INSIGHT

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Electric Vehicle Battery Supply Chain Analysis

How Battery Demand and Production Are Reshaping the Automotive Industry

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This electric vehicle battery supply chain report and database is the independent work and research from Automotive from Ultima Media, the business intelligence unit of Ultima Media and Automotive Manufacturing Solutions.

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1. Executive Summary

1.1 Lithium-Ion Batteries Will Reshape Automotive Supply Chains

Lithium-ion batteries are central to the success of automotive OEMs' electrification strategies in terms of improving the driving range and price competitiveness of electric vehicles (EVs). Carmakers and battery manufacturers are aiming to improve battery quality and bring down prices to below $100 per kilowatt hour (KWh), a rate at which EVs can compete with traditional internal combustion engine (ICE) vehicles.

However, battery technology and prices are not the only factors at play. As EV demand rises, it is becoming especially critical for manufacturers to manage the procurement and production of batteries. And there are serious questions over whether supply will keep up with demand across the battery supply chain.

Even before the Covid-19 crisis, there were growing reports of OEMs facing production issues as a result of difficulties sourcing batteries and cells. In the aftermath of global shutdowns and subsequent restarts following the first wave of the pandemic, EV production again felt the squeeze in supply as demand ramped up, impacting output of key products like Tesla's Model 3, for example.

More recently, the wider shortage of electronic components, including semiconductors and microchips, has compounded these issues. There are further bottlenecks in the supply of lithium and certain materials and minerals in the battery supply chain, with the risk of price spikes.

Such supply issues could lead to potential lost sales, unnecessary costs and lower profits for manufacturers at a particularly critical time. Analysis of the fast-developing battery industry reveals why many of these teething problems arise. Not only are there a new set of companies compared to the supply chain for internal combustion engines (ICEs), but the EV battery chain introduces new technologies, regulations, safety and environmental concerns.

But growth of the sector is set to be exceptional, propelled by 20% compound annual growth rates (CAGR) for global EV sales over the next decade. Battery production capacity will likely need to outpace EV demand to meet the rising need for lithium-ion power in other sectors, along with mitigating supply and production constraints. We estimate that global capacity for lithium-ion batteries will increase from 450 gigawatt hours (GWh) in 2020 to more than 2,850 GWh by 2030.

This supply chain will help to redefine the automotive industry, bringing strategic opportunities for many manufacturers and suppliers – but also considerable risks and disruptions.

This report tracks the rising scale and pace of the battery chain and maps out the detail of its fast-emerging supply chain. It will help OEMs, suppliers and service providers to better understand new requirements and evaluate the investments that the battery value chain will demand. One clear finding is that capitalising on the electric revolution will not just be about having the best technology or price – but also the need to build, secure and, where necessary, change battery capacity in different regions. This report will help stakeholders across the supply chain to anticipate and make these decisions.

1.2 The Future of Battery Supply Will Be Diversified

The battery supply chain is highly complex, made up of a number of critical minerals, materials and components, many sourced and produced from companies relatively new to the automotive sector. The locations for materials stretch across regions, including China, Africa, Australia and South America. The production of lithium-ion cells is also largely concentrated in Asia.

As the battery represents 30% or more of the value of a vehicle, established OEMs and tier suppliers – not to mention governments – want to take more control of the battery chain, rather than see profits and jobs shift to other players and locations. It has been estimated that a complete European battery supply chain, for example, from upstream materials to recycling, would be worth up to €250 billion ($303 billion) a year and could create 4m jobs across the EU.

OEMs such as the Volkswagen Group, Toyota, General Motors and BMW are establishing new supply partnerships and joint ventures to increase lithium-ion battery and cell production, in some cases with a view to commercialise this capacity by selling batteries to other OEMs. Tesla, meanwhile, is taking steps to gain more control and vertically integrate more aspects of battery production, including cell manufacturing but also the mining and processing of key materials. Other OEMs are considering the strategy that works best for them. But increasingly, carmakers are looking to a diversified battery strategy.

There are also emerging legislative and regulatory dimensions to this battery race. National governments in Europe and at the EU level, for example, are investing state money in supporting the development of a regional battery supply chain – as well as legislating for higher localisation rates. Trade agreements such as the EU-UK free trade deal, as well as the US-Mexico-Canada Agreement (USMCA), include targets for increasing regional battery content. In February, Joe Biden, the new US president, also signed an executive order to undertake a strategic review of critical supply chains, including for large capacity batteries for electric vehicles, as well as for semiconductors. Increasingly, over dependence on a single region or set of suppliers is seen not only as a competitive issue but also one of potential national security concern. Some experts, such as Simon Moores, head of lithium-ion battery data firm Benchmark Minerals, have referred to the push for regional battery production and supply chains as an ‘arms race’.

The competition is increasingly contentious. In the US, LG Energy Solution – the battery-focused division spun off by South Korean battery giant LG Chem – filed a trade-secret lawsuit against SK Innovation (SKI) that has resulted in a 10-year ban on SKI selling and importing batteries in the US (with an exception for supplying existing contracts with Volkswagen and Ford), raising serious questions over current supply and battery production plans. It also highlights how important securing and diversifying battery supply will be for OEMs.

Despite these challenges, a firm outline of an expanding battery supply chain is clearly taking shape. Battery manufacturers and startups have announced construction of more than 80 new gigafactories across the globe to produce lithium-ion cells and batteries, and many more will be needed over the next decade. Europe, though still far behind China and Asia in battery and cell production, is set to emerge as a major player, with the most announcements for new gigafactories so far. The US and North America have lagged behind but are also set for growth. China is expanding its base even further and will likely play a major role in the global battery and finished electric vehicle supply chain.

There is no guarantee that the announced gigafactories will all become reality, nor that the ambitious battery capacity targets that many battery suppliers have set will be achievable. These factories, after all, require tremendous capital investment, and they are dependent on fast-changing technology. The profitability of such operations is also far from a certainty. And yet, the demand for this capacity is set to grow exponentially.

There are also questions over the strategic role that EV batteries will ultimately play for OEMs. Some experts suggest that batteries are becoming commodities and will eventually offer little difference in price or performance. Research for this report indicates the contrary: EV batteries are a long way from being truly commoditised, with considerable differences in price, quality, driving range and energy density across different chemistries and combinations.

That is partly why it has become even more important that OEMs develop multiple supply relationships and partnerships with battery specialists. Whereas OEMs previously tended to have exclusive battery supply agreements, they are increasingly pursuing the best quality and competitive technology available, including a mix of contracts with multiple players and even in-house production. We ultimately expect that OEMs will want such flexibility that they could even switch battery suppliers mid-product cycle, so as to take advantage of available supply and improvements in technology.

The race to electrification will inevitably bring pain and disruption to many parts of the supply chain. For OEMs, developing and producing ICE powertrains have been part of how brands differentiate themselves; phasing out petrol and diesel threatens many manufacturing and engineering jobs, too. As EV powertrains have fewer components, many existing suppliers may be threatened and even eliminated.

But electrification and especially the battery supply chain represent one of the most significant growth opportunities across the automotive industry. The new manufacturing networks, supply patterns and business relationships will play a large role in defining the next generation of the automotive value chain.

2. Market Definitions

2.1 Defining the Automotive Battery Supply Chain

- This report focuses only on batteries for tractive power or powertrain – as used in electric and hybrid electric vehicles. It does not cover the conventional, usually lead acid (Pb) batteries used for starting an engine and for ancillary functions such as lights, dashboard and other electrical systems.
- Batteries for vehicle powertrains are currently more than 99% of lithium-ion chemical composition. However, in some applications, such as the smaller batteries fitted to hybrids such as the Toyota Prius, the battery is the Nickel Metal Hydride type (NiMH). However, even that composition is changing with later model versions moving to lithium-ion.
- Both passenger vehicles and commercial vehicles are included in the definition because there is significant innovation and growth from vehicles such as buses and trucks.
- The report predominantly focuses upon conventional 4-wheel vehicles and does not specifically refer to 2-wheel electric motorcycles, e-bicycles or e-scooters. However, the battery supply chain detailed in this report may also supply those products.
- The report lists a wide range of lithium cell suppliers and manufacturers supplying the automotive industry. However, whilst many battery companies exclusively cater to automotive, some also supply a mixture of sectors such as energy storage, consumer electronics and others. We have also included some lithium battery cell manufacturers that currently only supply to non-automotive sectors, because they are still part of the wider lithium battery supply chain (albeit at lower volumes). As EV volumes rise, there is a possibility that these manufacturers will also get involved in supplying the automotive sector.
- The report does not focus on companies predominantly involved in the NiMh or Pb battery supply chains, although there is some overlap between those companies and the lithium-ion battery supply chain.

2.2 Note on Units

This report refers to various electrical power units. They refer to the following energy units:

KWh = 1,000 (or one thousand) watts for 1 hour
MWh = 1,000,000 (or one million) watts for 1 hour
GWh = 1,000,000,000 (or one billion) watts for 1 hour

A typical EV has a battery pack of 50 KWh (50,000 watts for 1 hour). A factory producing 1 GWh per year of battery cells can therefore supply around 20,000 vehicle battery packs per year.

2.3 Lithium-ion Battery Types

The term 'lithium-ion' battery is an umbrella term that refers to a broad group of battery chemistries that include lithium, but which are subtly different. Within this category there are significantly different chemistries with a range of different price and performance characteristics suitable for different applications. In development there are various other battery types such as lithium-sulphur (Li-S), lithium-air (Li-Air) and solid state but these are yet to be commercialised.

Table 2.1 summarises the key types of lithium-ion batteries that OEMs are using in electric and hybrid vehicles.

Table 2.1 Lithium-Ion Battery Types

Type	Description
LFP	**Lithium Iron Phosphate.** A type of cathode material containing LiFePO4. LFP is one of the safest li-ion battery cathodes, but with lower specific energy.
LCO	**Lithium Cobalt Oxide –** LCO has high specific energy and high cost due to high cobalt content. It is cathode material with a chemical formula of LiCoO2. Models that use this technology include the Tesla Roadster and Smart ForTwo EV.
LMO	**Lithium Manganese Oxide** – LMO has around 30% lower energy density than LCO, hence most blend with Lithium Nickel Manganese Cobalt Oxide.
NMC	**Lithium Nickel Manganese Cobalt Oxide.** This composition can provide high specific energy or power with high density and thermal stability. That proportion of N, M and C is denoted by the numbers NMC111 and varies by company having switched from NMC111 to NMC442 to NMC622, and now NMC811, with the exact blend remaining secret. The LMO-NMC combination has been used by multiple EV manufacturers in the past including Nissan Leaf, Chevy Volt and BMW i3.
NCA	**Lithium Nickel Cobalt Aluminium Oxide** offers high specific energy and power for specific applications. Tesla is the only OEM to use this chemistry including for the Model 3 and the first Model S in 2012.
NCM	**Lithium Nickel Cobalt Manganese** contain cathodes containing nickel, cobalt and manganese.
Solid State	**Solid state batteries** use a solid separator material such as ceramic instead of the liquid separator as used in conventional lithium-ion batteries. However, solid state batteries still use lithium in the battery chemistry and are a related, but not entirely separate battery technology.

Source: Automotive from Ultima Media

3. The Race to Build the Battery Supply Chain

3.1 Battle of The Value Chain

There are clear opportunities that arise across the supply chain in the transition to electrification, with many aspects likely to change OEM and supplier relationships.

For example, OEMs have traditionally developed and produced ICE powertrains in house. But in the race to electrification, manufacturers are increasingly reliant on new suppliers across a complex and valuable supply chain. This shift in technology and production creates space for automotive suppliers – some traditional, others new to the industry – to capture (or re-capture) value.

For example, production of lithium-ion batteries, including key components such as cells, have been predominantly located in Asia. American and European OEMs are to this extent already on the backfoot in terms of competing with players in China, Japan and South Korea. The battery players who have emerged in the lead – including South Korea's LG Energy Solution, Japan's Panasonic and China's CATL – continue to establish major battery cell manufacturing bases in Europe and North America, along with a range of startups and even OEMs themselves.

Automotive manufacturers are pursing different business models to develop this regional value chain, including through joint ventures with cell suppliers, vertical integration and agreements to 'lock in' the supply of raw materials through large-scale purchasing agreements.

However, securing battery cells only addresses part of the overall manufacturing and supply chain challenge. There are many other dimensions to the total lifecycle of the battery value chain, including maintenance and recycling requirements.

Perhaps even more fundamentally, the automotive industry continues to struggle following the sharp fall in global vehicle sales in the wake of the Covid pandemic, leaving many OEMs and suppliers with shrinking margins. The transition to battery and EV supply chains puts a huge amount at stake for the automotive supply base. The entire industry needs to maximise its value proposition and cost base in the hopes of at least retaining its already tight operating margins.

3.2 Electric Vehicle Demand Forecast

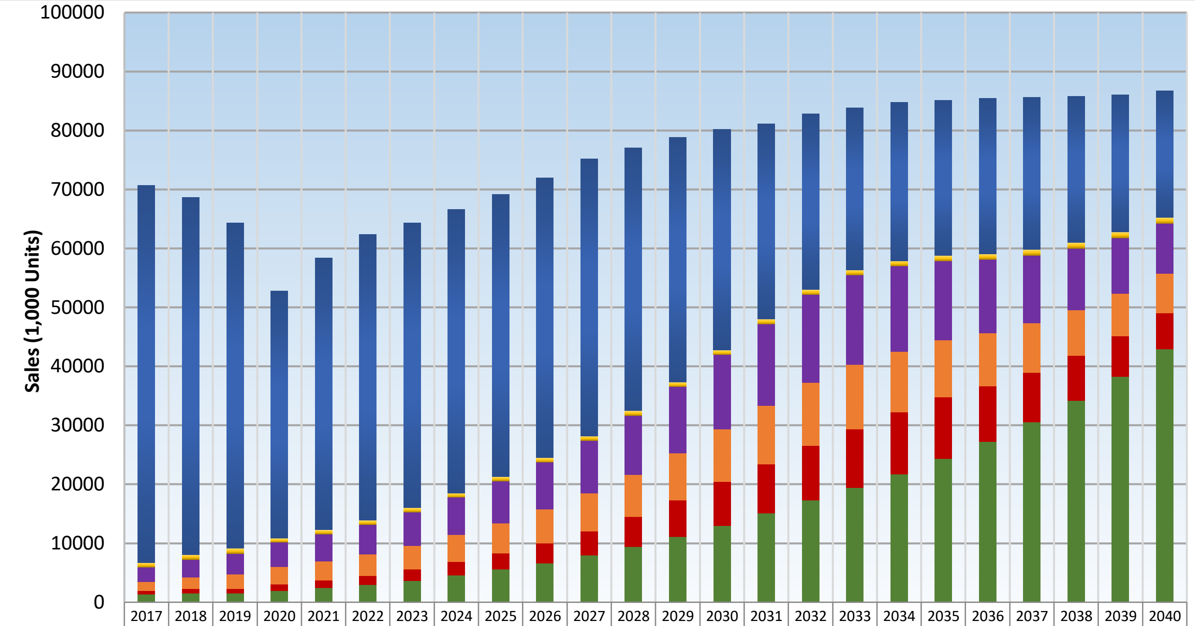
The battery supply chain is developing at a stunning pace even compared to expectations just a few years ago. The push to electrification is becoming increasingly central to the long-term prospects of many manufacturers.

Pre-Covid, a variety of factors were driving vehicle electrification, but the most significant was regulatory pressures, mainly in Europe and China and to a lesser extent in other regions, such as Japan. Post-Covid, consumer demand for battery and plug-in electric vehicles (PHEVs) has accelerated, spurred by a mix of improving technology, incentives from governments and OEMs.

According to our analysis, global electric passenger vehicle sales rose around 33% year-on-year in 2020 even as overall vehicle sales fell by around 20%. In Europe, sales of EV and PHEVs more than doubled in 2020. Globally, the share of EVs and PHEVs rose from 3.4% in 2019 to 5.6% (of which 3.7% were pure EVs), according to our analysis.

Combining EVs and all types of hybrids (including mild, full, and plug-in hybrids) accounted for 19.2% of the powertrain mix, meaning nearly one-fifth of all global passenger vehicle sales already have some sort of lithium-ion battery. By 2030, we forecast that 53% of global new vehicle sales will be fully electric or hybridised in some way.

