The Battery Technology Landscape

Primer Presentation to TPG Rise Climate

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Battery Technology Industry Overview

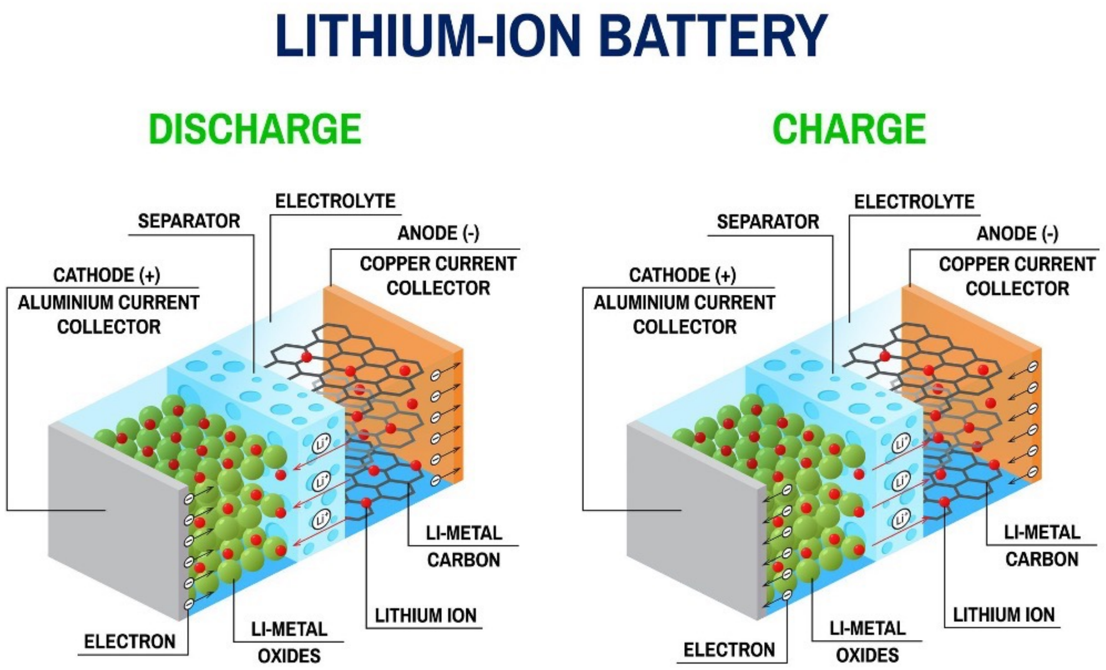
Lithium-ion battery technology is becoming ubiquitous and sodium-ion and solid-state show promise for the future

- The historically prominent lead-acid, nickel-cadmium, and nickel-metal hydride batteries are being phased out by lithium-ion, sodium-ion, and solid-state batteries in battery electric vehicle (BEV) applications and flow batteries complemented by supercapacitors in energy storage system (ESS) applications
- Within BEVs, the current focal point is how the development of traditional lithium-ion, sodium-ion, and solid-state lithium-ion battery technologies will shape the market

Battery Type	Application	Advantages	Disadvantages
Lead-Acid	• First type of rechargeable battery ever created • Low energy density relative to modern counterparts • Automobile starting, lighting, and ignition (SLI) batteries	• Relatively low cost, widely available • High discharge current	• Heavy and bulky, largely impractical for portable applications • Limited cycle life, maintenance requirements
Nickel-Cadmium	• Primarily in consumer portable electronics • Historically in hybrids and EVs, have since been replaced by lithium-ion and nickel-metal hydrides	• High discharge rate • High durability and wide temperature range • Low level of leakage and failure rate	• Toxicity of cadmium • “Memory effect”: loss of capacity if not fully discharged, high self-discharge rate
Nickel-Metal Hydride	• Higher energy density relative to NiCad • Popular replacement for NiCad in hybrid EVs, consumer electronics, and power tools	• No cadmium, a toxic heavy metal • No “memory effect”: no loss of capacity if not fully discharged	• Lower voltage than NiCad • Higher self-discharge rate • Limited availability, higher cost
Traditional Lithium-Ion	• Hybrids and EVs • Portable electronics • Renewable energy storage across wind and solar	• High energy density • Low self-discharge rate, fast charging • Long cycle life	• High cost • Flammability • Limited shelf life: periodic recharge needed
Sodium-Ion	• Structurally & functionally same to lithium-ion, but use sodium ions instead of lithium ions • Large-scale energy storage applications	• Cost-effective: sodium is abundant and cheap • Safer: less reactive than lithium	• Lower energy density • Low cycle life • Limited commercial availability
Solid State Lithium-Ion	• Type of lithium-ion battery that uses solid electrolyte rather than liquid • EVs and consumer electronics	• Higher energy density • Faster charging • Safer: less prone to overheating and fire	• Expensive manufacturing • High manufacturing precision requirements • Limited commercial availability
Flow	• Grid energy storage and integration • Microgrids and off-grid applications	• Scalable by varying electrolyte tank size • Long cycle life, high efficiency • Safe: electrolytes are non-flammable	• Complexity requires expensive mechanical components to circulate the electrolyte • Low energy density, limited temperature
Supercapacitors	• Short-term energy storage, high power output • Hybrids and EVs • Backup power	• Long cycle life • High power density, fast charging/discharging • Wide operational temperature range	• Low energy density, storage, and high cost • Voltage limitations, cannot provide continuous power

Sources: Avicene, Nature Journal

How Lithium-Ion Batteries Work



Example Charging Reaction:

$$LiCoO_2 \rightarrow Li_{1-x}CoO_2 + xLi^+ + xe^-, \quad (1)$$

$$6C + xLi^+ + xe^- \rightarrow Li_xC_6. \quad (2)$$

The Basic Working Principle

- The thermodynamically stable state for most metals is a metal oxide
  - For lithium, this is a lithium oxide which can include other elements as well that impact the stability
- Energy is released when a more thermodynamically stable state forms as it takes energy to form an unstable state
- The basic working principle of a battery is:
  - Charging forms the unstable state (Li ion graphite matrix) while discharging forms the Li oxide
  - The Li must migrate from the carbon to the oxide to discharge, however, the Li metal is not mobile, but Li ions are
  - Li must lose an electron to become an ion, and thus become mobile
  - Li ion regains electron and then goes back to the metal

