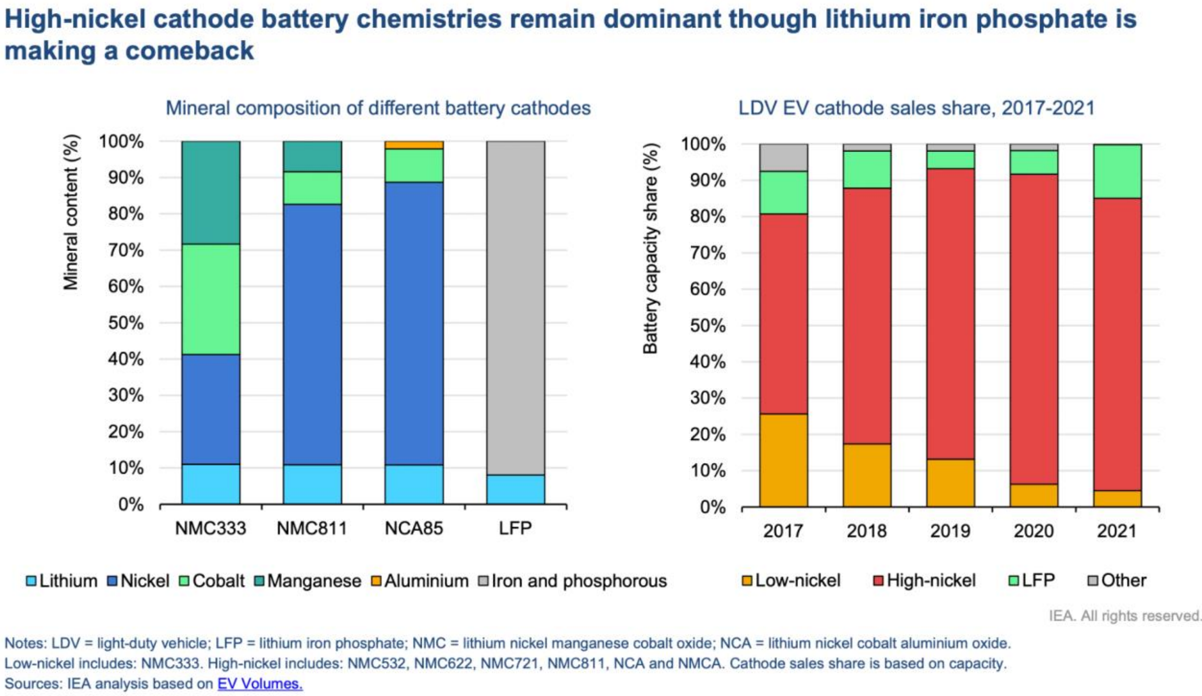
Source: International Energy Agency, "Global EV Outlook 2022," May 23 2022, https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf#page=142.

Exhibit 7: Lithium Ion Chemistry



Source: Charlie Bloch, James Newcomb, Samhita Shiledar, and Madeline Tyson, "Breakthrough Batteries: Powering the Era of Clean Electrification," Rocky Mountain Institute, January 2020, https://rmi.org/wp-content/uploads/2019/10/rmi_breakthrough_batteries.pdf

Exhibit 8: Chemistry Prevalence



Source: International Energy Agency, "Global EV Outlook 2022," May 23 2022, https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf#page=137.

