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What Drives Electric Vehicles (EVs)

Jason Bloom

Head of Fixed Income &
Alternative ETF Product
Strategy
Invesco

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What Drives Electric Vehicles

May 2022

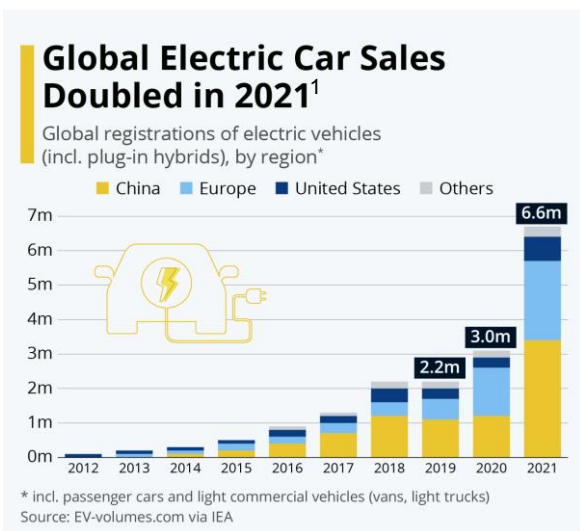
Jason Bloom
Head of FI & Alts

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Electric Vehicles – When the Ripple Becomes a Wave

Electric Vehicles (EVs) have become an increasingly hot topic as demand accelerates beyond expectations amid growing initiatives to combat climate change



IEA = International Energy Agency

Source:

¹Statista, *Global Electric Car Sales Doubled in 2021*, February 15, 2022

²AlixPartners, *Consumer interest in electric vehicles is approaching an inflection point*, October 27, 2021

³TIME, *We Watched Two Decades of Super Bowl Ads. Here's What They Say About Climate Change*, February 14, 2022

Bloomberg, *Super Bowl Ads, Conquests and Your Next Car*, February 17, 2022



Global EV sales more than **doubled y/y** in 2021, led by China & Europe – over 6.5 million passenger EVs were sold globally (**8.6%** of total car sales, up from 4.6% in 2020)



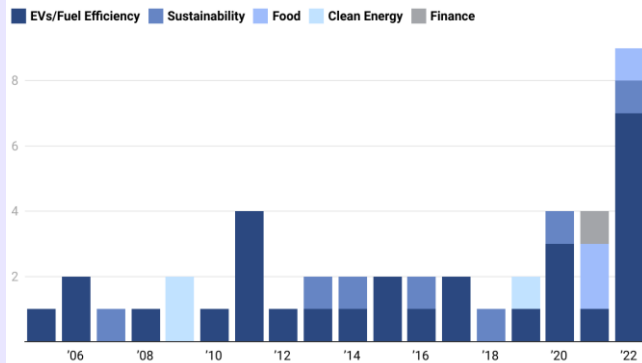
A 2021 survey by AlixPartners found that 'BEV (battery EV) Believers'—those very likely to buy a battery-electric as their next vehicle—have more than doubled in the past two years, from 11% to **25%** globally and from 5% to **19%** in the U.S.²

EV Commercials Dominated the Latest Super Bowl!

Companies like General Motors, BMW, Kia and Polestar spent a record **\$6.5 million** on average for a 30 second feature of their new EV models and SUVs³

Super Bowl ads referencing climate change, 2005-2022

During Super Bowl LV1, in 2022, more than twice as many climate-related ads were aired than during any previous year's game.