Roles of the Components

- Separator
  - Allows ion transfer but has no electrical conductance allowing for easier ion flow and improved battery performance
  - Allowing electrical current would short circuit the battery leading to thermal runaway
- Electrolyte
  - Enables both ion and electron flow
  - Can be liquid, gel, or dry polymer with liquid and gel used most frequently
  - Many additives are used to increase performance, however, most are manufacturer-specific secrets
  - Flammability is a concern with liquid electrolytes
- Anode
  - Negative half of a battery
  - 98% of commercially available anodes use graphite as it is cheap, has strong performance, and is easy to procure with Lithium-Titanate Oxide (LTO) composing the remaining 2%
- Cathode
  - Positive half of a battery
  - Many different types of Li oxides that are used for battery naming conventions (LFP, NMC, etc.)

Types of Lithium-Ion Batteries

Types of Cathode and Anode Pairings

Cathode	Anode	Energy Density (watt-hours/kg)	Cycle Life	Applications
LFP (Lithium-Iron Phosphate)	Graphite	90 - 120	2000 - 4000	Grid-scale energy storage, EVs
LMO (Lithium-Manganese Oxide)	Graphite	100 - 150	300 - 700	Power tools, medical devices
LCO (Lithium-Cobalt Oxide)	Graphite	150 - 240	500 - 1000	Consumer electronics
NCA (Nickel-Cobalt Aluminum Oxide)	Graphite	200 - 260	500	Medical devices, Tesla EVs
NMC (Nickel-Manganese-Cobalt)	Graphite	150 - 220	1000 - 2000	EVs, industrial/medical applications, e-bikes
LMO, NMC	Lithium-Titanate Oxide (LTO)	50 - 80	3000 - 7000	UPS systems, electric powertrains

Types of Electrolytes

Liquid

- Lithium-based electrolyte is used which includes a solvent (organic liquid) and a solute (dissolved salts)
- Advantages over solid-state electrolytes:
  - Higher ion conductivity, easier manufacturing, less expensive

Types of Separators for Liquid Electrolytes

- Separators enable ion transport but prevent physical contact between anode and cathode
- Polyethylene (PE) and polypropylene (PP) are the most commonly used materials
- There is ongoing research to find better materials for lithium-sulfur batteries since the physical contact prevention aspect is especially important

Solid-State

Inorganic Electrolytes		Polymer Electrolytes (PE)		
Oxides (LATP, LiSICON, LiPON)	Sulfides (Crystalline, Amorphous)	Polymer-Salt Complexes (PEO—LiBF4)	Gel PE (PVdF based)	Composite PE (PEO-LiI-Al2O)

- The role of the solid-state electrolyte is to allow ion transport but prevent electron conduction
- Li metal is a leading anode material while NMC or LFP are common cathodes
- Advantages over liquid electrolytes:
  - High energy density, increased safety, longer lifespan

Sources: Battery University, Maybank IBG Research, Irina (2015), Asian Development Bank, MDPI Journal, Nature