Figure 3.1 Global Passenger New Vehicle Powertrain Forecast by Type 2021-2040 (Units)



	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Pure ICE	63950	60580	55200	41952	46147	48455	48309	48116	47875	47445	46970	44622	41498	37348	33128	29815	27430	26881	26344	26344	25817	24784	23297	21433
NGV + FCV	800	850	900	630	693	714	728	743	757	773	788	804	820	836	853	870	888	905	923	942	961	980	999	1019
MHEV	2500	3000	3500	4200	4620	5082	5692	6375	7140	7997	8956	10031	11235	12583	13841	14948	15247	14485	13471	12528	11526	10489	9440	8496
HEV	1500	2000	2500	3000	3300	3630	4066	4553	5100	5712	6397	7165	8025	8988	9887	10677	10891	10346	9622	8949	8322	7740	7198	6694
PHEV	650	750	750	1050	1260	1537	1875	2288	2791	3405	4155	5069	6184	7420	8385	9224	9962	10460	10460	9414	8472	7625	6863	6176
EV	1300	1500	1500	1950	2399	2926	3658	4572	5532	6639	7900	9401	11093	12979	15056	17314	19392	21719	24325	27244	30514	34175	38276	42869

Powertrain type: Internal Combustion Engine (ICE), Natural Gas Vehicle (NGV), Fuel Cell Vehicle (FCV), Mild Hybrid Electric Vehicle (MHEV), Hybrid Electric Vehicle (HEV, or 'Full' Hybrid), Plug-in Hybrid Electric Vehicle (PHEV), Electric Vehicle (EV, or 'Battery' Electric Vehicle)

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

Figure 3.2 Global New Vehicle Powertrain Forecast Marketshare by Type 2020

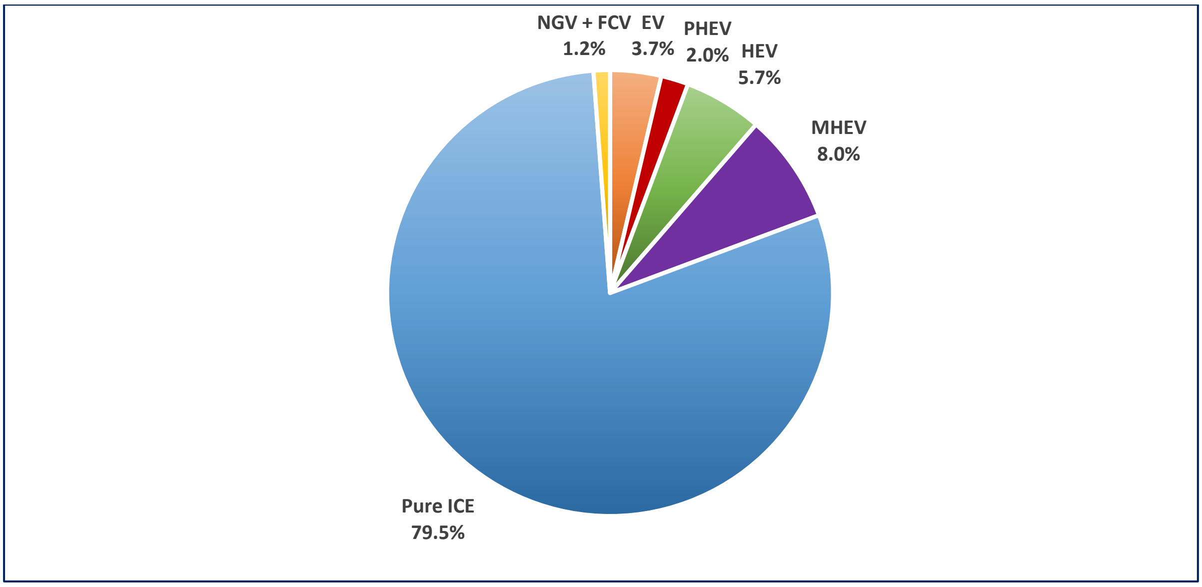


Figure 3.3 Global New Vehicle Powertrain Forecast Marketshare by Type 2030

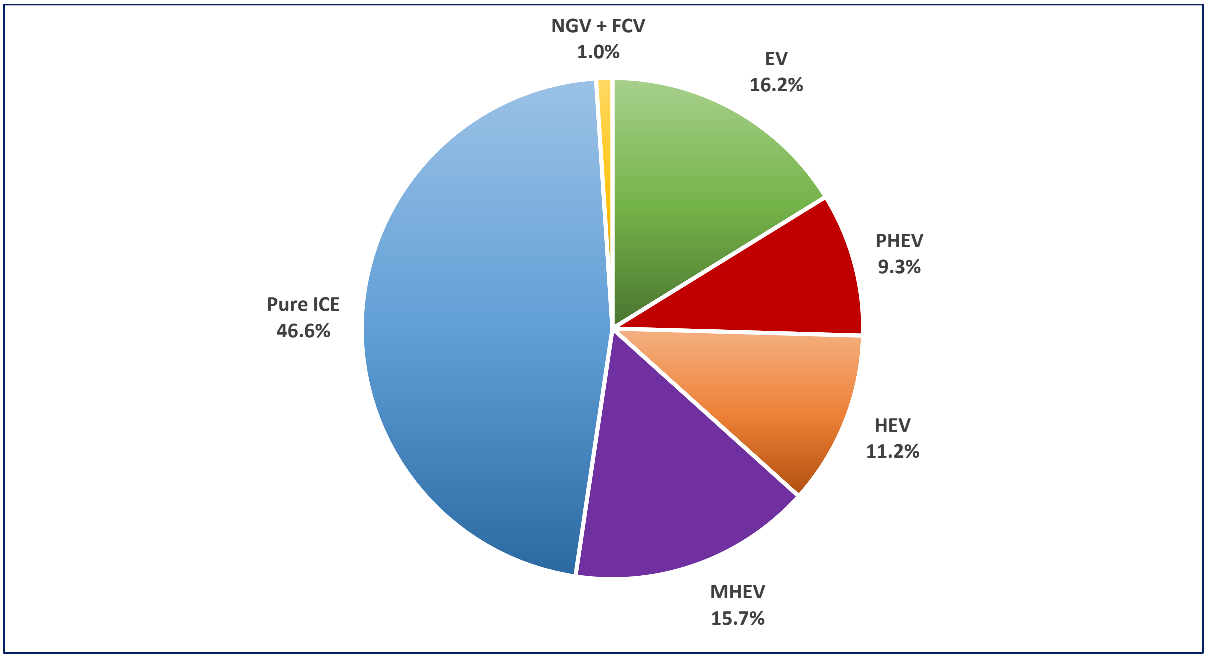
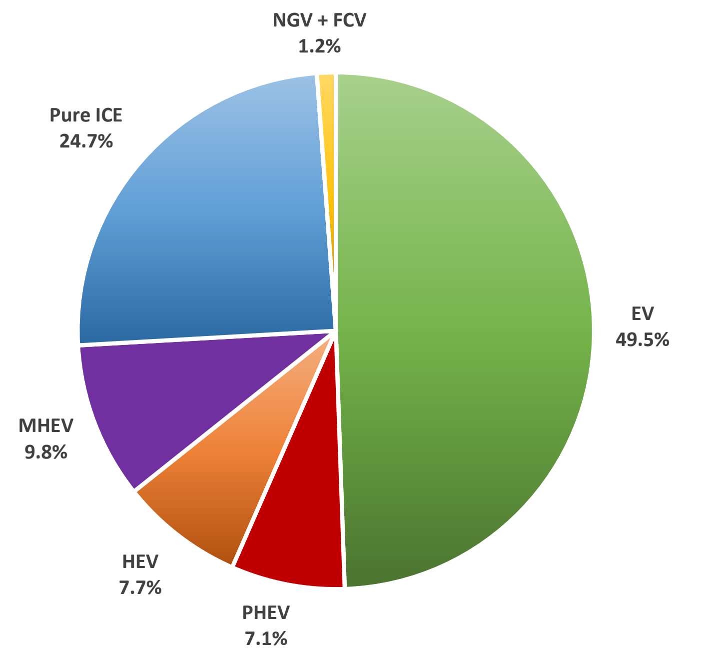


Figure 3.4 Global New Vehicle Powertrain Forecast Marketshare by Type 2040



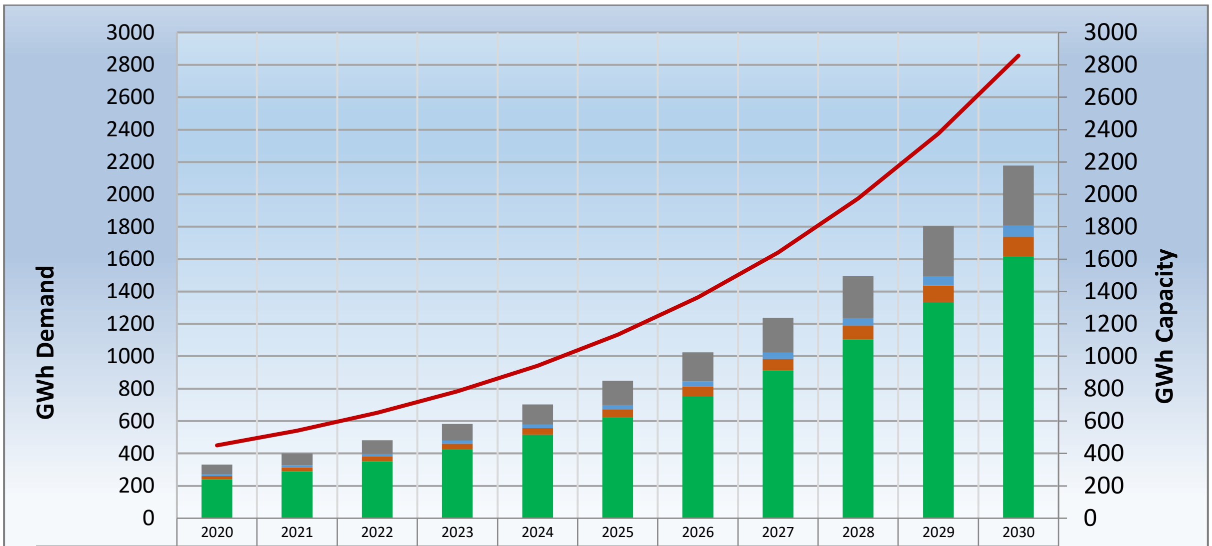
While we forecast global EV sales to grow by a remarkable 21% CAGR over the next decade, the increase in battery production and capacity will be even higher. That is because the kilowatt hour (KWh) battery capacity required per vehicle is likely to rise as well. We estimate the average vehicle battery capacity will increase by 3% per year over the next decade as battery prices fall, allowing OEMs to fit larger capacity batteries to improve driving range. Thus far, fully electric variants have also tended to be of the smaller to mid-size models in an OEMs range, which were easier to electrify to meet emissions targets. But OEMs will increasingly be compelled to electrify most if not all of their fleets. The increase in the e-SUV globally and electric pickup truck segment in North America, for example, will likely increase battery sizes and thus battery demand.

Demand for other home, consumer and energy storage products will also increase the need for gigawatt hour capacity.

Battery production will thus need to increase faster than EV sales volumes would suggest. Furthermore, battery capacity needs to exceed demand significantly because the theoretical maximum capacity of battery plants is rarely achieved as a result of technical and logistical issues. For example, there may be a slowdown due to a shortage of cobalt, cathodes or quality control issues, which could mean that not all cells produced will be viable. A rule of thumb is that a realistic production output is around 70% of the stated maximum capacity.

We forecast that while battery demand will rise from 330 GWh in 2020 to 2,180 GWh in 2030, battery production capacity will rise in the same period from 450 GWh to more than 2,857 GWh.

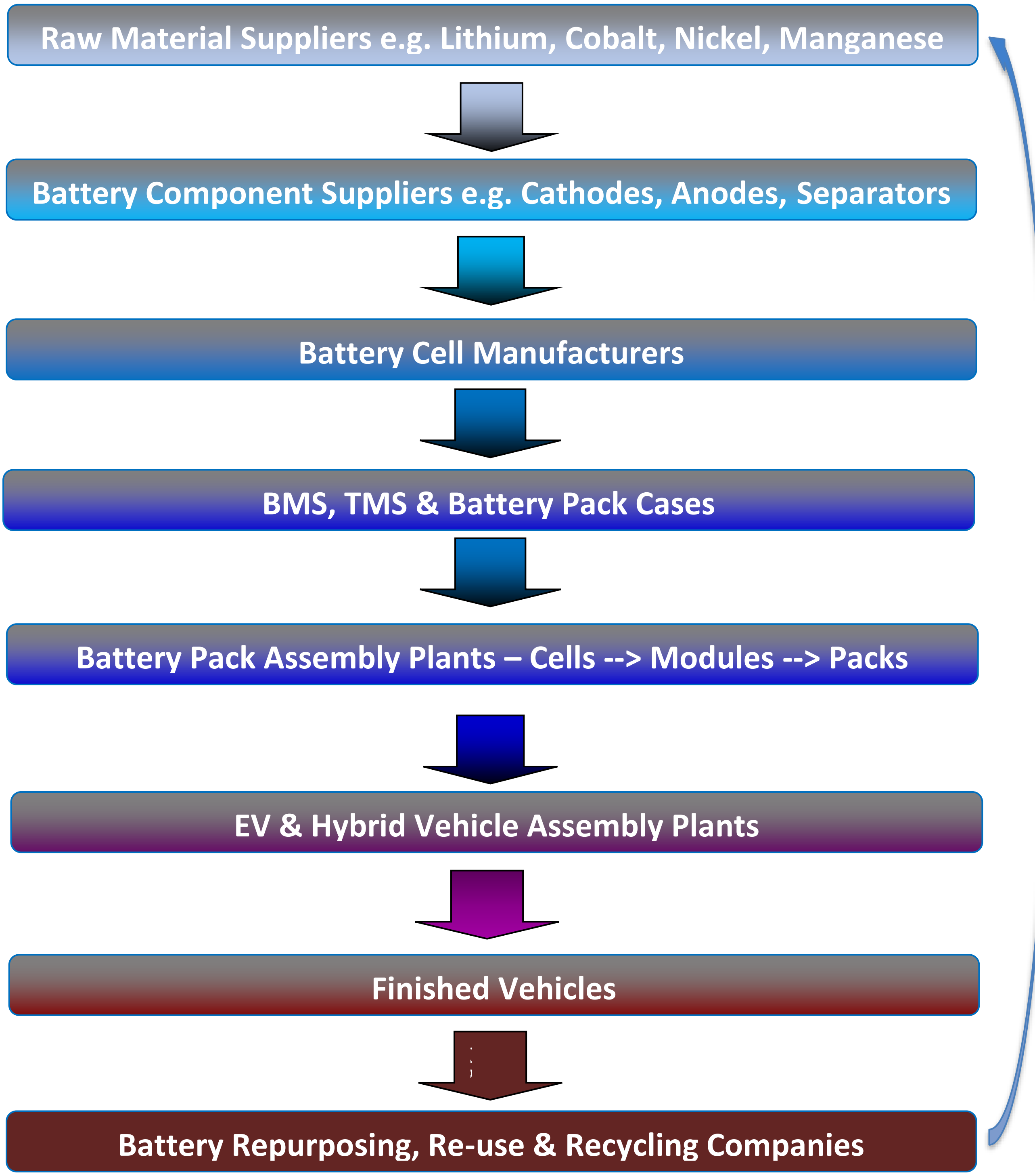
Figure 3.5 Global Lithium Battery Demand & Capacity Forecast by Sector 2020-2030



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Consumer	60	72	86	104	124	149	179	215	258	310	372
Storage	11	13	16	19	23	27	33	39	47	57	68
Electric CV	20	24	29	35	41	50	60	72	86	103	124
Electric PV	240	290	351	425	514	622	753	911	1103	1334	1615
Capacity	450	541	651	783	942	1134	1364	1641	1974	2375	2857

Figure 3.6 Battery Supply Chain Schematic Diagram

To understand and analyse the automotive battery supply chain, we have broken down the value chain into eight key stages. As volumes ramp up, the 'closed-loop' nature of the supply chain is becoming more important, including where batteries are recycled, and the raw materials fed back into the start of the supply chain to mitigate potential shortages of raw materials.



3.3 Localisation of the Battery Supply Chain

Not only is there an arms race for the battery supply chain, but the impetus to localise production grows as EV volumes accelerate. Logistics and supply costs play a key role here, as batteries are heavy, costly and complicated to move because of varying regulations around transporting hazardous goods. Carmakers such as BMW are organising supply chains around local lithium-ion battery manufacturing in all regions where it is feasible, in part to keep logistics costs to a minimum.

Although batteries are generally cheaper to manufacture in low-wage regions in Asia and specifically China, supply and transport costs are likely to eliminate that cost advantage when shipping to Europe or North America, for example. The localisation of battery production is also increasingly preferred because it helps to ensure visibility and security of supply. Increasingly, OEMs and regulators are focusing more on the sustainability of the EV and battery supply chain.

The Covid-19 crisis has further exposed weaknesses in single-sourced purchasing, lean inventory strategies and over-reliance on limited supply bases. The ongoing shortages of semiconductors and microchips highlight a potential problem for battery supply chains. Currently, China, South Korea and Japan dominate battery cell manufacturing, while raw minerals are sourced from several primary locations including Chile, China, Africa, as well as the US, Canada and Australia for some materials.

Even as battery cell manufacturing increases in North America and Europe, regional plants will still be reliant upon imports of cell components and raw materials from far afield, including politically sensitive areas such as cobalt mining from the Democratic Republic of Congo (DRC).

As hybrid and EV penetration increases, this reliance on particular regions and a narrow range of specialist companies will remain an inherent and growing vulnerability – not least when the supply chain is hit by shocks and shortages.

Put simply, manufacturers will need to build up commensurate raw material and cell component capacity alongside cell manufacturing plants. Otherwise, the full battery value chain is at risk not only of disruption but of considerable value being lost to Asia.

This risk is not lost on major OEMs or on governments keen to gain the investments and jobs expected to accompany it. But higher labour costs and environmental standards, along with lower economies of scale for now, will make it harder to suppliers and manufacturers to compete with countries in Asia.

That is partly why governments are targeting the battery value chain through legislation, including environmental standards and minimum sourcing levels, which are clearly aimed at discouraging imports and ramping up regional battery sectors. The European Commission, for example, has set a list of green criteria that imported batteries will need to meet, ranging from sustainability of raw material production, to energy used during manufacture.

In December 2020, the EU announced the roadmap for the environmental criteria for the production of lithium batteries, with a view towards increasing localisation.

Table 3.1 EU Roadmap For Rules Of Origin For European Lithium Battery Production

Date	Level of Localisation
Now until Dec 2023	No change
2024 to 2027	Key parts such as cathodes, anodes and chemicals must be sourced in the EU
2027 onwards	The target is for 100% sourcing from Europe, resilient and independent of foreign supply

European Commission Vice-President Maroš Šefčovič has also indicated that batteries that do not meet green standards could be banned from the European market, and that EU state aid would be steered under the Battery Alliance to European battery projects that do meet those standards. France and Germany in particular are pushing the idea of 'green batteries'.

The EU-UK free trade agreement also includes provisions for rising battery localisation in electric vehicles with a six-year phase-in period for EVs and batteries. Until the end of 2023, complete EVs, including hybrid, plug-in hybrid and battery electric vehicles, have a minimum origin threshold of 40% parts coming from the EU or UK, compared to 55% required for combustion engine vehicles. During this period, batteries must have at least 30% of parts sourced in the EU or UK. From 2024 to end of 2026, the origin threshold for finished EVs rises to 45%, while batteries must have at least 50% regional content. From 2027, the rules are expected to tighten further as part of wider EU and UK objectives to develop a regional battery supply chain.

A number of OEMs and experts have greeted the high localisation proposals with scepticism, voicing doubts about the viability of producing so much of the battery supply chain in such a short time frame.

State support is likely to continue. The EU and UK have been investing government money in developing the battery value chain. In January this year, the European Commission approved €2.9 billion in subsidies to support an EU battery industry, which came on top of

€3.2 billion in 2019. The funds are part of an objective for the EU to power at least 6m electric cars by 2025 and are adjoined to the latest 'European Battery Innovation' scheme set to go to 42 companies across 12 EU member states. The companies include European firms including BMW, French chemical firm Arkema and Swedish battery manufacturer Northvolt, but also foreign firms such as Tesla, which is building an EV and battery plant in Germany.

The French and German government have also given backing to the Automotive Cell Company (ACC), joint venture between SAFT and PSA Group, which plans significant battery cell production across two plants In Hauts-de-France in northern France and Kaiserslautern, Germany. The Germany government has also allocated €300m to German battery manufacturer Varta as part of a €1.5 billion in R&D. Varta intends to develop lithium-ion technology further with the aim of increasing the energy density of cells, as well as to put silicon-dominated anodes into mass production.

Developing a lithium-ion battery base is also a strategic issue in North America. Although the US has neither the same level of EV penetration nor growth trajectory for EVs as Europe or China, the Biden administration is set to drive a more ambitious climate policy, which is likely to include tightening fuel economy standards, providing purchase incentives and investment in charging infrastructure. Already, the administration has committed to purchasing American-made electric vehicles for government fleets.