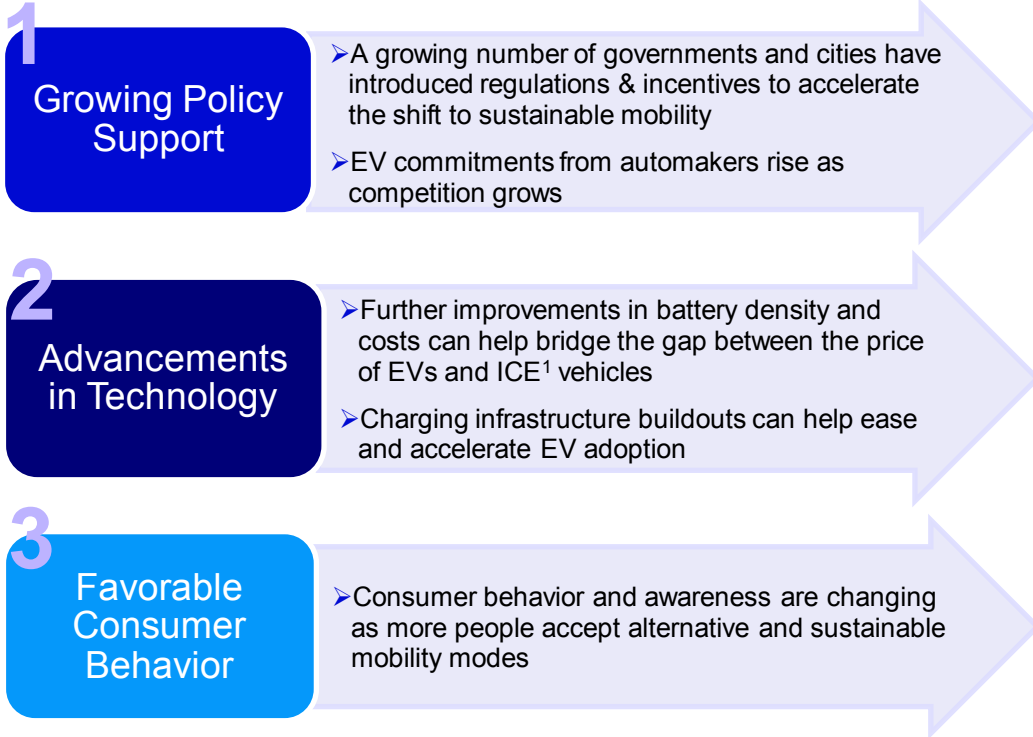


Ads were considered 'green' if they were promoting a green product/a product's green credentials, or highlighting environmental issues front and center.

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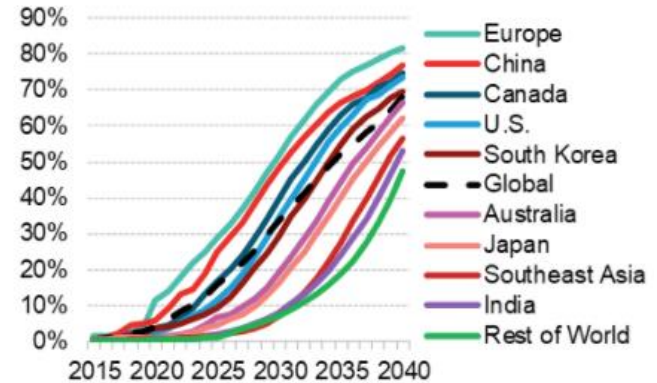
Key Drivers for the Electric Vehicle Outlook – The End of the ICE¹ Age?

“The years ahead will bring significant changes as electrification, shared mobility, vehicle connectivity and, eventually, autonomous vehicles reshape automotive and freight markets around the world” – BloombergNEF



“The (EV) move is seen as critical in the drive to cut greenhouse gas emissions to net zero by the middle of the century. Transport is the country’s **biggest single source** of carbon dioxide, eclipsing even the energy sector, and cars and vans contribute the vast majority of these emissions.”²

EV share of new passenger vehicle sales outlook by market - Economic Transition Scenario



Source: BNEF. Note: EVs include battery-electric and plug-in hybrid electric vehicles. Battery-electric vehicles represent 88% of total electric vehicle sales in 2030. Europe includes the EU, the U.K. and European Free Trade Association (EFTA) countries.