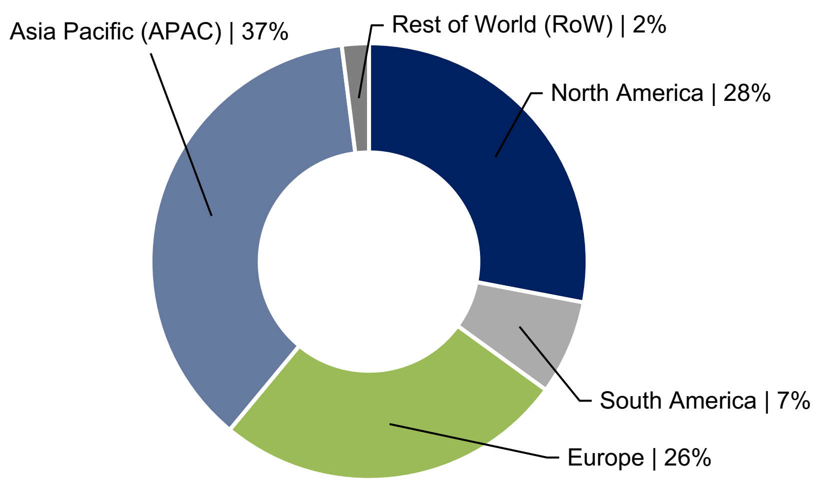
Future Battery Technology Trends

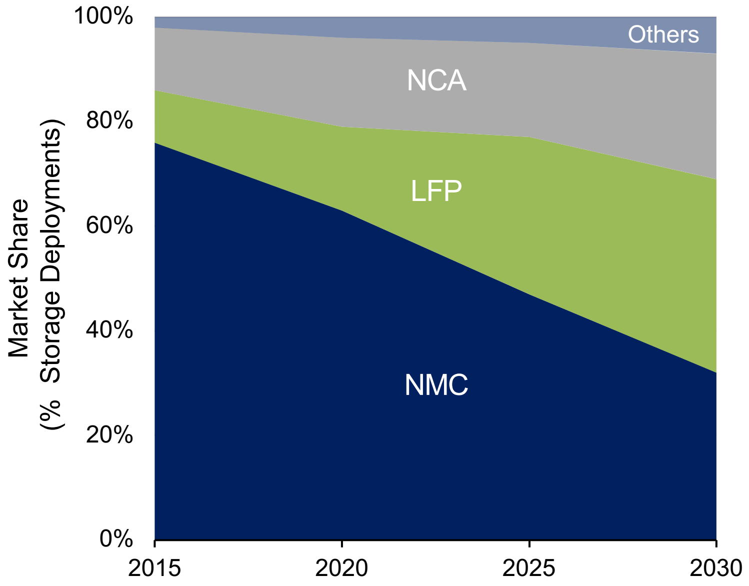
Technology	Advantages	Challenges	Time Scale
Silicon Anode	Up to 10 times higher lithium capacity than graphite, cathode agnostic, high material availability	320% swelling on cycle leads to crack growth in anode, low cycle life	Enrichment of graphite with silicon powder is already happening, full silicon anode within the decade
Dry Electrode Coating	Removes a solvent additive and drying process from manufacturing, lower cost and time	Calendaring process is harder to make fibrils with, patents	Very soon, potentially already on assembly lines
Lower Cobalt Content	Cobalt is expensive, toxic, and a strategic material, reducing it enables higher battery production	Cobalt is important for safety and performance	Trend is ongoing and will continue for foreseeable future
LMNO	Cobalt free, high energy density due to high voltage operation, low theoretical cost, safe	High voltage leads to quick degradation, poor electrical conductivity	Potentially in the next decade. Much research to be done
LFP	Very safe and long lasting. Cheapest material cost so lowest cost at scale	Performance is lower than NCA, NMC	China produces large volumes of LFP, trend is ongoing
Sodium Ion	Likely will replace lead-acid, low cost	Low energy density, larger sodium ion have tougher material requirements than Li	CATL is building supply chain now
Lithium Metal Anode	Removing the graphite and using pure lithium as anode can up to double energy density	Dendrite formation leads to short cycle life, high volume change, safety issues	Depends on system, not soon
Sulfur Cathode	1,675 mAh/g theoretical capacity, very cheap	Low conductivity- carbon is added	Depends on system, not soon
Li-S	True least cost lithium battery system, theoretical energy density of 2,510 Wh/kg (more than 10x NMC) Research has found density of 1,000 Wh/kg.	Polysulfide dissolution causes poor cyclability, anode corrosion, poor conductivity, and significant volume change	Big gap between industry and academia. Discrepancy seems due to quality of materials. Unlikely within this decade
Li-Air	Theoretical energy density of 11,400 Wh/kg (excluding air). Air is free. Research has achieved 685 Wh/kg at 1000 cycles	Lab only results, cycle life is still low	Unsure. Lots of recent progress in lab, potentially could be commercialized within decade

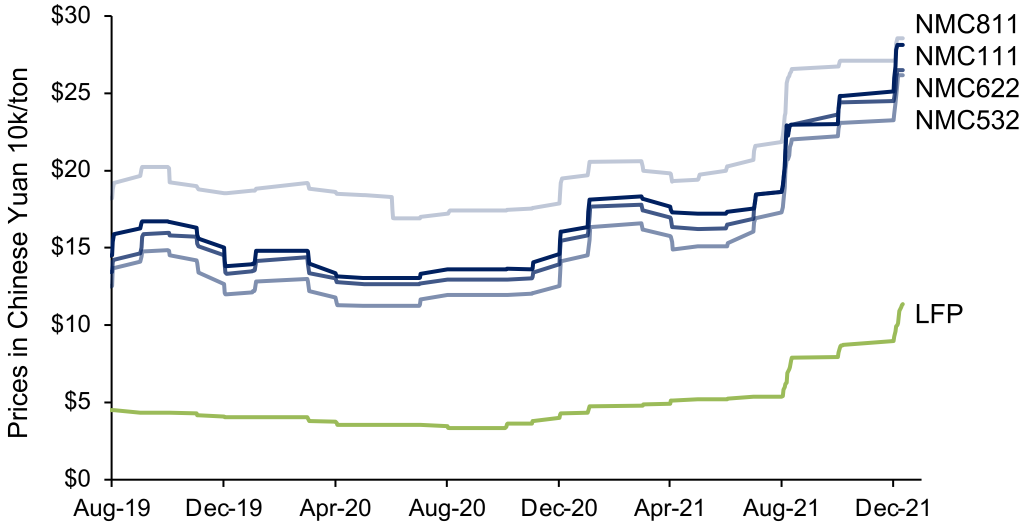
Sources: Canary Media, CE&N, McKinsey & Co, Frontiers in Energy Research

Market Segmentation of Lithium-Ion Batteries

LFP is growing, bolstered by cell-to-pack design, cost advantage, and adoption by leading APAC and US producers


Global Lithium-Ion Battery Market Share, By Region, 2020


Battery Chemistry Market Share Forecast, 2015 - 2030


Battery Cell Cathode Prices, 2019 - 2021

- The future of the lithium-ion battery industry is driven by the growth of electric mobility applications (26.4% CAGR) relative to applications such as consumer electronics (5.1% CAGR)
- The market for lithium-ion batteries is dominated by the Asia Pacific region (APAC)
  - APAC will grow in market share dominance as its existing EV market infrastructure will exhibit network effects
- NMC batteries have optimized to produce nickel-rich compositions that decrease reliance on cobalt
- LFP battery chemistry has been readily adopted as its cell-to-pack (CTP) design is competitive with NMC battery packs on an energy density basis, while cell-level specific energy remains at a significant discount[1]
  - APAC is benefiting most from the LFP cost advantage, in Q1 – Q3 2022, more than 85% of LFP batteries used in passenger EVs globally were in China
- Leading EV manufacturers have begun adopting LFP in their standard-range models
  - BYD, a leading Chinese EV manufacturer, commercialized its LFP Blade battery in March 2020
  - Tesla announced a switch to LFP batteries in Model 3 and Model Y vehicles in October 2021
  - Ford announced a plan in February 2023 to use LFP batteries in their late 2023 Mustang Mach-E and 2024 F-150 Lightning

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Sources: IndustryArc, WoodMac, Wind, J.P. Morgan, Bull Capital, Nature

[1] *Reference Appendix Chart 1.1*

Commodity Outlook

Lithium, graphite, nickel, and cobalt are the underlying commodities driving lithium-ion battery pricing

- As manufacturing costs decrease, batteries become increasingly sensitive to commodities
  - Li, Ni, and Co contribute roughly 13%, 21%, and 5% respectively to the total cost of an NMC811 cell
  - Assuming the current 75% cell-to-pack cost ratio, Li, Ni, and Co comprise 30% of a total battery pack cost
- Supply bottlenecks would occur from the upstream market as there are enough raw material deposits to supplement all demand projections

Lithium

- 30 times as much lithium would be required by the EV industry by 2040, far outpacing committed mine production
- Lithium extraction is largely restricted to Australia, Chile, and Argentina, with only four businesses controlling almost 60% of global production
- The majority of lithium exchanges are carried out over-the-counter (OTC), rather than on a lithium SPOT market