And recently in February, President Biden announced a 100-day review in the US to address critical supply chain items such as the sourcing of rare earth metals, lithium batteries and semiconductors – all items inextricably associated with the growth in electric vehicles.

The localisation of a North American battery supply chain will also be driven in part by the new rules of origin under the USMCA, which came into effect in July 2020. From a 62.5% localisation rate across the region to quality for tariff-free trade under NAFTA, the rate is rising in a phase manner to 70-75% over the next three years, including for core parts like batteries. As EV batteries represent around 40% of the value of a vehicles, OEMs will need to localise these components.

But as the dispute between LG Energy Solution and SK Innovation in the US has demonstrated, developing the battery chain is highly strategic and competitive. The recent decision by the US International Trade Commission to ban SK Innovation from the US for ten years put into stark contrast the importance and complexities for OEMs when it comes to securing long-term battery cell supply.

3.4 Diversifying the Supply Base

Until recently, OEMs have mainly established exclusive supply agreements with battery suppliers, or even exclusive joint venture partnerships. With relatively low volumes of electrification, it made sense for carmakers to commit to purchasing from a specific supplier as a means to mitigate risk and share potential gains together.

However, that approach is changing. With rising EV demand, there have already been bottlenecks in supply, meanwhile OEMs want to ensure they have flexible access to supply and new technology.

A good example of the changing approach to battery supply is with Tesla, which previously had an exclusive arrangement for cells with Panasonic, with which it jointly built the Gigafactory 1 near Reno, Nevada. However, Tesla CEO Elon Musk has criticised Panasonic for not meeting necessary levels of production. Tesla is temporarily using LG Chem batteries at its Gigafactory 3 in Shanghai and has agreed a supply arrangement with CATL for EVs built in Asia. Tesla is also planning to develop its own in-house cells to diversify its supply base even further.

Nissan also had an exclusive relationship for battery supply through AESC, a joint venture with Japan’s NEC. Although a good relationship when Nissan launched the Leaf EV in 2008, less than a decade later AESC was no longer the cheapest or best battery supplier. Arguably, the battery manufacturer became uncompetitive precisely because of this exclusive agreement. In 2016, Nissan announced plans to sell the unit and use a wider variety of suppliers, and it along with NEC eventually sold their majority stake to China’s Envision in 2019 (Nissan retains a 25% share).

Volkswagen, meanwhile, exclusively used Samsung SDI batteries for its previous generations of EVs, such as the e-Golf. For its hugely ambitious EV plans, including its MEB platform and the ID range, the group has diversified its procurement of batteries, forging supply agreements with LG Chem, Samsung SDI and SKI for production in Europe, CATL for China and SKI for North America from 2022 (the US ban on SKI allows four years to supply existing agreements with VW, but it is unclear if that will change). VW has also signed an agreement with Sweden’s Northvolt, and formed a joint venture with the company to build a battery production plant in Salzgitter, Germany, which will be called Northvolt Zwei.

Other OEMs, including BMW, have also signed multiple agreements with battery suppliers, including CATL, Samsung SDI and Northvolt. Toyota has established a joint venture with Panasonic, while also signing agreements with CATL.

This trend demonstrates that flexibility of battery supply is increasingly important. As battery technology evolves, OEMs want to make sure they can keep up, and so it is important to be able to either switch or to have additional access to new suppliers according to changing local requirements, price or performance parameters.

3.5 Vertical Integration in the Battery Supply Chain

Flexibility and control of supply will, however, continue to shape different strategies and relationships in the battery supply chain. While Nissan has moved away from vertical integration in battery supply, others are investing in precisely such capability and capacity, including new joint ventures with established battery players.

The transition to electrification already disrupts the control that OEMs have held over internal combustion engines. Most OEMs take an in-house approach to develop and build powertrains – comprising the engine, gearbox and transmission – as these modules help to differentiate brands in terms of quality, performance, reliability and even the exhaust sound. As batteries represent 30-40% of the cost of the manufactured vehicle, giving over this element to suppliers is a risk.

Joint ventures between OEMs and battery manufacturers bring clear benefits. They help to convince suppliers to invest as they will have a guaranteed customer, while sharing investment reduces the risk and upfront capital expenditure required on both sides. OEMs also gain insight into the battery manufacturing process, not only in terms of factory design and layout, but in producing cells and battery packs. The complete visibility and understanding of the battery supply chain ultimately allows the OEM to optimise battery performance and factory output.

Table 3.2 Vertical Integration and Level of Control in EV Batteries Compared by OEM

Low Control	Moderate Control	High Control	Total Control
Cell, module and pack outsourced to 3rd party supplier	Cell production outsourced. In-house module, pack design and manufacturing	Cell production through joint ventures/partnerships. In-house pack design and manufacturing	In-house manufacturing of cell, module and pack design
Many EV start-ups -	BMW	Nissan	BYD
Nio, Lucid, Fisker	Renault	Mitsubishi	
	Daimler	Tesla →	Tesla from 2021/22
	VW →	GM →	
	Ford→	PSA (Stellantis)	
		Toyota	

One of the best-known examples of a joint venture is the Tesla and Panasonic joint venture in Nevada, which is possibly the most successful partnerships between an OEM and battery supplier. Panasonic bring its battery manufacturing expertise to supplying the cells and then Tesla performs the module and pack assembly.

Other OEMs have also established major joint ventures for battery cell production, including Volkswagen Group with Northvolt and GM’s Ultium joint venture with LG Chem. Ford CEO Jim Farley has also said that the carmaker is interested in pursuing a model similar to Tesla or GM in producing batteries, even after the company had previously said it saw no advantage to building its own batteries.

OEMs are not just integrating battery cell production to save costs, but also to gain more flexibility, technological innovation and differentiation compared to other OEMs. Unlike other components, lithium-ion batteries are not commoditised and there is considerable competitive advantage to be had by developing and commercialising a specific battery technology.

This is an advantage that some OEMs may even look to commercialise further by supplying other manufacturers. Volkswagen Group’s joint venture with Northvolt will be able to sell to other carmakers; Ultium is also expected to sell to other brands beyond GM. China’s BYD, which builds its own batteries, is already a supplier to other OEMs. Another Chinese OEM, Great Wall, has spun out its own battery division to create SVOLT, which is investing in new capacity in Asia and Europe.

BYD is in fact a rare example of an OEM that also has fully in-house battery cell, module and pack production for its own vehicles. Its growth as a battery supplier was further supported by the Chinese government’s previous policy up to 2019, which required foreign OEMs selling EVs in China to fit a Chinese-made battery from its ‘white list’ to quality for subsidies – which greatly benefitted BYD and CATL. The government has since removed this requirement, further opening up the Chinese battery market.

Some OEMs are considering moves to achieve even more supply chain integration further upstream. This can be witnessed by the links being forged with the cathode manufacturers and mining companies who extract and process the raw lithium, cobalt, nickel and manganese elements used within lithium-ion batteries.

BMW Group has formed a joint technology consortium with Northvolt and Umicore, a Belgian developer of cathode materials for battery cells, but also in the development of a more holistic and sustainable supply chain including recycling – which is particularly important given the finite availability of some of the raw elements. In November 2018, BYD signed a contract to buy lithium-ion battery cathode materials from China's Beijing Easpring Materials Technology.

It has been reported that Tesla is in negotiations to purchase cobalt from Glencore specifically for Tesla's Shanghai plant. Furthermore, Tesla announced the acquisition of Maxwell Technologies in 2019, and Elon Musk suggested at the time that the company could enter the mining business to ensure it scales fast enough. On Tesla's 'battery day' in October 2020, the company confirmed that it intended to get involved in mining lithium in North America.

3.6 Ethical Supply Chains

Gaining more control of the battery supply chain is not just about securing supplies – it is also about securing the reputations of OEMs. The supply chain for lithium-ion batteries is increasingly under the scrutiny of environmentalists, regulators and consumers, with serious questions about the emissions and pollution created in the process, as well as the ethics and working practices in mining and mineral extraction, for example of cobalt from DRC. The fear is that brands could be tarnished with regulators, shareholders and customers if they are associated with poor practices and labour conditions in the supply chain.

As a result, corporate social responsibility (CSR) for electric vehicles is moving well beyond a tick-box exercise to become a business-critical issue to protect huge capital investment into electrification. OEMs are thus forging alliances with raw material suppliers partly to secure supply – but also to improve visibility of working conditions under which raw materials such as lithium, cobalt, nickel and manganese are mined and refined.

For example, BMW has announced a €540m contract with Ganfeng Lithium to 'lock-in' 100% of its supply of lithium hydroxide until 2025. But BMW is also concerned about the human rights and environmental impact of mining raw materials, and how it could tarnish its brand image. By being more involved in the value chain, BMW believes it can better control the conditions under which raw materials are procured.

In October 2019, BMW launched the 'Cobalt for Development' pilot project jointly with BASF SE, Samsung SDI and Samsung Electronics to promote responsible artisanal cobalt mining in the DRC. Since 2020, the carmaker began sourcing both lithium and cobalt directly before the materials are supplied to its battery cell suppliers, CATL and Samsung SDI. From 2021, it plans to manufacture its fifth generation EV powertrains without using any rare earth metals.

In September 2020, VW Group partnered with RCS Global, a specialist in analysing supply chains, with the aim of auditing its extensive supplier base to ensure that it conforms with human rights, safe working conditions and environmental protection. This strongly relates to the battery supply chain and issues around mines, raw materials, child labour, and health and safety.

Mercedes-Benz has said that it will only source battery cells in future with cobalt and lithium from certified mining sites, while the company also aims to significantly reduce cobalt levels.

Companies including China's SVOLT and CATL, as well as Tesla, have said that they are in the advanced stages of developing batteries that do not require any cobalt. Although this can reduce battery power density, engineers are developing ways around this. The elimination of cobalt would reduce the price of the battery as well as making companies less reliant on erratic supply from the DRC.

3.7 Changing Strategies for Battery Pack Integration

As the battery supply chain develops, the lines are increasingly blurring between supply and production roles of battery cells and complete pack manufacturing. The 'battery integration' process, for example, includes turning the basic individual cells into modules and then combining these to form the pack – effectively the hardware – which includes key software, namely the battery management system (BMS) and a thermal management system (TMS).

Battery performance is not just down to the individual cell, but how the battery modules and pack are combined into a single entity, processes which offer OEMs and suppliers more opportunities to add value. Larger OEMs are often more involved in the module and battery pack integration, while smaller OEMs and start-ups usually rely on battery cell suppliers to manage the production stages of cell, module and battery pack, and then deliver a complete, ready-to-install pack to vehicles.

These relationships vary based on OEMs and model programmes but demonstrate the fluid relationships between manufacturers and suppliers, as well as the room for new manufacturing and supply chain services. For example, there have been recent moves towards a combined 'cell-to-pack' process.

Tesla has made a patent application for a new approach to battery cells and pack assembly. Although not yet implemented, the process would see the cell manufacturing plant produce small-cell modules, which can then be combined like building blocks into complete battery packs. In September 2019, CATL introduced a similar process called 'cell to pack', which claims a higher energy density than usual batteries thanks to a tighter packing of the cells.

Like much around battery technology, these processes remain shrouded in secrecy, but they are aimed at simplifying the manufacturing and assembly process, pursuing efficiency and lower costs to deliver on the holy grail of reducing battery prices to $100 per KWh or below.

3.8 Potential Disruptors to Battery Capacity Demand

The expansion of the battery supply chain is contingent upon two things: the growth in EV market share and an expanding requirement for battery capacity in each vehicle. The first is almost guaranteed given the heavy regulatory push and massive OEM investment in EV development. However, the growth in battery capacity is not quite as clear cut.

Installing large, heavy and expensive batteries in vehicles is done to increase driving distances between charges and reduce ‘range anxiety.’ However, the vast majority of car journeys are within short distances and well within 50-60km rather than the 400km or more range that most new EV models promise. If vehicle batteries were more geared around this reality, than EVs would require neither the expense, capacity nor the long-charging times common today.

Proposing vehicles with shorter ranges would however require a significant change in mindset for consumers, and likely different business model for OEMs – such as battery swap or vehicle subscriptions, for example. But several OEMs and startups are pursing just these types of offers.

There also other technologies that may play a bigger role in the overall electrification and diversification of propulsion. Several OEMs, notably in Japan and South Korea, are investing in hydrogen fuel cell technology, for example. However, we don’t forecast fuel cell propulsion to play a major role in the overall powertrain mix for a variety of reasons, including a lack of fuelling infrastructure.

Many companies are also developing solid-state battery technology that they claim can reduce charging times to around 10 minutes. Toyota has revealed such a battery will be close to commercialisation in 2021 and will be fitted to vehicles for sale by 2025. Whilst we don’t anticipate solid state playing a significant role in the overall powertrain mix over the next decade, technology is developing fast and there is room for disruption.

3.9 Battery Supply Chain Is a Competitive Advantage

The rapid acceleration of electric vehicle demand and the commensurate ramping up of the battery supply chain creates multiple challenges. Bottlenecks in supply could ultimately stifle production, sales and consumer uptake, and put billions of dollars of investment at risk.

With other supply chain shortages, OEMs are already prioritising the production of vehicles with customer orders and those that deliver higher margins. It is notable that OEMs already tend to manufacture electric vehicles on a more ‘built-to-order’ basis, rather than for stock at compounds and dealerships. The result has been longer average waiting times for EVs in hot-selling markets. The longer customers have to wait, the more of a risk it is to sales.

These supply issues underline how important the battery supply chain is as EV production and sales ramp up. OEMs able to provide the best batteries will have advantages on range and price. But important, too, will be having a flexible, resilient and multi-sourced battery supply chain that can respond to fluctuating EV demand. In the race to electrification, development of the battery supply chain is going to be a clear competitive advantage.

There is a huge amount at stake. The fate of individual OEMs could be decided by the alliances they make with particular battery suppliers and the overall strategy they implement – whether it is full vertical integration, keeping suppliers at arm’s length or a variety of approaches across markets. That’s why it’s never been more important to understand the fast-developing battery supply chain, including its current and future capacity.

4. Battery Raw Materials and Minerals

4.1 Lithium Suppliers

Table 4.1 Leading Global Lithium Suppliers

Company
Albermarle
Sociedad Química y Minera de Chile (SQM)
Livent Corp.
Tianqi Lithium Industries Inc.
Ganfeng Lithium

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

4.2 Cobalt Suppliers

Table 4.2 Leading Cobalt Suppliers

Company
Glencore
China Molybdenum
Katanga Mining
Umicore
Eurasian Resources Group

4.1 Nickel Suppliers

Table 4.3 Leading Nickel Suppliers

Company
Vale
MMC Norilsk Nickel
Jinchuan Group Ltd.
Glencore
BHP Billiton Ltd.

Table 4.4 Leading Manganese Suppliers

Company
South32
Anglo American
Consolidated Minerals
Eramet
Vale

5. Battery Component Suppliers

5.1 Cathodes Materials

Table 5.1 Leading Cathode Materials Manufacturers

Company	Location	Clients
Umicore	Korea, China, Poland	Samsung SDI, LG Chem, Panasonic, Sony
Nichia	Japan	Panasonic, Sony, Hitachi, ASEC Envision, LEJ
Toda Kogyo	Japan	
Beijing Easpring	China	Samsung SDI, LG Chemicals, Sony, Hitachi SKI, Panasonic, BYD, Lishen
Ningdo Jinhe	China	Samsung SDI, LG Chemicals
GEM	China	
Shanshan Energy	China	CATL, Panasonic, Lishen
Xiamen Tungsten	China	
Kingray New Materials Science & Tech	China	Panasonic

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

5.2 Anode Materials

Table 5.2 Leading Anode Materials Manufacturers

Company	Location	Clients
Hitachi Chemicals	Japan	Samsung SDI, LG Chem, Panasonic, Hitachi
BTR Energy	China	Samsung SDI, LG Chem, Panasonic, Sony and BYD
Nippon Carbon	Japan	
Ningbo Shanshan	China	LG Chem, Sony, Lishen, BAK and BYD
Hunan Shinzoom Technology	China	BYD, CATL and Far East First
Jiangxi Zeto New Energy Tech	China	BAK Battery

5.3 Electrolytes

Table 5.3 Leading Electrolyte Manufacturers

Company	Location	Clients

CapChem Technology	China	Samsung SDI, Panasonic, Sony, BYD, Lishen, BAK and Coslight
Tinci Materials Tech	China	Sony, BYD, CATL, Guoxuan, Wanxiang A123, Coslight
Guotai-Huarong (GTHR)	China, Poland	Samsung SDI, LG Chemicals, ATL, Lishen, Panasonic
Panax-Etec	China	Samsung SDI, LG Chemicals
Mitsui Chemicals	Japan	LEJ
Ube	Japan	Panasonic
Mitsubishi Chemicals	Japan	Panasonic, Sony, Hitachi, AESC
Ningbo Shanshan	China	LG Chem, Sony, Lishen, BAK and BYD
Do-Fluoride Chemicals	China	BYD and King Long

5.4 Separators

Table 5.4 Leading Separators Manufacturers

Company	Location	Clients
Asahi Kasei	Japan	Samsung SDI, LG Chemicals, Panasonic, Sony, Hitachi, AESC Envision
Toray Tonen	Japan	Samsung SDI, LG Chemicals, Sony
SKI	Japan	Samsung SDI, Sony
Celgard	US	LG Chemicals, Panasonic, AESC Envision
Entek	US	
Senior Technology Material	China	LG Chem, BYD, Guoxuan, Lishen, CALB
Victory Precision Manufacture / Suzhou Greenpower New Energy Materials	China	BYD, LG Chem, CATL, SDI
UBE	Japan	Hitachi, AESC
Jinhui Hi-tech	China	BYD, BAK
BNE	China	CALB, Coslight
Cangzhou Mingzhu	China	BYD, CALB., ATL, and Lishen
Shanghai Energy New Materials	China	Samsung SDI, LG Chem, ATL, BYD
Zhongke Science and Tech	China	LG Chem, BYD, Lishen, BAK
Donghang	China	Narada, Guangdong Great Power
Newmi Tech	China	LG Chem, Lishen, Coslight
Sinoma	China	BYD, ATL, Eve Battery

6. Battery Cell Market and Production

6.1 Largest Global Battery Cell Companies

Battery cell manufacturers have rapidly risen to prominence within automotive battery supply chains as producers of the key component of lithium-ion batteries. The success of any OEM's electrification strategy relies heavily upon the partnerships, alliances and joint ventures forged with battery cell manufacturers.

These companies, some of whom have only recently entered the automotive industry, are emerging as leading tier-1 suppliers and manufacturing integrators as carmakers ramp up electrification plans. The technology developed by the battery cell manufacturers has the potential to make them 'kingmakers' in the automotive value chain, and in helping to determine the success of electric vehicle programmes.