Exhibit 9: Battery Capacity

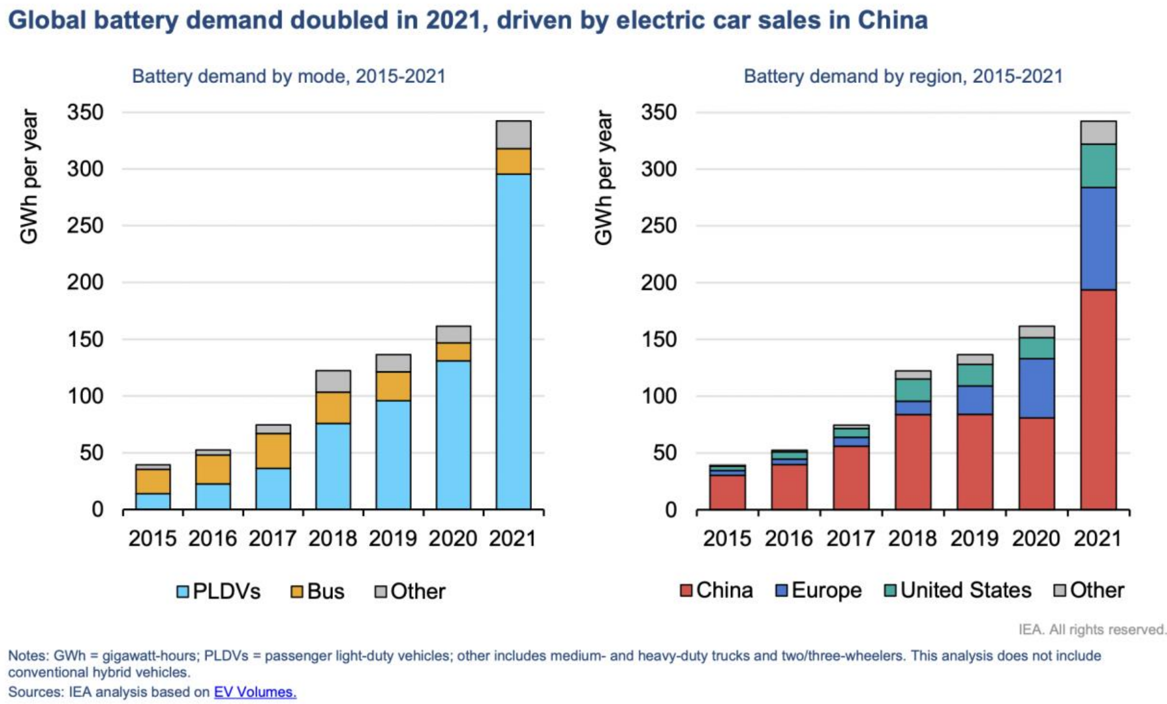
Battery capacity deployed in electrified vehicles by cell supplier, from January to May 2021, gigawatt-hours

Rank	Cell supplier	EV makers served / under contract	GWh	% market share	% growth, 2016 to 2020
1	Contemporary Amperex Technology Co. (CATL)	BMW, Dongfeng Motor Corp., Honda, SAIC Motor Corp., Stellantis, Tesla, Volkswagen Group, Volvo Car Group	21.5	26	3,400
2	LG Energy Solution	General Motors, Groupe Renault, Stellantis, Tesla, Volvo, VW Group	21.4	26	1,193
3	Panasonic	Tesla, Toyota	14.1	17	214
4	Samsung SDI	BMW, Ford, Stellantis, VW Group	5.5	7	399
5	BYD Co.	BYD, Ford	5.5	7	113
6	SK Innovation	Daimler, Ford, Hyundai, Kia	3.4	4	226
7	China Aviation Lithium Battery (CALB)	GAC Motor, Zhejiang Geely Holding Group Co.	2.7	3	321
8	Gotion High-Tech	Chery Automobile Co., SAIC, VW Group	1.4	2	23
9	Automotive Energy Supply Corp. (AESC)	Groupe Renault, Nissan	1.4	2	46
10	Ruipu Energy Co. (REPT)	Dongfeng, Yudo Auto	0.6	1	100
	Other		4.2	5	122
	Total		81.6	100	355

SOURCES: ADAMAS INTELLIGENCE; BUSINESSKOREA; ELECTRIVE; BMW, FORD, HONDA, VOLVO

Source: Lawrence Ulrich, "Who's Powering the EV Revolution?" *IEEE Spectrum*, September 2021. https://spectrum.ieee.org/media-library/eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJpbWFnZSI6Imh0dHBzOi8vYXNzZXRzLnJibC5tcy8yNzI3Nzc5NS9vcmlnaW4ucG5nIiwiZXhwaXJlc19hdCI6MTY1NTg0MDA0Mn0.hNLZyz2lzgQO2AE2xo929UFJR88ZI8deMggYf--x2Gw/image.png.

Exhibit 10: Global Battery Demand



Source: International Energy Agency, "Global EV Outlook 2022," May 23 2022, https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf#page=138.