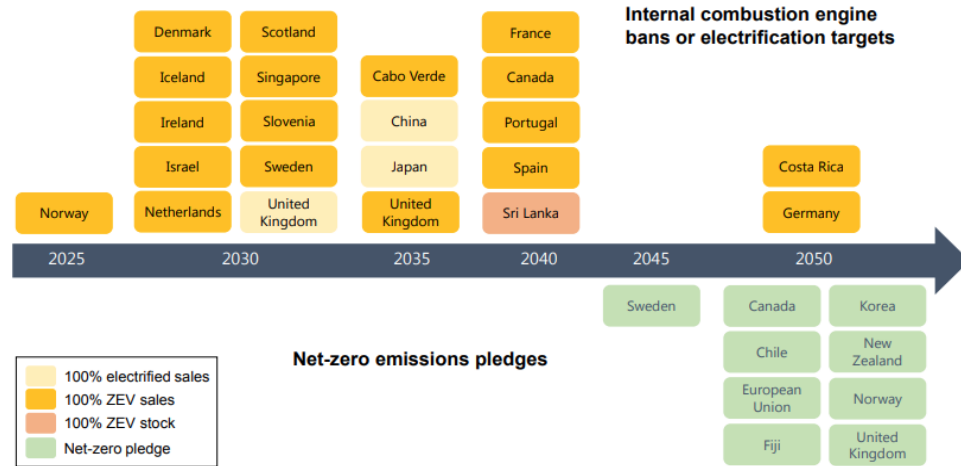
¹ICE = Internal Combustion Engine

Source: ²The Times, *The environmental impact of electric cars*, July 22, 2021
BloombergNEF, *Electric Vehicle Outlook 2021*, June 09, 2021

Policy Support Should Continue to Drive EV Adoption

“The task facing policymakers across the world is to accelerate the move to mass adoption – and step towards a future of total transport decarbonization” – International Energy Association (IEA)¹

More than 20 countries have electrification targets or ICE bans for cars & 8 countries plus the European Union have announced net-zero pledges²



Source: IEA, Global EV Outlook 2021, April 2021

Notes: Only countries that have either an ICE ban or electrification target or with net-zero emissions in law or proposed legislation have been included. Those with net-zero emissions policy documents only, e.g. Japan and China, have not been included. European Union refers to the collective pledge of the 27 member states. Some individual countries also have net-zero emissions pledges either in law or proposed legislation (Denmark, France, Germany, Hungary, Ireland, Luxembourg, Slovenia, Spain, Sweden and the Netherlands). The targets reflect the status as of 20 April 2021. Electrified vehicles here include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell electric vehicles (FCEVs) and hybrid electric vehicles (HEVs), depending on the definitions of each country. ZEV = zero-emission vehicle (BEVs, PHEVs and FCEVs)

Source:

¹IEA, EV City Casebook and Policy Guide 2021 Edition, March 2021

²IEA, Global EV Outlook 2021, April 2021

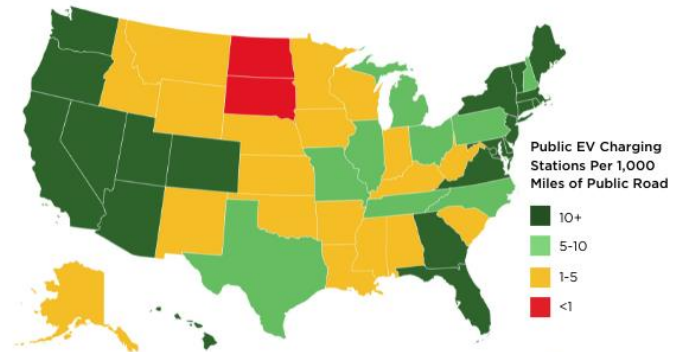
³Energy.gov, President Biden, DOE and DOT Announce \$5 Billion over Five Years for National EV Charging Network, February 10, 2022

⁴Car & Driver, States to Get \$5 Billion to Build a Massive EV Charging Station Network, February 10, 2022

EV Charging Infrastructure Buildout

- Under the Bipartisan Infrastructure Law's National EV Infrastructure (NEVI) Formula Program, Dept. of Transportation and Dept. of Energy announced in February that **\$5 Billion** in funding will be allocated over the next five years to build out a national EV charging network in the U.S., including in rural areas³
- By 2030, the government is aiming to have a network of half a million charging stations, with EV drivers able to gain access to a charging port at least every 50 miles across the U.S.⁴