The largest battery cell manufacturer by current capacity is South Korea's LG Energy Solution (an independently run spinoff of LG Chem), supplying a diverse range of OEMs across the world. But other manufacturers are fast adding capacity, including the remarkable growth of China's CATL. All of the top five battery manufacturers, including LG Energy Solution, BYD, Panasonic, CATL and SK Innovation, are expanding plants globally, including in Europe and North America.

One of the most striking aspects of the leading battery cell manufacturers is that almost half (44%) of current capacity is controlled by Chinese-owned companies, and some 93% of capacity is controlled by Asian companies. North American and European OEMs pushing towards electrification are thus almost completely reliant upon these Asian battery suppliers. However, battery cell companies are fasting expanding their capacity in global regions, while a number of new players and startups are emerging.

Table 6.1 Top 20 Lithium Battery Cell Manufacturers 2020

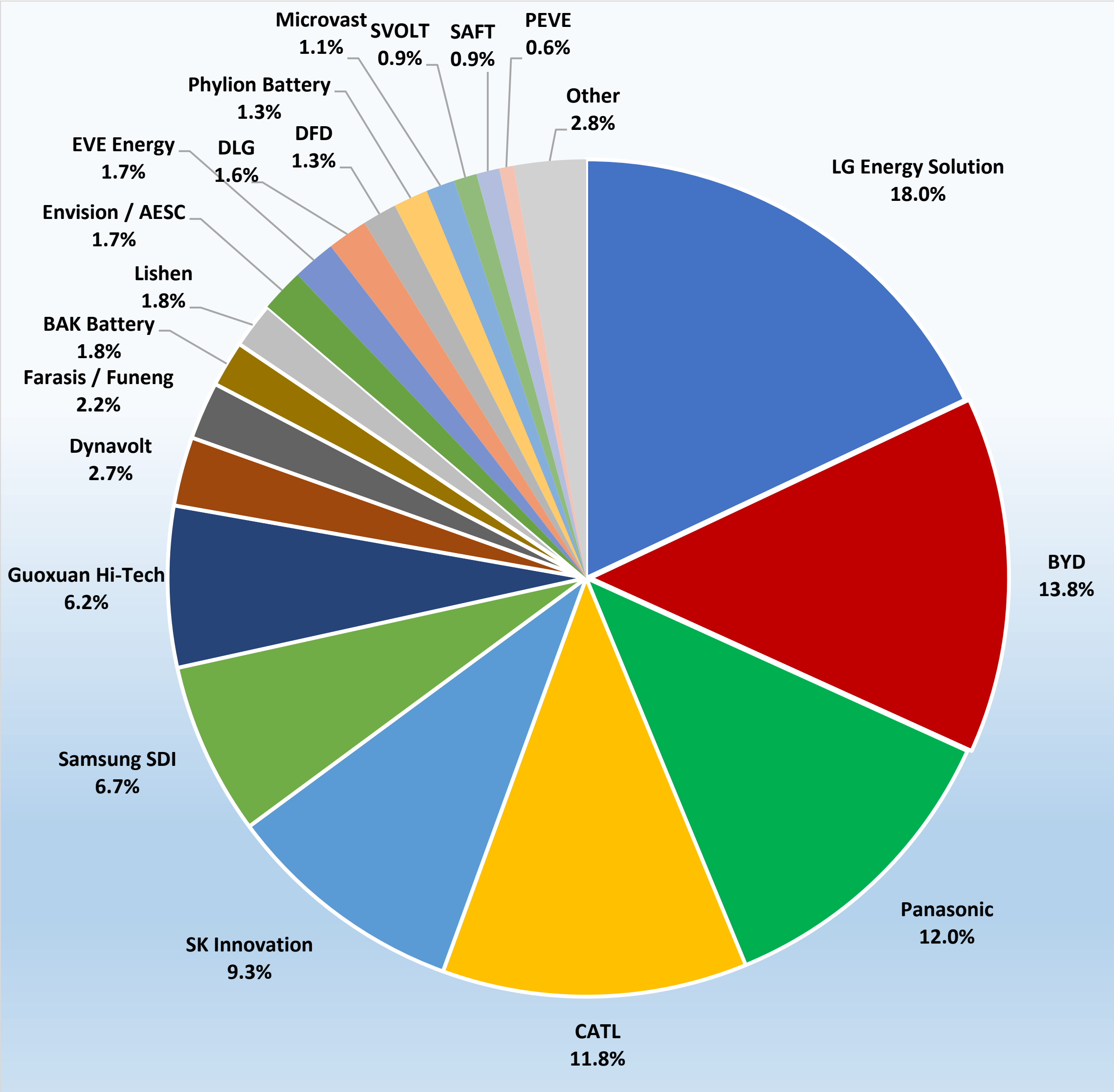
Rank	Company	Country	Capacity In 2020*	Plants 2020	OEMs supplied (not exhaustive)
1	**LG Energy Solution (LG Chem)**	South Korea	81 GWh	5	FCA, Ford, Geely, General Motors, Hyundai, Jaguar, Renault-Nissan-Mitsubishi (RNM), Tesla, VW, Volvo
2	**BYD**	China	62 GWh	6	BYD, Toyota
3	**Panasonic**	Japan	54 GWh	10	BMW, Ford, Honda, Tesla, Toyota,
4	**Contemporary Amperex Technology Co. Limited (CATL)**	China	53 GWh	6	BAIC, BMW, Daimler, Dongfeng, Foton, GAC, Geely, Honda, Hyundai-Kia, Nanjing Golden Dragon, RNM, SAIC, Stellantis, Toyota, Volvo, VW Group, Xiamen King Long, Yutong Bus, Zhongtong Bus
5	**SK Innovation (SKI)**	South Korea	42 GWh	5	Daimler, BAIC, Hyundai, Jaguar Land Rover, Ferrari, Kia, VW Group
6	**Samsung SDI**	South Korea	30 GWh	13	Akasol, BMW, Hyundai-Kia, JAC, Stellantis, Volvo, VW Group
7	**Guoxuan High Tech Power**	China	28 GWh	5	Ankai Bus, BAIC Motor, Dongfeng Motor, JAC, Jianghuai Automobile, Jinlong, Shanghai Sunwin, Shenwo, Zhongtong Bus, Zoomlion
8	**Dynavolt**	China	12 GWh	2	
9	**Farasis / Funeng**	China	10 GWh	1	BAIC, Changan, Great Wall, Jiangling
10	**BAK Battery**	China	8 GWh	3	
11	**Lishen**	China	8 GWh	1	Dongfeng, JAC, Geely, Jinlong, Kandi Tech, Zhongtong, Qingyuan, FAW
12	**Envision AESC**	China	7.5 GWh	3	Nissan
13	**EVE Energy**	China	7.5 GWh	1	Geely, Kia Motors
14	**DLG**	China	7 GWh	2	
15	**DFD**	China	6 GWh	1	
16	**Phylion Battery**	China	6 GWh	1	
17	**Microvast**	China	5 GWh	1	Foton, Hengtong, Jinlong, Zhongtong Bus
18	**SVOLT**	China	4 GWh	1	Great Wall
19	**SAFT**	France	4 GWh	2	Stellantis
20	**PEVE**	Japan	2.5 GWh	4	Toyota

	Others		12.5 GWh		
Total			**450 GWh**		

*Installed capacity expected by the end of 2020

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

Figure 6.1 Top 20 Lithium Battery Cell Manufacturers Production Capacity Share 2020



6.2 Battery Cell Manufacturing Plants

Some 74% of current battery cell manufacturing capacity is located in Asia and that dominance is likely to continue. Currently, around 13% of capacity is in Europe and 10% in the US (the majority of which is currently Tesla's joint venture with Panasonic).

However, rising EV demand in Europe, along with regulations to encourage local battery supply, will lead to considerable growth in European battery cell manufacturing plants and the wider upstream supply chain. We predict that Europe will more than double its plant capacity share from 15% in 2020 to 33% by 2030 and reach a capacity of 950 GWh. Capacity in Asia, meanwhile, is expected to rise to 1,620 GWh.

As of 2020, there were nine current gigafactories for batteries in Europe, while we estimate that around 30 new plants have already been announced or are under construction. There will doubtless be many more to reach the expected demand for batteries.

North America will also experience a rapid rate of growth, albeit from a lower starting point. Sales of EVs are expected to rise faster over the next decade, with the Biden administration likely to tighten fuel economy standards and encourage more investment in electrification. The new USMCA protocol will require higher rules of origin for vehicle components including for batteries, which will further encourage OEMs and manufacturers to source batteries within North America.

Eight new gigafactories have been announced in the US along with the existing seven. However, two of those factories, from SK Innovation, are at least partly in doubt after the US imposed restrictions on SKI in response to a lawsuit from LG Energy Solution. There are currently no existing or planned gigafactories outside of the US in North America, however OEMs including GM and Ford are investing in EV production capacity in Canada and Mexico, for example.

By 2030, we expect North American battery production to grow in line with the market, for its market share to remain constant at around 10%.

Of course, there is no guarantee that all of the plants announced will come to reality or reach the high capcity levels promised. Some companies are startups that will need to finance hugely capital-intensive projects. In other cases, suppliers from China and other countries might struggle to break into new markets in Europe or the US. However, we do expect demand for battery capacity to grow, and those suppliers who are able to produce and supply battery cells are likely to have ready customers.

Table 6.2 Lithium Battery Plants and Production Capacity Forecast by Region 2020 vs 2030

Region	Current plants	Future plants being built*	Total current + future plants*	2020 capacity (GWh, % share)	2030 capacity (GWh, % share)
Asia Pacific	**99**	**56**	**155**	**345 GWh (77%)**	**1,627 GWh (57%)**
Europe	**11**	**26**	**37**	**60 GWh (13%)**	**950 GWh (33%)**
N. America	**8**	**10**	**18**	**45 GWh (10%)**	**280 GWh (10%)**
Global	**118**	**92**	**210**	**450 GWh**	**2,857 GWh**

*Factories under construction or announced

Figure 6.2 Lithium Battery Production Capacity by Region 2020 vs. 2030

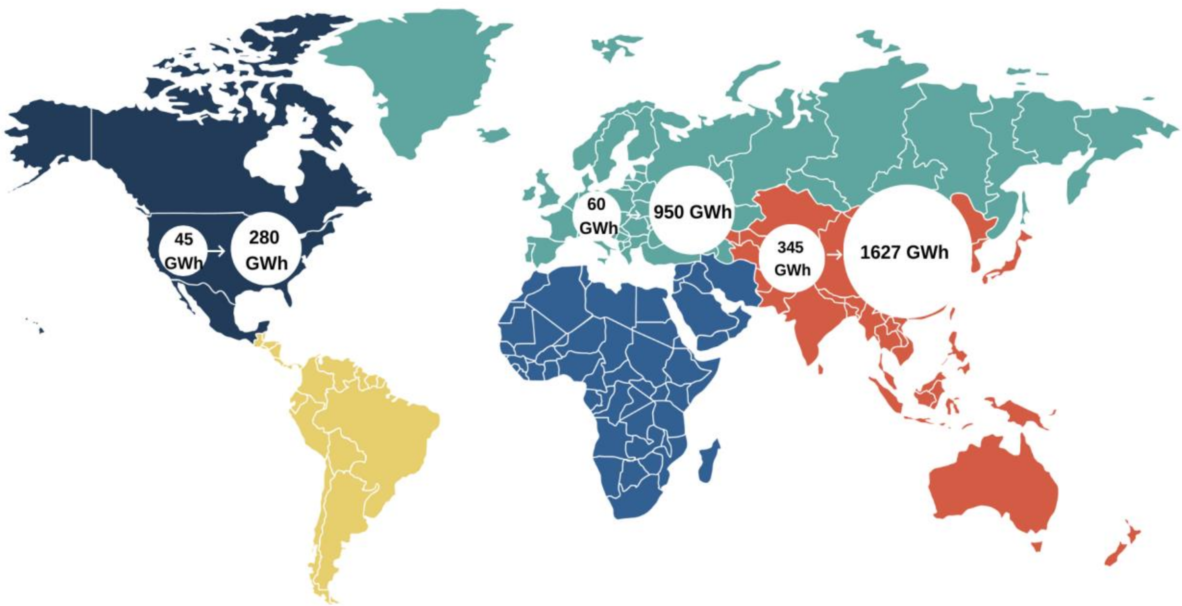


Table 6.3 Europe Lithium Battery Plants Current and Announced

Rank	Company	Location	Start Date	Capacity
1	LG Energy Solution	Wroclaw, Poland	2018	45 GWh to 70 GWh later
2	SK innovation	Komarom, Hungary, Plant 1	2020	7.5 GWh
3	Samsung SDI	Goed, Hungary	2020	2.5 GWh to 20 GWh by 2028
4	Envision AESC	Sunderland, UK	2010	2.5 GWh
5	Leclanche	Willstatt, Germany	2020	1 GWh to 2.3 GWh by 2024
6	AMTE Power	Thurso, Scotland	-	1 GWh to 5 GWh
7	Bollore	Ergue-Gaberic, France	2009	500 MWh* a form of lithium / solid state battery
8	Akasol	Langen, Germany	2018	300 MWh up to 800 MWh
9	Liacon	Ottendorf-Okrilla, Dresden, Germany	2019	300 MWh
10	Tesvolt	Germany	2020	255 MWh for Energy Storage applications
11	Samsung SDI Battery Systems	Premstatten, Graz, Austria	2015	Former plant of Magna Steyr battery systems
12	AMTE / BritishVolt	Blyth, near Newcastle, UK	2023	35 GWh
13	Italvolt	Italy	2024	35 GWh rising to 70 GWh
14	BMZ / Terra & others	Karlstein, Germany	?	34 GWh
15	Morrow Batteries	Arendal, Norway	2024	8 GWh, rising to 32 GWh
16	Listrom	North Rhine-Westphalia, Germany	?	30 GWh
17	SK innovation	Ivancska, Hungary, Plant 3	2024	Rising to 30 GWh

18	Zorlu / GSR Capital	Turkey	2022	25 GWh
19	Tesla	Gruenheide, Germany	2021	Model Y and Model 3 production alongside battery production capacity of a claimed 100-250 GWh.
20	Northvolt Zwei	Salzgitter, Germany	2024	16 GWh rising to 24 GWh
21	Verkor	France	2023	16 GWh rising to 50 GWh
22	CATL	Erfurt, Thuringia, Germany	2022	14 GWh rising to 100 GWh
23	Microvast	Brandenburg, Germany	2021	12 GWh
24	Northvolt Ett	Skelleftea, Sweden	2021	8 GWh rising to 40 GWh in 2024
25	Inobat	Voderady, Bratislava, Slovakia	2021	100 MWh in 2021 rising to 10 GWh by 2024
26	SK innovation	Komarom, Hungary Plant 2	2022	9.8 GWh rising to 16 GWh
27	Automotive Cell Company (SAFT/Stellantis)	Hauts-de-France, France	2023	8 GWh rising to 24 GWh by 2030
28	Automotive Cell Company (SAFT/Stellantis)	Kaiserslautern, Germany	2024	8 GWh rising to 24 GWh by 2030
29	Samsung SDI	Plant 2, Goed, Hungary	2021	7.5 GWh
30	Farasis Energy	Bitterfeld-Wolfen, Germany	2022	6 GWh rising to 16 GWh
31	SVOLT	Uberhelm, Germany	2023	6 GWh rising to 24 GWh
32	Lithops / FAAM	Teverola, Napoli, Italy	2021	200 MWh rising to 2.5 GWh (military, industrial and

				storage applications)
33	FREYR	Mo I Rana, Norway	2022	Rising to 40 GWh
34	GSR Capital	Trollhättan, Sweden	2020?	Rising to 20-25 GWh
35	Panasonic	Norway	Not yet announced	MoU with Equinor & Norsk Hydro
36	Blackstone Resources	Braunschweig, Germany		Initially 100m battery cells
37	Akasol - Gigafactory 1	Darmstadt, Germany	2021	2.5 GWh rising to 5 GWh

Plants under construction or announced – not all details fully confirmed. List may not be exhaustive

Table 6.4 North America Lithium Battery Plants Current and Announced

Rank	Company	Location	Start Date	Capacity
1	Panasonic-Tesla	Gigafactory 1, Nevada, US	2016	35 GWh rising to 39 GWh in 2021
2	LG Energy Solution (LG Chem)	Holland, Michigan, US	2013	3 GWh rising to 24 GWh in 2028
3	Envision AESC	Smyrna, Tennessee, US	2012	2 GWh rising to 8 GWh in 2028
4	Imperium3	Imperium, New York, US	2019	3 GWh rising to 15 GWh
5	SAFT	Jacksonville, Florida, US	2011	1 GWh
6	A123 Systems	US Plant 1, Michigan, US		150 MWh
7	A123 Systems	US Plant 2, Michigan, US		150 MWh
8	Samsung SDI	Auburn Hills, MI, US		Production & sales
9	Ultium (GM-LG Chem)	Lordstown, Ohio, US	2022	30 GWh
10	SK innovation*	2nd Plant, Georgia, US	2023	11.7 GWh (*US ban on SKI for 10 years except for VW and Ford puts plants in doubt)

11	Do Fluoride Chemicals (DFD) / KORE Power			10 GWh (energy storage applications, not auto)
12	SK innovation*	Commerce, Georgia, US	2022	9.8 GWh (*US ban on SKI for 10 years except for VW and Ford puts plants in doubt)
13	Tesla	Austin, Texas, US	-	Cybertruck, Semi, Roadster, Model Y but also battery cell production to further integrate the supply chain
14	Tesla	Gigafactory 2, Buffalo, New York, US	-	2 GWh battery production for solar plant (not automotive)
15	Tesla	Fremont, California		Currently a vehicle assembly plant, Tesla indicated a pilot battery production line would be built for in-house cell production up to 10 GWh
16	Akasol – Gigafactory 2	Detroit, Michigan, US	2021	400 MWh to 2 GWh by 2023
17	SVOLT	US	-	Unknown
18	Microvast	Clarksville, Tennessee, US	2022	2 GWh

Plants under construction or announced – not all details fully confirmed. List may not be exhaustive