Graphite

- Of the raw material inputs, graphite has the highest proportion of volume in a battery cell
- China produces nearly 50% of global synthetic graphite and 70% of global flake graphite
- The majority of flake graphite processing and anode production takes place in China, creating supply securitization risk

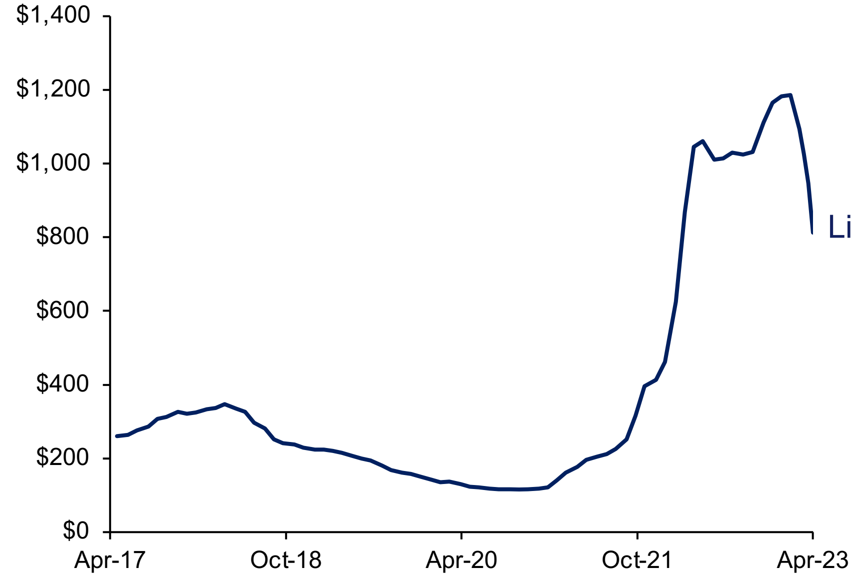
Nickel

- The global demand for nickel used to produce lithium-ion batteries amounts to less than 5% of the world market for primary nickel
- Indonesia is the largest nickel producer, accounting for 33% of global production and 22% of reserves
  - An export ban on nickel ore was imposed to retain a larger portion of the value chain domestically

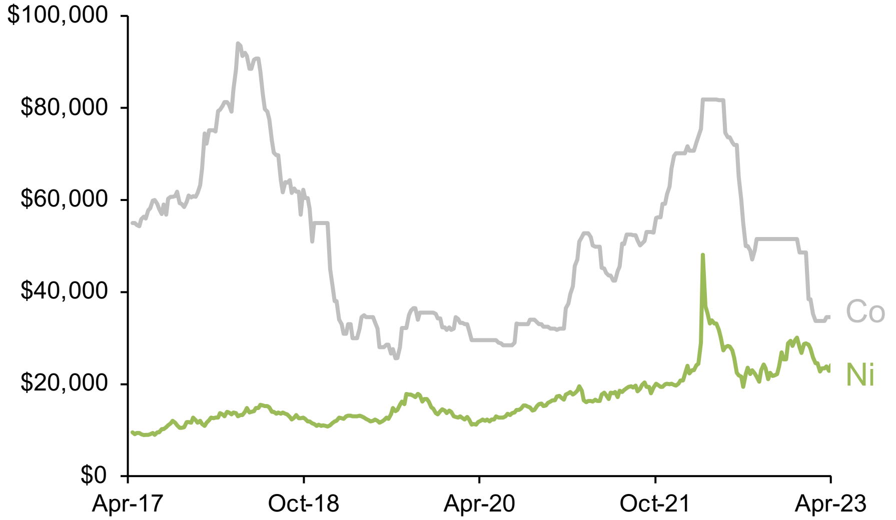
Cobalt

- Currently, cobalt presents the greatest procurement risk and is the dominant market-value contributor per unit of all battery raw material inputs
- The Democratic Republic of the Congo accounts for 69% of production and 50% of reserves, of which 80% is controlled by Chinese companies
- Australia, a FTC, is the second-largest cobalt producer, however, 94% of Australian exports were directed to China in 2022

Lithium Price Chart, 2017 - 2023



Nickel and Cobalt Price Chart, 2017 - 2023



Sources: Cowen, Nature Public Health Emergency Collection, Nature Energy, Bloomberg, Nature

Battery Technology Future Growth Prospects

Two potential narratives towards price stabilization may unfold over the next decade

- In the near term, batteries will continue to be differentiated by cathodes but anode alternatives to graphite, namely silicon or lithium-metal, may become the differentiated decision drivers
- The development of recycling technology and innovation extending battery life will likely reduce raw material requirement estimates

Price Stabilization Under Currently Commercialized Technologies

Scenario 1: Rapid price stabilization due to insufficient raw material supply

- Upstream market pricing is likely to remain opaque
    - Current contractual agreements are long-term and there are no definitive indications of a shift to a dominant SPOT market
    - The lithium market lacks homogeneity as there are various purity grades and chemistries
    - Vertical integration has been a common theme among leading producers
        - Volkswagen acquired a 15% share of QuantumScape and a 20% share of Northvolt
- Oligopolistic upstream market segment structure
    - 80% of global supply is supplied by 5 lithium producers
- A duration mismatch exists between the projected rise in commodity demand and the time needed to complete operational upstream facilities

Development Timelines for Domestic Operations

Establish Resource	Mineralogy	Scoping Studies	Beneficiation/Extraction/ Separation Pilot Plant
2 – 5 years	1 – 3 years	1 – 3 years	2 – 10 years
Environmental Assessments	Letters of Intent	Feasibility Study & Funding	Construction & Startup
Variable	Concomitant with 1 – 5 years	2 – 4 years	2 – 3 years

Scenario 2: Eventual price stabilization due to a technological ‘lock-in’

- Adopting a single battery technology produces increasing returns over time
    - LFP’s market traction is positioned to have especially scalable returns
- Potential market disrupting technologies would be adopted after NMC or LFP technology has reached mass-market dominance
    - The cost-curve produced would be too difficult to counter
- Raw material scarcity poses a significant barrier to adoption of a single battery type and projections estimate that NMC, LFP, and NCA chemistries will maintain market share through 2030