EV CHARGING INFRASTRUCTURE BY STATE*



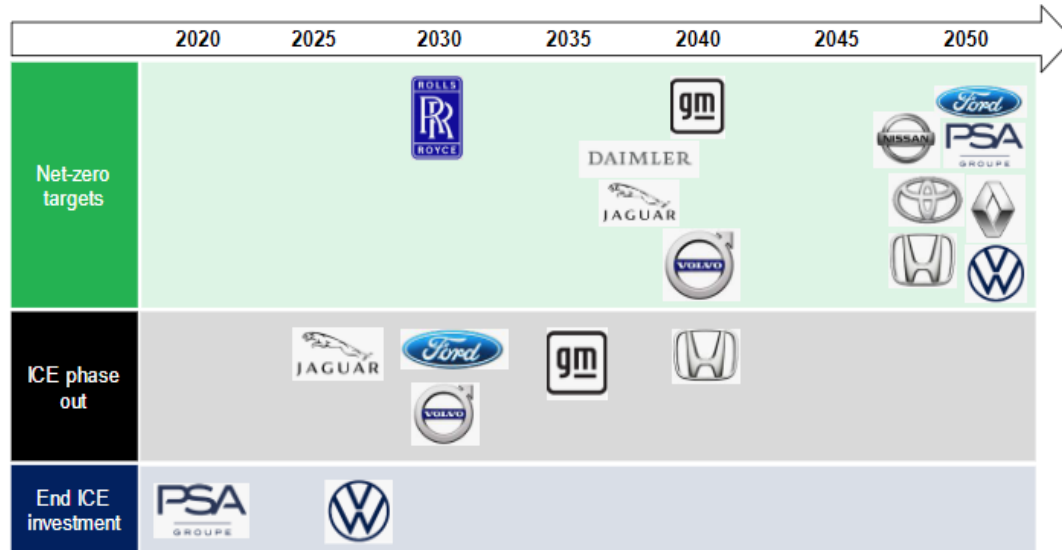
Source: Environmental and Energy Study Institute (EESI), *Beyond Cities: Breaking Through Barriers to Rural Electric Vehicle Adoption*; October 22, 2021

*EV charging data as of August 2021, public road mileage as of 2019.

The Auto Industry's Race to "Going Electric"

As the call for the electrification of transport fleets grow, an increasing number of automakers have pledged some form of electric vehicles, in fear of being left behind

Figure 41: Automakers' drivetrain development targets



Source: BNEF. Note: Ford ICE phase-out target is for Europe only. Excludes interim targets.

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"The future of Bentley will be fully electric. By 2030, **no more combustion engines**. We are not only working on one electric car but a full family of electric cars." – Adrian Hallmark, CEO



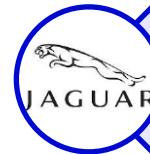
General Motors announced an investment of \$35B in EV and autonomous vehicle product development until 2025 & looks to **phase out gas/diesel vehicles by 2035**



Volkswagen wants 50% of its vehicle sales to be electric by 2030 and **nearly fully electric by 2040**. 2026 will be the last year it launches a combustion platform



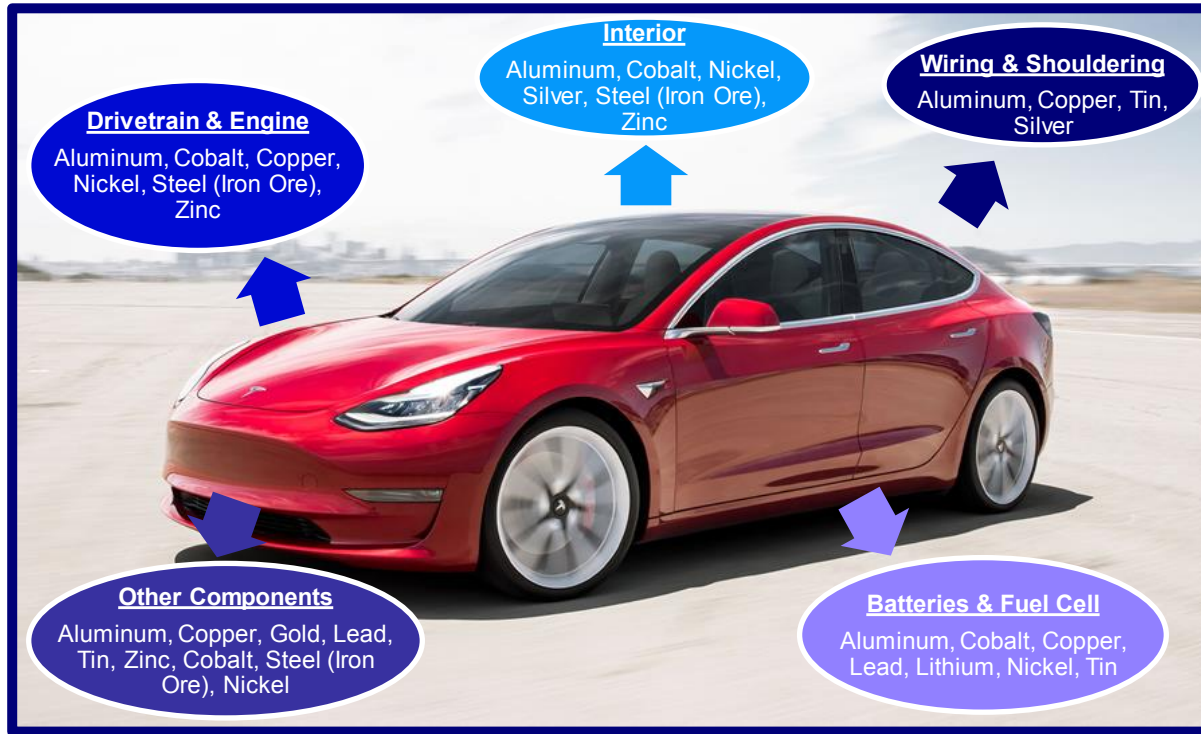
Audi will only launch new fully electric models from 2026 onwards and **aims for all car sales to be electric in 2030**