Table 6.5 Asia Pacific Lithium Battery Plants Current and Announced

Rank	Company	Location	Start Date	Capacity
1	BYD	Plant 1, Xining, Qinghai, China	2018	24 GWh rising to 36 GWh in 2028
2	LG Energy Solution	Nanjing, China 1st plant	2016	20 GWh rising to 60 GWh in 2028
3	BYD-Changan JV	Bishan, Chongqing, China	2020	20 GWh rising to 36 GWh in 2028
4	SKI	Yancheng, China	2020	20 GWh
5	CATL-SAIC JV	Changzhou, Jiangsu, China	2018	18 GWh rising to 36 GWh
6	CATL-FAW JV	Xiapu County, Ningde Fujian Province, China	2019	-
7	CATL	Xining, Qinghai, China	2020	15 GWh
8	LG Energy Solution	Ochang, Seoul, S. Korea	2010	12 GWh
9	CATL	Ningde, Fujian, China	-	10 GWh rising to 100 GWh in 2028
10	Panasonic	Suminoe, Osaka, City, Japan	2010	10 GWh rising to 20 GWh by 2023
11	Guoxuan High-Tech	Qingdao, China	2018	8 GWh in 2020 rising to 20 GWh in 2028
12	Guoxuan High-Tech	Hefei, Anhui, China		13.5 GWh
13	Guoxuan High-Tech	Kunshan, China		
14	Guoxuan High-Tech	Nanjing, China		
15	Guoxuan High-Tech	Wuhan, China		
16	CATL-Dongfeng JV	Wuhan, China	2020	9.6 GWh
17	BYD	Plant 1 Shenzhen, Guangdong, China	2018	8 GWh
18	BYD	Plant 2 Shenzhen, Guangdong, China		8 GWh
19	Panasonic	Kasai City, Himeji, Japan	2020	8 GWh rising to 20 GWh in 2028
20	Funeng	Ganzhou, Jiangxi, China	2016	10 GWh rising to 35 GWh by 2028
21	BAK Battery	Shenzhen, China	-	8 GWh rising to 20 GWh in 2028

22	Lishen	Tianjin, China	-	8 GWh rising to 42 GWh in 2028
23	SKI-BAIC JV	Changzhou, Jiangsu China	2020	7.5 GWh rising to 10 GWh in 2028
24	EVE Energy	Huizhou, China	-	7.5 GWh rising to 15 GWh in 2028
25	Dynavolt	Fujian, China	2017	6 GWh rising to 10 GWh
26	Dynavolt	Hubei, China	2017	6 GWh rising to 15 GWh
27	Do Fluoride Chemicals (DFD) / KORE Power	China		6 GWh (energy storage applications, not auto)
28	Phylion Battery	Suzhou, Jiangsu, China	2016	6 GWh rising to 25 GWh by 2022
29	Microvast Power Systems	Huzhou, China	2019	5 GWh (with plans to expand to 9 GWh by 2022)
30	Tianneng	Zhejiang, China	2020	5 GWh rising to 15 GWh in 2028
31	DLG	DSD, Shandong China		5 GWh
32	Coslight	Chongqing, China	2019	4.5 GWh
33	Coslight	Harbin, China	2020	4.4 GWh
34	SVOLT	Changzhou, Jiangsu, China	2019	4 GWh rising to 18 GWh later
35	SKI	Seosan, South Korea	-	3.9 GWh rising to 4.7 GWh in 2022
36	SKI	Jeungpyeong, South Korea	-	3 GWh rising to 10 GWh in 2023
37	Samsung SDI	Ulsan, South Korea	2020	3 GWh rising to 23 GWh by 2023
38	Envision AESC	Zama, Kanagawa, Japan	2009	3 GWh
39	Youlion	Suzhou, China	-	2.5 GWh rising to 6 GWh in 2023
40	Samsung SDI	Xian, China	2020	2 GWh rising to 32 GWh by 2028
41	Samsung SDI	Cheonan, South Korea		
42	Samsung SDI	Cheongu, South Korea		
43	Samsung SDI	Gumi, South Korea		
44	Samsung SDI	Tianjin, China		

45	Samsung SDI	Wuxi, Jiangsu Province, China		
46	Samsung SDI	Bacninh Province Yenphong District, Vietnam		
47	Samsung SDI	Seremban, Malaysia		
48	Samsung SDI	Noida, India		Production and Sales
49	Panasonic	1st plant, Dalian, China	2018	2 GWh to 22 GWh in 2028
50	Panasonic	2nd pant, Dalian, China	2019	2 GWh
51	BYD	Huizhou, China	2018	2 GWh
52	SAFT	Changxing, China	-	2GWh, later 5.5 GWh SAFT 40:60 JV with Tianneng Energy Technology (TET)
53	DLG	DETSD, Shandong, China		2 GWh
54	CBAK Energy	Dallan, China		2 GWh
55	Panasonic	Sumoto, Japan	2017	1 GWh rising to 5 GWh by 2023
56	Penghui Power /Guangzhou Great Power Energy & Tech	Guangzhou, China	2019	1 GWh rising to 4 GWh and then 10 GWh in 2028
57	China Aviation Lithium Battery (CALB)	Luoyang, China		1 GWh rising to 10 GWh in 2028
58	China Aviation Lithium Battery (CALB)	Jiangsu, China		
59	Energy Absolute	Thailand	2019	1 GWh rising to 50 GWh by 2022
60	Tenpower	Plant 1, Zhangjiagang, China		1 GWh
61	Tenpower	Plant 2, Zhangjiagang, China		1.5 GWh rising to 5 GWh in 2022
62	Panasonic	Suzhou, Jiangsu, China	2012	Consumer electronics cells
63	Panasonic	Wuxi. China	2012	
64	Panasonic	Beijing, China	2012	
65	Primearth EV (PEVE)	Miyagi, Taiwa, Japan	-	400,000 Li-Ion batteries

66	Primearth EV (PEVE)	Shizuoka, Tokyo, Japan	-	200,000 Li-Ion batteries
67	PEVE/ Sinogy Toyota	Sinogy China		
68	Lithium Energy Japan (GS Yuasa/ Mitsubishi JV)	Inobanba-cho, Nishinosho, Kisshoin, Minami-ku, Kyoto, Japan	2007	
69	Blue Energy Co. (GS Yuasa/ Honda JV)	Osadano-cho, Fukuchiyama City, Kyoto Japan	2009	20m cells per year mainly for hybrids
70	LG Energy Solution/Vinfast JV	Hai Phong, Vietnam	2020	-
71	BAK battery	Zhengzhou, China		
72	BAK battery	Chengdu, China		
73	Farasis Energy	Ganzhou, Jiangxi, China		unknown
74	Leclanche / Exide JV	Gujarat, India	2020	
75	Inverted Energy	Okhla, Delhi, India	2020	100 MWh
76	Shandong Winabattery	Old Plant, Minquan, China	2016	
77	Shandong Winabattery	New Plant, Minquan, China	2020	3 Billion Ampere Hours (Ah)
78	Zhuoneng New Energy Corporation	Shenzhen, Guangdong, China		
79	CITIC Guoan Group/CITIC Monguli Power Technology Co.	Beijing China		
80	Tohoku Murata Manufacturing	Motomiya Plant, China		
81	Cenat New Energy / Evergrande	Shanghai, China		
82	Cenat New Energy / Evergrande	Jiangxi, China		
83	Cenat New Energy / Evergrande	Guangxi, China		

84	Cenat New Energy / Evergrande	Jiangsu, China		
85	Yinlong New Energy Co	Zhuhai, Guangdong, China		
86	AVIC Lithium Battery Co.	China		EVs, power storage, military, rail transit, & mining equipment.
87	Desai Battery Technology Co.	China		Energy storage
88	Shenzhen Waterma Battery	Shenzhen, China		Automotive, energy storage
89	Vaillant, Shandong Weineng Environmental Protection Power Technology Co.	Shouguang City, China		Automotive & military
90	Shenzhen Kayo Battery	Dongguan, Guangdong, China	2014	Consumer applications only
91	Dongguan Large Electronics	Dongguan, Guangdong, China	2002	Consumer applications only
92	Shenzhen HLC Battery Technology	Shenzhen, Guangdong, China		Industrial applications only
93	Guangzhou Fullriver Battery New Technology	Guangzhou, Guangdong, China		Consumer & industrial applications only
94	Perfect Amperex Technology	Dongguan, Guangdong, China		Consumer applications only
95	Shandong Goldencell Electronics Technology	Shenzhen, Guangdong, China,		Consumer & automotive ancillary batteries
96	Shenzhen Eastar Battery	Shenzhen, Guangdong, China,		Consumer & automotive ancillary batteries
97	HZM Electronics	Zhongshan, Guangdong, China		Consumer applications only
98	Xiangyang Ahead Cell Technology	Xiangyang, Hubei, China		Consumer applications only
99	GrePow	Shenzhen, China		Consumer, sports, vehicles

100	A123/Wanxiang	Hangzhou, Zhejiang, China	2021	80 GWh
101	LG Energy Solution	North Maluku, Indonesia	2024	$12bn deal by LG and CATL
102	CATL	Indonesia	2024	$12bn deal by LG and CATL
103	BYD	Xi-an, Shaanxi, China	2023	30 GWh
104	SVOLT	Suining, Sichuan, province, China	2022	20 GWh
105	SVOLT	Huzhou, Zhejiang province, China	2022	20 GWh
106	SVOLT	Jintan, China		18 GWh
107	SVOLT	Hunan province, China		40 GWh
108	SVOLT	Hubei province, China		40 GWh
109	LG Energy Solution	2nd plant Nanjing, China	2023	28 GWh to 35 GWh in 2028
110	BYD	Plant 2 Xining, Qinghai, China	planned	20 GWh
111	EVE Energy-SK Innovation JV	-		20-25 GWh
112	Farasis Energy	Zhenjiang, Jiangxi China	2021	20 GWh up to 120 GWh
113	CATL	Yibin, Suchuan, China	2022	15 GWh to 30 GWh in 2024
114	EVE Energy	Jingmen, Hubei, China		11 GWh (6 GWh energy storage & 5 GWh power batteries)
115	Vision	Jingshan, Hubei, China	2021	10 GWh rising to 30 GWh
116	LG Energy Solution-Geely JV	China	2021	10 GWh
117	CATL-Geely JV	Jingzhou, China	2021	10 GWh
118	CATL-GAC JV	Guangzhou, Guangdong, China	2021	10 GWh / 400,000 battery packs per year
119	Sunwoda	Nanjing, China		10 GWh
120	Tata Group	Dholera, Gujarat , India	2021	10 GWh rising 50 GWh
121	Funeng Technology / BAIC JV	Shunyi, Beijing. China		8 GWh
122	Sichuan Energy Investment	Sichuan, Chengdu, China	2021	10 GWh

	Huading Guolian Power Battery Industrial Base			
123	Lithium Werks	Nanjing, Jiangsheng, Shanghai., China	2021	8 GWh rising to 500 GWh by 2030
124	Envision AESC	Wuxi, Jiangsu, China	2021	8 GWh rising to 20 GWh by 2028
125	Imperium3	Townsville, Australia	2022	6 GWh rising to 18 GWh
126	CBAK Energy	Nanjing, China		2 GWh up to 8 GWh
127	Jiangsu Tafel New Energy Technology Co., Ltd.	Jiangsu, China		3 GWh by 2021 rising to 6 GWh by 2022
128	Penghui Power/Guangzhou Great Power Energy & Tech	Changzhou, Jiangsu, China	2021	2 GWh
129	BHEL-Libcoin consortium	India		1 GWh rising to 30 GWh
130	Jiangsu Fengchuen New Energy Power Technology Co.,/ Sichuan Lvran Technology Group Co. Ltd	Qindao, China	2021	0.5 GWh rising to 8 GWh
131	Prime Planet Energy and Solution (Panasonic/ Toyota JV)	Tokushima prefecture, Japan	2022	Batteries for up to 500,00 vehicles a year
132	Toshiba/Suzuki/ Denso	India	2021	
133	Primearth EV (PEVE)	Jiangsu, China	2021	100,000 batteries a year
134	Blue Energy Co., Ltd. (GS Yuasa / Honda JV)	Osadano-cho, Fukuchiyama City, Kyoto Japan	2009	20 million cells / year mainly for hybrids
135	Adani	Gujarat, India	-	-
136	Amara Raja	Hyderabad, India	2021	500 MWh
137	Amperex Tech (TDK)	Gurumgram, Haryana, India	2021	1 GWh

138	Ather Energy			
139	AMTE Power & InfraNomics	Australia		
140	EVE Energy	Huizhou, Guangdong, China		JV between EVE Energy and StoreDot
141	Gangfeng Lithium China		2019	100 MWh. pilot plant for solid state batteries
142	HBL Power	India	Planned	
143	Hero / Electrovaya	India	Planned	
144	High Energy Batteries	India	Planned	
145	JSW Energy	India	Planned	
146	Li Energy	Thondi, Tamil Nadu, India	2021	
147	MARII	Malaysia	Planned	
148	McNair	Dongguan, Guangdong, China	Planned	
149	Monbat (EAS Batteries)	India	Planned	
150	National Power	Beijing, China	Planned	
151	ProLogium	Taiwan	2020	Collaboration with NIO
152	ProLogium	Taiwan		5 GWh Collaboration with WM motors
153	Reliance	India		
154	Lishen	Wuhan, China	Planned	
155	Lishen	Qingdao, China	Planned	

Plants under construction or announced – not all details fully confirmed. List may not be exhaustive

7. Companies Providing Battery Management Systems (BMS), Thermal Management Systems (TMS) and Battery Pack Cases

The battery cell and the chemistry contained therein usually get the most attention in terms of the lithium-ion battery supply chain and is understandably where many OEMs and battery manufacturers are focusing development and production investment. However, there are other key parts to the overall EV battery architecture and software, with many companies – including OEMs and tier suppliers – pursing added value service and technology.

A single raw battery cell (which is slightly larger than a consumer 'AA' battery) on its own is of little use in a vehicle. An EV needs a usable battery pack with a battery management system (BMS) and a thermal management system (TMS) to ensure safe charging, to monitor individual cells, regulate temperature and control demand discharge under a wide range of driving scenarios and atmospheric conditions. The overall battery pack case enclosure is also important in thermal management and ensuring the reliability of individual cells.

The battery pack together is a very sophisticated piece of hardware and chemistry, as well as software, all of which plays a critical in battery and EV performance.

Table 7.1 Leading Battery Management Systems (BMS) Companies

BYD
CATL
Eberspächer
Ficosa
G-Pulse
Hella
Idneo Engineering Services Company
Leclanche
LG Chem
Lithium Balance
Nuvation Energy
NXP Semiconductors
Panasonic Corporation
Renesas Electronics
Robert Bosch
Roboteq
SVolt
Tesla

Other: Analog Devices, AVL LIST, Battery Systems, Calsonic Kansei Corporation, Continental, Denso Corporation, Elithion, Hitachi, Horiba Mira, Infineon Technologies, Intel Corporation, Ion Energy, Johnson Matthey, Marelli, Maxim Integrated Products, Midtronics, Mitsubishi Electric, Navitas System, Orient Technology, Preh, Ricardo, Samsung SDI, Silicon Labs, ST Microelectronics, Texas Instruments, Toshiba Corporation, Vitesco Technologies

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

Table 7.2 Thermal Management Systems (TMS) Companies

Borgwarner
Calsonic Kansei
CapTherm Systems
Continental
Dana
Gentherm
Hanon System
LG Chem
MAHLE
Robert Bosch
Samsung SDI
Valeo
VOSS Automotive

Table 7.3 Battery Pack Companies

ArcelorMittal
Constellium
Thyssenkrupp
EDAG Group
Gestamp
Hitachi
SGL Carbon
Voestalpine

8. Disruptive Battery Cell Technologies

OEMS and battery manufacturers are investing significantly in electrification through a variety of lithium-ion battery technology, capacity for which this report focuses on. However, there is investment in applications for a range of other electric vehicle battery technology, notably for 'solid state' batteries and hydrogen fuel cells, as well as other types of batteries.

Solid-state lithium batteries feature solid electrolyte lithium (rather than liquid), which have higher thermal stability and can tolerate higher temperatures, with higher voltages, have greater range and shorter charging times. A number of companies are developing solid-state batteries, including small cells (which are cheaper to produce) but also larger cells that would be more suitable for EVs.

Toyota, together with Panasonic, has more than 1,000 patents for solid-state batteries. Other OEMs including Nissan and Volkswagen are also investing in the technology. Volkswagen has invested $300m in QuantumScope, a US-based specialist in solid-state batteries.

The technology, however, is still under development and is not ready for commercial use in electric vehicles. Toyota has said that it would have a working prototype with solid-state technology as early as this year, however it would not be until 2025 that such vehicles would enter production. Vacuum and consumer product manufacturer Dyson, which had been set to launch an EV based on solid-state battery technology, abandoned the project in part because of the time it would take to make the technology viable alongside supporting the capital investment needed to develop an EV (Dyson continues to develop this battery technology, however).

While solid state could be a disruption in EV batteries, we do not expect it to play a large role in battery capacity and supply chains over the next 5-10 years.

Other technologies are in play too, including lithium-sulphur batteries and even aluminium-air batteries, which could offer potential in the longer term, but are unlikely to supplant the current drive to increase lithium-ion battery production capacity.

There is also investment in hydrogen fuel cell technology, with carmakers including Toyota and Hyundai already putting vehicles on the market. Fuel cells might also be more effective in the long run for electrifying commercial vehicles. However, it currently lacks the fuelling infrastructure to be a mass alternative to electrification.

Table 8.1 Companies Developing Potentially Disruptive Battery Cell Technologies

Company	Details	Battery Type
Solid Power	Investment, from Ford, BMW, Hyundai, Daimler, Samsung	Solid State
Quantum Scape	$300m investment from VW. Claims a battery that can charge to 80% in 15 mins.	Solid State
BlueSolutions	Investment from Daimler	Solid State
Innolith	Energy density of 1000 Wh/kg,	Lithium-ion
Ionic Materials	$65m investment from Renault-Nissan-Mitsubishi	Solid State
Libtec consortium	Honda, Nissan, Toyota, Panasonic	Solid State
ProLogium	Enovate	Solid State
SVOLT		Solid State
AMTE Power		Silicon anode
Enovix		Silicon anode
Enevate		Silicon anode
Hibar Systems	Acquired by Tesla	Lithium-ion
Sila Nanotechnology		Silicon anode
OXIS Energy		Lithium-S
Métalectrique Research & Development (MAL)	LG Chem, Sanyo, Johnson Matthey, the UK MoD (DSTL) and Southampton University	Aluminium-Air
Maxwell Technologies	Acquired by Tesla, Maxwell is a specialist in ultra-capacitors and Tesla is interested in its dry electrode / solid state batteries	Lithium-ion, Solid State
NanoGraf	Graphene anode manufacturer	Lithium-ion
Kreisel Electric	Collaboration with Shell	Lithium-ion
QuantumScape	Recently listed on the stock exchange and partnering with VW	Solid state
Dyson	Dyson continues with investment in solid state technology despite abandoning its EV car project.	Solid state
SES		Solid state
StoreDot	Collaboration with EVE Energy. Daimler, BP, Samsung and TDK have invested	Silicon anode
Foxconn	Limited production by 2024	Solid state
Toyota	Limited production by 2024	Solid state

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

9. Battery Pack Assembly Plants

Battery pack assembly plants take the raw individual battery cells (just slightly larger than an individual 'AA' consumer battery) and combine them into 'modules'; these modules are then combined into complete battery packs, incorporating the BMS, TMS, and enclosure to create a usable battery system. This is referred to as battery pack 'integration'.

