Gigafactory Report

2023

PAN AMERICAN FINANCE

About

The report provides an insight into the globally upcoming Gigafactory market based on the research conducted by Pan American Finance (PAF) and its research partner, Alchemy Research and Analytics. The report provides an overview of the upcoming Gigafactory capacity investment, its key drivers, major market players, and the outlook across North American and European regions. The report covers some vital topics, including the capacity pipeline in the major countries and regions, the partnerships and joint ventures for critical materials and technology, major policy drivers impacting investor decisions, and emerging challenges. The secondary research of this report relied on credible publications of government authorities, industry associations, and research institutions, together with news reports, press releases, trade journals, and similar other sources.

The report is an outcome of the collaboration between PAF and its research partner, Alchemy Research and Analytics. We want to thank the following team members for their contribution in preparing the report:

- L. Warren Pimm, Partner and Sr. Managing Director - Pan American Finance
- Elizabeth Akinnitire, Intern - Pan American Finance
- Tapas Bhowmik, Senior Manager - Alchemy Research and Analytics
- Souradeep Basu, Associate Manager – Alchemy Research and Analytics
- Maurya Mukherjee, Senior Analyst – Alchemy Research and Analytics

Table of Contents

1.0 | Introduction

The rise of Gigafactories holds a crucial role in meeting the surging demand for batteries by significantly expanding manufacturing and supply chain capacity. However, these facilities come with substantial capital expenditure (CAPEX) requirements, demanding significant long-term investment commitments. This is especially relevant as the global electrification of transportation undergoes a monumental transformation, poised to reshape various aspects of industrial, commercial, and personal transportation into a zero-carbon ecosystem over the next few decades.

This transition carries profound implications that extend beyond transportation itself. It touches upon critical areas such as energy security, industrialization, employment opportunities, and geopolitics. Governments of major economies have made resolute commitments to achieve net-zero emissions by 2050, underscoring the urgency of this shift. Notably, regions like Europe, India, and China are taking decisive steps to phase out internal combustion engine (ICE) vehicles by 2030. This mandate necessitates sweeping changes across the transportation industry and its entire supply chain.

In response to this shift, extensive research and development initiatives are underway, spanning various sectors, including automotive, trucking, shipping, and aviation. These efforts are driving demand for and investment opportunities in transformative technologies like advanced batteries, charging infrastructure, and power management systems. The convergence of these factors underscores the significance of Gigafactories in supporting the transition to a sustainable and emissions-free future.

Our report, the Pan American Finance 2023 Gigafactory Report, offers a comprehensive overview of demand drivers, opportunities, challenges, and the current landscape in major markets. It delves into global Gigafactory trends and region-specific factors, along with critical investment considerations for potential market entrants. The report covers key aspects such as the Gigafactory pipeline, major players and ventures, policy dynamics, financing, the battery production lifecycle, recycling, and the current Gigafactory outlook.

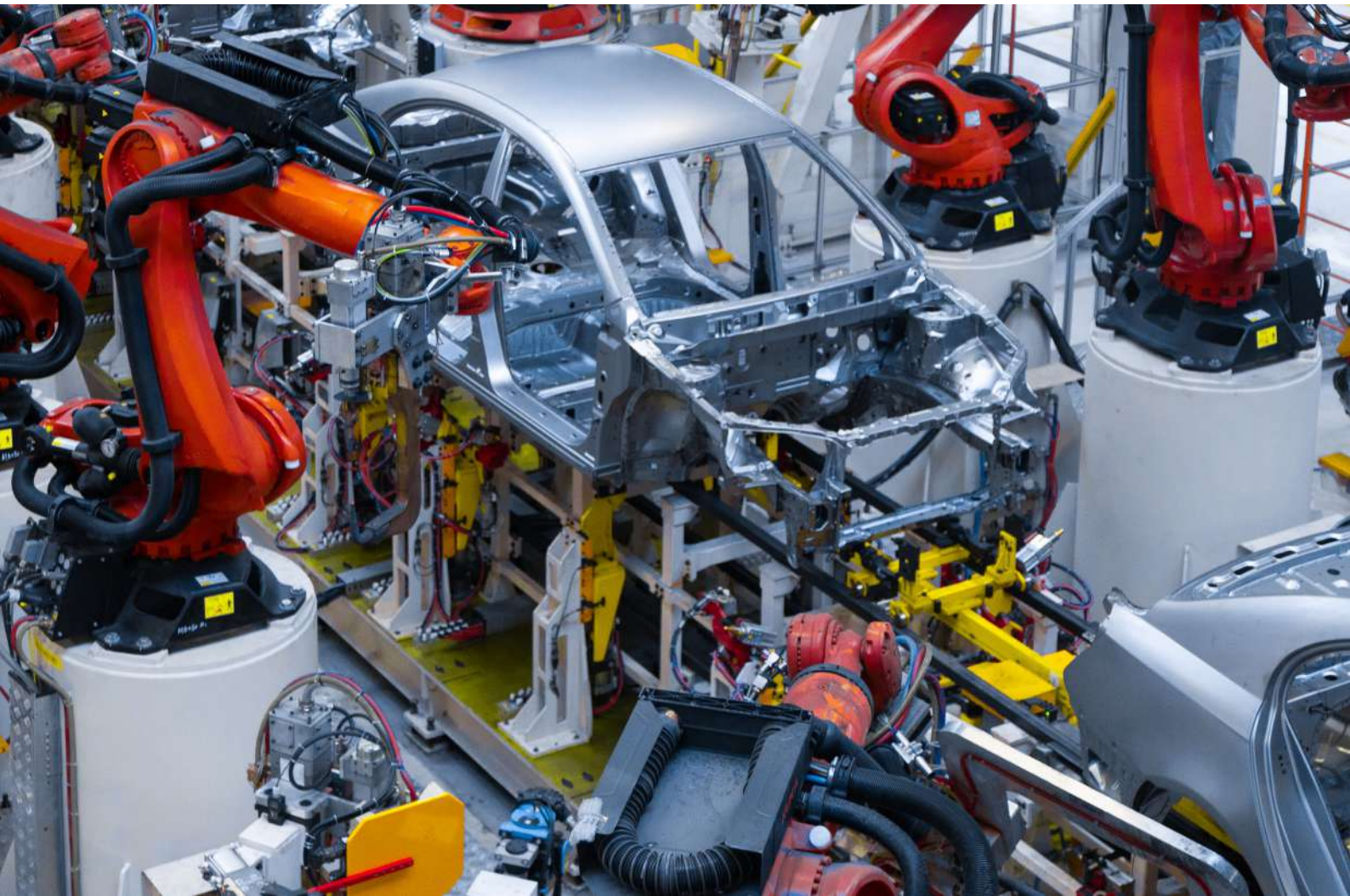
We invite you to explore our inaugural Gigafactory Report, providing valuable insights into this transformative industrial endeavour. As we continue to monitor market developments in the coming months, we eagerly anticipate keeping you informed of the evolving landscape.

2.0 | Executive Summary

The transition to electric mobility worldwide is propelling an unprecedented scale of industrial investment in batteries. Over $300 billion is required in capex to meet electric vehicles' battery demand by 2030. Such batteries must be cheap and locally sourced to ensure rapid adoption. Gigafactories, through economies of scale, are geared for such objectives. Active policy push contributed to a spike in the Gigafactories' pipeline – since 2019, the number of such projects announced rose by more than 400%. By April 2023, there were 360 such projects announced for gigawatt-scale manufacturing.

Most of the interest is in the upcoming projects planned in North American and European regions. In the US, the upcoming projects (announced and under-development) aggregate to about 1,000GWh of capacity by 2030. This is close to the existing battery supply capacity worldwide. Potentially, the numbers could go higher, considering that some of the prospective investments haven't disclosed firm capacity size estimates. Relative to the US, the Canadian pipeline is lower, at 145GWh, but rising as the investors queue up. Upfront policy support and incentives, as set out by the US Inflation Reduction Act (US IRA), drew the Gigafactory investment contours for the North American region.

Until recently, subsidies were not the primary reason for the Gigafactory opportunity for the European region. It was instead about European countries being regarded as high demand centers for electric vehicles and the need to diversify away from a concentrated battery supply chain. The pipeline is thus concentrated around the main industrial bases such as Germany. About 40% of the tracked capacity in the pipeline, worth 1,880GWh, is concentrated between Germany and Hungary. Others in the lead include Italy, France, and Norway. The region's opportunity, however, is under the shadow of competitive subsidies. US IRA's package makes for a better proposition to set up a Gigafactory in the US. As a few instances indicate, some countries are attempting to address this through upfront government interventions and assurances to investors.



All the same, there is a lot more to the Gigafactory investment landscape than the government incentives. For one, the original equipment manufacturers (OEMs) in automotive and battery production spaces are leading the momentum in Gigafactory investment. About three-quarters of the global Gigafactory pipeline is based on OEMs' projects. The striking element of the emerging landscape is how the Gigafactory business is forcing a vertical integration – automotive OEMs have entered into strategic joint venture partnerships with battery producers, technology companies, recyclers, and even mining companies. In particular, acquiring stakes in critical mineral assets is integral to OEMs' strategy to gain a competitive advantage. Recent mining deals for Cobalt, Nickel, and Lithium assets stand out for the leading automakers involved, such as Tesla, Ford Motors, General Motors, Stellantis, and Volkswagen.

For most stakeholders, the integrity of the supply chain might be the defining factor in the overall calculation. This involves access to critical minerals and the capabilities to process them. The Chinese concentration in this regard stays unchanged in all projected scenarios, even as other options, such as in Canada, emerge as de-risking options. Also important is the role of technology. The dominance of Lithium-Ion is evident in the upcoming battery facilities. Yet, the encouraging results in alternatives, especially Sodium Ion, suggest that the projected trend in battery technologies may not be so apparent or predictable. The layers of uncertainties are enhanced once we factor in the multitude of competitive battery chemistries, necessary equipment, and human resources. As Gigafactories progress in the planning/development stages, the resource demand will pressure an already tight and competitive market of raw materials, equipment, and technologies.

With many unknowns, the evolving Gigafactory business holds learning opportunities across the spectrum. The capex involved won't be limited to batteries, as the upstream segment is drawn into capacity addition to meet demand. This means a much bigger or broader capex cycle than what is apparent from project announcements. Furthermore, the vertically integrated Gigafactories business would operate quite differently from the conventional models of globally integrated units in automotive manufacturing. Therefore, the industry's outlook is one of significant flux to arrive at an equilibrium eventually.

3.0 | Gigafactory Pipeline

3.1
Introduction

Based on the information available through April 2023, it is anticipated that the Gigafactory battery manufacturing sector will see an aggregate commissioned capacity exceeding 6 terawatt-hours (TWh). This substantial growth in manufacturing capacity can be attributed to the surging demand for electric vehicles (EVs). Furthermore, it is expected that additional projects will be announced as the Gigafactory pipeline continues to evolve, potentially driven by increased demand from various industries.

Nevertheless, it is important to acknowledge the prevailing uncertainties surrounding the success of these projects. While capacity is often a primary consideration when evaluating Gigafactory investments, other critical factors must also be taken into account. These include geographical location, political considerations, the participation of key market players, and the specific technological configurations employed. In essence, these factors may ultimately exert a more significant influence on the prospects of success within the industry than sheer production capacity.

3.2
Existing Battery Capacity and Market Share

The battery production landscape has been significantly influenced by growing demand for electric vehicle (EV) batteries. Notably, Panasonic, a key Tesla supplier, reported a substantial 45% increase in battery sales in 2022.

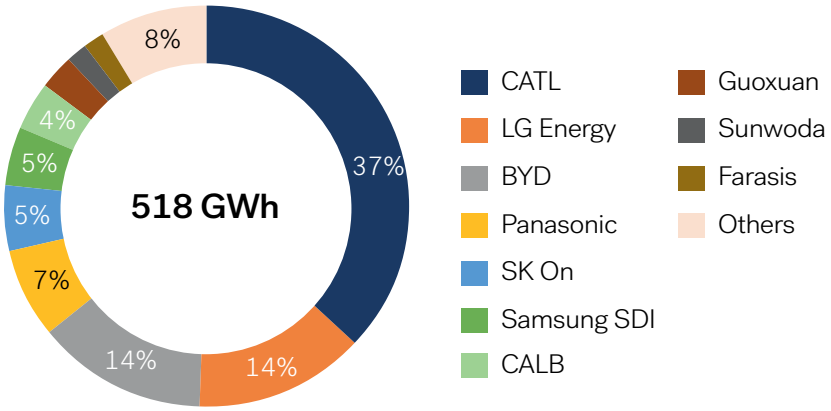
A handful of Chinese and South Korean manufacturers have become dominant players in global battery production, serving as benchmarks for the emerging Gigafactory sector. Their early entry into the market gave them an advantage, securing access to critical raw materials, showcasing strong manufacturing capabilities, and establishing vital investment relationships.

Most major players among the top 10 EV battery producers are actively engaged in the rapidly evolving Gigafactory landscape. For instance, CATL, the largest battery producer, initiated Gigafactory plans in Germany, with intentions for expansion. Additionally, entities like SK On, LG Energy, Samsung, and General Motors (GM) have announced strategic joint ventures for Gigafactory projects.

The demand for electric vehicles has led established manufacturers to focus on localizing production capacity, a trend expected to continue. This suggests additional production facilities will likely be located near major demand centres. Many industry leaders have adopted the concept of massive gigawatt-scale factories. For instance, CATL's battery facility in Germany began with an impressive 8 gigawatt-hours (GWh) production capacity in December 2022, with plans to scale up to 14GWh.

Furthermore, these established manufacturers have pursued vertical integration within their business models, a trend also seen in upcoming Gigafactory projects. Leading global battery manufacturers, such as BYD and Great Wall, have expanded their presence across the entire value chain, enhancing their competitive positions.

Electric Vehicle Battery Producers' Market Share (2022)



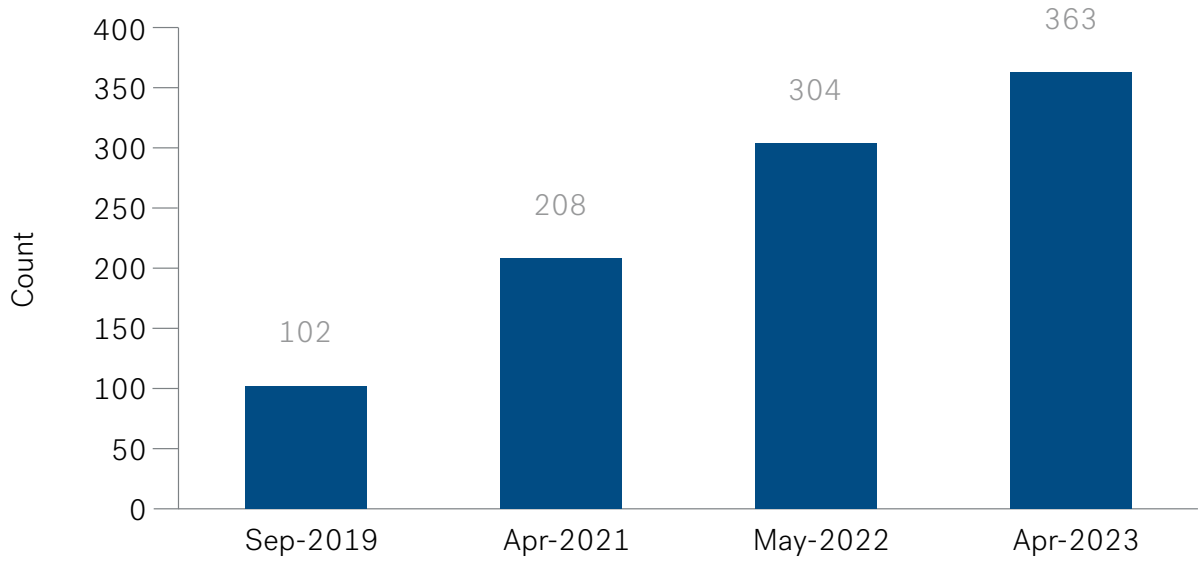
Source: SNE Research

3.3

Capacity Under Development

The Gigafactory landscape has witnessed remarkable growth since 2015 when there were only three projects in development, according to Benchmark Minerals. Fast forward to the 2019, and we find ourselves with a Gigafactory pipeline of 102 projects which has more than tripled to date, now encompassing 363 projects. The driving force behind this expansion is the burgeoning electric vehicle (EV) industry, which demands localized and cost-effective battery production. Furthermore, policy-driven incentives have amplified investment commitments in two primary regions: North America and Europe. The introduction of the United States Inflation Reduction Act (IRA) in August 2022 not only incentivized domestic production in the US but also incited a European policy race to attract competitive investments.

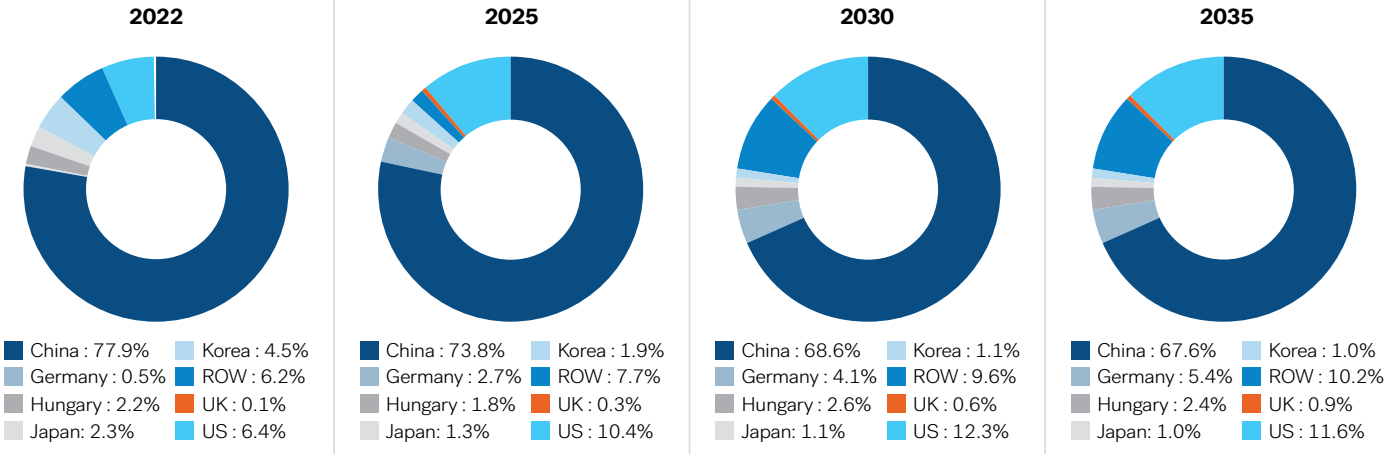
Number of Global Gigafactory Projects Announced and Under Development



Note: Data comprises tracked projects announced, planned or in development stages

Source: Benchmark Minerals

Relative Share of Countries in Upcoming Battery Production



Source: Benchmark Minerals

Looking ahead to 2030, it is anticipated that Gigafactories in North America will boast a combined pipeline capacity of 1 terawatt-hour (TWh), spanning across the United States, Canada, and Mexico. Major corporations such as Ford Motors, Ultium, and Hyundai are making substantial investments to bolster capacity in the US. For example, Ford is actively establishing nearly 130 GWh of capacity across three production units, with plans for commissioning within the next 6-7 years. Ultium, a joint venture between General Motors and LG Energy Solutions, along with Tesla, have also announced plans to scale up their manufacturing capacity to 100 GWh each. The emergence of "battery belt" clusters in select US states, including Tennessee, Michigan, Georgia, Arizona, and South Carolina, has been driven by attractive incentives and support measures. Interestingly, these locations often coincide with existing conventional vehicle assembly units, facilitating synergies for developers.