Under a plan called "Reimagine," the brand will be all-electric, with **battery versions of the whole lineup by 2030**, with \$3.4B investment annually in new technology

EV Metals Demand

“The transition from petrol to electric vehicles is an important step in the move to a net-zero future. With the demand for EVs growing rapidly, the demand for commodities used for EVs is also expected to grow.”¹



Source: ¹Mining Technology, *Concerns for mineral supply chain amid booming EV sales*, February 10, 2022

EV Metals Demand Continued...


All manufacturers involved in the process of building an EV, its battery and its charging infrastructure will need to purchase the metals used for production

EV Manufacturers




Logos of EV manufacturers: Tesla, NIO, Rivian, SAIC (上汽集团 SAIC MOTOR), XPENG, Lucid, Mullen, Proterra, GreenPower MOTOR COMPANY, Lightning eMOTORS, Meccanica, and Nikola (NIKOLA MOTOR COMPANY).

Battery Manufacturers



Logos of battery manufacturers: CATL (宁德时代), BYD, LG Energy Solution, Panasonic, SK innovation, Samsung SDI (三星SDI), Microvast (微vast), QuantumScape, and CALB.

Charging Station Manufacturers



Logos of charging station manufacturers: Chargepoint, EVgo (FAST CHARGING), Shell, Mercedes-Benz DAIMLER, G² MOBILITY, EVBOX, RWE, ABB, SIEMENS, bp, HYUNDAI, and Webasto (Feel the Drive).

Copper 	Aluminum 	Nickel 	Cobalt 	Lithium 	Iron Ore 	and more...
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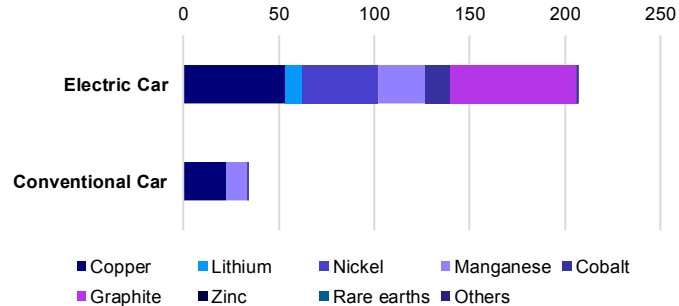
The Need for Speed – Producing in the Past, Consuming in the Future

Today, the data shows a looming mismatch between the world’s strengthened climate ambitions and the availability of critical minerals that are essential to realizing those ambitions” – Fatih Birol, IEA

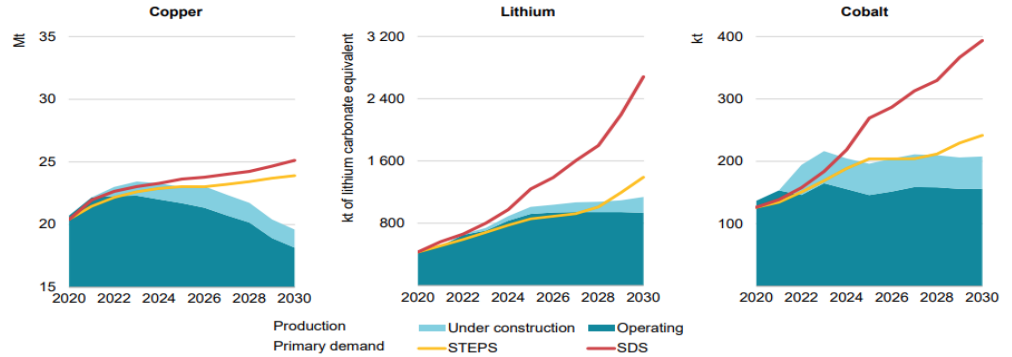
Strong EV growth could place severe strains on global supply chains, particularly in raw materials:

- A typical EV requires **6x** the mineral inputs of a conventional car
- EVs and battery storage have already displaced consumer electronics to become the largest consumer of lithium and are set to take over stainless steel as the largest end user of nickel by 2040

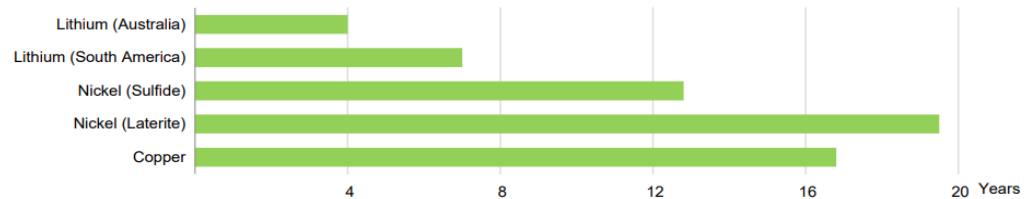
Minerals used in electric cars compared to conventional petrol cars (kg/vehicle)



Committed Mine Production & Primary Demand



Average observed lead time for selected minerals (from discovery to production)¹



“How policy makers and companies handle the challenges around reliable and sustainable supply will determine whether critical minerals are a vital enabler of clean energy transitions or a bottleneck in the process”

¹Note: Global average values are based on the top 35 mining projects that came online between 2010 and 2019. IEA analysis based on S&P Global Data
Source: International Energy Agency (IEA), The Role of Critical Minerals in Clean Energy Transitions, May 2021; for all above unless otherwise stated

The Great Battery Race – Evolving Technology

With EV sales expected to surge, global battery demand could increase over five-fold between 2020 & 2025¹ – Having a wide variety of potential battery chemistries to switch between could help debottleneck future EV growth

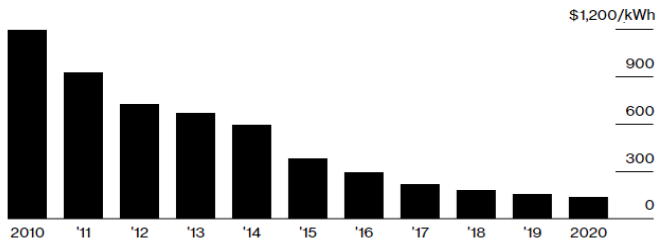
Battery costs represent the largest obstacle for the EV/ICE price parity², posing a major roadblock in the acceleration of EV adoption:

- Batteries currently make up **40-50%** of the cost for EVs²
- Battery pack prices need to drop to \$60/kWh for EVs to be cheaper than internal combustion engine (ICE) vehicles in all segments & countries – **BloombergNEF expects this in 2029³**
- Rising metal prices due to looming shortages could derail the decade long decline in Lithium-ion battery prices – In 2021, lithium-ion batteries hit an all-time low of \$132/kWh⁴

Steady State

Lithium-ion battery prices persistently declined during the last decade

■ Pack prices



Source: BloombergNEF

Source:

¹S&P Global Market Intelligence, *EV Impact: Battery disruptors are jolting metal supply chains*, September 21, 2021

²Bloomberg, *EV Battery Prices Risk Reversing Downward Trend as Metals Surge*, September 14, 2021

³Bloomberg, *Hyperdrive Daily: The EV Price Gap Narrows*, May 25, 2021

⁴Mining Technology, *Concerns for mineral supply chain amid booming EV sales*, February 10, 2022

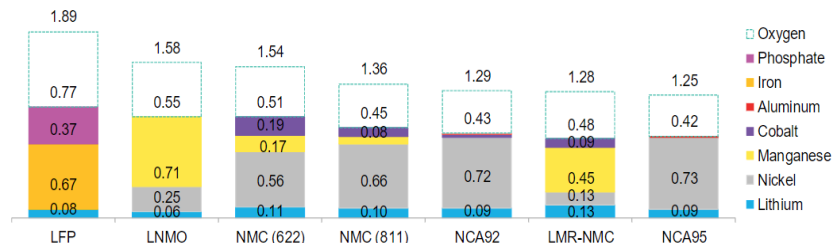
⁵Macquarie, *Big changes in EV battery chemistry are underway – still favours nickel...for now*, February 01, 2022