OEMs often consider that they can achieve product differentiation and competitive advantage on everything that goes on top of the basic battery cell, including the BMS and pack assembly. For example, two OEMs may well use the same CATL cells, but with better software and thermal management, they can often eke out a few percentage points further range or quicker charging – factors that often influence consumers in purchasing one vehicle over another. Overall, battery pack assembly is a key competitive advantage for OEMs.

Depending on the OEM, the battery pack assembly plant and location may vary. Some smaller start-ups will arrange for pack assembly to be outsourced to a third party or have the cell manufacturer provide this service. Larger volume OEMs will often arrange for the battery pack assembly to be located close to the vehicle production site or even right alongside the assembly line to minimise logistics costs and improve supply chain efficiency – but also to keep the control of the critical pack assembly process in-house and retain it as a competitive advantage.

Table 9.1 Battery Pack Assembly Plants

Company	Location	Date	Details
ATW Automation (owned by Tesla)	Germany		Acquired by Tesla to assembly battery packs for the upcoming vehicle assembly plant in Berlin
Audi	Brussels, Belgium		Audi primarily uses LG Chem cells. Audi is one of the few EV OEMs that assembles the modules and packs itself in its own assembly plants. 3 GWh output in 2020
BMW			For its existing generation of electric and hybrids BMW has mostly used Samsung SDI cells (with the exception of A123 Systems for its ActiveHybrids) but has signed an agreement with CATL batteries for its next generation of EVs, including the iNext series. In its efforts to diversify its supply base, BMW has also formed a technology consortium with

			Swedish battery manufacturer Northvolt and Belgian battery materials specialist Umicore
	Dingolfing, Germany (Competence Centre for E-drive Production)		BMW invested $100m in this plant to design, develop and manufacture its core electric drive components including the power electronics, BMS and the vehicle electrical system using cells supplied by Samsung SDI
	Munich, Germany		Part of the vehicle assembly plant will be used to assemble battery modules
	Leipzig, Germany		Part of the vehicle assembly plant will be used to assemble battery modules from 2021
	Regensburg, Germany		Coating of cells from 2021, full battery assembly from 2022
	Spartanburg, South Carolina, USA		Hybrid battery assembly and production of hybrid versions of BMW X3 and X5
	Tiexi, China		BMW Brilliance Automotive (BBA) JV plant includes a high voltage battery centres, and was recently expanded to build battery modules, including for the new BMW iX3 EV
	Thailand		Localised battery production with the Dräxlmaier Group for BMW 5 series PHEVs
BMZ GmbH	Karlstein, Germany		TerraE consortium co-founded by BMZ. Production of up to 80m lithium-ion batteries with a total capacity of around 4 GWh annually potentially rising to 8 GWh
Bolloré	Ergue-Gaberic, France		Bolloré assembles battery packs for its buses with a manufacturing capacity of 300 MWh
BorgWarner/ Romeo Power Technology	Vernon, California, US	2019	60:40 joint venture and BorgWarner investment in Romeo, which launched a battery pack plant in 2017
BYD			BYD is highly vertically integrated designing, producing and assembling in-house the complete electrical power train system including cells, modules and battery pack
	Shenzhen, China		14 GWh in 2018
	Qinghai, China		12 GWh in 2018, 24 GWh in 2019
	Huizhou, China		2 GWh in 2018
	Xi’an, Shaanxi, China		From 2023 up to 30 GWh battery production

	Chongqing, China		From 2023 this is JV between BYD and Changan Automobile. 5 to 6 GWh first stage, 10 GWh second stage
	Amazonas, Brazil		18,000 battery modules assembly per year for buses
Continental		2008	LG Chem has been Daimler's primary supplier of battery cells. Daimler then assembles its own battery packs at 9 locations throughout the world, sometimes with subsidiaries like its 100%-owned Deutsche Accumotive, and in some cases through JVs with local partners. Daimler has also signed a supply agreement with CATL, not specifying any specific models yet
Daimler	Nuremberg, Germany		333 MWh lithium-ion batteries for HEVs such as Mercedes S400 BlueHYBRID
	Kamenz, Germany plant 1	2019	Deutsche Accumotive develops, and assemble LG Chem cells and have produced 70,000 lithium-ion batteries packs since 2012 for Mercedes and Smart
	Kamenz, Germany plant 2	2012	
	Stuttgart-Untertürkheim, Germany, plant 1		
	Stuttgart-Untertürkheim, Germany, plant 2		
	Sindelfingen, Germany		
	Beijing, China		Joint-venture partner BAIC have added battery production at an engine factory
	Bangkok, Thailand		Battery production with local partner Thonburi Automotive
	Tuscaloosa, Vance, USA		Near the Mercedes SUV plant, which will build electric SUVs from 2022
	Jawor, Poland		Battery assembly facility for EQ range
Ford	Valencia, Spain		
	Rawsonville, MI, US		

Ford Otosan	Kocaeli, Turkey	2022	Battery packs for E-transit
Geely	China		JV with Geely Automobile Holdings
GM	Brownstown, Michigan, US	2010	Original battery assembly plant for Volt production. Today assembles battery pack for hybrids and replacement packs for aftersales
GM (Ultium JV)	Lordstown, Northeast Ohio, US	2021	$2.3bn JV between LG and GM to build a 30 GWh battery cell assembly plant in Lordstown
GS Yuasa	Miskolc, Hungary	2017	500,000 batteries per year
Hyperbat	Coventry, UK	2019	Up to 100,000 vehicles
Jaguar Land Rover	Hams Hall near Birmingham, North Warwickshire, UK	2020	Jaguar Land Rover Battery Assembly Centre
Johnson Matthey Battery Systems (Cummins)			One of Europe's largest lithium-ion battery systems suppliers, processing over 70m cells a year and supplying volume production of batteries for global markets. Tier supplier Cummins acquired the company in 2018
	Poland		Battery cell manufacture and pack assembly
	UK		
Kreisel Electric	Freistadt, Austria		800 MWh battery pack factory that supplies BMW, VW and McLaren Automotive with battery packs and electric powertrains for orders up to 10,000 vehicles. Kreisel currently has a supply agreement with Samsung SDI
Microvast	Brandenburg, Germany	2021	Ramp up to 8-12 GWh. Assembles battery packs with cells imported from China
Northvolt	Gdansk, Poland		Production site for battery modules and energy storage solutions. An increased investment will mean an initial capacity of 5 GWh in 2022 and potential for 12 GWh
Renault - Nissan - Mitsubishi	Sunderland, UK	2013	Nissan designs and manufactures battery packs in-house for its own use for Nissan Leaf and e-NV200 van. Cells provided by AESC Envision.
	Flins, France		Renault
	Blainville, France		Renault vans
	Barcelona, Spain		Nissan battery assembly. Factory is slated to close

	Kusatsu City, Japan		Mitsubishi Outlander PHEV battery pack is designed in house by Lithium Energy Japan, a JV between GS Yuasa, and Mitsubishi Corporation
Scania	Södertälje, Sweden	2023	For Scania trucks and buses. Cells will be supplied by Northvolt.
Stellantis	Nersac, France	2021	Pilot plant as part of ACC JV with Saft before ramping up battery production in 2023
	Trnava, Slovakia		Batteries for multiple brands
	Hauts-de-France, France	2023	Cell manufacture and pack assembly through ACC JV with SAFT and PSA/Opel. Initially 8 GWh eventually 24 GWh
	Kaiserslautern, Germany	2023	Cell manufacture and pack assembly through ACC JV with SAFT and PSA/Opel. Initially 8 GWh eventually 24 GWh
	Mirafiori complex, Turin, Italy	2020	€50m initial investment to build a battery assembly 'hub'
	Zaragoza, Figueruelas, Spain		
Tesla	Gigafactory 1, Reno, Nevada, US	2016	JV with Panasonic 23 GWh 2020 35 GWh future
	Gigafactory 2, Buffalo, New York	2017	This plant produces photovoltaic solar cells unrelated to automotive
	Gigafactory 3, Shanghai, China	Dec 2019	Batteries & cars. Target of 15 GWh battery production by 2023. Battery packs assembled using cells from various suppliers, including Panasonic, LG Chem and CATL
	Gigafactory 4, Grünheide, Germany	2021	Tesla's new plant will produce vehicles Model Y Model 3. and batteries. Battery capacity TBA 100-250 GWh. Elon Musk has said Tesla will make the plant the largest battery plant in the world.
	Fremont, California		Pilot plant initially, but Up to 10 GWH. Currently a vehicle assembly plant, Tesla indicated a pilot battery production line would be built for in-house cell production
	Austin, Texas, US		Cybertruck, Semi, Roadster, Model Y but also battery cell production to further integrate the supply chain

Valmet Automotive	Salo, Finland	2021	Modules and battery packs
Valmet Automotive	Uusikaupunki, Finland		Modules and battery packs and vehicle contract manufacture
Volvo	Ghent, Belgium	2020	XC40 Recharge and battery pack assembly
	Vigo, Spain		Battery assembly
	Ridgeville, South Carolina, US	2021	
VW	Salzgitter, Germany	2020	12 GWh potentially increasing to 30 GWh in JV with Northvolt
	Wolfsburg, Germany		Up to 500,000 EV battery packs per year
	Brunswick, Germany		Battery module assembly
	Ingolstadt, Germany		Audi reported to build battery plant

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

10. Automotive OEM Hybrid & Electric Vehicle Assembly Plants

In analysing the battery supply chain, it becomes increasingly apparent that the location of EV assembly plants is very important, perhaps even more so than with conventional ICE powertrains. The weight of the batteries, regulation around the movement of hazardous goods, and the security of supply and localisation of the supply chain are all critical factors intertwined with the chosen location of plug-in hybrid and electric vehicle assembly plants.

Furthermore, the battery sourcing model varies within those parameters, for example with some OEMs importing batteries completely from outsourced companies, whereas other OEMs such as Audi and Tesla assembly the batteries in the same actual plant as the vehicle itself.

OEM strategies also vary in terms of how they produce electric vehicles in plants. Many OEMs have and continue to opt to add EVs alongside existing ICE models, including GM, BMW and recently Volvo Cars. However, more OEMs are following the VW Group approach (and of course that of a pure EV OEM like Tesla), which includes converting a number of plants into purely electric vehicle production sites, such as Zwickau, Dresden and Emden in Germany. GM and Ford are now also converting more factories to produce purely EVs. BMW, which has mainly favoured a flexible approach, is now developed a pure EV platform and will make its upcoming plant in Hungary a dedicated manufacturing site for EVs.

The table below details many – but not all – locations for variants of hybrid, plug-in and fully electric vehicles.

Table 10.1 OEM Hybrid & EV Vehicle Assembly Plants

OEM	Brands	Models	Location	Details
Ai-Ways	Ai-Ways	U5 ION, U7 ION, RG (planned)	Shangrao, Jiangxi province, China	Jiangling Motors Holding, is the JV between Jiangling Motors and Changan
Alexander Dennis	ADL, BYD	Hybrid and electric Buses	Falkirk, Scotland	Includes a partnership with BYD on electric buses
Ankai	Ankai	Buses	Hefei, Anhui province, China	
Aston Martin	Aston Martin	Lagonda EV	St Athan, Wales, UK	EV may be delayed to 2025

BAIC	Foton, Aumark	Aumark EV, Toano EV van	Weifang, Shandong province, China	
BAIC	Beijing	E150EV, Wevan 307EV, EV EU5, EX3	Qingdao, Shandong province, China	
BAIC	Beijing	E150, EV160, EV200, D70 EV	Daixing, Beijing, China	
BAIC	Borgward	BXi7	Miyun, Beijing, China	
BAIC	Beijing, Senova	Senova D50 EV, Beijing EX200, EX5, ECS, EX360	Zhuzhou, Hunan province, China	
BAIC	Arcfox	Arcfox EV GT (planned 2020), EV (planned)	Zhenjiang, Jiangsu province, China	JV between BAIC and Magna
BAIC	Beijing	EX360, Wevan 407, ev Lite	Changzhou, Jiangsu province, China	
Baoneng	Changan, Baoneng, DS, Qoros	Eado EV, DS9 PHEV (previous) now new Baoneng plans	Shenzhen, Guangdong province, China	Baoneng acquired plant from Changan PSA JV, also acquired 50% of Qoros Auto
Beijing North	Neoplan	NEV buses	Fengtai, Beijing, China	North Huade Neoplan, owned by Beijing North Vehicle, China Highway Machinery Co.
Best	Best	Shuchi E-Bus	Yantai, Shandong province, China	
Bisu	Bisu	E-mini truck	Nanchong, Sichuan province, China	
BMC	BMC	Truck, military	Pinarbasi, turkey	
BMW	BMW	Ix3 EV, 5-Series PHEV, iX, i4 (planned)	Dadong plant, Shenyang, Liaoning province, China	BBA JV between BMW and Brilliance Auto
BMW	BMW, Zinoro	ix3 (from 2022), 3 series EV, Zinoro 1E	Tiexi plant, Shenyang, Liaoning province, China	BBA JV between BMW and Brilliance Auto.

				Tiexi also builds batteries
BMW	Mini, Spotlight, Great Wall	Mini EVs (planned)	Zhangjiagang, Jiangsu province, China	Spotlight Automotive JV between Great Wall and BMW
BMW	BMW	3 Series, 5 Series, 7 Series, X5 PHEV	Amata city, Rayong, Thailand	
BMW	BMW	X1 PHEV, X2 PHEV	Regensburg, Bayern, Germany	
BMW	BMW	3 Series PHEV, I4 (2021)	Munich, Bavaria, Germany	EV from 2021
BMW	BMW	iNext EV and iX EV, 5 and 7 series PHEV, 7 EV (2022)	Dingolfing, Bavaria, Germany	EVs from 2021
BMW	BMW	i3 EV, 2 Series PHEV, Mini Electric (2023)	Leipzig, Saxony, Germany	Electric Mini From 2023 (previously i8 PHEV)
BMW	BMW	Future EV platform	Drebrecen, Hungary	Opening in 2025 to produce only EVs including new EV platform
BMW	BMW	5 Series PHEV	Graz, Austria	Magna Steyr contract manufacturing
BMW	BMW, Mini	Mini PHEV	VDL Nedcar, Bom, Netherlands	
BMW	Mini	Mini Electric	Oxford, England	
BMW	BMW	PHEV versions of X3 and X5	Spartanburg, SC, USA	
Bollore	Bollore	Electric bus	Ergue-Gaberic, France	
BYD	BYD	K9 e-bus	Dalian, Liaoning province, China	
BYD	Jinma	Jinma Bus	Wuqing, Tianjin, China	JV with Tianjin Public Transport Corp
BYD	BYD	Qin EV300, Qin EV450, Song EV499, Song Pro, EV Bus-K9,K8	Xian, Shaanxi province, China	

BYD	BYD	Sirui, e1, E3, S2, Yuan EV, Song EV, Song PHEV, Bus K9, EV Truck K5, T7, Van V3	Changsha, Hunan province, China	
BYD	BYD	BYD electric vehicles	Changzhou, China	Join venture with Changan with annual capacity of 400,000 autos
BYD	BYD	Tang, Tang PHEV, e6, Han EV, Han PHEV	Shenzhen, Guangdong province, China	
	BYD		Shaoguan, China	
	BYD		Shangluo, China	
BYD	BYD / Daimler		China	Shenzhen Denza New Energy Automobile JV between BYD and Daimler
BYD	Olectra		Jedcheria, Telangana, India	
BYD	BYD	Buses	Komarom, Hungary	
BYD	BYD	Buses	Beauvaus, France	
BYD	BYD	Buses	Allonne, France	
BYD	BYD	Buses	Lancaster, CA, US	
BYD	BYD	Short range vehicles	Ontario, Canada	
BYD	BYD	Buses	Campinas, Sao Paolo, Brazil	Electric bus chassis
BYD	Changan	4 models planned	Kutaisi, Georgia	JV between Changan & AiGroup. Originally launch planned for 2020
BYD	BYD, Alexander Dennis	Buses	Falkirk, Scotland	Joint venture for buses with Alexander Dennis
Byton	Byton		Xiqing, Tianjin, China	Former Tianjin FAW Huali plant, acquired in 2018 by Byton
Byton	Byton	M-Byte (2021 - planned)	Qixia, Nanjing, China	

Byton	Byton	M-Byte (planned 2021), E-Tuktuk (planned 2020)	Gunsan, Jeollabuk, South Korea	Previous GM Korea plant. 2019 agreement Myoung Shin Industry and Byton, to build Byton models
CH Auto	Qiantu, Mullen	Qiantu K50 (Dragonfly K50)	Suzhou, Jiangsu province, China	JV between Mullen Tech and CH Auto
Changan	Changan	EV sedan (planned)	Dingzhou, Hebei province, China	
Changan	Changan Bus	EV Ruixing ES30	Dingzhou, Hebei province, China	
Changan	Changan	CS15 E-Pro	Hefei, Anhui province, China	
Changan	Chana, Oshan, EULove	EULove EV, Oshan EV	Lishui, Nanjing, Jiangsu province, China	
Changfeng	Leopaard	CS9 EV	Changsha, Hunan province, China	
Changjiang	Changjiang	E-Boss, e-Glory, e-Cool (all on hold)	Hangzhou, Zhejiang province, China	Company filed for bankruptcy Q4 2020
Changjiang	Leapmotor	Leap Coup, Minicar T03, C11 SUV	Jinhua, Zhejiang province, China	
Changjiang	FDG	e-vans, logistics vehicles	Guian, Guizhou province, China	
Chery	Chery		Aragua, Venezuela	
Chery	Jetour, Karry	Yo-Yo EV, Jinyou EV, X70s EV	Kaifeng, Henan province, China	
Chery	Qoros	EV500 (planned)	Changshu, Jiangsu province, China	
Chery	Exeed, Chery, Arrizo, Tiggo	Arrizo 5e, Exeed PHEV	Changchun Lu, Wuhu, Anhui province, China	
Chery	Chery, Arrizo, Tiggo	eQ1, eQ, Arrizo 5e, Tiggo e	Huajing Nan Lu, Wuhu, Anhui province, China	