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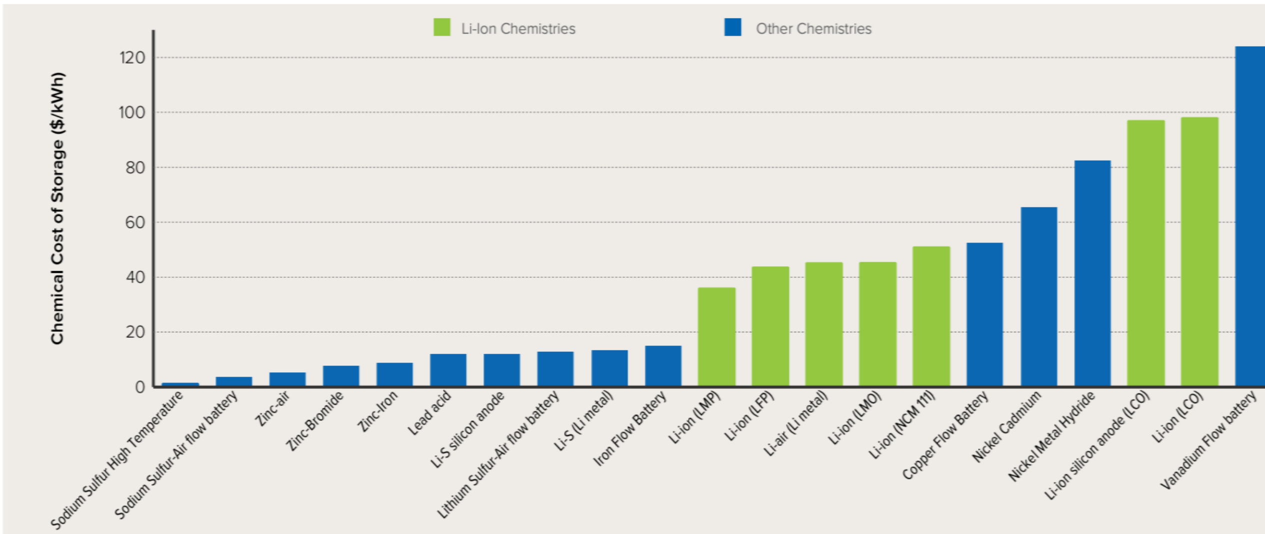
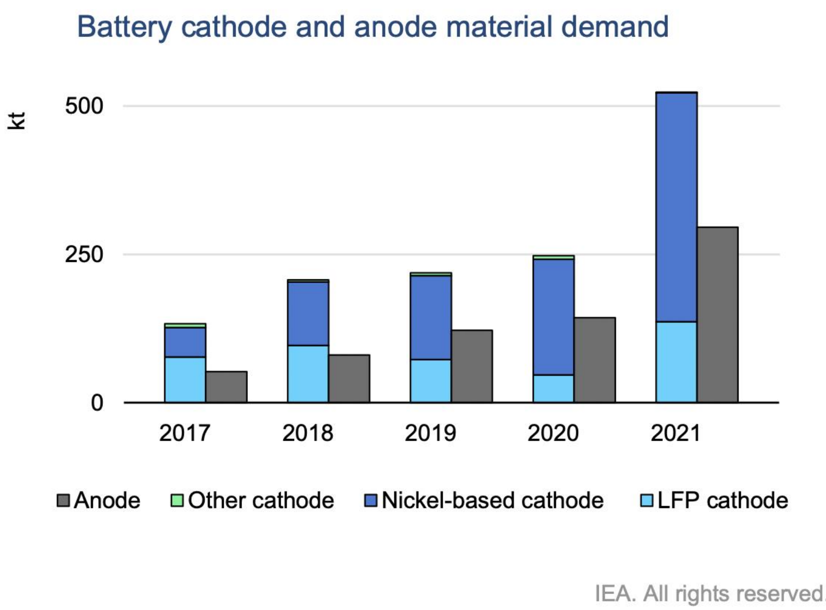
Exhibit 11: Cost of Materials

Estimated Cost of Raw Materials for Different Battery Chemistries[24]



Source: Charlie Bloch, James Newcomb, Samhita Shiledar, and Madeline Tyson, "Breakthrough Batteries: Powering the Era of Clean Electrification," Rocky Mountain Institute, January 2020, https://rmi.org/wp-content/uploads/2019/10/rmi_breakthrough_batteries.pdf

Exhibit 12: Battery Material Demand



Notes: kt = kilotonnes; LFP = lithium iron phosphate. Nickel-based cathode includes: lithium nickel manganese cobalt oxide NMC333, NMC532, NMC622, NMC721, NMC811; lithium nickel cobalt aluminium oxide (NCA) and lithium nickel manganese cobalt aluminium oxide (NMCA).
Sources: IEA analysis based on EV Volumes.

Source: International Energy Agency, "Global EV Outlook 2022," May 23 2022, https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf#page=140.

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