Major Upcoming Gigafactories in the US

Company/Venture	Capacity (GWh)	Location	Scheduled
Ultium Cells	50	Lansing, Michigan	2025
LG Energy	20	Holland, Michigan	2025
Ford Motors	35	Marshall, Michigan	2026
Our Next Energy (ONE)	20	Ven Buren, Michigan	2027
Ultium cells	50	Spring Hill, Tennessee	2023
Ford Motors	43	Stanton, Tennessee	2026
Ford Motors	86	Glendale, Kentucky	2026/30
Volkswagen	-	Chattanooga, Tennessee	-
Freyr	34	Coweta, Georgia	2029
Hyundai and SK On	35	Bartow, Georgia	2025
Hyundai and LG	30	Bryan, Georgia	2025
Panasonic	30	De Soto, Kansas	2025
Tesla*	100	Nevada	-
Envision AESC	30	Florence, South Carolina	2030
Stellantis	23	Kokomo, Indiana	2025
Statevolt	54	Imperial Valley, California	-
Kore Power	12	Buckeye, Arizona	2024
Honda	40	Ohio	2024

*Capacity expansion project

Source: News reports, press releases

In Canada, the Gigafactory pipeline has indirectly benefited from the IRA, which spurred increased battery demand from North America and influenced changes in local policy. The Canadian government has adjusted its policies to stay competitive with the US IRA subsidy support. As a result, in April 2023, Volkswagen-led PowerCo committed to investing 7 billion CAD in a 90 GWh Gigafactory to be based in Ontario. Mexico has also gained prominence for US automakers' electric vehicle manufacturing due to its proximity to the US and the advantages of a free trade agreement. Tesla, for instance, has announced plans for a proposed Gigafactory project in Mexico.

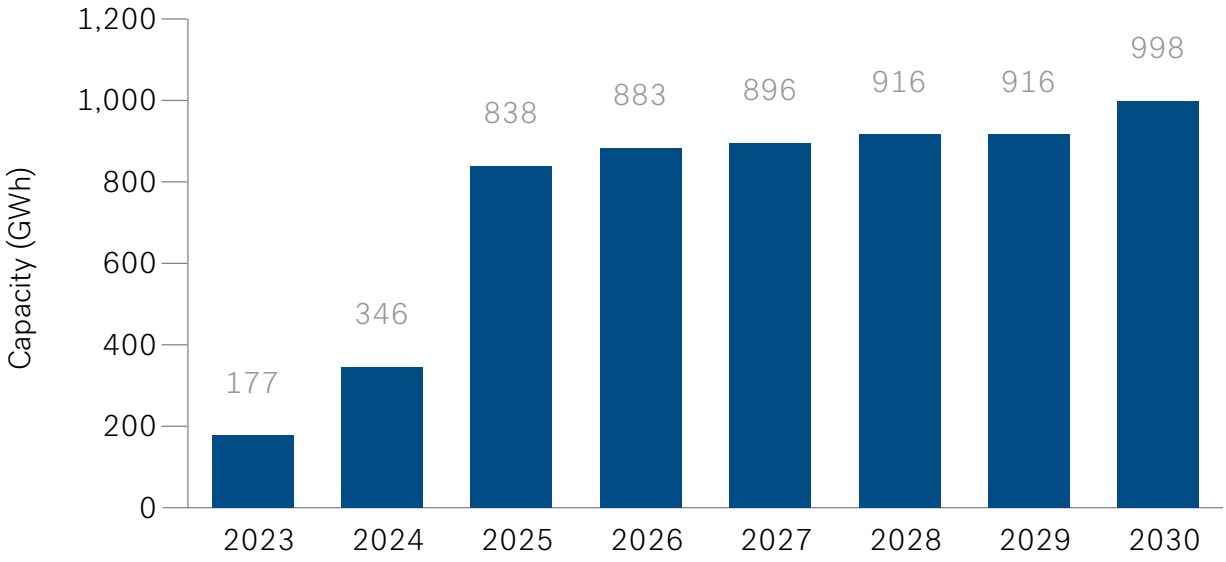
Gigafactory Investments in Canada (Indicative)

Company/Venture	Capacity (GWh)	Location	Scheduled
Stellantis and LG Energy Solution	45	Ontario	2024
Volkswagen (Powerco)	90	Ontario	2027
Stromvolt	10	Ontario	2030
Northvolt*	-	Quebec	-

*The company has reportedly shortlisted the production site.

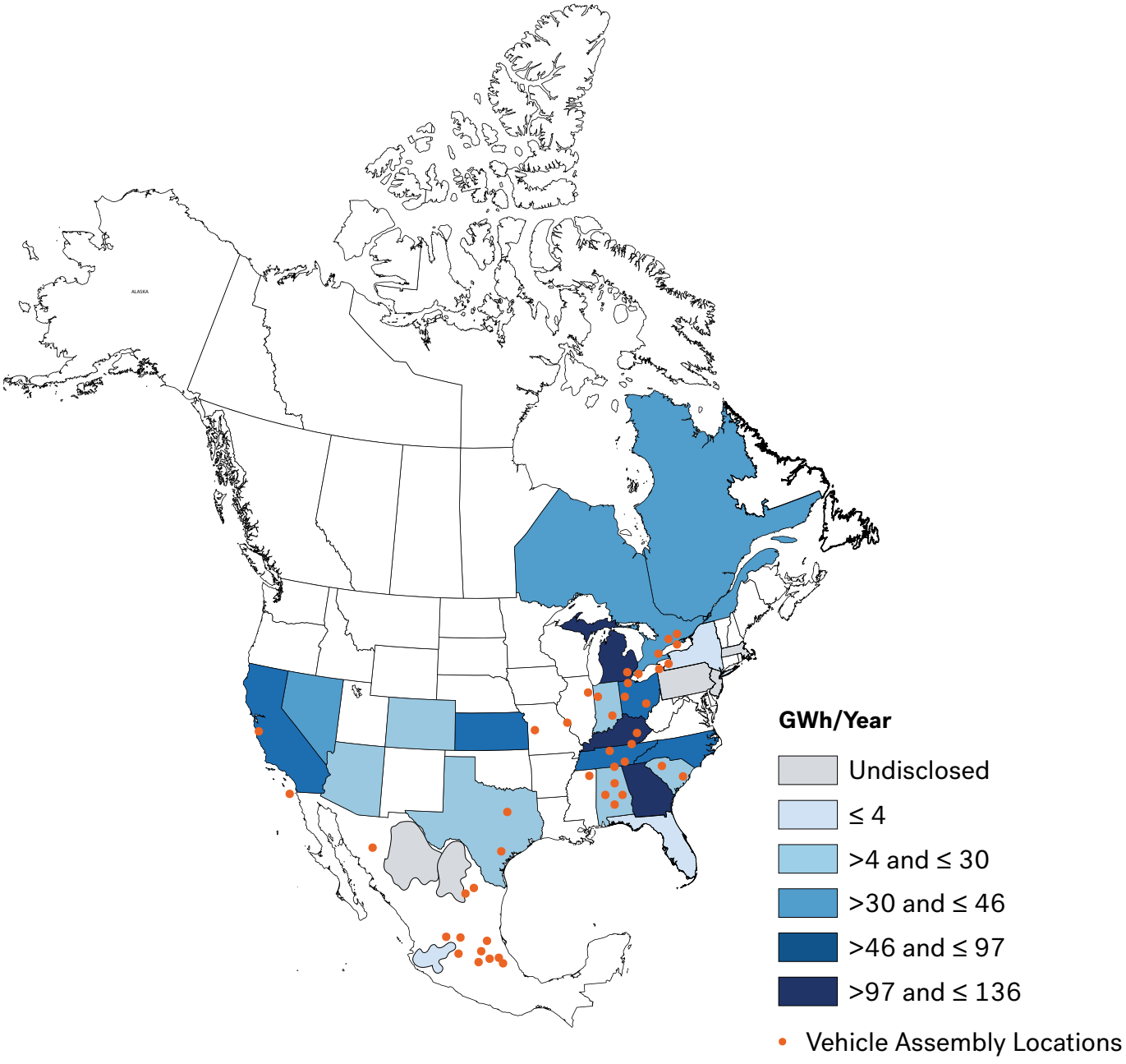
Source: News reports, press releases

Announced Capacity for Gigafactory in North America



Source: Argonne National Laboratory (report as of November 2022)

Clustering of the North American Gigafactory Capacity under Development



Source: Argonne National Laboratory

In Europe, the Gigafactory sector has recently shown positive momentum, boasting a pipeline capacity of 1.3 TWh. Germany leads the European Gigafactory project pipeline with an estimated capacity of approximately 365 GWh, followed by Italy and France with roughly 160 GWh each. Legacy automakers like Volvo and Volkswagen (VW) are driving this pipeline, accompanied by the entry of startups and technology providers. Similar to the US, European development plans are partly motivated by the desire to reduce dependence on Chinese supply chains. However, potential European investors and project developers have remained cautious as policy dynamics continue to evolve. The IRA's generous incentives have prompted European policymakers to become more assertive in incentivizing Gigafactory investments. The French government, for example, has secured Gigafactory investments through incentive packages and deal sweeteners, although these subsidies await review by the European Commission.

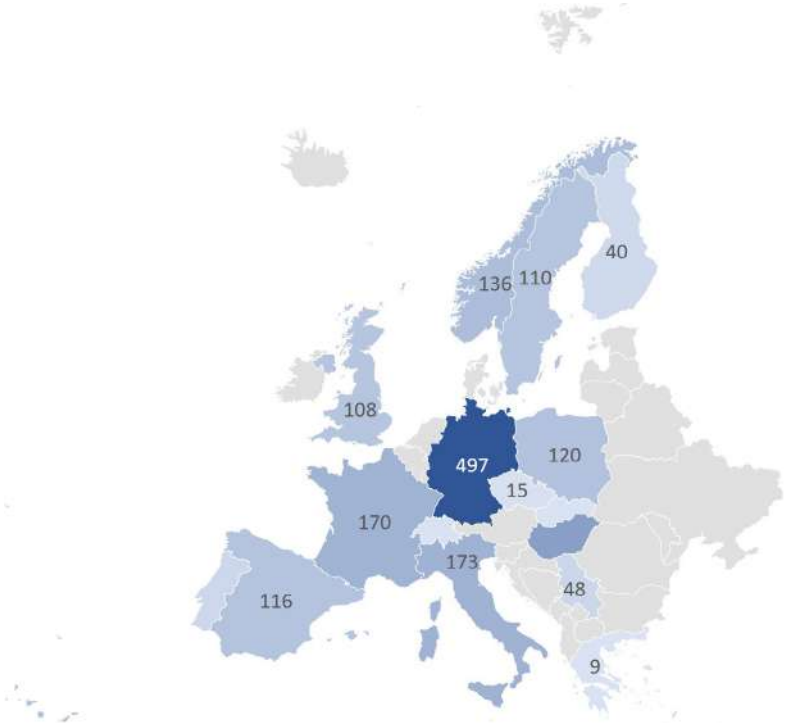
Europe's Major Tracked Gigafactory Projects under Development

Country	City	Company	Capacity (GWh)
Germany	Berlin	Tesla	125
Italy	Termoli	ACC	120
Poland	Wroclaw	LG Chem	115
Germany	Erfurt	CATL	100
Hungary	Debrecen	CATL	100
Germany	Schleswig-Holstein	Northvolt	60
UK	Coventry	West Midlands	60
Sweden	Skellefteå	Northvolt	60
France	Dunkirk	Verkor	50
Sweden	Gothenburg	Volvo	50
Hungary	Iváncsa	SK on	50
France	Dunkirk	ProLogium	48
Portugal	Portugal	CALB	45
Italy	Scarmagno	Italvolt	45
Norway	Kristiansand	Morrow	43
Norway	Mo i Rana	FREYR Battery	43
Germany	Salzgitter	VW	40
Germany	Kaiserslautern	ACC	40
France	Douvrin	ACC	40
Spain	Sagunt	VW	40
Spain	Navalmoral de la Mata	Envision Group	30
France	Douai	Envision AESC	24

Note: Data above accounts for two-thirds of the total European capacity tracked

Source: Transport and Environment (report as of February 2023)

A Regional View of the Planned European Gigafactory Capacity (GWh)



Source: Transport and Environment (report as of February 2023)

Despite the rapid growth in the global Gigafactory pipeline, several challenges and uncertainties persist, including financial constraints, raw material access, and offtake security. In the US, the UK-based company Britishvolt faced difficulties in executing its planned Canadian Gigafactory, citing challenges in securing finance, among other issues. Similarly, the Ultium joint venture between General Motors and LG Energy decided to pause its plans to develop a fourth Gigafactory project. In Europe, leading companies such as Northvolt, Polestar, and Iberdrola have hinted at potential relocations of their planned facilities. A study by Transport and Environment in February 2023 estimated that one-fifth of the announced Gigafactory capacity in Europe faces a high risk of delay, downsizing, or cancellation. Addressing these challenges may necessitate a comprehensive region-wide policy shift involving increased financial support for such projects to counteract the influence of competitive subsidies.

In conclusion, the Gigafactory pipeline has experienced rapid expansion due to the surging global demand for EVs and supportive policy changes in Europe and the US. However, investor caution persists, and the landscape remains dynamic as countries engage in a competitive policy race to attract Gigafactory developments.

3.4

Evolving Technology Choices

The trend of shifting battery chemistry away from lithium-ion production is informative of the growing landscape of upcoming Gigafactories. By the end of 2022, Lithium Nickel Manganese Cobalt Oxide (NMC) stood as the dominant choice of battery chemistry, followed by Lithium Iron Phosphate (LFP) and Nickel Cobalt Aluminium Oxide (NCA). For many battery producers with Gigafactories under development, the choice of battery chemistry is critical, as it involves commitment to a single technology and chemistry for a minimum of 10 years. Due to the evolving nature of battery technology, the Lithium-Ion production pipeline may not accurately represent the future battery production trends.

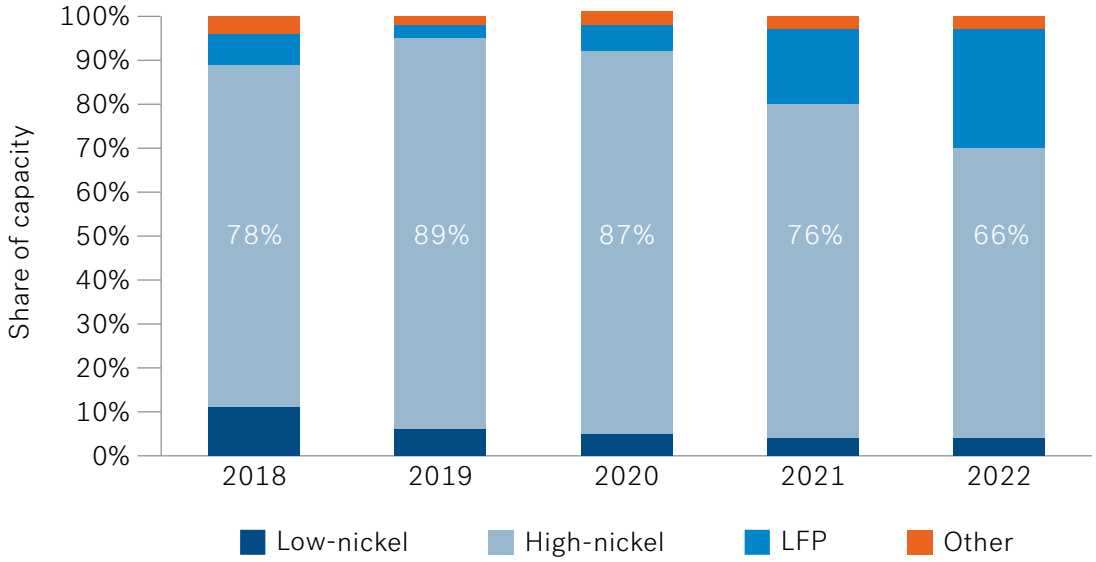
In March 2023, the company EnerVenue adopted a non-Lithium technology option to set up a Gigafactory in Kentucky, US. The company set up a 1GWh battery production unit for metal-hydrogen batteries. It involves the use of metal hydrides as cathode and anode and hydrogen gas as electrolyte. The first phase of this plant, once stabilized, will make way for expansion to a total 20GWh worth of capacity. The battery process is still being perfected for critical factors like energy density and infrastructure.

The majority of novel battery chemistry technology options are currently awaiting commercial success. An exception to this may be sodium-ion battery technology. The abundant availability of Sodium has increased its cost-effectiveness. This, combined with a potentially higher battery energy density than lithium-ion batteries make for an attractive proposition. A mass scale of production process appears to be gradually taking root, led by the Chinese manufacturers.

Globally, about 20 sodium-ion battery factories are in the planning/development stages (as of April 2023). Chinese companies, with 16 such factories in process, are ahead of the curve in commercializing sodium-ion for electric vehicle deployment.

The application of sodium-ion batteries fit better for grid-scale energy storage segment because they require more space than lithium-ion batteries. So, even as the fine-tuning for automotive use progresses, the demand from utilities and renewable-storage projects presents a significant opportunity. There are other unexplored areas, such as the emission-free aviation (signified in United Airlines' stake in Natron Energy) that could potentially widen the scope of Sodium-ion batteries.