Battery technology is evolving rapidly amid increasing competition to **balance costs, vehicle range, charging speed etc.**

- Generally, the **higher the nickel content** of the battery, the higher the energy intensity and therefore, the longer range between charges
- **Cobalt is needed to maintain stability** in the battery performance by preventing overheating
- Macquarie estimates that nickel content of batteries in EV sales last year grew 125% y/y while cobalt grew by “only” 55% y/y⁵

Figure 266: Metal content of selected lithium-ion battery cathode materials




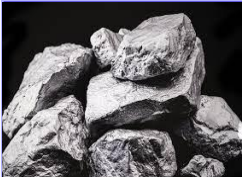

kg/kWh



Source: BNEF. Note: See Appendix A for a glossary of chemistry names.

Fundamentals of the Component EV Metals

Energy transition is already generating new demand for battery metals and mineral resources

	Copper	<ul style="list-style-type: none">➤ Copper is often known as the “heart & veins” of EVs – used in electric motors, batteries, inverters, wiring and even charging stations – Current EVs require over 3-4x more copper in comparison to an ICE vehicle¹➤ Wood Mackenzie estimated that by 2030, there will be over 20 million EV charging points globally, consuming 250% more copper than in 2019¹
	Aluminum	<ul style="list-style-type: none">➤ Aluminium plays a significant role in the light-weighting of electric and hybrid vehicles – reducing weight is one of the most effective ways to improve the energy efficiency of EVs and batteries²➤ The car industry used about 18% of all aluminum consumed worldwide in 2019, and demand is expected to double by 2050 as car companies transition to EVs (International Aluminum Institute)
	Nickel	<ul style="list-style-type: none">➤ Nickel use in lithium-ion batteries is growing rapidly as automakers try to improve battery performance and substitute high-cost cobalt for cheaper nickel³ – Batteries without nickel tend to have lower battery density➤ Currently, battery manufacturing accounts for around 8% of total primary nickel consumption² – Demand is estimated to outpace supply leading to a deficit in 2024-2030³
	Cobalt	<ul style="list-style-type: none">➤ Mined cobalt is refined into cobalt sulfate, and used in the production of precursors for battery cathode active material – needed to maintain stability in the battery performance by preventing overheating➤ By 2029, passenger EVs will overtake consumer electronics as the biggest end-use segment for cobalt³➤ Automakers and battery manufacturers continue to identify cobalt as a key risk to their supply chains with 70% of global production concentrated in the Democratic Republic of the Congo³
	Iron Ore	<ul style="list-style-type: none">➤ Iron Ore is essential in the production of steel, which is perhaps the most widely used input in auto manufacturing – Almost all (98%) of iron ore is used in steelmaking (National Minerals Information Center)➤ Steel is used in construction of a car’s chassis and body, including the roof, body, door panels and the beams between doors

Source:

¹CMEGroup, *Copper’s Role in Growing Electric Vehicle Production*, April 20, 2021

²ING, *Electric vehicles to drive metals demand higher*, October 13, 2021

³BloombergNEF, *Electric Vehicle Outlook 2021*, June 9, 2021

Key Considerations for the EV Outlook



Stalled Economic Growth

- *Slowing growth, particularly in **China**, could threaten demand for EVs given its lead in EV adoption and metals demand*
- ***Tightening central bank policies** could be deflationary and lower consumption for all goods, risking a potential recession*
- ***New COVID-19 strains/variants** could be immune to vaccines causing a slowdown in the global economic recovery*



Potential Supply Relief

- *Persistent raw material shortages could **lower regulatory hurdles** for mining projects, introducing a relief valve for the supply chain*
- *Continued tightness in energy supplies could lead to a **potential reversal or hold off in current green policies and regulations**, leading to increased metals production*
- ***Easing geopolitical tensions** could provide relief for the flow of raw materials, allowing more supplies onto the markets*



Slowdown in the ESG/EV Trend

- *EV demand growth could slow if raw material prices continue to move higher slowing the path to closing the **EV/ICE price parity** – gap between the price of EVs and ICE vehicles*
- ***ESG sentiment** could stall if current green policies continue to drive inflation, causing pain for consumer wallets i.e., raising the question of “Are we moving too fast?”*

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