CHJ	Lixiang (Ideal)	Ideal One	Changzhou, Jiangsu province, China	
CIMC	CIMC, C&C	e-truck	Sanshan, Wuhu, Anhui province, China	
CRRC	CRRC	CRRC e-Bus	Zhuzhou, Hunan province, China	
Daewoo	Daewoo	e-bus	Ulsan, South Korea	
DAF	DAF, Paccar	CF electric truck	Eindoven, Netherlands	
Daihatsu	Daihatsu, Toyota, Mazda	Toyota Probox HV	Ooyamazaki-cho, Otokuni-gun, Kyoto, Japan	Daihatsu plant also producing Toyota and Mazda models
Daimler	Mercedes, Daimler	C Class PHEV, EQE, EQC	Bremen, Germany	EV from 2021
Daimler	Mercedes Vans	e-Sprinter	Dusseldorf, North Rhine-Westphalia, Germany	
Daimler	Evo	Evo Bus	Mannheim, Baden-Württemberg, Germany	
Daimler	Mercedes-Benz	EQ range e.g. EQA C-SUV	Rastatt, Baden-Württemberg, Germany	From 2020
Daimler	Mercedes-Benz	E Class, S Class PHEV, EQ range (2021)	Sindelfingen, Baden-Württemberg, Germany	EV from 2021
Daimler	Mercedes-Benz	Daimler fuel cell vehicle	Stuttgart, Baden-Württemberg, Germany	
Daimler / INEOS	Smart, INEOS	Smart EQ Fortwo, Future Grenadier EVs	Hambach, Moselle, France	INEOS took over plant in Q1 2021, produces Smart on contract
Daimler	Mercedes-Benz Vans	eVito	Vitoria, Basque Country, Spain	
Daimler	Fuso	eCanter electric truck	Tramagal, Portugal	

Daimler	Mercedes-Benz Trucks	eActros	Wörth, Baden-Württemberg, Germany	Starting in 2022
Daimler	Mercedes-Benz	EQB	Kecskemet, Hungary	From 2021
Daimler	Daimler Trucks	Thomas Built Bus	High Point, NC, US	
Daimler	Mercedes-Benz	EQS, EQE	Tuscaloosa, Alabama, US	From 2022
Daimler	Western Star	Electric trucks	Portland, OR, US	
Daimler	Mercedes-Benz	Sprinter Vito, EQV	Gonzales Catan, Argentina	
Daimler	Mercedes-Benz	EQC400, EQE (planned)	Shunyi, Beijing, China	JV between BAIC and Daimler
Daimler	Mercedes-Benz	EQB SUV (planned), EQA SUV(planned)	Boxing Road, Beijing, China	JV between BAIC and Daimler
Daimler	Smart, Geely	smart EVs (planned)	Xian, Shaanxi province, China	JV between Geely and Daimler
Daimler	Denza	Denza EV 400, Denza X PHEV, Denza EV SUV	Pingshan, Shenzhen, Guangdong province, China	JV between BYD and Daimler
Dongfeng	Dongfeng	Special purpose EVs	Urumuqi, Xinjiang, China	
Dongfeng	Dongfeng, Skio	Skio EV, ER30, Junfeng EV ER30	Xiangyang, Hubei province, China	
Dongfeng	Dongfeng	EV garbage truck	Shiyan, Hubei province, China	
Dongfeng	Luxgen, Yulon	Yulu EV2, U5 EV	Hangzhou, Zhejiang province, China	JV between Dongfeng and Yulon Group (Taiwan)
Dongfeng	Dongfeng	Special purpose EVs	Pingshan, Shenzhen, Guangdong province, China	
Dongfeng	Fengxing	Fengxing EV T5 (planned)	Liuzhou, Guangxi province, China	
Dongfeng	Dongfeng	EV buses	Xiangyang, Hubei province, China	
Dorcen	Dorcen, Qiling	Dorcen E20, Qiling EV Pickup	Fuzhou, Jiangxi province, China	JV between Dorcen and JMC

Enovate	Enovate	ME7	Changsha, Hunan, China.	Completion late 2020
FAW	Senia	EV Senia R7	Jilin, Jilin province, China	Plant owned 70% by Shandong Baoya, 30% FAW
FAW	Hongqi	E-HS9	Changchun, Jilin province, China	
FAW	Bestune	E-01	Changchun, Jilin province, China	
FAW	FAW	Sitech EV	Changchun, Jilin province, China	
FAW	FAW trucks		Port Elizabeth, Eastern Cape, South Africa	Plans for hybrid/electric trucks
FAW, Haima	Haima	Freema EV	Longhua, Haikou, Hainan province	JV between Haima and FAW
Feidie	Wuzheng, Dito	Wuzheng, Dito EV trucks	Hangzhou, Zhejiang province, China	
Fisker	Fisker	Ocean SUV	Graz, Austria	Contract manufacturer Magna Steyr will build the Fisker EV in 2022
Fisker	Fisker	Future EVs	China	Agreement with Foxconn to develop and manufacture EVs
Ford	Ford, Mazda	Hybrid variants	Rayong, Thailand	
Ford	Ford	New EVs using VW's MEB platform	Cologne, North Rhine-Westphalia, Germany	Ford is investing $1 billion to make the plant its European electrification centre
Ford	Ford	Focus hybrid	Saarlouis, Saarland, Germany	
Ford	Ford	Puma mild hybrid	Craiova, Romania	
Ford	Ford	Kuga PHEV, Transit Connect Van	Valencia, Spain	Transit production moving to Mexico plant

Ford	Ford	Transit Custom PHEV	Golcuk, Kocaeli, Turkey	
Ford	Ford	Explorer hybrid	Chicago, IL, USA	
Ford	Ford Truck	Escape hybrid	Louisville, Kentucky, USA	
Ford	Ford	F-150 EV	Rouge Electric Vehicle Center, Dearborn, Michigan, USA	From 2022
Ford	Ford	Mustang Hybrid	Flat Rock, Michigan, US	From 2021
Ford	Ford	e-Transit van	Kansas City, US	
Ford	Ford, Lincoln	Fusion hybrid, Fusion PHEV, MKZ Hybrid	Hermosillo, Sonora, Mexico	
Ford	Ford	Mustang Mach-e	Cuautitlan, Izcalli, Mexico	
Ford	Ford	Future EVs	Oakville Assembly Complex, Ontario, Canada	From 2024
Ford	Ford, Mazda	Ranger hybrid (future)	Pretoria, Gauteng, South Africa	
Ford	Changan Ford	Mustang Mach-e	China	From late 2021
Fuda	Wuzhoulong	Special purpose EVs, buses	Longgang, Shenzhen, Guangdong province, China	
Fujian	Yudo	Yudo ¶ 1, 360, pro, E-Shock	Putian, Fujian province, China	
Fujian Motor	Soueast	DX3 EV, Lingyue EV, DEARCC EV	Fuzhou, Fujian province, China	
GAZ	GAZ		Sogutlu, Sakarya, Turkey	
Geely	Emgrand, Geometry	Emgrand EV, Gse, Geometry EV SUV, Geometry A	Jinzhong, Shanxi Province, China	Geely subsidiary Shanxi New Energy Auto Co, plant
Geely	Maple	Maple 30X EV	Hangzhou, Zhejiang province, China	JV between Geely and Kandi
Geely	ZD (Zhidou)	Zhidou D3, D2, D1	Ningbo, Zhejiang province, China	

Geely	Polestar, Volvo, Lynk & Co	Models on CMA platform under Volvo, XC40, Polestar 2, Lynk & Co	Luqiao, Taizhou, Zhejiang province, China	Also brands Polestar and LYNK & Co
	Polestar	Polestar 1 PHEV	Chengdu, China	
Geely	Geely, LEVC	TX5, electric LCVs	Yiwu, Zhejiang province, China	
Geely	Volvo	S60L, XC60 hybrids	Chengdu, China	Zhongjia Automobile Manufacturing (Chengdu) (ZAMC)
Geely	Volvo	S90, S90L hybrids	Daqing, China	Daqing Volvo Car Manufacturing (DVCM)
Geely	Farizon, Geely	e-TRUCKS, methanol vehicles	Nanchong, Sichuan province, China	Geely's CV production base
Geely	Volvo	XC40 PHEV, XC40 Recharge P8 EV	Ghent, Belgium	EV and battery productions started in 2020, plans to treble output
Geely	Volvo	XC60, V60, V60 Cross Country, V90, V90 Cross Country, XC90 PHEV	Torslanda, Gothenburg, Sweden	Volvo Cars Torslanda (VCT)
Geely	Volvo	S60 PHEV XC90 EV (future) EV batteries (future)	Ridgeville, Beverly County, South Carolina, US	Volvo to add battery plant and EV version in future
Geely	Lotus	Evija	Norwich, England	Starting in 2022
Geely	LEVC, London Taxi	Electric taxis, van	Ansty, England	
GM	Buick, Chevrolet,	Velite 5 EV	Jinqiao, Pudong, Shanghai, China	JV between SAIC and GM
GM	Cadillac, Buick	CT6 PHEV (2017-2018)	Jinsui Lu, Pudong, Shanghai, China	JV between SAIC and GM -plant mainly for Cadillac
GM	Wuling	Wuling Rongguang EV	Yufeng, Liuzhou, Guangxi province, China	

GM	Corvette	Future EV	Bowling Green, KY, US	Future Corvette EV (not yet confirmed). All GM vehicles will be battery by 2035
GM	Cadillac, Chevrolet		Fairfax, KS, US	GM recently withdraw Malibu hybrid; all vehicles will be battery by 2035
GM	Chevrolet, Cruise	Bolt, Bolt EUV, Cruise AV	Orion Assembly in Orion Township, Michigan, US	Bolt EUV in 2021
GM	Cadillac, GMC	Lyriq EV	Spring Hill, Tennessee, US	GM has invested $2 billion to make Spring Hill a third EV plant Lyriq launch in 2021
GM	GMC, Cruise	Hummer EV, Cruise Origin	Factory ZERO Hamtramck,, Detroit, Michigan, US	Production from 2021. GM's first EV-only manufacturing plant
Golden Dragon	Golden Dragon, Skywell	e-buses, e-vans	Zhetang, Lishui, Nanjing, Jiangsu province, China	
Golden Dragon	Golden Dragon	e-buses, special purpose vehicles	Xiamen, Fujian province, China	
Great Wall	Great Wall, Ora, Wingle	HEV Wingle pickup, Ora IQ, Ora R2	Baoding, Hebei province, China	
Great Wall	Wey	P8	Xushui, Baoding, Hebei province, China	
Great Wall	Ora	Ora R3 EV	Taizhou, Jiangsu province, China	
Greenwheel	Greenwheel	Hydrogen Fuel Cell bus, Kanghete bus (EV), e-logistics vehicles, e-refrigerated vans	Rugao, Jiangsu province, China	

Greenwheel	Greenwheel	EV (planned)	Gaoming, Foshan, Guangdong province, China	
Guilin	Wuling Motors	LNG buses, EV, CNG buses	Guilin, Guangxi Zhuang Autonomous Region, China	
Guilin	Daewoo	E-buses, PHEV buses	Guilin, Guangxi Zhuang Autonomous Region, China	JV between Guilimn Bus Groupo and Daewoo
Haima	Haima	7X PHEV (planned)	Zhengzhou, Henan province, China	previously produced Xpeng models at this plant as contract manufacturers.
Hanteng	Hanteng	Hanteng X7 PHEV, X5 EV, Xingfu	Shangrao, Jiangxi province, China	
Honda	Honda		Suzuka, Japan	
Honda	Honda	Clarity PHEV, Clarity EV, Acura PLX Sport Hybrid	Sayama, Saitama, Japan	Potentially closing by 2022
Honda	Honda	New EVs	Yori plant, Japan	
Honda	Honda		Ogawa, Japan	
Honda	Honda	CR-V Hybrid	Wuhan, Hubei, China	Dongfeng Honda Automobile Co., Ltd.
Honda	Honda	Accord Hybrid	Rojana, Uthai, Ayuthaya, Thailand	
Honda	Honda		Gebze, Kocaeli, Turkey	
Honda	Honda	Accord Hybrid, Acura NSX	Marysville, Ohio, USA	
Honda	Honda	CR-V Hybrid	East Liberty, Ohio, US	
Honda	Honda	Insight, CR-V Hybrid	Greensburg, Indiana, US	
Honda	Honda	Civic hybrid	Ontario, Canada	
Hybrid Kinetic	Hybrid Kinetic	H500, H600, K350	Ningbo, Zhejiang province, China	

Hyundai-Kia	Hyundai	Elantra PHEV, I30	Shunyi, Beijing, China	JV between BAIC and Hyundai
Hyundai-Kia	Kia	K5 PHEV, e-Niro, Sorento PHEV	Hwaseong, South Korea	
Hyundai-Kia	Hyundai	Sonata HEV, Sonata PHEV	Asan, Chuncheongnam, South Korea	
Hyundai-Kia	Kia	Soul EV, Soul Booster EV	Gwangju, South Korea	
Hyundai-Kia	Hyundai, Genesis	ix35 Fuel Cell, Porter EV, Ioniq 5 EV, Kona EV	Ulsan, South Korea	
Hyundai-Kia	Hyundai		Sriperumdubur, Kanchipuram, Tamil Nadu, India	
Hyundai-Kia	Kia	Ceed and XCeed PHEV	Zilina, Slovakia	
Hyundai-Kia	Hyundai	Kona EV	Nosovice, Czech Republic	Hyundai Motor Manufacturing Czech (HMMC)
Hyundai-Kia	Hyundai	I20 hybrid	Izmit, Kocaeli, Turkey	Hyundai has discussed plans for a future battery centre in Turkey
Hyundai-Kia	Kia, Horki	Horki 300E	Yancheng, Jiangsu province, China	JV between Dongfeng, Yueda and Kia
Hyundai-Kia	Kia	KX3 EV, K5 PHEV	Tinghu, Yancheng, Jiangsu province, China	Plant 2. JV between Dongfeng, Yueda and Kia
Hyundai-Kia	Hyundai	Local EV model (future)	Chennai, India	Hyundai has announced a $200m investment to produce a local EV model for India
Hyundai-Kia	Hyundai		Jurong, Singapore	Due in 2022 the Hyundai Motor Group Innovation Centre (HMGICS) will also produce EVs
Hyundai-Kia	Kia		Quito, Ecuador	
Ikarbus	Ikarbus		Beograd, Serbia	

IKCO	IKCO, SAIPA		Maracay, Venezuela	
JAC	JAC, VW, NIO	i-EV4, i-EV5, SOL e20x, NIO ES8, EC6, ES6	Hefei, Anhui province, China	JAC (owned 75% by VW), with NIO contracting use of PV plant. Plant is JV between JAC and regional investment players
JAC	JAC	Iev6e	Anqing, Anhui province, China	
JBM	JBM	bus	Mathura, Uttar Pradesh, India	
JBUS	Hino, Isuzu	EV bus	Tochigi, Japan	JBUS plant assembles buses for Hino, Isuzu
JBUS	Toyota, Hino, Isuzu	Toyota Sora FCEV	Komatsu-shi, Ishikawa, Japan	Sora Fuel Cell bus
Jiangren	Singulato	Electric CV (planned 2020/2021)	Zhuzhou, Hunan province, China	
JLR	Jaguar, Land Rover	Jaguar E-Pace PHEV (Oct 2020)	Changshu, Jiangsu province, China	JV between Chery and Jaguar Land Rover
JLR	Land Rover	Defender, Discovery PHEVs	Nitra, Slovakia	
JLR	Range Rover, Land Rover	Evoque, Discovery Sport PHEVs	Halewood, England	
JLR	Jaguar	XJ, Future EVs	Castle Bromwich, England	Jaguar to be all-electric brand by 2025. Plans for electric XJ reported to be cancelled
JLR	Jaguar, Range Rover	F Type, Range Rover, Range Rover Sport, Velar PHEV, future EVs	Solihull, England	Solihull will be home to JLR's electric modular architecture and the first Land Rover EV by 2024
JLR	Jaguar	I Pace EV, E Pace PHEV	Graz, Austria	Contract manufacturing by Magna Steyr

JMC	Ford, JMC, Fushan, Aiways	Ford Territory EV	Nanchang, Jiangxi province, China	JV between JMC and Ford
JMC	JM	Yizhi EX5, E200N, E200L, E160L, E100B	Mount Lu, Nanchang, Jiangxi province, China	JV between Jiangxi Jiangling Motors and Renault
JMC	JMC, Ford	e-SUVs (planned)	Xiaolan, Nanchang, Jiangsu province, China	JV between JMC and Ford
JMC	JM	Yizhi EVs (planned)	Kunming, Yunnan province, China	
KAMA	KAMA	Kama NEV truck	Shouguang, Shandong province, China	
Karma	Karma		Moreno Valley, CA, US	
Karsan	Hyundai, PSA		Nilufer, Bursa, Turkey	
King Long	Higer, King Long		Jingwei, Xian, Shaanxi province, China	
King Long	King Long, Apolong	e-buses, e-vans	Xiamen, Fujian province, China	
Leapmotor	Forta	e-trucks, buses	Zhangzhou, Fujian province, China	Wholly owned by Leapmotor
Lifan	Lifan	630 EV, 320 E, 820 EV	Jiyuan, Henan province, China	
LinkTour	LinkTour, Yogomo	K-ONE, Yogomo E330	Xingtai, Hebei province, China	JV between Yogomo and Great Wall
Lordstown	Lordstown	electric pickup	Lordstown, OH, US	
Lucid	Lucid	Air EV	Casa Grande, AZ, US	Lucid Air production starting in 2021
Mahindra	Mahindra		Satpur, Nashik, Maharashtra, India	

Mahindra	Skoda, Daimler, Mahindra	Chakan, Maharashtra, India		
Mahindra	Mahindra		Bangalore, Karnataka, India	
Marco Polo	Marco Polo		Germiston, Johannesburg, Gauteng, South Africa	
Mazda	Mazda	Mazda2 HV	Hamakata, Hofu-Shi, Yamaguchi	
Mazda	Mazda	CX-30	Hiroshima, Japan	
Minan	Minan, Lantu	electric logistics vehicles (planned), EV sedan (planned)	Huai'an, Jiangsu province, China	
McLaren	McLaren	Arturas PHEV	Working, Surrey, UK	
Minsheng	Nezha, Hozon	Nezha N01	Tongxiang, Zhejiang province, China	
Myongohin	Byton	M-Byte	Gunsan	Contract manufacturer Myongshin agreed with Future Mobility Corp (FMC) to produce the Byron M-byte from 2021
Nanjun	CNJ	special purpose EVs	Yanjiang, Ziyang, Sichuan province, China	
Navistar	Navistar		Benoni, Johannesburg, South Africa	
NEVS	NEVS, Iconiq	EV Guoneng 93 (Saab 93-E), Iconiq e-MPV, Iconiq Seven	Binhai, Tianjin, China	
NEVS	NEVS, Iconiq	EV planned	Songjiang, Shanghai, China	Owned by Evergrande
NEVS	NEVS		Trolhattan, Sweden	Plant not active but could see future EVs