Trend in Electric Vehicle Battery Chemistry Distribution



Source: IEA

Major Instances of Sodium-Ion Battery Production and Commercialization

	Country (Project)	Development
HiNA Battery	China	Launched the first sodium-ion battery in 2017 when it was founded. As of February 2023, a test electric vehicle equipped with this battery was launched.
Reliance Group	India	With acquisition of UK startup Faradion (pioneer in sodium ion with patented technology), the company marked its entry in sodium-ion battery market.
AMTE Power	UK	Production of sodium-ion batteries based on technology licensed from Faradion (acquired by Reliance in 2022).
Natron Energy	US	Established production line in 2020, based on the Prussian-blue cathodes in sodium-ion battery. It has signed major partnerships since then.
CATL	China	Company announced that its production lines will release sodium-ion battery-fitted vehicles within 2023.

Source: News reports, press releases

4.0 | Key Enterprises and Ventures

4.1
Introduction

The global Gigafactory pipeline involves multiple enterprises coming together, sharing respective areas of core competence towards a complex and integrated production unit. Battery and automobile original equipment manufacturers (OEMs) corner the maximum share of the pipeline, largely through joint ventures and strategic partnerships. Others in the fray include mining companies, technology providers, startups, and equipment suppliers. Varied business structures and models are accordingly in the works.

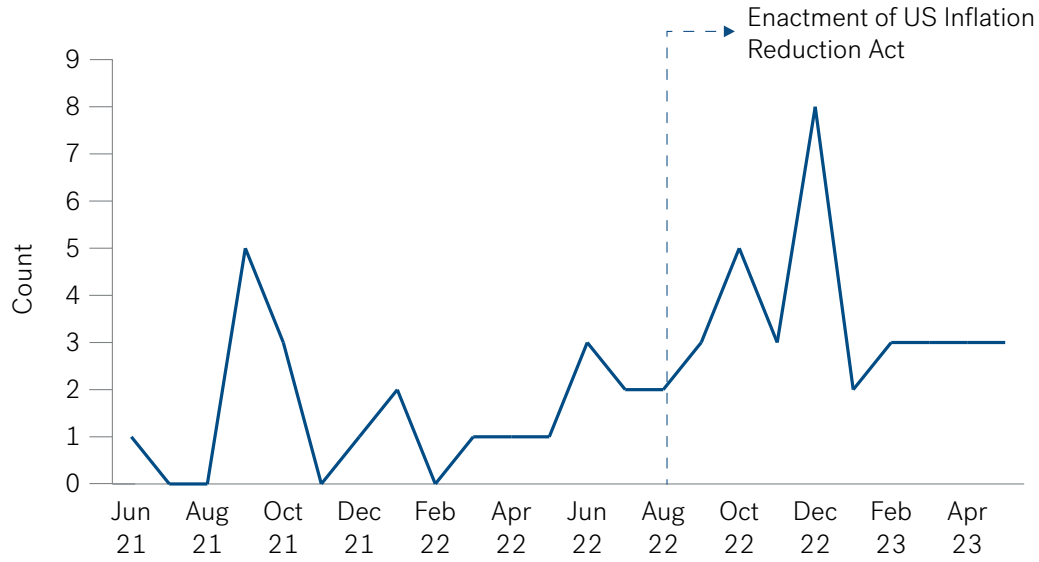
The discussion about the business enterprises assumes significance because of the emerging dynamics in the business. Gigafactories' verticalized structure is apparently counter to the conventional (and currently operational) globalized model in the capital-intensive manufacturing businesses. Many of the OEMs are, for instance, securing stakes in the mining business for an edge in access to active minerals of batteries. Meanwhile, technological innovations (e.g., solid-state batteries) are facilitating market entry in the Gigafactory business that is otherwise marked by its characteristic high entry barriers due to scale and funding.

4.2
OEM Partnerships/Joint Ventures

Roughly three-quarters of the existing global Gigafactory pipeline is based on joint ventures and related partnership structures between the automobile and battery OEMs. Automakers lead the trend here. Most of them in the US and European markets are not fully prepared to make the transition from conventional to electric mobility. The Chinese competition is an exception in this regard, where the ongoing partnerships are predominantly aimed at capacity addition, supply security and market share retention.

The pattern in announcements of battery production partnerships is indicative of the rising interest in the field. Yet, the underlying business conditions continue to evolve. The latest announcements might thus be subject to cancellations if commercial terms subsequently appear less attractive. A few such cases are gradually surfacing. In May 2023, the automaker Volkswagen and major equipment manufacturer Bosch cancelled their plans to set up a battery manufacturing joint venture. In January 2023, Ford Motors and Sk Innovation cancelled their planned joint venture for a Turkish battery manufacturing plant. In the same month, General Motors and LG cancelled the planned fourth battery production plant under their existing joint venture enterprise Ultium.

Battery Production Partnership Announcements Since Mid-2021



Note: The data includes partnership announcements related to battery recycling and material sourcing

Source: Reuters News (Refinitiv Eikon database)

For automobile OEMs, the joint ventures constitute a critical step to acquire and integrate the technology in the shifting vehicle powertrains. The luxury automotive manufacturers' segment stands out in this. They need to develop typical high-performance and niche vehicles that can substitute the premium offerings in conventional engines. In September 2021, the Germany luxury automaker Mercedes-Benz took an equity stake in the European battery cell manufacturer Automotive Cells Company (ACC) for development and production of high-performance cells and modules. The sports car manufacturer Porsche AG is progressing similarly with acquisition of stakes in the US-based Group 14 Technologies, a producer of advanced silicon-based carbon technology for Lithium-ion batteries. The acquisition is aimed at securing battery supply for Porsche's high-performance vehicle powertrains. Beyond such niche segment focus, the OEM partnerships are led by motivations of technology access – as of February 2023 about 10 leading automakers had a stake in the development and fine-tuning of solid-state battery technology. Though a promising option, it is still subject to technical challenges and is thus in the process of development and refinement.

The commercial arrangements of the OEM partnerships are getting finalized despite various extraneous challenges. The US-China trade restrictions, for instance, place impediments for companies on both sides seeking to capitalize on the opportunities. The joint venture partnerships are thus accordingly tweaked to accommodate requirements.

The Ford-CATL partnership is one notable example deviating from traditional model, with Ford Motors holding 100% ownership stake, licensing the Lithium Phosphate from CATL. Such an equity structure helps Ford qualify for the benefits under the US Inflation Reduction Act. Yet, the deal is not without challenges with policymakers in both countries placing it under scrutiny for implications in trade relations. The partnerships with Chinese companies are nearly unavoidable, as their leadership lies in not just existing capacities but also the ongoing expansion in critical/active materials (over 90% share of globally planned cathode and anode expansion). The China-based world's top battery producer CATL has tie-ups with most of the leading US and European automakers and in December 20222 commenced the first batch of its German battery cell manufacturing plant. The South Korean battery producers (LG, SK On) are following a similar route of OEM partnerships.

For many companies, joint venture partnerships also mean bypassing the conventional supply chains. The automakers have adopted this route to secure supply of essential metals including Lithium, Cobalt, Nickel, and Copper among others. Tesla, for instance, had been in discussions with Glencore to buy a stake in the latter's cobalt mining assets. While Tesla's planned deal did not materialize, CATL could finalize a 25% stake in Cobalt producer CMOC's business (as of November 2022). In this context, the Chinese companies have been following this route for quite some time, with some their leading battery producers seeking African and Chilean Lithium mines.

The US and European companies, especially those in the automotive sector, currently lead the way due to the competition and demand pressure. Pure-play mining companies on a standalone basis may not have the supply ready in time. Furthermore, automakers and pure-play mining companies have a dichotomous relation to the critical metals/materials required – mining companies seek a multi-year investment cycle to meet long-term demand, whereas automakers' horizon is much shorter with a focus on cheaper access through scale. Effectively, with contractual offtake agreements, automakers supply the capital to get such mining projects onstream which were otherwise not too attractive.

Automakers' Direct Deals/Partnerships with Miners

	Mining company	Metal	Type	Location	Detail
Ford	Liontown Resources	Lithium	Binding off-take and debt financing	Australia	150,000 tonnes per year of spodumene concentrate; A$300 million debt facility
	ioneer	Lithium	Binding off-take	US	7,000 tonnes per year of lithium carbonate
	Lake Resources	Lithium	MoU	Argentina	25,000 tonnes per year of lithium
	PT Vale and Huayou	Nickel	Three-way partnership	Indonesia	120,000 tonnes per year nickel processing plant
	Huayou	Nickel	Off-take		84,000 tonnes per year
	BHP Nickel West	Nickel	MoU	Australia	MoU for supply from 2025
	Rio Tinto	Lithium, aluminium and copper	MoU	Argentina and Canada	Exploring Ford becoming the foundational customer for Rincon lithium project
	Vale	Multiple	MoU		Explore potential opportunities across the EV value chain
General Motors	Livent	Lithium	Off-take and pre-payment	South America	Lithium hydroxide supply from 2025; pre-payment of $198mn
	Controlled Thermal Resources	Lithium	Strategic investment	US	
	Queensland Pacific Metals	Nickel, Cobalt	Equity investment	Australia	Invest up to $69mn
	Glencore	Cobalt	Off-take	Australia	
	GE Renewable Energy	Rare earths	MoU	North America and Europe	Develop magnet supply chain
Stellantis	Vulcan Energy Resources	Lithium	Equity investment and binding off-take	Germany	€50mn investment
	Controlled Thermal Resources	Lithium	Binding off-take	US	25,000 tonnes per year of lithium hydroxide
	GME Resources	Nickel, Cobalt	MoU	Australia	
Renault	Vulcan Energy Resources	Lithium	Binding off-take	Germany	26,000 to 32,000 tonnes in total from 2026
	Terraframe	Cobalt	MoU	Finland	Annual supply for 15GWh of battery capacity
	Managem Group	Cobalt	MoU	Morocco	5,000 tonnes per year of cobalt sulphate from 2025 for 7 years
Volkswagen	Ganfeng	Lithium	MoU	China	10 year deal
	Vulcan Energy Resources	Lithium	Binding off-take	Germany	Lithium hydroxide for five years from 2026
	Huayou	Cobalt, Nickel	MoU for joint venture	Indonesia	Annual output of 120,000 tonnes of nickel and 15,000 tonnes of cobalt
	Tsingshan	Nickel	MoU for joint venture	Indonesia	
	Canadian government	Lithium, Nickel and Cobalt	MoU	Canada	
Daimler	Rock Tech Lithium	Lithium	MoU	Canada, Germany	10,000 tonnes of lithium per year from 2026
	Canadian government	Lithium, Nickel and Cobalt	MoU	Canada	

	Mining company	Metal	Type	Location	Detail
BMW	European Lithium	Lithium	MoU	Austria	$15mn pre-payment if binding contract agreed
	Mangrove Lithium	Lithium	Equity investment	Canada	Lead investment in Series A financing for lithium refinery technology
	Lilac Solutions	Lithium	Equity investment	US	Lithium extraction technology start-up
	Livent	Lithium	Off-take	Argentina	€285mn contract for lithium supply from 2022
	Ganfeng	Lithium	Off-take	Australia	€540mn for lithium hydroxide between 2020-24
	Managem Group	Cobalt	Off-take	Morocco	€100mn for cobalt between 2020-25
	Glencore	Cobalt	Off-take	Australia	
Toyota	ioneer	Lithium	Binding off-take	US	4,000 tonnes of lithium carbonate per year for five years
	BHP	Nickel	MoU	Australia	Nickel sulphate supply
Hyundai	Arafura Resources	Rare earths	Binding off-take	Australia	1,500 tonnes of neodymium praseodymium oxide per year

Note: Data represented above excludes Tesla's as they are mostly existing supplier relationships.

Source: Financial Times (as of November 2022)

4.3
Technology Providers and Developers

The manufacturing pipeline for electric vehicle batteries is not limited to the OEM partnerships. Though relatively lesser in proportion, a part of the upcoming capacities is led by technology providers, or those entities engaged in the development chain of battery cell components based on certain technology configuration. Supply linkage in the battery components together with technological know-how enabled market entry for these enterprises. The competitive edge of such enterprises would lie within technology, considering that the scale and profitability are two key known entry barriers in the Gigafactory landscape

Technology Providers Setting up Battery Manufacturing Capacities (illustrative)

	Country (Project)	Details
GUS Technology	Taiwan	Though focused on Lithium Titanate and NCM materials, the company entered the battery manufacturing space for potentially Taiwan's first Gigafactory unit.
Recharge Industries	UK	The Australia-based battery technology company acquired the bankrupt Gigafactory enterprise Britishvolt
Kontrolmatik Technologies	US	Turkish engineering and system integration enterprise, planning LFP-based Gigafactory.
Kore Power	US	Developer of Lithium cells and battery storage solutions, the planned Gigafactory will cater to both electric vehicles and energy storage sectors.
ProLogium	France	The Taiwan-based company plans to use its proprietary solid-state battery technology for the Gigafactory project.

Source: News reports, Press releases

To an extent, within technology providers, one could also consider the potential involvement of equipment suppliers and their related entities. Mckinsey estimates indicate that about 60% of the Gigafactories' total planned investment could be directed at manufacturing equipment. The same report also points out that the majority of the equipment manufacturers for Gigafactories will be from the Asia-Pacific region. Volkswagen's Saltzgitter Gigafactory's equipment manufacturing contract went to China-based Wuxi Lead Intelligent Equipment. But, with limited production capacities and longer team times, the enterprises are likely to be acquired or engaged with strategic partnership arrangements. Tesla had acquired Grohmann Engineering in 2017, as part of measures to acquire the know-how and capabilities.

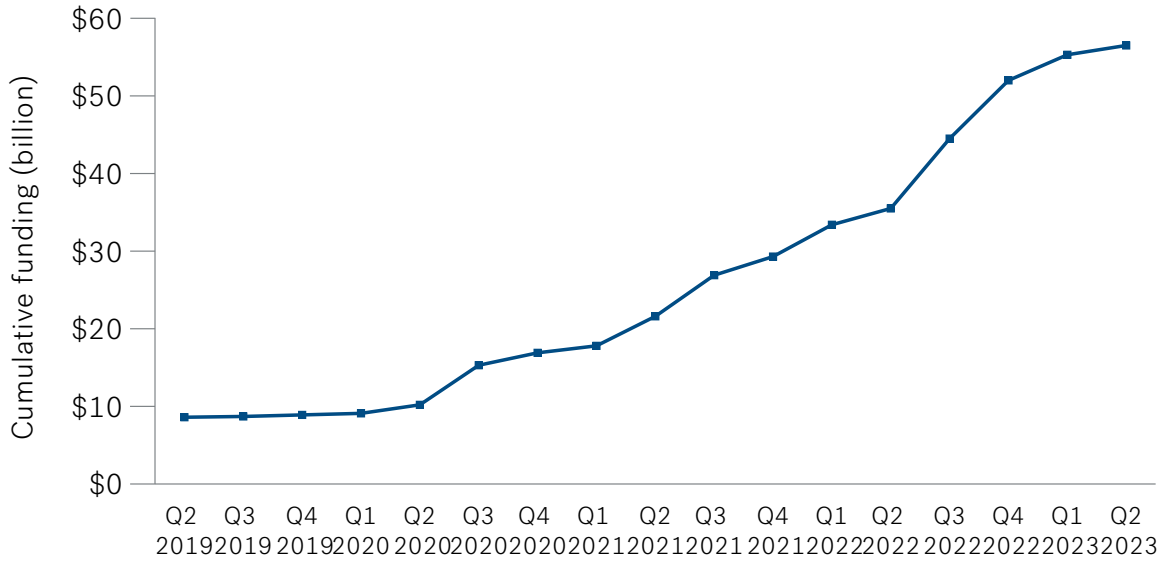
4.4
Startups

Startups are leading some of the major Gigafactory projects under development. Investor interest, as reflected in the venture capital (VC) funding, helped get the enterprises take off. Battery energy is part of the overall clean energy theme where VC investments have been directed the most. By end of 2022, about two-thirds of the total global VC investment was towards batteries, energy storage and renewable energy.

PitchBook's February 2023 estimate held the Swedish Gigafactory manufacturer Northvolt as the highest-funded European startup for the $5.5 billion raised till that date. French battery startup Verkor and the US-based Our Next Energy (ONE) are other notable case of startups engaged in the Gigafactory line-up. There are others similarly engaged in the development process.

In quite a few cases, the technology-led differentiation of the startups is clear. Nanotech Energy, founded in 2014, is in the process of finalizing the site for its planned £1 billion Gigafactory in the UK. The company offers a proprietary non-flammable electrolyte for its lithium-ion batteries and graphene-based electrodes which together result in a battery packs with a higher value proposition. Another similar example is that of Natron Energy, whose sodium-ion battery packs helped attract funding from entities including United Airlines and Liberty Energy.

Trend in Cumulative Funding in Battery Tech/Startup Segment



Source: Crunchbase

Market entry of well-funded startups in the Gigafactory space is an encouraging factor for market depth. While necessary though, it is not a sufficient condition for growth and sustenance. The profitability of the business will be tested for every enterprise regardless of its legacy endowment in resources or strategic arrangement in supply chain.