Sources: Nature, Market.us, MarketsandMarkets, The New York Times

Battery Technology Future Growth Prospects

Two potential narratives towards price stabilization may unfold over the next decade

- Forward-looking technical innovation has an emphasis on developing alternative technology that decouples BEV batteries from scarce materials
- Market disrupting technologies propose several orders of magnitude of cost savings if commercialized as point solutions

Market Disruption by New Technologies

Scenario 3: Indefinite price stabilization due to market disrupting technology

- Sodium-Ion Batteries (SIBs)
  - Sodium-ion batteries have the same working principle as lithium-ion batteries, which allows them to be a point solution capable of utilizing existing infrastructure with input availability
  - Competitive specific energy has not yet been developed, however, sodium batteries present several advantages including maintaining charge in colder temperatures and discharging safely to 0V
  - In 2021, CATL announced plans to industrialize sodium-ion EV batteries in 2023 with a sodium-ion and lithium-ion mixed battery pack that has recently been adopted by automaker Chery
  - The United States accounts for over 90% of the world's readily mined reserves for industrial sodium
  - Out of 20 planned or under construction sodium battery factories, 16 are in China affording them with 95% of the world's capacity to make sodium batteries
- Solid-State Batteries (SSB)
  - Current projections indicate that solid-state batteries will not be available at an industrial scale before 2030
  - Solid-state battery technology is potentially able to easily replace the technology inside liquid electrolyte lithium-ion production lines

Raw Material Closing Price Comparison

Cathode Material	Cost
Li_2CO_3	$69,000 USD/Ton
Na_2CO_3	$400 USD/Ton
Co	$71,000 USD/Ton
Ni	$23,000 USD/Ton

*As of 01/06/22

Sources: Nature, Market.us, MarketsandMarkets, The New York Times

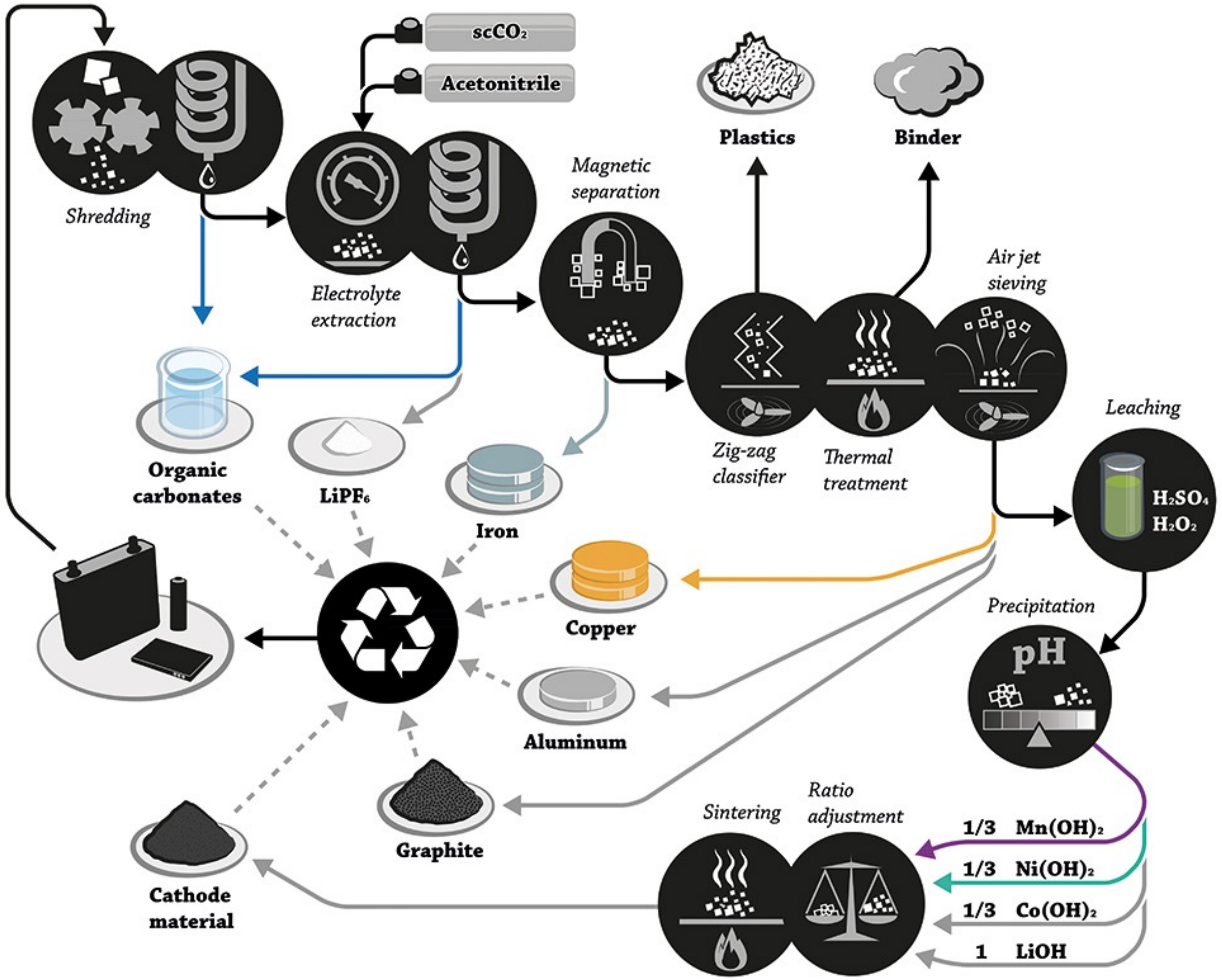
Lithium-Ion Battery Recycling Overview

Recycling has not yet reached profitability in the United States

- Outside of the Asia Pacific region, most recycling operations are currently unprofitable
- Profitability is heavily dependent on cathode chemistries and associated raw material market pricing, as well as the relative complexity of the separation process
- As battery chemistry transitions toward LFP and away from NMC chemistry that includes expensive cobalt material inputs, the potential profitability of recycling will decrease
- EV lithium-ion batteries are retired when they reach 80% of their initial energy storage capacity but they can be reused for a second life