5.0 | Policy Backdrop Impacting Gigafactory Pipeline

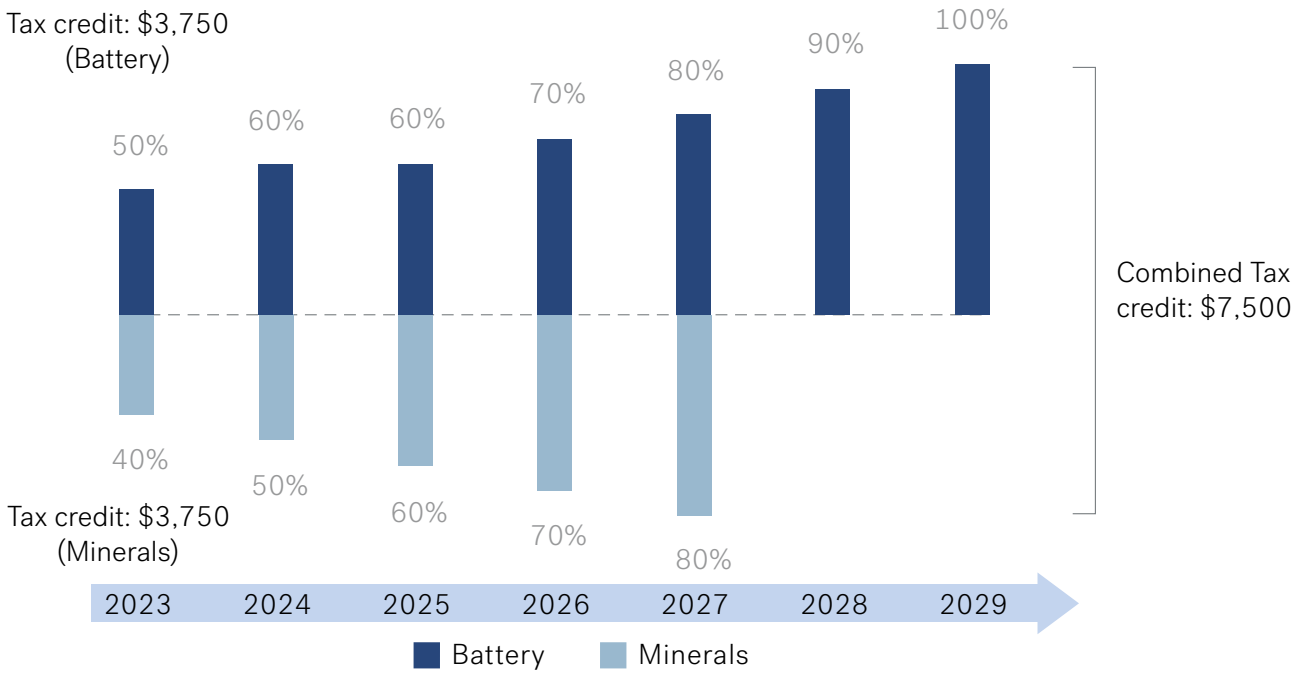
5.1
Introduction

The global Gigafactory pipeline benefits significantly from an enabling policy environment, especially one that has clear and upfront subsidies. Presently North America (US primarily) and Europe are in focus for the rapid growth of battery manufacturing pipeline. The US federal policy support made a marked difference in the policy landscape for upcoming capacities. The motivation is to incentivize diversification in global battery manufacturing base, away from China as much as feasible. European clean energy and decarbonization goals constitute an important demand-driving factor in battery production investment. It is the visibility in funding that can make the difference in securing private investments.

5.2
US

The $370 billion Inflation Reduction Act (IRA) is the most important and landmark legislation to promote clean energy investments in the US. It is notable for the incentives for local manufacturing. The tax credits offered for locally sourced and produced electric vehicles constitute the major draw for investors. For most part, the regulation has effectively tipped the balance, with the clear tax credit offer of $3,750 for those electric vehicles meeting either battery or critical mineral sourcing norms. For meeting both, the tax credit is worth $7,500 per vehicle. In this regard, manufacturers are assured of tax credits on the production side.

Minimum Local Sourcing Requirement for US Electric Vehicle Tax Credits



Notes:

(a) Battery requiremennts refer to minimum share of manufacturing/assembly in North America

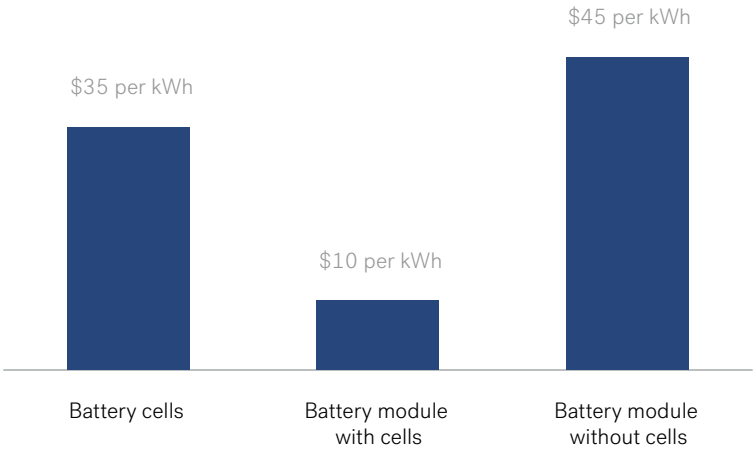
(b) For minerals, the requirement refers to minimum share of sourcing within US, or trade partners of US, or recycled in North America

(c) Tax credit refers to the tax benefit available to each electric vehicle, based on fulfillment of criteria

Source: US Department of Energy.

The US IRA's Section 13502, "Advanced Manufacturing Production Credit," comprises tax credits for the domestically manufactured battery cells and modules. A tax credit, equivalent to 10% of production cost, is available for the enterprise using the applicable critical minerals including aluminum, antimony, barite, beryllium, cerium, caesium, chromium, cobalt, dysprosium, europium, fluorspar, gadolinium, germanium, graphite, indium, lithium, manganese, neodymium, nickel, niobium, tellurium, tin, tungsten, vanadium, yttrium and others. The same tax credit is available for active electrode materials used in production. For battery and its components however, the tax credit follows a slab on per kWh basis.

Production Tax Credits for Battery Manufacturing



Source: US Department of Energy

The battery production credits/incentives impact the balance significantly. Thus, for instance, a 30GWh battery cell manufacturing capacity stands to gain about $1.05 billion in potential production credit, based on the criteria. For plants configured for battery modules without cells, the incentive is proportionately a bigger sum. This is the context in which some of the major Gigafactory projects are apparently skewed for US-based locations – Northvolt was reported to have been actively considering US (instead of a European location) for its next planned capacity, in part due to the potential $8 billion worth of subsidies involved.

There are other federal initiatives running concurrently to promote investments in the battery ecosystem. The funding or other support measures (such as capacity building measures, etc.) are extended through allocations under different schemes. One such measure was the $2.8 billion worth of funding extended in October 2022 under the Bipartisan Infrastructure Law (BIL) for battery and its component manufacturing. The funding was directed at 20 companies for their projects across 12 US states. The Bipartisan Infrastructure Law budgeted over $7 billion towards domestic manufacturing in critical minerals and batteries. Around the same time as BIL's funding for battery projects, the US federal government announced the launch of American Battery Materials Initiative – aimed at taking a holistic approach at the policy measures for sustainable supply in critical minerals in sustainable energy.

State-level support is complementing the federal side to attract manufacturing investments. The upcoming capacities, based on US Department of Energy's report (as of November 2022) indicate a clustering across what is also christened as the Battery Belt. The US states of Georgia, Kentucky and Michigan could play a dominant role. Others in the fray include Kansas, North Carolina, and Tennessee. To make the most of the opportunity, state-level authorities are actively offering incentives to competitively secure the projects. It makes for a radical change in the industrial growth outlook when prospective investors factor-in the state support together with that of federal policy.

US States Policy Support for Battery Manufacturing Investments (illustrative)

	SUPPORT / INCENTIVES
Michigan	$1 billion in approved incentives for Ford Motors' battery manufacturing project
Kansas	$829 million incentives for the Panasonic battery manufacturing plant.
Georgia	$358 million in incentives (grants/tax breaks) for FREYR Gigafactory project.
Tennessee	$40 million sanctioned for the LG Chem's battery cathode plant.

Source: News reports, press releases

5.3
Canada

Lately, the Canadian policymakers have been engaged in realigning the industrial framework and incentive structure to attract the global investments. The long-term goals of net-zero and rationalization of carbon emissions across sectors led to emphasis on transport electrification. A richly endowed mineral resource base and a highly evolved industrial infrastructure in mineral processing and refining places it favourably against other countries. However, the US federal policy's IRA forced the Canadians to offer a competitive proposition for future battery manufacturers.

As of April 2023, the government announced the Budget 2023, proposing a 30% investment tax credit for clean energy technology manufacturing activities. Among other eligible areas, this includes battery and its related component production/investment. The tax credit is meant to cover the cost of machinery and equipment used in the production process across the supply chain. The legislation also covers the battery production investments directed at energy storage systems. Th tax credit adds to the previously offered 15% tax credit offered in the clean energy investments (Budget 2022). The Budget also put forth Canada Infrastructure Bank's $20 billion allocation for clean energy and clean-growth infrastructure projects, the latter being assumed to include battery and related projects.

The investment tax credit could cost the exchequer C$4.5 billion over a five-year period starting 2023-24, and an additional C$6.6 billion during the period between 2028-29 and 2034-35. The credit will be valid for property that is acquired and becomes available for use starting January 2024, and will be in effect till 2034. A phaseout of this package will start in 2032.

The budgeted incentive for manufacturing complements the government's Critical Minerals Strategy that was released in December 2022. The strategy document identified six critical minerals as priority for the required impetus in supply chain. These are Lithium, Graphite, Nickel, Copper, and rare earth elements. At a policy level, the strategy/plan outlined the objectives in facilitating investments through expeditious approvals, streamlined processes for financing, promoting research and development, etc. The Budget 2022 had a C$4 billion allocation in this regard to push the ongoing project proposals.

In November 2022, the government proposed a 2% tax on corporate stock buybacks to incentivize reinvestment of profits in the business. The tax is expected to be in force starting January 2024. Around the same time, the Canadian government could also activate the previously planned Canada Growth Fund with a $15 billion capitalization aimed at helping investors and entrepreneurs mitigate risks related to new technologies and infrastructure.

5.4
Europe

The European policy support for battery and related component manufacturing has been driven by the region's decarbonization and climate mitigation objectives. The underlying growth and demand for clean energy and transport electrification prompted measures at facilitating institutional funding for private investments. Beyond this, the policy/funding support has been through the various budgeted schemes or policies.

Some of the major investment areas are classified under the 'Important Projects of Common European Interest' (IPCEI), based on which the relevant resources are streamlined across the region to help the commercial viability. The IPCEI-based projects in 2019 and 2021, involving both member states and private enterprises, contributed €8.2 billion and €11.9 billion respectively in investment flow to the battery value chain. Another category of funding is routed through the Under Horizon Europe – a €95.5 billion budget fund for 2021-2027 to help promote research and innovation projects in climate change and sustainability-related areas. The fund has allocated €925 million towards the battery-related projects so far. Separately, the European Investment Bank has been driving the funding for major battery projects. This includes the funding extended to Sweden's Northvolt Gigafactory in July 2020.

There is an additional funding channel available for sustainability projects through the Invest EU Fund, supported by European Union's guarantees. The duration is for 2021-2027. The budget guarantee is worth €26.2 billion, and the fund aims to mobilize over $372 billion (including public and private investments). Battery supply chain projects are part of the qualified investment proposals that secure funding under this category, as exemplified in some of the recent instances.

The funding available through schemes is still apparently falling short for the region, as it competes for attractive projects seeking the best incentives (led presently by US federal policy of IRA). Some steps are underway to close the gap. Importantly, the policymakers are aiming at a coherent regional framework for the prospective investment projects in the renewable and energy transition realm. In March 2023, the European Commission presented a proposal for regulation – the Net Zero Industry Act (NZIA), targeting domestic production of at least 40% of the technology/systems needed to achieve climate and energy goals by 2030.

Among other measures, NZIA will enable investment conditions through simplified/rapid permitting, facilitate market access of the technologies, and promote research and development through initiatives such as regulatory sandboxes. Battery technologies are among the listed strategic technologies in focus for NZIA. The regulation will be deliberated and agreed upon by the European Parliament and the Council of European Union before official adoption and enactment. It is seen as a somewhat positive step in the direction of offering a competitive option for Europe to secure the critical manufacturing investments. The individual members states of the region are meanwhile exploring means to incentivize. France, for instance recently succeeded in securing investment commitments for Gigafactory projects through a package of tax breaks and grant offers.

EU's Approved Member States' Aid for Battery Manufacturing Investment

Country	Aid for battery manufacturing investment
Sweden	$350 million EIB loan for Northvolt Gigafactory project.
Hungary	$89 million government support for Samsung's Gigafactory project.
Spain	$837 million aid for Volkswagen and other Gigafactory projects.

Source: News reports, press releases

5.5

Other Countries/Regions

The policy interest in battery manufacturing is high in many other countries, as evident in recent measures announced. At the other extreme though is China, where the conventional state-led industrial policy since 2000s ensured a dominant position of domestic enterprises – four of the top 10 global battery producers are in China. The country continues to attract investments in this space – Tesla's Shanghai Gigafactory for instance received government aid to enable a commercially viable development process. Other countries are not in the same footing and are instead seeking to make use of the emerging opportunity in battery-led electrification and energy storage segments.

A handful of countries globally have announced concrete measures to attract the typical Gigafactory-scale of battery manufacturing. Quite of a few of them are endowed by the critical resource base – for instance, Australia's mineral resource is an important differentiator. Indonesia, with its nickel reserves comes closer though there has not been a firm announcement on battery manufacturing subsidy. The urge to diversify supply chains beyond the China-centric structure has brought to the fore multiple locations in contention. As subsidy-based competition for projects is unsustainable for majority of countries, many seek options in participating through any part of the global battery supply chain.

Countries Promoting Investments in Local Battery Production Facilities

Country	Policy support / initiative
Japan	Subsidy allocation worth $2.6 billion for domestic battery manufacturing facilities of at least 3GWh capacity.
South Korea	$5.32 billion worth of financial support for domestic firms seeking to invest in North America. The policy aid will help firms cope with the US legislation's norms.
Thailand	$0.74 billion subsidy budget for domestic production of electric vehicle batteries.
Australia	$1.2 billion allocation (as of 2021) under manufacturing strategy roadmap, in which battery production enterprises are included for aid.

Source: News reports, press releases

6.0 | Costs and Financing

6.1
Introduction

The Gigafactory pipeline, for its unprecedented nature in scale and technology, brings a lot of unknown factors in the investment evaluation matrix. These are capital-intensive projects, where a significant share has dependencies in access to raw materials and technology. Policy funding is thus accordingly playing an important role to moderate the otherwise deterring nature of high upfront costs. With time, as announced projects progress in the development stages, procedural approvals, resourcing linkages and other factors will play the role in viability.

6.2
Capital cost

Fundamentally, Gigafactories are meant for economies of scale in the unit costs of batteries and electric vehicles developed under the single roof. Over time, there appears to be a rise in the unit size of each such manufacturing facility. The upfront costs of the facilities, factoring in the land, fixed input costs, and the raw material input linkages, make such facilities a tough balancing act in commercial viability and project management. The emerging global manufacturing pipeline is unprecedented in scale and complexity, as the focus is on vertical integration to maximize efficiencies and market share.

The development pipeline provides some indications of the capital costs related to the Gigafactories. The local factors make the difference, as evident in the per GWh capital cost in North American projects versus those in the European region. In the same comparison, the Chinese factories show a lower average cost, at about $72 million per GWh. The cost advantages (or lack of it) are conditional to the factors including the battery chemistries (for instance China's monopolistic position in LFP), supply chain control and the endowed infrastructure base.

Indicative Capital Costs of Major Projects under Development

Company/venture	Location	Capacity (GWh)	Cost per GWh
FREYR	Georgia, US	34	$50 million
CATL	Debrecen, Hungary	100	$74 million
ACC	Termoli, Italy	40	$50 million
Tesla	Berlin, Germany	100	$55 million
LG Energy Solution	Arizona, US	43	$128 million
ONE	Michigan, US	20	$80 million
Tesla	Nevada, US	100	$36 million
Honda and LG	Ohio, US	40	$110 million
Northvolt	Sweden	60	$50 million
Volkswagen	Ontario, Canada	90	$58 million
CATL	Thuringia, Germany	14	$140 million
Italvolt	Piedmont, Italy	45	$84 million

Note:

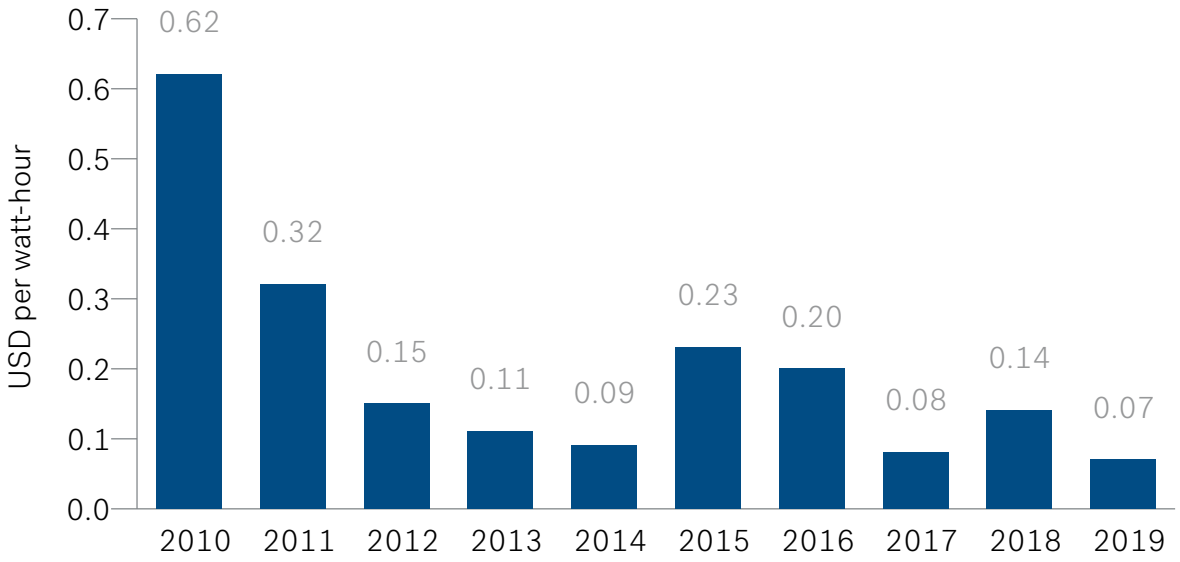
(a) Volkswagen Canada project has a standing government commitment of C$13.2 billion in funding support. The cost indicated above refers to company's proposed investment

(b) Tesla's Nevada project is planned at the same location which houses the company's operational Gigafactory

Source: Press releases and news reports

At an aggregated level, the long-term trend appears to indicate a pattern of decline in the average capital cost of battery manufacturing facilities. The possible factors to attribute such a trend include the active policy support extended for the facilities (global leaders like CATL and BYD got policy aid in early stage), easier financing, and development of efficient supply chain linkages, among others. Technology adds to the mix, to the extent that the choice of one or another battery chemistry impacts the upfront investment.

Historical Trend in the Announced Capital Cost of Battery Manufacturing

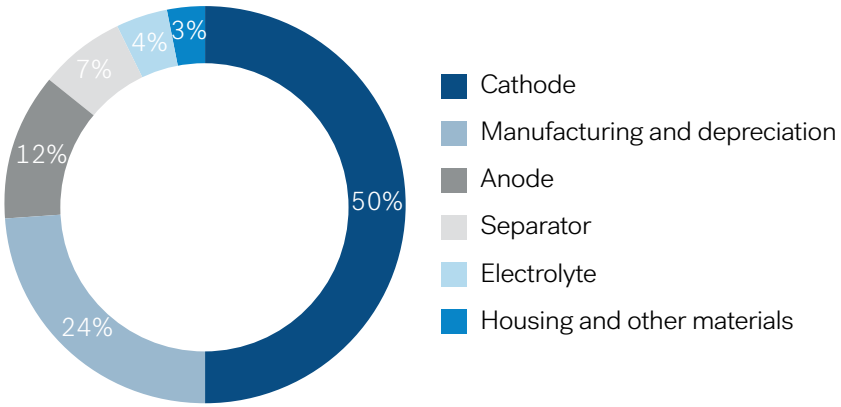


Note: Data points include batteries for electric vehicles and energy storage, and reflect average costs in each year of commissioning

Source: IEA

Some of the major parts of the manufacturing process add to the upfront investment cost. The vertically integrated structure of upcoming Gigafactories aims to mitigate some of this through scale. The dominant LFP battery chemistry, for instance, imposes a significant cost share for electrodes, especially the cathode. Cell assembly and finishing are other broad segments. Equipment supply thus assumes a critical role in the current Gigafactory pipeline – cost estimates and supply reliability could sharply change with progress in the Gigafactories' under development. McKinsey's estimates (as of May 2022) indicate that about 60% of upcoming capital investment in European battery manufacturing will be towards the critical equipment.

Distribution of a Typical Lithium-Ion Battery Cell Cost



Source: Visual Capitalist

6.3
Critical Inputs in Cost Structure

Raw materials cost of the upcoming production facilities is largely centred on the critical minerals. Not all developers are likely to have access to near-assured supplies. The relative scarcity and competing demand will reflect in the prices as capacities come to fruition. Already, the prices of some of the most important battery metals have risen in tandem with the rush to secure supplies.

Average Cost of Critical Battery Metals

Metal	Price per tonne (6-month average)	Application in batteries
Lithium Carbonate	$82,141	Cathode
Copper	$9,417	Current Collectors
Cobalt Sulfate	$8,767	Cathode
Nickel Sulfate	$6,488	Cathode
Manganese Sulfate	$947	Cathode

Source: Visual Capitalist

The role of critical inputs assumes importance in cost structure because every single Gigafactory may not be able to build out a totally vertically integrated business model with full control over its back-end supply. Similarly, the long-term contracts to secure raw materials may be limited to a select few of the pipeline. In such a scenario, the onus will be on commercial arrangements – joint ventures, strategic partnerships, and the like for best and competitive rates. Indicative estimates suggest that this could become a challenging task for both developers and financiers.

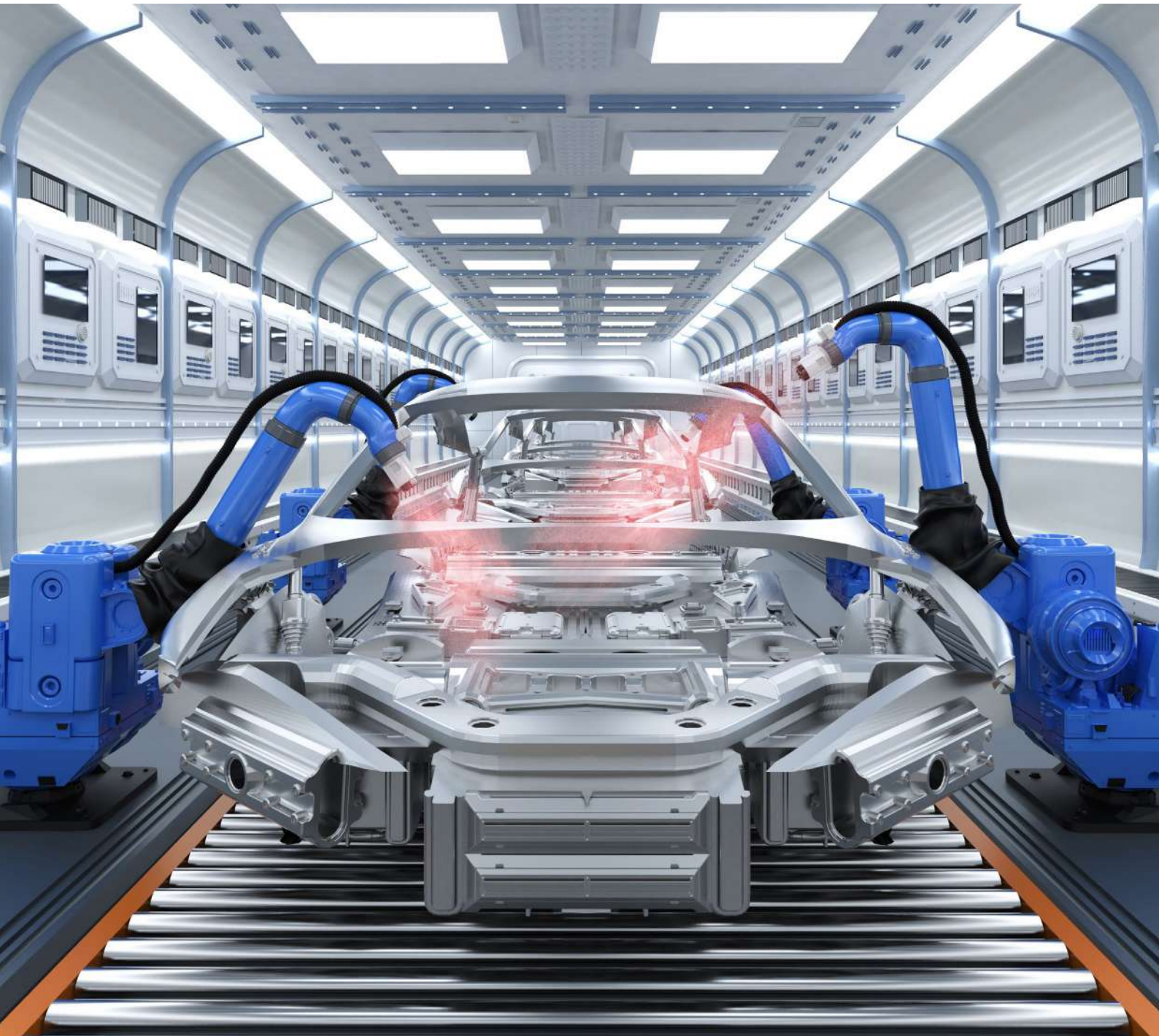
Illustration of Material Requirement for 20 million Vehicles at Tesla

Commodity	Material required (tonnes)	Global production (tonnes, 2021)	Share of 2021 global production
Lithium	755.4K	532K	142%
Cobalt	61.4K	170K	36%
Aluminium (battery)	14.6K	68M	+0%
Aluminium (vehicle)	6.6M	68M	10%
Copper (vehicle)	1.8M	21M	9%
MagREO (NdPr, Dy, Tb)	18K	58K	31%
Manganese	19K	7.5M	+0%
Nickel	670.4K	2.7M	25%
Graphite	1.1M	1M	113%

Source: Mining.Com (as of August 2022)

In effect, it is not so much about the price per se. The moot point is raw material supply lagging far behind the apparently accelerating demand. The pressure on the backward linkage is evident from the steps of existing OEMs. Tesla, in its quarterly earnings report for 2023, held lithium refinery supply (and not price) as a 'choke point' in production. In this backdrop, in May 2023 Tesla announced the setting up of a Texas-based lithium refining plant, which will commence production by end of the year. This could position Tesla as the only North American auto OEM refining its own battery metal.

Other OEMs are aiming to match the pace. Chinese battery and automobile manufacturer BYD has been in discussions to acquire six African Lithium mines worth about 25 million tonnes of the ore. The US-based General Motors, through its equity finance arm GM Ventures, has a strategic agreement with EnergyX to develop the latter's extraction and refining technology. The Japanese companies are finding policy support in critical minerals. Japan's Ministry of Economy, Trade and Industry is planning to subsidize up to half the cost of mine development and related upstream activity of domestic companies. It is meant at incentivizing initiatives at securing mineral supply for the electric vehicle and other industries dependent on rare earth minerals.



6.4

Funding by Type

The huge Gigafactory pipeline, despite its promise, faces challenges in securing funding. Factors such as the complexity of projects, long-winded route of approvals, technology, and supply chain linkages together shape the investor perceptions. For many developers, the lack of firm orders or customer linkages for the projects proved to be a constraint in seeking timely funding. As a result, the financing of such projects is from a mix of avenues including private equity, institutional funding, debt/bonds, etc.

Recent Major PE Funding in Gigafactory Projects

	Gigafactory project developer/promoter	Particulars
Greybull Capital	Britishvolt	As of February 2023, the PE investor was approached among other investors to take over the financially stressed venture.
KKR	FREYR	As of December 2022, FREYR was in discussion for about $500 million funding from KKR.
Fifth Wall and Franklin Templeton	ONE	$300 million Sevries B funding for the startup-led gigafactory project in Michigan

Source: Press releases and news reports

Enterprises with strong and credible backing of equipment manufacturing, supply chain sourcing or joint ventures with major end-use customers have had access to the private equity and bond issuance routes of funding, among other avenues. Notable names of the industry such as Northvolt raised over $1 billion through bonds. The dollar-denominated bond market has also been tapped into by the incumbent battery manufacturers for capacity expansion. A notable example is CATL's $1.5 billion bond issue in September 2020 to fund its planned capacity expansion.

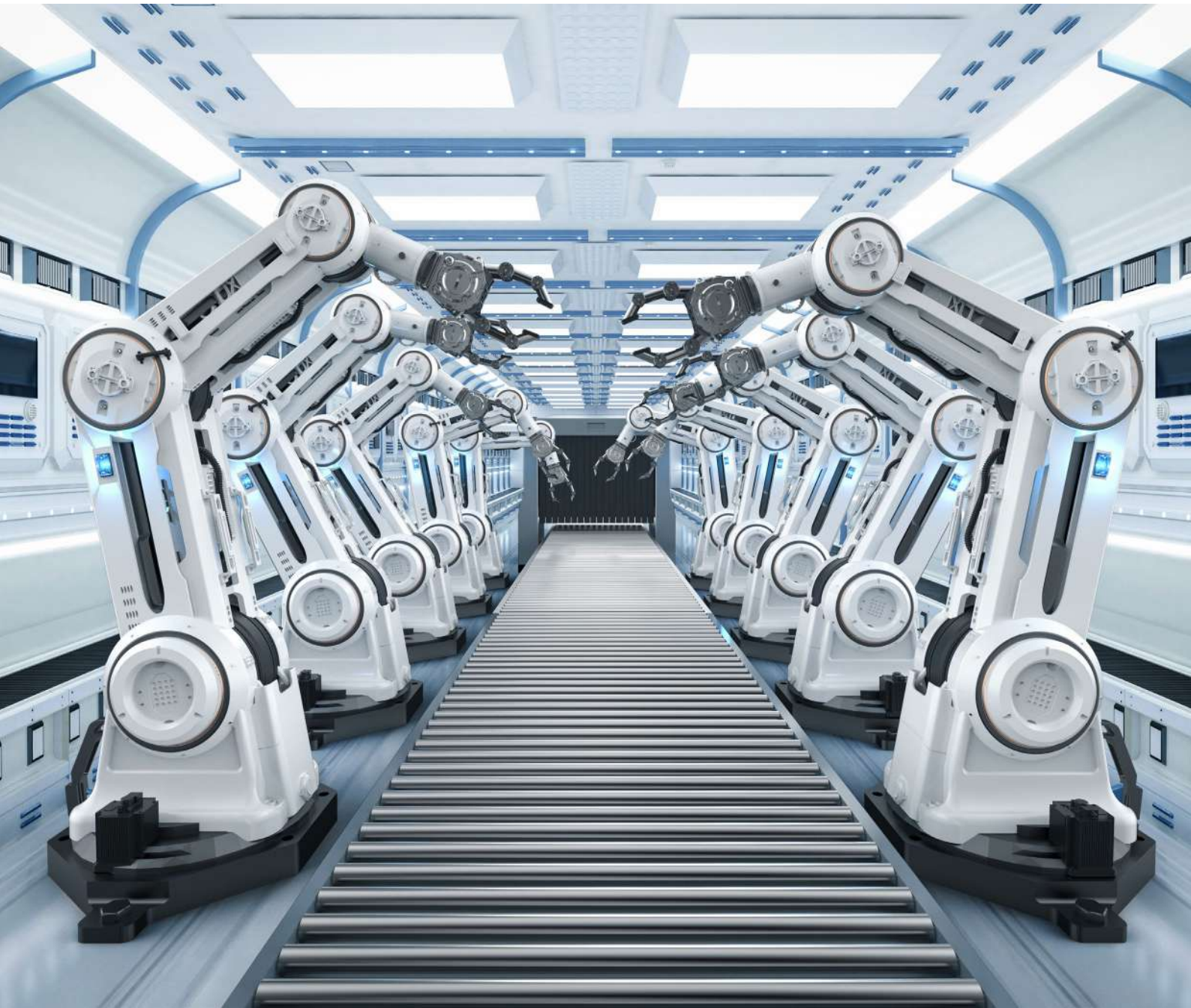
Bond Issuance by Major Companies to Fund Battery Manufacturing Projects

	Bond issuance
Northvolt	As of July 2022, the company announced issuance of $1.1 billion convertible notes, as part of fund raise for Gigafactory.
LG Chem	$300 million worth of new 'green bonds' to fund project development
Sk On (Sk Innovation)	Green bond' offering worth $900 million in the US dollar bond market, with guarantees from Kookmin Bank
Honda	In March 2022, company announced issuance of $2.75 billion dollar-denominated green bonds. The proceeds will go towards battery production, among other electrification initiatives underway.

Source: Press releases and news reports

Policy funding, through grants or institutional channel loans, are among the other key funding sources in the Gigafactory pipeline. Beyond the stated policy goals to incentivize the manufacturing investments, the policy makers have been extending support to enable the commercial viability of such capital-intensive projects. Some of the important instances of policy support are in the US market – the state of Michigan committed about $2 billion worth of funding to attract major big-ticket projects during 2022. The support is over and above the federal offering under the Inflation Reduction Act. The authorities in the state have officially created an incentive/funding pool to sustain the investment flow. In Canada, official commitment to match US subsidies helped secure Volkswagen's Gigafactory project. European countries are doing the same, in varied measures – the Hungarian government reportedly offered $800 million in grants to attract CATL's proposed Gigafactory project; ACC received about €437 million in grant funding to help get the production base in Germany; and the French government had direct policy-level interventions to secure Gigafactories at Dunkirk, through undisclosed incentives such as in terms of competitive energy prices and tax credits.

With a dynamic phase of the Gigafactory industry landscape, a clearer picture of funding structure will be evident after a while. Some of the most important areas such as the business model, competitive strength in the supply chain, and geopolitical factors, together add to the flux. The investors might prefer to look at the models of a few in the pipeline before determining the course of action for the path ahead.

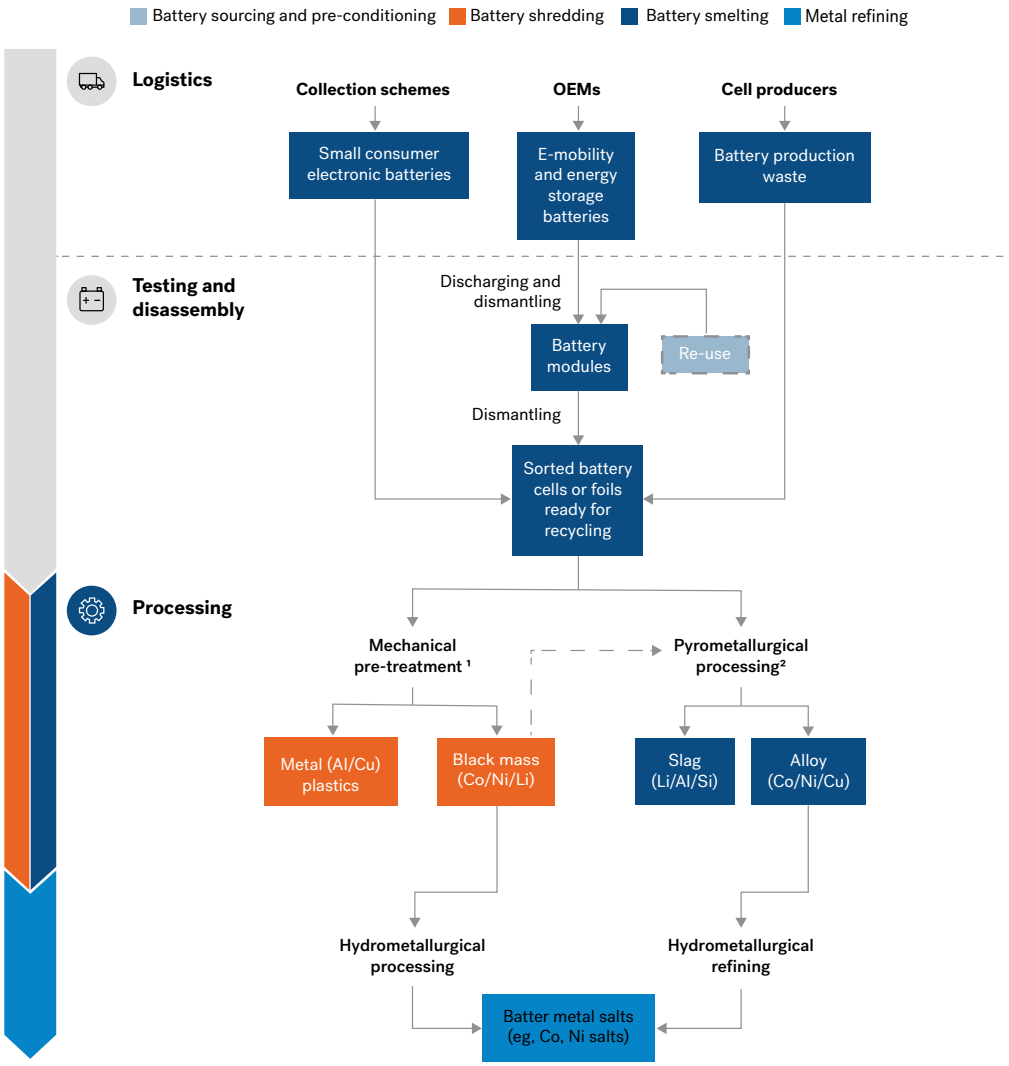


7.0 | Battery Recycling

7.1
Introduction

The globally strong Gigafactory pipeline has brought to the fore the battery recycling segment of the chain that has otherwise been largely nascent till recently. Multiple factors, ranging from sustainability concerns to localization and supply chain diversification, contribute to a heighted business interest and investment in recycling. To be sure, it is still a limited underlying base – predominant short-term demand arises from the Gigafactories' production scrap till electric vehicle fleet expands reasonably for end-of-life batteries. The leading global markets in Gigafactory capacities are more likely to overlap with the upcoming demand hotspots in battery recycling.