> ***"The more battery designs and chemistries are heterogeneous, the more it undermines the ability to generate economies of scale in recycling processes."*** - Nature Journal

- By 2030, material recycling is projected to only help decrease EV costs by roughly 1%, however, material recycling presents long run benefits including roughly 10% cost savings and a 60% increase in EV uptake by 2060
- Current projections on the longevity of recycling technology hinge on the maintenance of current battery technologies into the future without the aforementioned market disruptions



Source: Nature

Regulatory Overview

The Inflation Reduction Act brings key incentives to the table

Clean Vehicle Credit (New Passenger Vehicles Only)

- Final assembly must take place in North America
- $3,750 if an increasing percentage of the value of the battery's critical minerals are either extracted and processed in the US or a Free Trade Agreement country or recycled in North America
  - Critical minerals as defined in the IRA's Section 45c(6) are aluminum, cobalt, graphite (natural and synthetic), lithium, manganese, and nickel
  - 40% market-value-based target for a vehicle placed in service before 2024, 50% in 2024, 60% in 2026, 70% in 2026, and 80% in 2027+
- $3,750 if an increasing percentage of the value of the battery's components is manufactured or assembled in North America
  - 50% market-value-based target for a vehicle placed in service before 2024, 60% in 2024-25, 70% in 2026, 80% in 2027, 90% in 2028, 100% in 2029+
- Expires for vehicles with battery components manufactured or assembled by a foreign entity of concern (i.e., China, Russia, North Korea, Iran, etc.) starting in 2024
- Expires for vehicles with battery-critical minerals extracted, processed, or recycled by a foreign entity of concern starting in 2025
- As of April 17th, only 10 models qualify for the full credit[1]

Battery Cell + Pack Manufacturing Credit

Advanced Manufacturing Production Credits

Component	Credit	Specification
Electrode Active Materials	10% of production costs	Cathode, Anode, Anode Foils, Solvents, Electrolytes
Cell	$35 per kWh	>12 Wh of capacity and >100 Wh/L density
Module	$10 per kWh	>7 kWh of capacity
Critical Minerals	10% of production costs	Al, Co, Li, Graphite, Mg, + more

- The advanced manufacturing production credits will phase out from 2030 to 2032
  - 75% in 2030
  - 50% in 2031
  - 25% in 2032

Commercial and Fuel Cell EV Credit

Qualifications:

- Vehicles with a gross vehicle weight rating (GVWR) below 14,000 lbs. must have a battery capacity of at least 7 kWh
- Vehicles with a GVWR above 14,000 lbs. must have a battery capacity of at least 15 kWh.
- The tax credit amount is equal to the lesser of the following amounts:
  - 15% of the vehicle purchase price for plug-in hybrid electric vehicles
  - 30% of the vehicle purchase price for EVs and FCEVs
  - The incremental cost of the vehicle compared to an equivalent internal combustion engine vehicle
- Maximum tax credits may not exceed $7,500 for vehicles under 14,000 lbs. and $40,000 for vehicles above 14,000 lbs.
- This tax credit cannot be combined with the Clean Vehicle Tax Credit

Sources: Cowen, The Wall Street Journal, U.S. Department of Energy, Bloomberg, U.S. Treasury Department

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[1] *Reference Appendix Chart 1.3*

Battery Technology Universe

Companies are mostly private, or listed outside the US

Li Integrators	
CATL	300750.CH
LG Energy Solutions	373220.KR
Samsung SDI	006400.KS
BYD Company	1121.HK
CALB	3391.HK
SK Innovation	096770.KS
Tesla	TSLA
Proterra Inc.	PTRA
FREYR Battery SA	FREY
Microvast Inc	MVST

Solid State	
Solid Power	SLDP
QuantumScape	QS
Factorial	Private
Ionic Materials	Private
ElecJet	Private

Lithium-Metal Anode	
QuantumScape	QS
SES.AI	SES
Solid Power	SLDP
Sion Power	Private
Blue Solutions	Private
ProLogium	Private

Lithium Titanate	
Microvast	MVST
Toshiba	6502.JP
Altair Nanotechnologies	Private

Zinc	
EOS Energy	EOSE
Urban Electric Power	Private

Silicon Anode	
Amprius	AMPX
Enovix	ENVX
Group 14 Technologies	Private
Nanoramic Laboratories	Private
OneD Battery Sciences	Private
Sila Nanotechnologies	Private
StoreDot	Private