Battery Production Scraps are the Primary Global Supply for Battery Recycling Until 2030



¹ Batteries are typically being thermally treated (80-600°C) before and/or after crusing to remove the electrlyte (deactivation), optimize the sepration of electrode and current collector foil, minizize impurities that could disturb subsequent hydrometallurgical steps and reduce metals to their elemental form for optimized hydrometallurgical processing.
² Smaller battery packs can be processed straight into smelter.
Source: McKinsey Battery Insights

7.2
Regulatory Thrust

With sustainability concerns in focus, policy and regulatory norms are laying down the required practices for the battery production, distribution, and disposal process. Such norms are notable in the backdrop of the major electric vehicle penetration in some of the major markets globally. An important case in point is the European region. Starting May 2023, the new European Battery Regulation came into force. It is to be implemented across the European Union member countries to mitigate the environmental impact of the installed base of electric vehicle batteries.

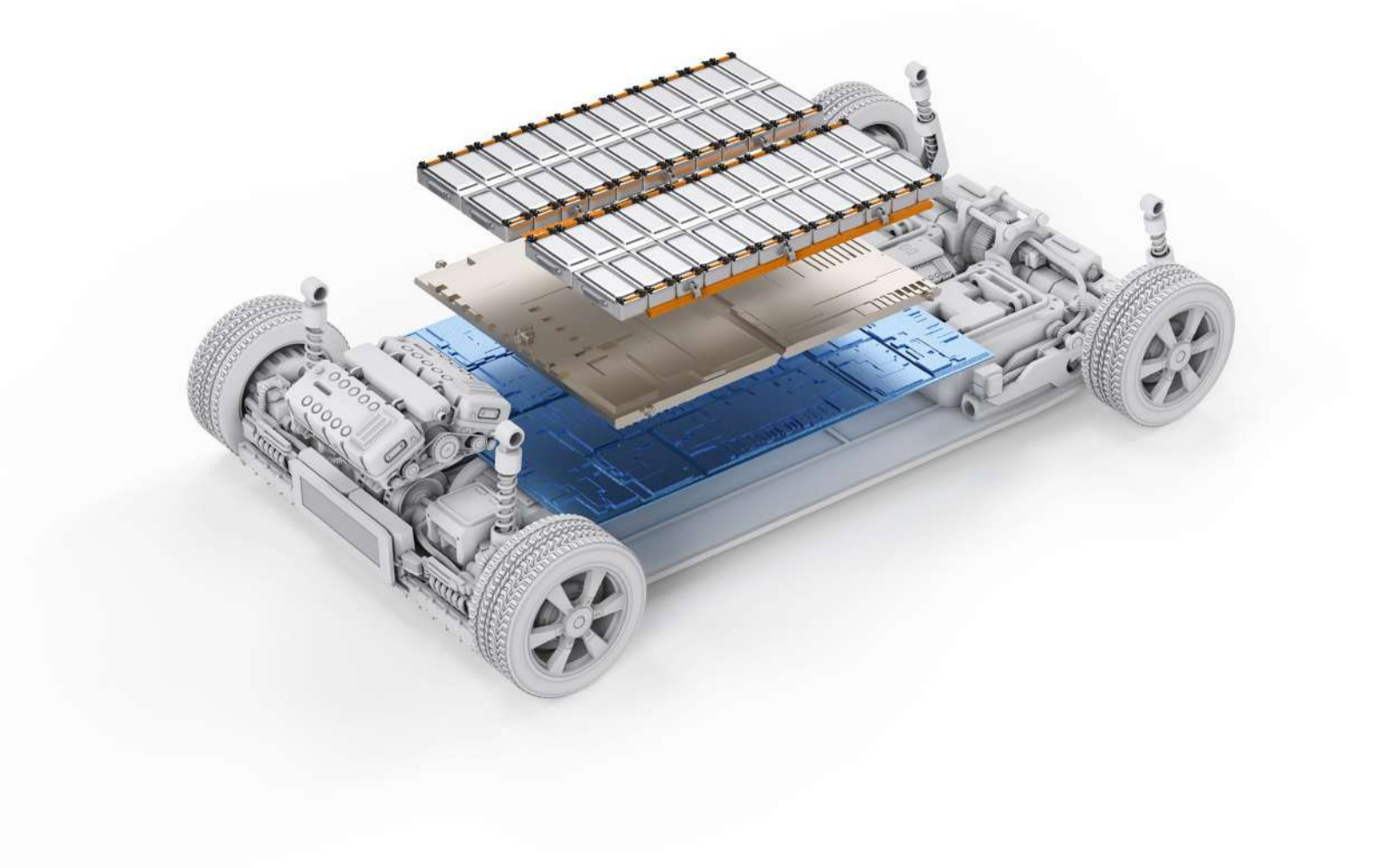
The elaborate regulations comprise critical elements for tracking and reporting the aspects related to the batteries' specific parameters for environmental impact. One such requirement is the 'battery passport' – a digital document for the traceability of communication between manufacturers, users and the recycling operators. The digital documentation will cease when the battery gets recycled. The documentation norm will be valid from May 2026, for batteries above 2kWh in the European Union market.

Carbon footprint is among the major parameters tracked, in which battery recycling is likely to play an important role. Using lifecycle assessment, the European regulations require mandatory declaration of carbon footprint from May 2024 onwards. On the supply side, another set of European Union regulations passed in March 2023, namely the Critical Minerals Act, set ambitious targets for recycling. It requires recycling to meet at least 15% of consumption by 2030. The European regulations help set the base for an otherwise nascent recycling industry in Lithium, among other minerals.

Policy propositions and packages vary across markets in terms of their impact on recycling. In the US, the federal legislation Inflation Reduction Act (IRA), made a major dent in attracting investments in electric vehicles and its related component manufacturing, especially in batteries. The legislation offers incentives through tax credits for indigenous manufacturing. The key point in this direction is that the tax credit disbursement for consumers is linked to the extent that the battery material is sourced from domestic production units, or from the US trade partners (foreign trade agreements).

In effect, the IRA sets incentives for OEMs who not only need to maximize the domestic production share but also diversify away from the Chinese sources in the supply chain. Recycling is critical to help meet the requirement. Recycling also helps meet the localization requirement in the US because most of the existing new mineral production or processing facilities are beset with challenges in procedural approvals. The complementary support for this regulation is observed in the policy funding made available for recycling. In February 2023, the battery material and recycling startup Redwood Materials secured a $2 billion conditional loan from the US Department of Energy to augment supply of critical minerals involved in the battery supply chain.

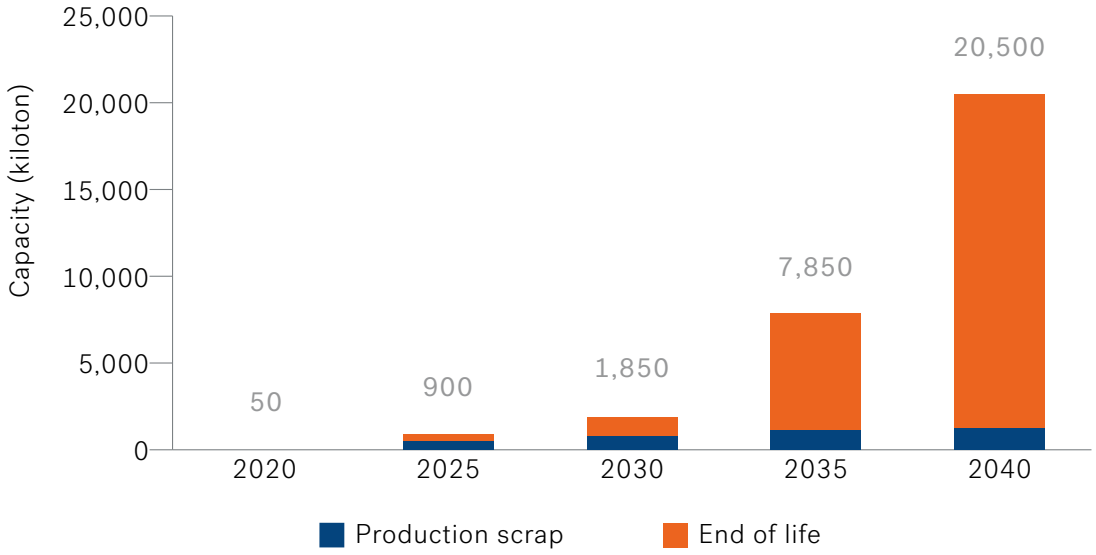
To be sure, the role of policy and regulatory initiatives is contingent on the underlying segment's growth. When observed in this perspective, the implications of such initiatives will take some time to materialize. The critical mass required for the battery recycling business is yet to be reached. The total supply chain is still concentrated in the Chinese industrial ecosystem. It is thus the emerging demand and opportunity in this business that the investors are likely to track and pursue.



7.3
Major Battery Demand Segments

The recycling demand for electric vehicle batteries is largely limited to production scrap. An expansion in the electric vehicle fleet will shift the recycling focus to end-of-life batteries. Most of the industry reports such as Mckinsey's concur that it will be only after 2030 when the end-of-life electric vehicle batteries can be available as a critical demand base for recycling. Thus, over the next decade or so, the production scrap of electric vehicle batteries is the major demand driver.

Projected Global Supply of Electric Vehicle Battery for Recycling



Source: McKinsey

The Gigafactory pipeline is a major demand driver for battery recycling. Some of the major projects under development incorporate recycling in the design and plan. This is in keeping with a circular manufacturing process – one involving a production and supply chain to recover or recycle the resources used in creating the products. A Gigafactory has an estimated average scrap rate of 8% - 10%. But such average estimates are conditional to the assumptions of technology and plant-specific parameters. EY's report for instance refers to Gigafactory scrap rates at 20%-30% in the early stages of production.

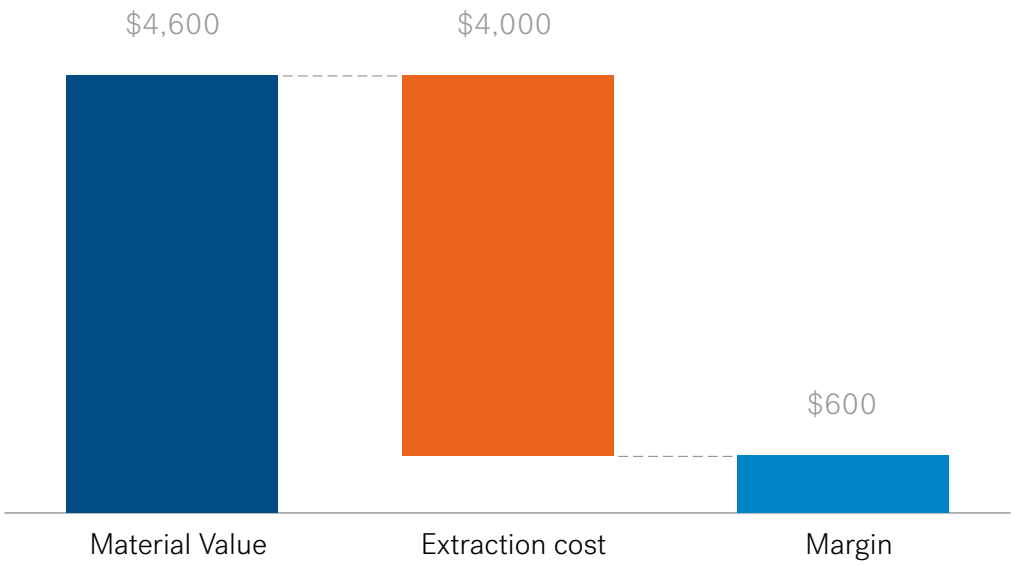
Gigafactories in Pipeline with Battery Recycling Facilities

Company/ Group	Gigaf actory in plan/development	Recycling plan
Northvolt	150GWh combined capacity across three European locations by 2030	By 2030, 50% of raw material requirement to be met through recycling. A joint venture with Hydro, named Hydro Volt, is part of the initiatives in this regard.
Verkor	16GWh capacity planned at the Port of Dunkirk	Pilot project (operated by Startup Mecaware) to test using production-based carbon dioxide to recycle battery production rejects.
Britishvolt	30GWh capacity planned by 2030 at Blyth, UK.	Partnered with Glencore for recycling facility to process manu-facturing scrap.
Powerco (Volkswagen)	40GWh total capacity planned by 2025/2030 at the Saltzgitter plant, Germany.	Plant being designed for closed-loop recycling, especially with over 90% for raw materials.
Panasonic	30GWh capacity planned for 2025 commissioning at Kansas, US.	Partnered with recycling company Redwood Materials for planned 30% recycled Lithium and 100% recycled Cobalt.

Source: Press releases, respective companies

Scale is an important factor in ensuring profitability. Other factors in the scheme include recovered metals' price, battery cell chemistry, and battery supply chain localization. With some assumptions in the battery closed loop recycling and extraction/processing costs, the ballpark estimate of the monetary value is $600 per tonne of battery material by 2025 (McKinsey, March 2023). The same projections suggest the potential value addition growth reaching closer to the path of primary metals, based on technology maturity and its adoption.

Estimated Monetary Value in Per Tonne of Electric Vehicle Battery Recycling

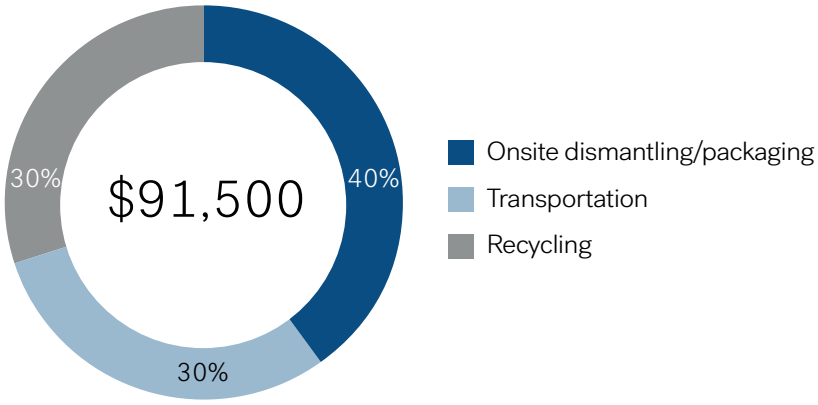


Source: McKinsey

The demand for recycling is not restricted to the Gigafactories under development. The existing battery manufacturing capacities are headed in the same direction. Tesla is among the notable and earliest movers in this regard. The company had reported over 90% recycling rate in battery raw materials (as of 2021). Panasonic's battery cells at Tesla's Nevada Gigafactory progressively incorporate a higher rate of recycling for raw materials. In January 2023, the world's largest electric vehicle battery producer CATL announced a $3.4 billion (¥23.8 billion) investment for battery recycling capacity in China, through its subsidiary Brunp. In the Chinese market, Brunp and GEM contribute half of the recycling business. The momentum is picking up in similar pattern in South Korea, where a clustered presence of top manufacturers (LG, Samsung and Sk On, among others) made it a ripe market for recycling for the electric vehicle demand.

After electric vehicles, the next major battery demand segment is that of grid-scale energy storage. It is gradually coming to the fore with expansion in deployment. Recycled batteries, whether generated in the manufacturing process, or through the end-of-life stage of the electric vehicle fleet, are finding way in the battery storage systems. One such project, and the largest of its kind, was commissioned in February 2023, connected with a Californian solar farm. It uses repurposed electric vehicle batteries. The same batteries, once fully exhausted in the storage application, can then be part of the recycling process for commercial extraction value. A rising base of renewable-plus storage projects feeds the recycling demand, especially with regulatory requirements. Yet, this is a nascent and emerging sub-segment of battery recycling with lack of defined policy and framework in many of the leading global markets.

Cost Breakup of Decommissioning a 1-MWh NMC Lithium-Ion Battery Storage System

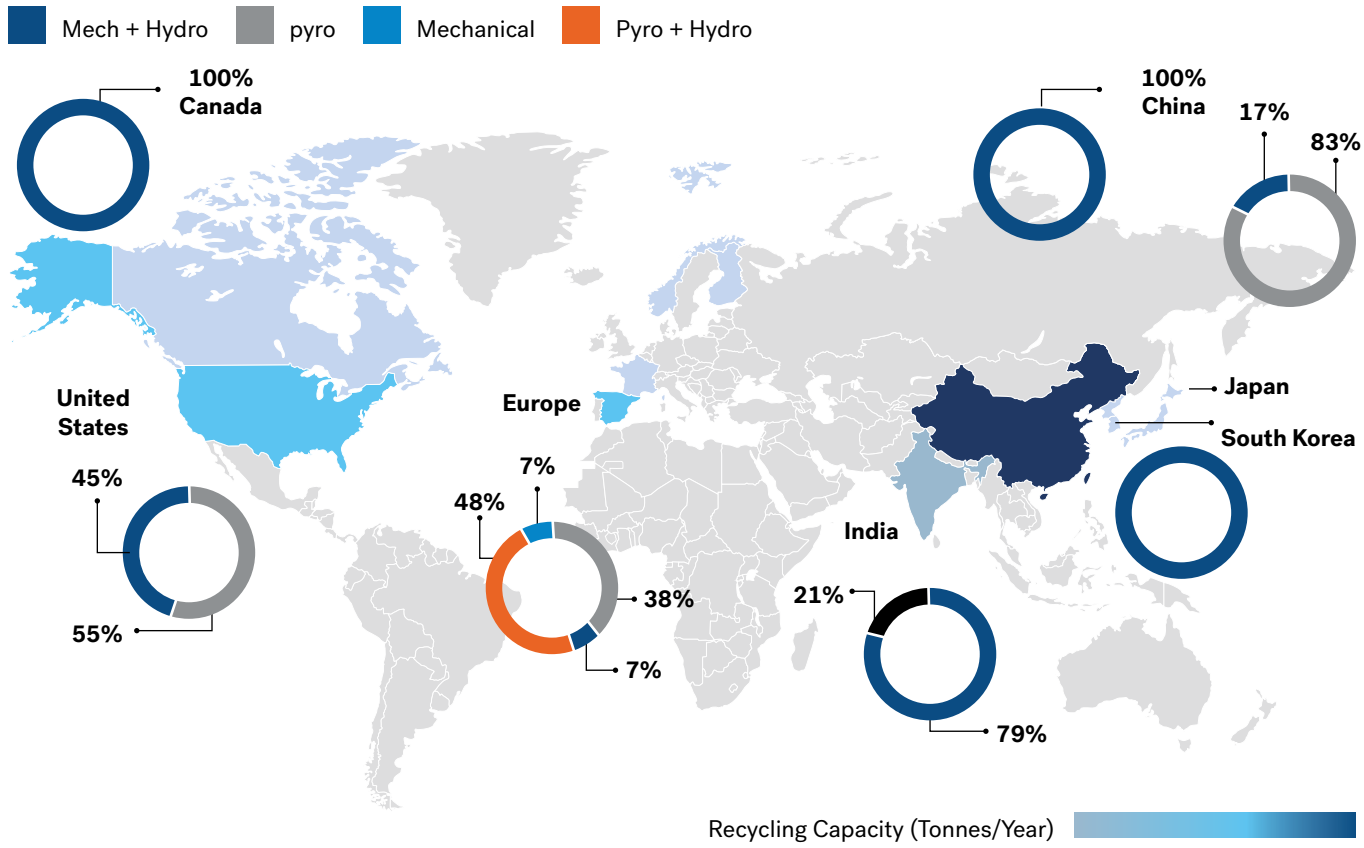


Source: Green Clean Solar

7.4
Technology and Key Market Players

There are established recycling technologies in place for the typical Lithium-Ion and other major battery chemistries in use. The process entails multiple stages based on the choice/ requirement of recycling, input feedstock and expected output quality (largely critical minerals). To generalize though, there are four steps, namely preparation, pre-treatment (pyrolysis and mechanical), pyro-metallurgy and hydrometallurgy. The combination of the steps varies across the recycling plants. In some cases, there are standalone recycling capacities, adopting either one of mechanical, pyrometallurgical or hydrometallurgical processes.

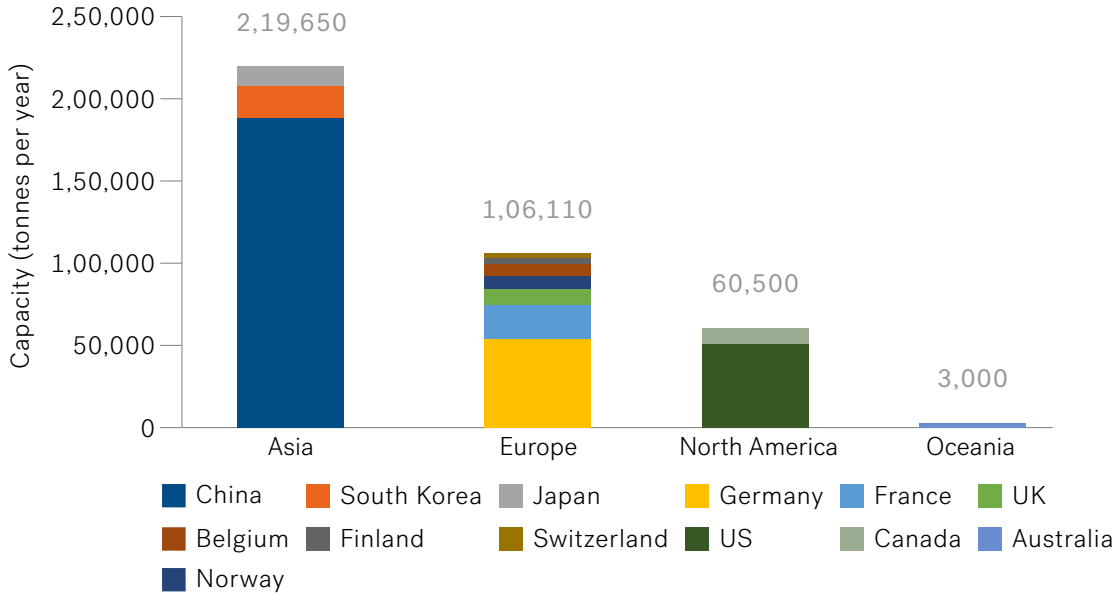
Global Recycling Capacity by Technology



Source: Niti Aayog, Government of India

The technology profile of battery recycling varies across countries and regions. This is in part a reflection of the existing industrial base in mineral processing and refining. China's dominance is a given factor. The European and US-based capacity is gradually coming to the fore, with incentives available for the domestic manufacturing units. The prevalent recycling processes vary between Chinese hybrid modes of mechanical with hydro and European combination of mechanical, hydro and pyrometallurgy.

Existing and Planned Lithium-Ion Battery Recycling Capacity by Region (2021)



Source: Canary Media

Some of the key global recyclers include Ecobat, Umicore, Accurec, SunEel, Kyoei Seiko, and Brunp, among others. Most of the recycling companies' existing production systems are configured for multiple battery chemistries and production scraps. With Lithium-Ion batteries lately assuming a significant share, there is progressively a business case for redesigning for efficiency. With rising demand for recycling, the upcoming investments are not just for capacity expansion but also to re-configure for a diversified input feedstock in Lithium-Ion and other leading battery formulations. In February 2023 for instance, the US-based multi-national recycling company Ecobat announced the setting up of a dedicated Lithium-Ion recycling facility in Arizona, US.

The dynamic business landscape of battery supply chain, led primarily by Gigafactory pipeline, impacts the linkages of recycling industries as well. Various business models are in the play, as enterprises find the best and optimal route to capitalize upon opportunities. Progressively, the direction is towards integration and consolidation as enterprises situated at different points of the value chain find business interest to control the specific areas of backward and forward linkages. The Gigafactories in development are already visible examples of integrated operations.

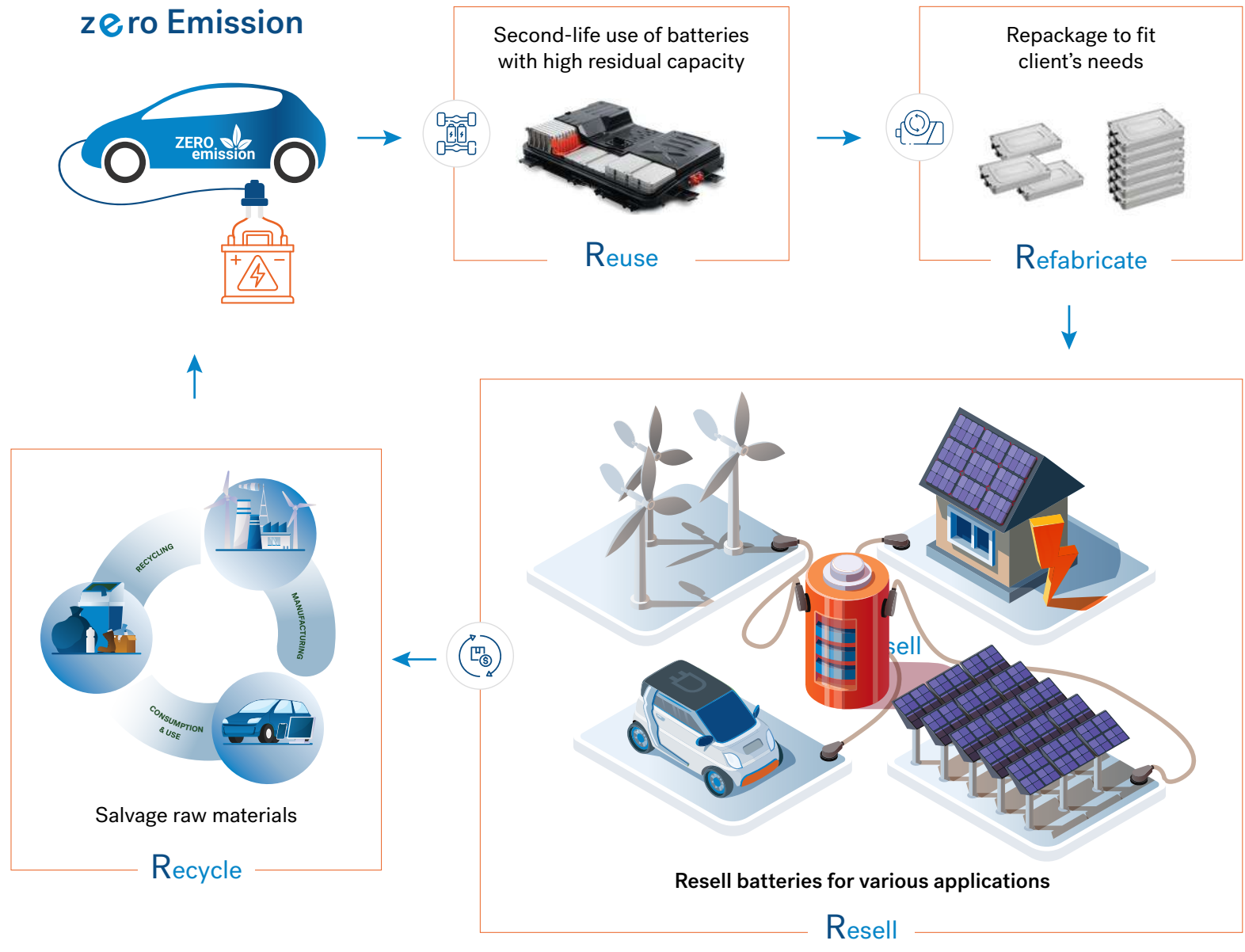
Emerging Integrated Structure in Recycling Business

Vertically integrated	Cross-value chain partnerships	In-house OEM recyclers
Individual companies operate across the value chain for end-to-end offering. There is limited reliance on partnerships.	Grouping of specialized companies to operate under a partnership agreement for recycling solutions.	Tie-ups between automobile OEMs and cell manufacturers for closed-loop production and supply chain control. This is evident in major upcoming Gigafactories.
umicore BASF We create chemistry	SOLVAY VEOLIA	Hydro northvolt

Source: McKinsey

The shifting industry structure and consolidation could also enable a wider space for new technologies, and innovations. The policy push to incentivize localization coupled with regulatory and business focus on the carbon footprint would also bring in competitive focus on carbon footprint. The investors' thrust on sustainability tracking of battery capacities adds to the momentum. Leading European companies in the battery recycling space, for instance, could be progressing towards a vastly lower carbon footprint than their Asian counterparts. For the similar reasons, Asian recyclers are also seeking entry in European markets for expansion.

End-of-life Batteries will be the Primary Source for Battery Recycling after 2040



8.0 | Outlook

8.1
Introduction

Over $300 billion of investment may be required, to meet the global battery demand generated by energy transition targets. This is reflected in automobile and battery OEM's capex trends which indicate they have already committed investments of this scale by 2030. However, investment opportunities in Gigafactories still require careful consideration by prospective investors and developers. The markets still face several uncertainties such as evolving battery chemistries, innovation in the manufacturing processes, changes in policies/regulations, strategic partnerships, and access to raw materials.

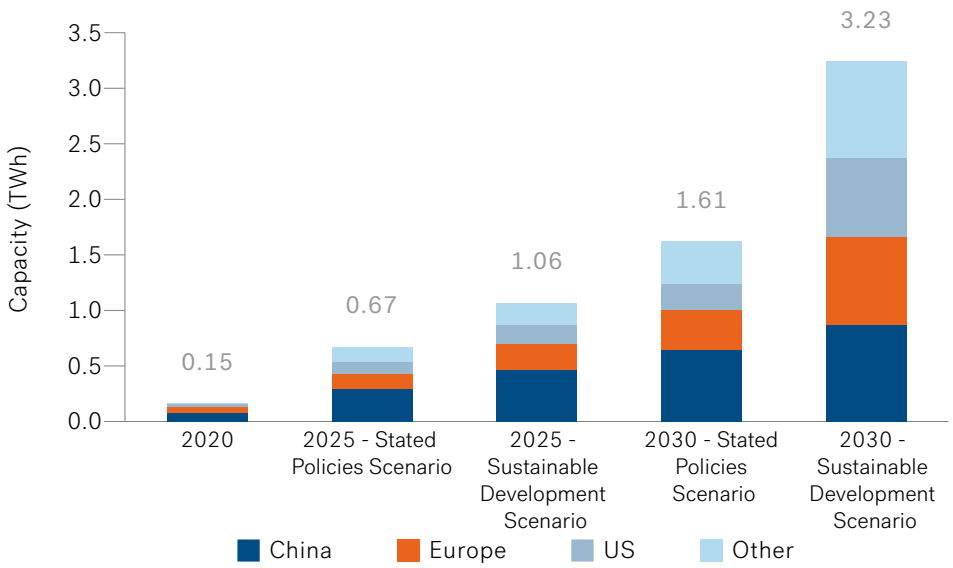
8.2

Demand/Opportunity in the Global Battery Business

Electric vehicles are becoming a readily adopted and conventional form of transportation. Demonstrated by the rising share of new electric vehicle sales, reaching over a third by 2035. The push to electrify transport in developed and emerging economies provides massive untapped investment opportunities, supported by government-funded purchase subsidies that derisk and simplify market entry. IEA's projection of 3.2TWh for announced planned electric vehicle production by 2030 may underestimate the latent demand present in emerging markets. This is because in some leading markets electric vehicle sales have outperformed market expectations, prompting policymakers to economize incentivising subsidies.

According to McKinsey approximately 90% of the global battery production demand originates from mobility applications. The remaining 10% is attributed to stationary storage and consumer electronics. However, Battery-based energy storage is progressively increasing in its demand. This is partly because it allows power generation to meet demand at all times, which provides short-term reliability to the grid. In addition, the cost of batteries has seen a price drop of 89% in the last decade (Mrsustainability,2021) and favourable regulatory changes in the European, US and Asian power markets have created a viable business model for battery-based storage investment.

IEA's Projection of Electric Vehicle Battery Demand



Note: Sustainability Development Scenario denotes the modelling scenario where all sustainability goals are met

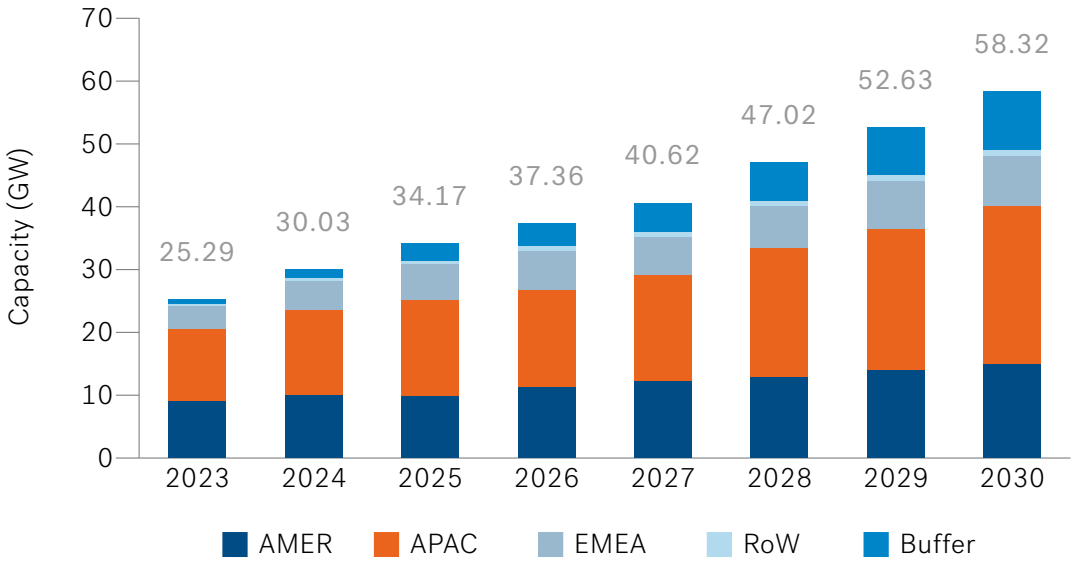
Source: IEA (as of October 2022)

BNEF projections indicate a five-fold rise in the annual battery storage installations by 2030, compared to the installed base in 2021. The global power capacity (GW) expansion is reinforced by the increasing number of grid-scale storage units. These typically entail higher unit sizes than off-grid or behind-the-meter units. Rising deployment for grid management roles is likely to involve higher capacity sizes in the respective markets.

The US storage market is the world's largest, however estimates indicate that China's market could surpass the US by 2025. This is partly due to China's 30GW energy storage by 2025 target. The US market meanwhile is characterized by an expanding project pipeline of utility-scale predominantly hybrid projects (storage- linked renewable energy). California, Texas and Southwest regions are the focal points of the US battery storage pipeline.

Countries with rising renewable energy penetration in the grid supply are likely to drive demand for grid-scale energy storage systems. As such, a market opportunity exists in long-duration energy storage (LDES), i.e., battery systems which that can offer storage above 4 hours' duration, as LDES may become a critical resource for grid operators to improve the reliability of the grid.

Projected Global Annual Battery Storage Installation



Note: Buffer is an estimate/headroom that is not explicitly allocated to any specific application.