Sodium Ion	
CATL	300750.CH
Natron Energy	Private
HiNa Battery	Private

Iron-Oxide	
ESS Tech	GWH
Form Energy	Private

Battery Technology Financial Comps

Next generation battery manufacturers have a long journey to profitability

Next Gen Battery Manufacturers		Trading Data				Cash Burn			Profitability			Valuation					
Company	**Category**	**YTD**	**1-Year**	**Short Int.**	**Mkt Val**	**Cash**	**FCF**	**Runway (Years)**	**Gross**	**EBITDA**	**ROIC**	**EV/Revenue**	**Rev'22**	**Rev'25**	**Rev CAGR**	**EV/EBITDA**	**EBITDA '25**
FREYR	Integrator	-15%	-22%	7%	1,032	563	-269	2.1	-	-	-16%	-	0.0	279.3	-	-	-123.9
Proterra	Integrator	-69%	-82%	7%	265	311	-360	0.9	-8%	-67%	-34%	0.33x	309.4	784.7	36%	-	-52.3
Microvast Holdings	Integrator/LTO	-31%	-79%	5%	328	327	-233	1.4	4%	-68%	-22%	0.86x	204.5	633.9	46%	-	20.6
Solid Power A	Solid State	-9%	-71%	5%	410	323	-92	3.5	19%	-451%	-2%	8.24x	11.8	16.6	12%	-	-75.3
QuantumScape A	Solid State	35%	-51%	15%	3,366	1,062	-376	2.8	-	-	-27%	-	0.0	2.8	-	-	-293.7
SES AI A	Li-Metal Anode	-41%	-77%	1%	654	390	-61	6.4	-	-	-16%	-	0.0	50.0	-	-	-135.1
Eos Ener Entps A	Li-Metal Anode	43%	-12%	10%	242	20	-217	0.1	-755%	-1,153%	-255%	22.48x	17.9	269.0	147%	-	-22.1
Enovix	Silicon Anode	6%	35%	16%	2,090	323	-119	2.7	-275%	-1,920%	-15%	286.21x	6.2	21.5	51%	-	-115.2
Amprius Technologies	Silicon Anode	19%	-	1%	799	74	-11	6.9	-99%	-273%	-	150.64x	4.8	22.6	67%	-	-25.3
ESS Tech	Iron-Oxide	-56%	-80%	6%	165	141	-96	1.5	-197%	-11,503%	-45%	33.51x	0.9	226.5	533%	-	-26.8
Eos Ener Entps A	Zinc	43%	-12%	10%	242	20	-217	0.1	-755%	-1,153%	-255%	22.48x	17.9	269.0	147%	-	-22.1
Average		**-7%**	**-45%**	**7%**				**2.6**	**-258%**	**-2,074%**	**-69%**	**65.59x**			**130%**	**-**	
Median		**-9%**	**-61%**	**7%**				**2.1**	**-148%**	**-802%**	**-24%**	**22.48x**			**59%**	**-**	

Established Tier 1 Suppliers		Trading Data				Cash Burn			Profitability			Valuation					
Company	**Category**	**YTD**	**1-Year**	**Short Int.**	**Mkt Val**	**Cash**	**FCF**	**Runway (Years)**	**Gross**	**EBITDA**	**ROIC**	**EV/Revenue**	**Rev'22**	**Rev'25**	**Rev CAGR**	**EV/EBITDA**	**EBITDA '25**
Contemp Amperex	Integrator/Sodium	2%	-10%	-	140,512	30,842	4,286	7.2	24%	-	19%	2.70x	53,664.7	79,957.2	14%	-	12,861.6
LG Energy Solution	Integrator	23%	20%	-	99,228	4,696	-5,260	0.9	16%	12%	4%	5.17x	19,811.6	34,247.4	20%	43.3x	5,830.2
Samsung SDI	Integrator	16%	13%	-	37,829	2,449	-130	18.9	21%	16%	11%	2.57x	15,574.7	21,455.0	11%	15.8x	3,541.1
BYD H	Integrator/Auto	19%	-1%	-	98,771	10,371	6,462	1.6	14%	10%	14%	1.53x	61,269.7	113,618.6	23%	16.0x	10,512.6
CALB H	Integrator	15%	-	-	4,742	1,257	-	-	-	-	-	-	-	11,475.6	-	-	1,324.5
SK Innovation	Integrator	10%	-21%	-	12,518	8,652	-4,814	1.8	9%	7%	5%	0.47x	60,410.8	58,774.6	-1%	6.4x	4,554.2
Toshiba	Integrator/LTO	-6%	-18%	-	14,225	2,103	-656	3.2	26%	6%	11%	0.65x	25,485.1	24,582.6	-1%	11.5x	1,836.4
Average		**11%**	**-3%**	**-**				**5.6**	**18%**	**10%**	**11%**	**2.18x**			**11%**	**18.6x**	
Median		**15%**	**-5%**	**-**				**2.5**	**18%**	**10%**	**11%**	**2.05x**			**13%**	**15.8x**	

(all figures in $USD mm unless otherwise stated)

Microvast Holdings Inc. (MVST, $0.96)

Learnings from our past investment in battery technology

Company Description

- Li Battery integrator with novel polyaramid separator technology and specialized experience in lithium-titanate battery design
- $297m market cap, $327m cash, and two covering analysts at $8 TP
- Merged with SPAC in July 2021, raising $822m, including $540m PIPE proceeds from Oshkosh, Blackrock and Koch
- 61% and 65% of revenue came from China in 2021 and 2022 respectively despite trying to reduce Chinese footprint
- Rare battery technology company without short report and positive projected EBITDA by 2025
- Meaningful capacity buildout in Europe and America, targeting 7 GWh and 11 GWh per year by 2023 and 2025 respectively

Key Events

- October 2022: Launched energy division to focus on BESS market
- November 2022: $200m DOE grant to produce separators with GM
- December 2022: Won 1.2GWh battery energy storage project contract

Original Thesis

1. **Lucrative battery factory economics**
   - IRA projections for Clarksville 2GWh facility would yield $90m annually and CV target market remains highly viable for consumer subsidies
   - $200m grant from DOE would cover roughly half the CAPEX requirements for separator plant
2. **Leading technology portfolio**
   - FCG Cathode, Polyaramid Separator, LTO patents and robust R&D team
   - Flagship 53.5Ah NMC Li-ion cell is highly competitive (235 Wh/kg Energy Density, >5000 Cycle Life, 48 minutes for 80% DoD)
3. **Operational experience and sales inflection**
   - Energy storage division and contract win
   - Oshkosh's 10,000 EV order to replace USPS fleet
   - 35% yoy growth in 2022 and 65% yoy growth guidance in 2023
   - Decade of experience in sales and manufacturing in Asian markets

microvast

Dec 2022: Senate starts questioning DOE grant

Jan-Feb 2023: Stock continues downward trend while QCLN recovers

Mar 2023: Earnings call and email interactions make us lose faith in management

Compounding value versus mispricing. Quality of management teams.

Appendix

Appendix

Chart 1.1

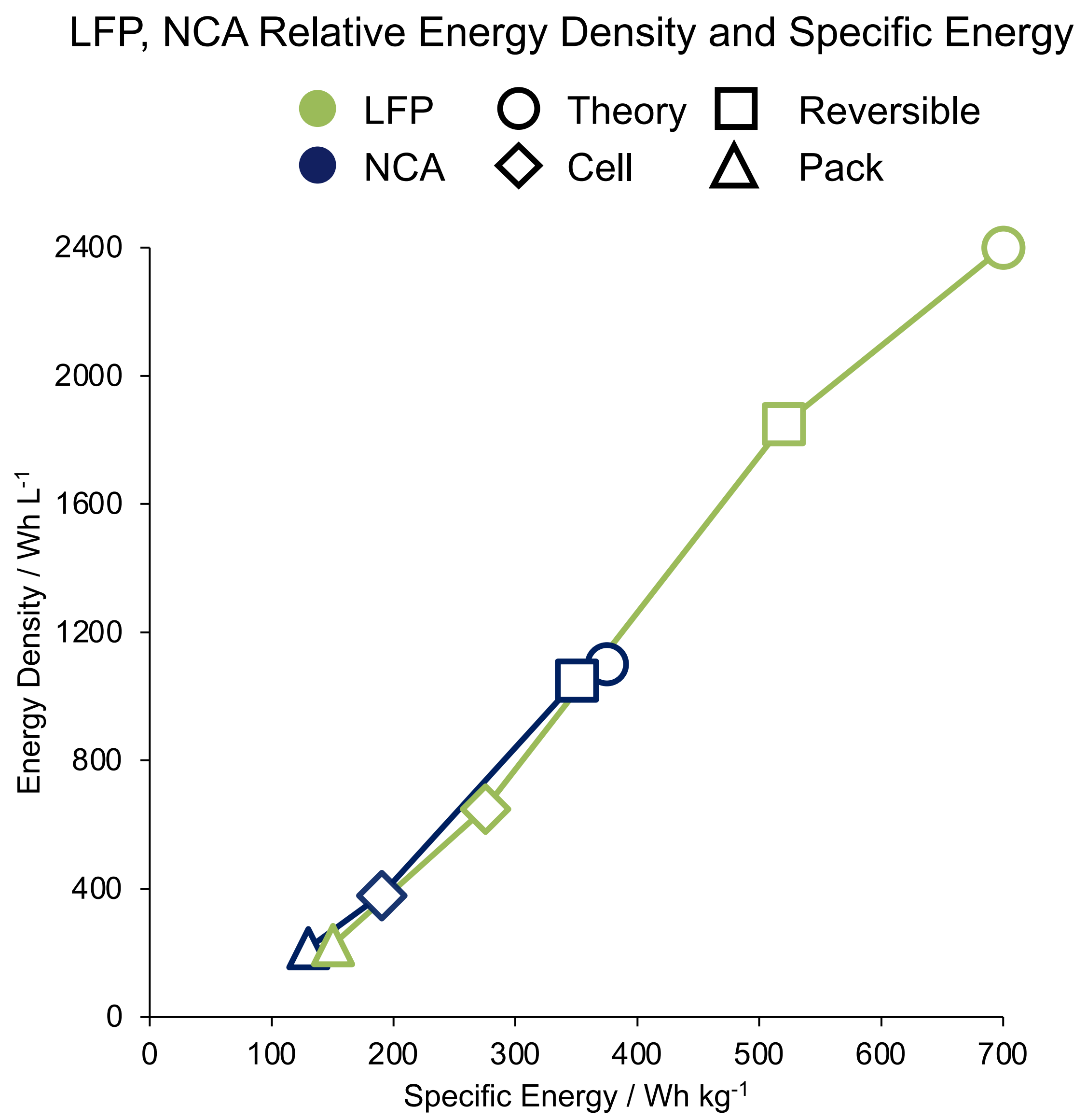
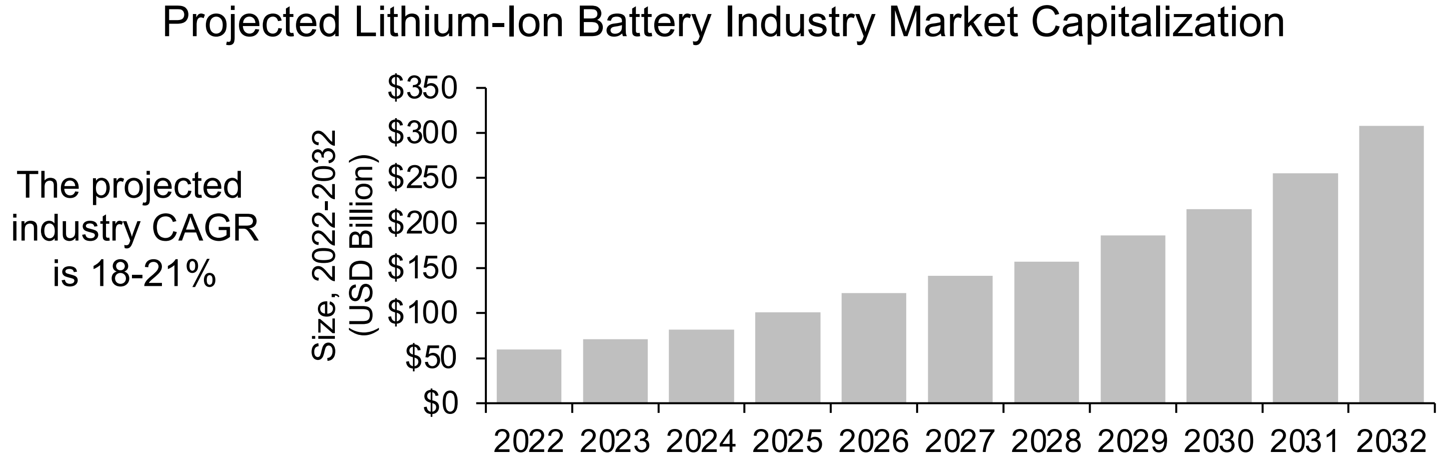


Chart 1.2



The projected industry CAGR is 18-21%

Chart 1.3

Model	MSRP Limit	EV or Plug-In Hybrid
Chrysler Pacifica	$80,000	Plug-In Hybrid
Ford F-150 Lightning	$80,000	EV
Lincoln Aviator Grand Touring	$80,000	Plug-In Hybrid
Chevrolet Bolt	$55,000	EV
Cadillac Lyriq	$80,000	EV
Chevrolet Blazer	$80,000	EV
Chevrolet Silverado	$80,000	EV
Chevrolet Equinox	$80,000	EV
Tesla Model 3	$55,000	EV
Tesla Model Y	$80,000	EV

Sources: Nature, U.S. Treasury Department, Market.us

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