Source: BNEF

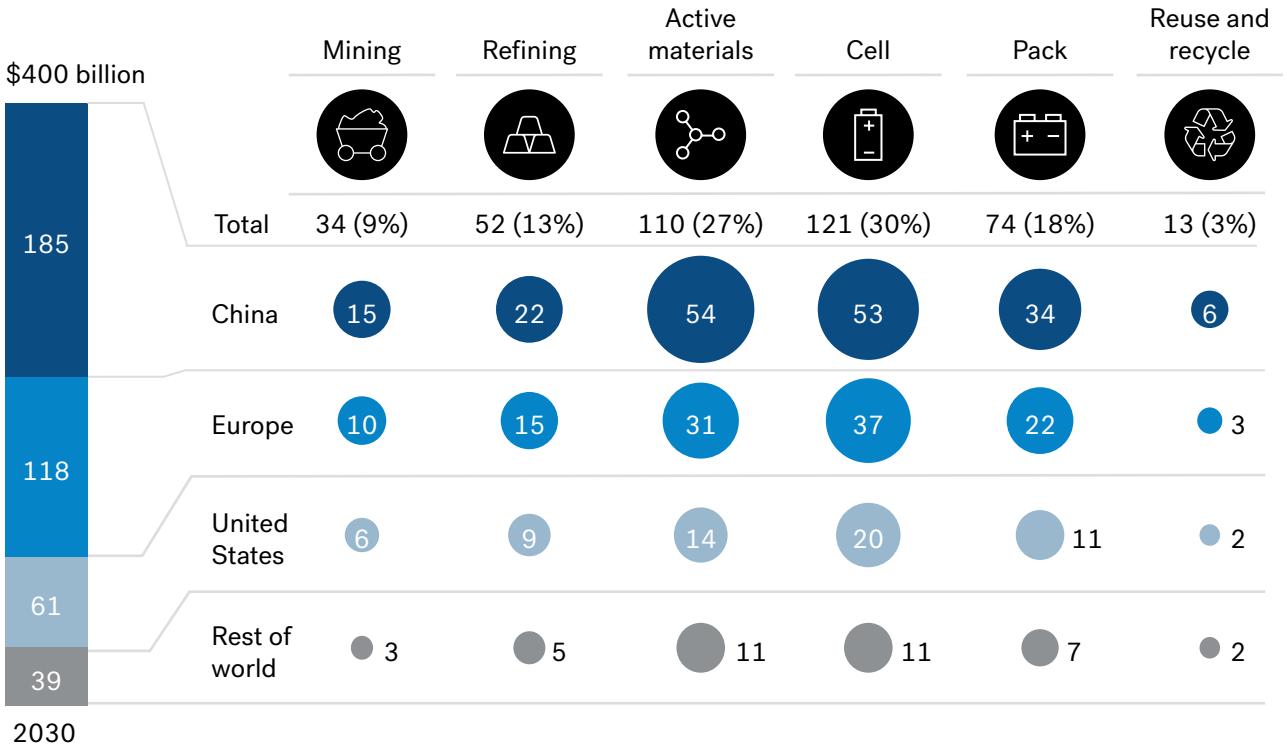
8.3

Battery Supply Chain Factors Influencing Investment

The revenue of batteries across the entire supply chain, per McKinsey's projections points to $400 billion by 2030 – five times the estimated level as of 2022, due to accelerating demand. The widespread use of Lithium-Ion batteries creates several opportunities across the supply chain. A significant share of the projected revenue pool across the supply chain is derived from cell manufacturing and active materials. In addition, aspects of the supply chain, such as recycling, emerge from recent emphasis on sustainability and have the potential for exponential growth.

Recent major advancements in battery technology have focused on enhancing battery material chemistry, cell energy density and cell-to-pack design. Many of the ongoing innovations seek to economize the scarce critical raw minerals' utilised in battery production. Notable examples are the use of silicon as a close substitute for the graphite used in battery anodes and the development of lithium metal anode variations. These modifications assist in increasing the battery's energy density.

Revenue Projection Scenario for 2030 across the Lithium-Ion Battery Supply Chain



Source: McKinsey

The dynamic technology space is not devoid of its own challenges. Firstly, the right technology must be selected based on the investments techno-economic feasibility . Once completed, swift action is required to acquire the necessary raw materials, machinery, other inputs, as well as the human resource base needed to operationalize the investment.

Furthermore, a majority of the emerging battery technologies will have to be introduced without the benefit of large- scale deployment testing. This adds a layer of uncertainty, due to the large number of suppliers and related quality and reliability standard commitments.

Emerging Alternatives in Commercial Deployment of Batteries

Battery technology	Adoption by manufacturers
Sodium-Ion	Globally leading battery producers CATL and BYD will be deploying sodium-ion batteries in the EV production lines within 2023.
Lithium Metal (solid-state batteries)	Battery technology provider QuantumScape has a joint venture with Volkswagen for testing deployment of its Lithium Metal prototypes.
Lithium Iron Phosphate (cathode)	Tesla is using LFP-based batteries in some of its vehicle production lines. Ford and Volkswagen announced plans to include LFP in their product offerings.

Source: MIT Technology Review; Electrek; Electrive and IEA

The choice of technology and its related parts boil down to raw material requirements. For Gigafactories, the Cathode and Anode active materials (about 70% of battery cell weight) are the most important consideration. The battery manufacturing pipeline imposes demand pressure on the existing competitive minerals market. The relevant minerals required for battery production include Graphite, Lithium, Nickel, Manganese and Cobalt. Other minerals in the list include Oxygen, Iron and Phosphorous. Notably, demand growth in Phosphorous, while not as crucial as other minerals, may face supply challenges due to its popular use in fertilizer production.

Innovations Impacting Battery Cell Components

	2010s		2020s		2030s	
Cathode	LCO	LMO LFP NMC/NCA	LFP NMC/NCA	LFP NMC/NCA LMFP/LMNO	NMC/NCA LMFP/LMNO Sulphur	LMFP/LMNO Sulphur
Separator/ electrolyte	Polymer/ liquid	Polymer/ liquid	Polymer/ liquid	Polymer/ liquid	Polymer/liquid/ advanced liquid/ semi-solid	Advanced liquid Semi-solid
Anode	Graphite	Graphite	Graphite	Graphite Graphite+ Silicon	Graphite and Silicon Lithium metal Silicon anode	Lithium metal Silicon anode
Casing	Cylindrical	Cylindrical Pouch	Prismatic Cylindrical Pouch	Prismatic Cylindrical Pouch	Cylindrical Prismatic Pouch	Cylindrical Pouch

Source: McKinsey

LCO: Lithium Cobalt

LMO: Lithium Manganese Oxide

LFP: Lithium, Iron, Phosphate

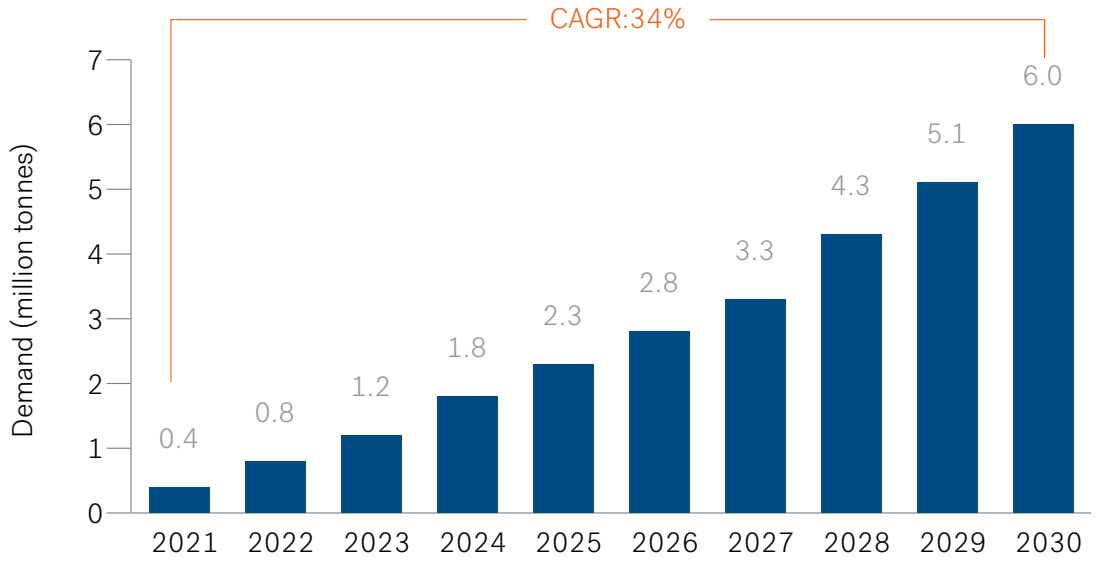
NMC: Lithium, Manganese Cobalt

NCA: Lithium, Nickel, Cobalt, Aluminum Oxide

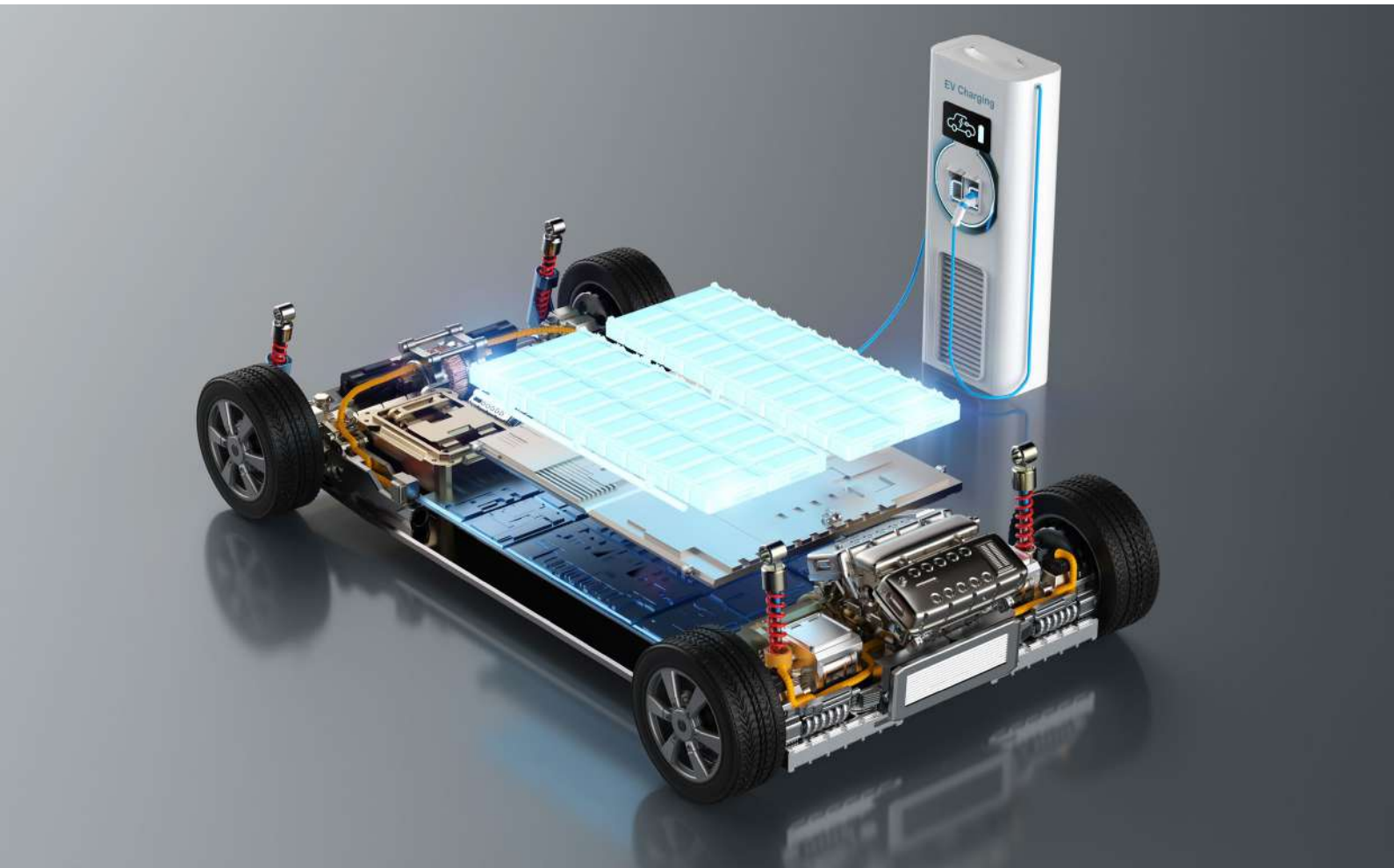
LMFP: Lithium, Manganese Iron Phosphate

LMNO: Lithium, Manganese Nickel Oxide

Projected Active Material Demand Globally



Source: PwC (Strategy&)



8.4
Investment outlook

The capex required to finance the increased battery production demand is subject to a multitude of factors such as location, policy support/incentives, technology choice and the like. This is not limited to battery production alone . Other upstream/midstream segments such as mining, refining, and processing will require a similar scale up to accommodate demand. Tesla's investment outlook, for instance, amounts to $500 billion worth of spending, as it spans across the value chain.

OEMs' Capex Commitments Toward Battery Capacity by 2030

Company	Partnerships	Battery investment
BMW	Battery: Envision AESC, Northvolt, CATL, EVE Energy, Samsung SDI, Solid Power, ONE Materials: European Lithium, Glencore, Ganfeng Lithium, Green Lithium, Lilac Solutions, Livent, Managem, Mangrove Lithium, Umicore OEM: Great Wall, Brilliance, Stellantis	$10.0B
BYD	Materials: Chengxin Lithium, Easpring, Shanshan, Youngy Lithium OEM: Toyota, Daimler, GAC, FAW	$7.2B
Changan	Battery: CATL, BYD, CALB, A123 OEM: Ford, Suzuki, Stellantis, Mazda, Nio, Jiangling, Huawei	$7.5B
Ford	Battery: LGES, SK On, Panasonic, Samsung SDI, Solid Power Materials: BHP, Huayou Cobalt, Ioneer, Lake Resources, Lilac Solutions, Liontown Resources, Rio Tinto, Syrah Resources, Vale OEM: Volkswagen, Changan, JAC, Jiangling	$7.0B
Geely	Battery: CATL, LGES, Farasis, CALB, Sunwoda, SK On OEM: Mercedes, Volvo, Renault, Lotus, Proton, Lifan, Baidu, WM Motor	$6.2B
General Motors	Battery: LGES Materials: Controlled Thermal Resources, Glencore, Livent, Posco Chemical OEM: Honda, SAIC, Wuling, FAW	$7.5B
Honda	Battery: CATL, LGES, Blue Energy, Ultium, Envision AESC Materials: Hanwa OEM: GM, GAC, DFM	$2.2B
Mercedes-Benz	Battery: LGES, SK On, CATL, Farasis, Envision AESC, Factorial Energy, StoreDot Materials: Rock Tech Lithium, Sila Nano OEM: Geely, BYD, BAIC, Nissan, Rivian	$30.0B
Nio	Battery: Envision AESC, LGES, CATL, Sunwoda OEM: DFM, Renault, Mitsubishi	$1.0B
Nissan	Battery: Envision AESC, LGES, CATL, Sunwoda OEM: DFM, Renault, Mitsubishi	$5.0B
Renault	Battery: Envision AESC, LGES, Verkor Materials: Vulcan Energy, Managem, Terrafame OEM: DFM, Geely, Brilliance, Nissan, Mitsubishi, Samsung	$2.4B
Rivian	Battery: Samsung SDI OEM: Mercedes	$2.5B
SAIC	Battery: CATL, CALB, Guoxuan, Sunwoda Materials: Tsingshan OEM: GM, VW, Wuling, GAC, WM Motor	$1.0B
Stellantis	Battery: ACC, CATL, BYD, Svolt, LGES, Samsung SDI, Factorial Energy Materials: Controlled Thermal Resources, Vulcan Energy OEM: GAC, BMW, DFM, Changan	$24.0B

Company	Partnerships	Battery investment
Tesla	Battery: Panasonic, LGES, CATL, BYD Materials: Albemarle, BHP, CNGR, Core Lithium, Fangyuan, Ganfeng Lithium, Glencore, Huayou Cobalt, Vale, Kamoto Copper, Liontown Resources, Livent, Minara Resources, Norilsk Nickel, Prony Resources, Sumitomo Metal, Syrah Resources, Talon Metals, Umicore, Yahua Lithium	$200.0B
Toyota	Battery: CATL, Panasonic, GS Yuasa, Toshiba, EV Energy, Fin Dreams (BYD), Prime Planet Materials: BHP, Ioneer OEM: BYD, FAW, GAC, Mazda, Subaru, Suzuki, Daihatsu	$13.6B
VinFast	Battery: ProLogium	$2.0B
Volvo	Battery: LGES, SK On, Northvolt, CATL, Samsung SDI, Guoxuan (Gotion), QuantumScape Materials: Ganfeng Lithium, Huayou Cobalt, Tsingshan, Nano One, Umicore, Vulcan Energy, CBMM OEM: FAW, SAIC, JAC	$3.3B
VW Group	Battery: LGES, SK On, Northvolt, CATL, Samsung SDI, Guoxuan (Gotion), QuantumScape Materials: Ganfeng Lithium, Huayou Cobalt, Tsingshan, Nano One, Umicore, Vulcan Energy, CBMM OEM: FAW, SAIC, JAC	$57.0B

Source: Reuters

Announced per unit capital costs indicate that US battery projects could be costlier than their Chinese counterparts. The Chinese influence on the global battery value chain could be moderated with sustained subsidies and protectionist policies in the US and Europe. A recent Goldman Sachs' analysis report estimated that $160 billion worth of investment by 2030 is required by the US and Europe to pare their electric vehicle battery dependence on China. A similar report by PwC arrived at similar conclusion, with the global investment prediction of roughly $300 billion, including investment from China. Multiple structures will together contribute to such an investment spending – including state funding, joint ventures/ strategic partnerships, public SPACs and private equity, among others.

About Pan American Finance

Pan American Finance has a deeply experienced team, combining professionals with financial expertise (investment banking, capital markets) and operational experience (engineering, project development, business process management). These complementary skill sets allow us to understand the most attractive opportunities for growth within the following value chains.

Sustainable Energy

Climate Finance

Sustainable Living

Disclaimer

This presentation is for informational purposes. The information contained in this presentation does not purport to be complete. All of the information contained herein is subject to change without notice. Each recipient of this presentation should conduct its own independent investigation and assessment of the contents of this presentation and make such additional enquiries as it deems necessary or appropriate

Pan American Finance, LLC and its affiliate PAF Securities, LLC (together "Pan American Finance" or "PAF") have based this document on information obtained from sources it believes to be reliable, but which have not been independently verified. Except in the case of fraudulent misrepresentation, PAF makes no representation or warranty (express or implied) of any nature or accept any responsibility or liability of any kind for the accuracy or sufficiency of any information, statement, assumption, or projection in this document, or for any loss or damage (whether direct, indirect, consequential, or other) arising out of reliance upon this presentation. Statements made in this presentation relating to the fund are intended as a summary and not a complete description and may be subject to change. PAF is under no obligation to keep current the information contained in this document.

This document is not intended for distribution to, or use by, any person or entity in any jurisdiction or country where such distribution or use would be contrary to law or regulation. The information herein does not constitute an offer to sell or solicitation of an offer to make investments in designated investments in any jurisdiction. The information herein does not take into account the investment objectives, financial situation or needs of any person and should not form the basis of any investment decision.

The returns and valuations in this presentation are preliminary and tentative only. Nothing in this presentation is, or should be relied on as, a promise or representation as to future developments.

PAN AMERICAN FINANCE

Contact us

Pan American Finance LLLP, PAF Securities LLC and Pan American Finance (UK) Ltd

Miami office: 601 Brickell Key Drive, Suite 604, Miami, Florida 33131

London office: 48 Dover Street, London W1J 8HS, United Kingdom

Tel: +1 (305) 577 – 9799 • Fax: +1 (305) 577 – 9766

www.panamfinance.com