Nio	EVs		Hefie, China	JAC are the contract manufacturer
Nova	Nova bus		St Eustach, QC, Canada	
Otkar	Iveco, Land Rover		Arifiye, Sakarya, Turkey	
Paccar	Paccar		Bayswater, Victoria, Australia	
Piaggio	Piaggio	3-wheeler	Baramati, Maharashtra, India	
Piaggio	Piaggio		Pontederia, Tuscany, Italy	
Pininfarina	Various		Cambiano, Piemonte, Italy	Low volume, specialised contract production
Renault-Nissan-Mitsubishi	Mitsubishi, Qizhi	Qizhi PHEV, Qizhi EV	Changsha, Hunan province, China	JV between Guangzhou Auto Corp (GAC) and Mitsubishi
Renault-Nissan-Mitsubishi	Mitsubishi, Nissan, PSA	Mitsubishi EV I-MiEV, eK Wagon, Peugeot EV iOn, Citroen EV C-Zero	Mizushima Plant, Kurashiki, Okayama Japan	Mitsubishi plant also producing Nissan and PSA models
Renault-Nissan-Mitsubishi	Mitsubishi	Mitsubishi Outlander PHEV	Okazaki, Aichi prefecture, Japan	
Renault-Nissan-Mitsubishi	Fuso, Nissan, Daimler	Mitsubishi Fuso models, Daimler Trucks -UD Trucks	Kawasaki, Japan	
Renault-Nissan-Mitsubishi	Mitsubishi, RMA	I-Miev	Leamchabang, Chonburi, Thailand	Mitsubishi Thailand
Renault-Nissan-Mitsubishi	Fuso		Temsa, Adana, Turkey	
Renault-Nissan-Mitsubishi	Nissan	Nissan NV200, e30	Zhengzhou, Henan province, China	JV between Dongfeng and Nissan

Renault-Nissan-Mitsubishi	Nissan	Ariya EV	Tochigi, Japan	From 2021
Renault-Nissan-Mitsubishi	Nissan	Nissan X-Trail HV, Serena e-POWER	Miyako-gun, Fukuoka, Japan	Nissan Kyusho plant
Renault-Nissan-Mitsubishi	Nissan	Leaf	Oppama, Yokosuka, Kanagawa, Japan	
Renault-Nissan-Mitsubishi	Nissan, Volvo Truck	UD trucks / Volvo	Bangsaothong, Samutprakan, Thailand	
Renault-Nissan-Mitsubishi	Nissan	Kicks ePower SUV	Thailand	
Renault-Nissan-Mitsubishi	Nissan	Leaf EV	Smyrna, Tennessee, US	
Renault-Nissan-Mitsubishi	Nissan	Leaf EV, Qashqai hybrids	Sunderland, UK	
Renault-Nissan-Mitsubishi	Nissan	NV-200 electric van	Avila, Castile and Leon, Spain	Plant is set to close
Renault-Nissan-Mitsubishi	Renault, Jinbei	Master EV (planned), Jinbei e-LCV (planned)	Shenyang, Liaoning province, China	JV between Renault and Brilliance Auto
Renault-Nissan-Mitsubishi	Renault, Dacia	K-ZE City, Dacia Spring Electric (planned 2021)	Shiyan, West of Wuhan, Hubei province, China	eGT-New Energy Vehicle (EGT-NEV), JV between Dongfeng and Renault (transferred to Nissan after Renault pulled out of China domestic market)
Renault-Nissan-Mitsubishi	Renault, Smart	Renault Clio PHEV, Smart for four EV	Revoz, Novo Mesto, Slovenia	
Renault-Nissan-Mitsubishi	Renault	Megane EV, hub for EV platforms	Douai, France	EVs starting in 2021 on CMF-EV platform

Renault-Nissan-Mitsubishi	Renault, MCA	Kangoo EV	Maubeuge, France	
Renault-Nissan-Mitsubishi	Alpine	Future EVs	Dieppe, France	Alpine to be converted to pure electric brand
Renault-Nissan-Mitsubishi	Renault	Master ZE	Blainville, France	
Renault-Nissan-Mitsubishi	Renault	Zoe	Flins, France	Plant will end assembly in 2024 and convert to recycling centre
Renault-Nissan-Mitsubishi		Renault Captur PHEV, Zoe, Twizy	Valladolid, Castile and Leon, Spain	Twizy moving to Renault Samsung plant in Busan, South Korea
Renault-Nissan-Mitsubishi	Oyak Renault	Clio hybrid	Bursa, Turkey	
Renault-Nissan-Mitsubishi	Renault, Renault Samsung, Nissan	Twizy, SM3 ZE	Busan, South Korea	
Rimac	Rimac		Zagrebm Croatia	
Rivian	Rivian	R1S, R1V, Amazon delivery vehicle	Normal, IL, USA	Production starting in 2021
Ruineng	Enovate	ME7	Shaoxing, Zhejiang province, China	
SAIC	MG	e ZS	Zhuanghou, Henan province, China	
SAIC	Maxus	EV80, EV EG10, FCV 80, EG50	Wuxi, Jiangsu province, China	
SAIC	Roewe, MG, Marvel	MG eMG6, Roewe e550,e950, e50, EV Marvel, Marvel R	Lingang, Pudong, Shanghai, China	
SAIC	Roewe, MG, Marvel	Roewe e50, ei6 PHEV, ei5 PHEV, EV ER6	Pukou, Nanjing, Jiangsu province, China	

SAIC	MG, Roewe	MG eHS PHEV, Roewe EV Clever	Ningde, Fujian province, China	
SAIC	MG		Rayong, Thailand	
SAIC	MG		Panchmahal, Gujarat, India	
SAIC	VW, SAIC	MEB vehicles ID.3 & ID.4 Audi brand	Anting, Shanghai, China	From 2020, JV with SAIC
Sanhuan	Tri-ring, Sitom	EV trucks	Shiyan, Hubei province, China	
Seres	Seres		Mishawaka, IL, USA	
Shenlong	Shenlong, Sunlong, Sunwin	EV buses, FCEV, CNGVs	Minhang, Shanghai, China	
Singulato	Singulato	EV Ic3 (planned)	Suzhou, Jiangsu province, China	
Singulato	Singulato	e-PVs (planned)	Tongling, Anhui province, China	
Sitech	Sitech	DEV1, DEV Lite	Guian, Guizhou province, China	
Solaris	Solaris	Electric bus	Owinska, Poland	
SOR	SOR	Electric bus	Libchavy, Czech Republic	
Ssangyong	Ssangyong	Korando EV (planned 2021)	Pyeongtaek, South Korea	
Stellantis	Jeep	Jeep Commander PHEV (planned)	Changsha, Hunan province, China	JV with GAC and FCA
Stellantis	Fiat, Jeep	EVs	China - TBC	JV with Foxconn
Stellantis	Fiat, Maserati	500e, Gran Turismo, GranCabrio (2021)	Miraflori, Piemonte, Turin, Italy	Battery production
Stellantis	Ferrari	SF90 Stradale hybrid	Maranello, Emilia-Romagna, Italy	
Stellantis	Fiat	Panda hybrid	Pomigliano d'Arco, Campania, Italy	
Stellantis	Jeep	Jeep Renegade PHEV	Melfi, Basilicata, Italy	
Stellantis	Jeep	Wrangler PHEV	Toledo (Ohio) North Assembly Plant, US	

Stellantis	Chrysler	Durango Hybrid	Jefferson Assembly Plant, Detroit, Michigan, US	
Stellantis	Chrysler	PHEV	Warren (Michigan) Truck Assembly Plant	
Stellantis	Jeep	Future Jeep PHEV	Detroit Assembly Complex – Mack ('Detroit 2), Michigan, US	Will launch all-new 3-row Jeep and PHEV version
Stellantis	Chrysler	Pacifica Hybrid	Windsor, ON, Canada	
Stellantis	Chrysler	Portal EV Minivan	Brampton, Canada	
Stellantis	Opel, Vauxhall	Future EMP2 platform	Russelsheim, Hessen Germany	Next generation Astra and future DS model will be on electrifiable platform
Stellantis	Opel	Opel Crossland X PHEV	Eisenach, Thuringia, Germany	
Stellantis	Peugeot, Citroen, DS	Peugeot 508, DS7 Crossback PHEV	Mulhouse, France	
Stellantis	Peugeot, Citroen	Peugeot 3008 HEV, PHEV & EV by 2022	Sochaux, France	
Stellantis	Peugeot, Citroen, Opel, Vauxhall, Toyota	Electric and hybrid vans	Sevel Nord, Lieu Saint-Amand, France	Also some Toyota models
Stellantis	Peugeot, Citroen	Peugeot 508, DS7 Crossback PHEV	Rennes-la-Jannais, France	
Stellantis	Peugeot, Citroen	DS3 Crossback E-Tense, Opel Mokka X PHEV and EV, Citroen E-Mahri	Poissy, France	
Stellantis	Peugeot, DS, Opel / Vauxhall	Peugeot e-208 & DS 3 Crossback E-Tense,	Tremery, France	

		Opel/Vauxhall Corsa-e		
Stellantis	PSA	Peugeot e-208, Batteries for all brands	Trnava, Slovakia	electrified powertrain assembly line
Stellantis	Opel	Opel e-Corsa	Zaragoza, Aragon, Spain	
Stellantis	Peugeot, Citroen	e-2008, e-C4	Vigo, Galicia, Spain	Plus Battery assembly
Stellantis	Peugeot, Citroen		Buenos Aires, Argentina	
Subaru	Subaru		Yajima, Japan	
Suda	Suda	Suda EV	Sanmenxia, Henan province, China	
Sunwin	Sunwin	E-Bus	Qingdao, Shandong province, China	
Suzuki	Suzuki, Mitsubishi	Suzuki HV, Bandit HV	Shizuoka prefecture, Japan	
Suzuki	Suzuki, Mazda	Suzuki Wagor R HV, Mazda HV Flair	Shizuoka prefecture, Japan	
Suzuki	Suzuki		Rayong, Thailand	
Suzuki	Suzuki		Gurgaon, Haryana, India	
Suzuki	Suzuki		Manesar, Haryana, India	
Suzuki	Suzuki		Mehsana, Gujarat, India	
Suzuki	Suzuki		Esztergom, Hungary	
Tata	Tata, Ford		Sanand, Gujarat, India	
Tata	Marcopolo	Bus	Dharwad, Karnataka, India	
Tata	Tata		Rosslyn, Pretoria, Gauteng, South Africa	
Tesla	Tesla	Model 3, Model Y	Lingang, Pudong, Shanghai, China	100% owned by Tesla HK
Tesla	Tesla	Model Y & Battery assembly	Gruenheide, Brandenburg, Germany	From 2021

Tesla	Tesla	Model 3, S, X	Tilburg, Netherlands	Knockdown assembly of finished vehicles, not full production
Tesla	Tesla	Cybertruck	Austin, TX, US	Planned
Tesla	Tesla	Model 3, S	Fremont, CA, US	
Tongjia	Tongjia	Electric Bull van	Baoji, Shaanxi province, China	
Toyota	Toyota	Corolla PHEV, RAV4 PHEV	Teda, Tianjin, China	JV between FAW and Toyota
Toyota	Toyota, Isuzu, Dongfeng		Gateway City, Plaeng Yao, Chachoengsao, Thailand	
Toyota	Hino, MINE		Banpo, Chachaoengsao, Thailand	
Toyota	Toyota, Hino		Amata Nakon, Chonburi, Thailand	
Toyota	Toyota		Bangalore, Karnataka, India	
Toyota	Toyota		Burnaston, England	
Toyota	Toyota Motor Manufacturing France SAS	Yaris Hybrid	Valenciennes, France	
Toyota	Toyota		Arifiye, Sakarya, Turkey	
Toyota	Toyota	Camry Hybrid, Avalon Hybrid	Georgetown, KY, USA	Toyota Motor Manufacturing Kentucky Inc. (TMMK)
Toyota	Toyota	Highlander Hybrid	Princeton, IN, USA	Toyota Motor Manufacturing Indiana, Inc. (TMMI)
Toyota	Toyota		Indaiatuba, Sao Paolo, Brazil	
Toyota	Toyota		Zarate, Argentina	
Toyota	Toyota	Prius	Iwate prefecture, Japan	
Toyota	Toyota	JPN TAXI (LPG) starting 2021	Miyagi prefecture, Japan	

Toyota	Toyota	JPN TAXI (LPG) (produced till Q4 2020)	Shizuoka prefecture, Japan	Toyota Motor Kyushu assembly plant for Lexus
Toyota	Toyota, Lexus	Lexus UX EV, Lexus RX HV	Miyawaka, Fukuoka Prefecture, Japan	
Toyota	Toyota, Lexus	Toyota EV C+, FCV Mirai, Lexus LC HV	Motomachi, Toyota City, Aichi prefecture, Japan	
Toyota	Toyota	Prius	Tsutsumi, Alchi Prefecture, Japan	
Toyota	Toyota	Prius, Estima Hybrid	Fujimatsu, Kanya Prefecture, Japan	
Toyota	Toyota		Tahara, Japan	
Toyota	Toyota, Daihatsu		Tsutumi, Japan	
Toyota	Toyota		Nagakusa, Japan	
Toyota	Toyota	Alphard Hybrid, Velfire Hybrid	Inabe, Mie Prefecture, Japan	
Toyota	Toyota, Daihatsu		Takaoka, Japan	
Toyota	Hino		Koga, Japan	
Toyota	Hino		Hamura, Japan	
Toyota, Daimler	Mercedes, Hino, Toyota	Thonburi, Muang, Samutprakan, Thailand		
UD Truck	UD		Rosslyn, Pretoria, Gauteng, South Africa	
Van Hool	Van Hool	bus, coach	Koningshooikt, Belgium	
VDL	VDL	bus, coach	Valkenswaard, Netherlands	
Volvo Group	Volvo Bus, Scania		Bangalore, Karnataka, India	
Volvo Group	Volvo Truck, UD Truck		Wacol, Queensland, Australia	
Volvo Group	VN Series trucks, VNR electric from 2020		Dublin, VA, USA	

Volvo Group	Mack		Aragua, Venezuela	JV between VW and FAW
VW Group	VW, Audi	A6L e-tron, PHEV Magotan	Changchun, Jilin province, China	JV between FAW and VW
VW Group	VW	e-Bora	Qingdao, Shandong province, China	JV between FAW and VW
VW Group	VW, JAC	EV Passenger cars (planned 2022-2023)	Zhujiang Lu, Hefei, Anhui province, China	JV between JAC and VW (VW 75% ownership)
VW Group	Audi, VW, Skoda, SAIC	Q4 e-tron, MEB platform, ID.4 X, ID 3, Skoda E Vision (planned) VW Tiguan L PHEV	Jiading, Shanghai, China	JV between SAIC and VW
VW Group	VW	Passat PHEV	Nanjing, Jiangsu province, China	JV between FAW and VW
VW Group	Audi, VW, FAW	MEB platform, ID.4 CROZZ, Audi Q2L e-tron, Roadmap E	Foshan, Guangdong province, China	JV between FAW and VW
VW Group	Volkswagen	Passat GTE PHEV, ID.4 (2022), MEB-based models	Emden, Lower Saxony, Germany	Will become pure EV plant, current Passat will be phased out
VW Group	Volkswagen, Seat	Golf PHEV, Seat Tarraco, future EV	Wolfsburg, Lower Saxony, Germany	e-Golf ended 2020, future EV model will be highly automated
VW Group	VW Commercial Vehicles	ID. Buzz, Multivan hybrid	Hanover, Lower Saxony, Germany	From 2022
VW Group	Audi, Seat, VW	ID.3, ID.4, Audi Q4 e-tron, Seat el-Born	Zwickau-Mosel, Saxony, Germany	Converted to all electric production from 2020
VW Group	Porsche	Taycan, Taycan Cross Turismo EV	Zuffenhausen, Stuttgart, Baden-Württemberg, Germany	
VW Group	Porsche	Macan EV	Leipzig, Saxony, Germany	From 2022

VW Group	Audi	Hybrid variants, future EVs	Ingolstadt, Bavaria, Germany	EVs on MEB and PPE platforms
VW Group	Audi	e-tron GT PHEV, R8 EV	Böllinger Höfe, Baden-Württemberg, Germany	R8 from 2022
VW Group	Audi	A6, A7 Sportback, A8 PHEVs	Neckarsulm, Baden-Württemberg, Germany	
VW Group	VW	ID.3	Transparent Factory, Dresden, Sachsen, Germany	ID.3 from 2021, e-Golf production ended 2020
VW Group	Skoda	Superb iV PHEV	Kvasiny, Czech Republic	Future EV expected
VW Group	Skoda	Enyaq iV EV	Mlada Boleslav, Czech Republic	
VW Group	Audi, Seat, Skoda, Skoda, VW	VW e-up, Skoda Citi-go EV, Seat Mii EV, Audi Q7 e-tron PHEV	Bratislava, Slovakia	
VW Group	Audi	Q3 PHEV	Gyor, Hungary	Plant also builds electric motors
VW Group	Audi	e-tron, e-tron Sportback SUV	Brussels, Belgium	Also assembles batteries in the same plant
VW Group	Bentley	Bentayga hybrid	Crewe, UK	Bentley will offer first EV by 2025 and become all-electric by 2030
VW Group	Lamborghini	SIÁn FKP 37 hybrid, future EV	Sant' Agata Bolognese, Emilia-Romagna, Italy	EV by 2025
VW Group	VW	ID.4 (2022), Future SUV EV	Chattanooga, Tennessee, US	Will also build batteries and have R&D centre for EV
VW Group	Audi	Q5 PHEV	San Jose Chiapas, Mexico	
VW Group	VW		General Pacheco, Argentina	

VW Group	Seat	Leon, Cupra, Cupra Formentor PHEV	Martorell, Spain	First pure EV by 2025
VW Group	MAN	eTGM truck, hybrid trucks	Streyr, Austria	Low volume output
VW Group	MAN	Lion's City E bus, hybrid bus	Starachowice, Poland	
VW Group	Scania	Hybrid and electric trucks	Sodertalje, Sweden	Battery plant and long-range EV truck by 2023
Wanxiang	Wanxiang, Karma	EV (planned)	Hangzhou, Zhejiang province, China	Wanxiang owns Karma Automotive
Wanxiang	Wanxiang	E-bus	Xiaoshan, Hangzhou, Zhejiang province, China	
Wanxiang	Wanxiang	EV-buses, PHEVs special vehicles,	Songjiang, Shanghai, China	
Weltmeister (WM)	WM	EX5-Z, EX-6	Huanggang, Hubei province, China	
Weltmeister	WM	EX5, EX6 Plus	Wenzhou, Zhejiang province, China	
Wulong	Southwest, Wulong	e-bus	Kunming, Yunnan province, China	
Xpeng	Xpeng	P7, G3	Zhaoqing, Guangdong province, China	Contract manufacturing using Haima Automobile Group
Xingma	CAMC	e-truck	Maanshan, Wuhu, Anhui province, China	
Yaxing	AsiaStar, WertStar	EV buses	Yangzhou, Jiangsu province, China	Previously Yaxing Benz
Yinlong	Yinlong	EV Buses	Lanzhou, Gansu province, China	
Yintong	Yintong	e-bus	Zhuhai, Guangdong province, China	JV between Yintong and FAW Bus

Youngman	Youngman	electric bus	Jinhua, Zhejiang province, China	
Yutong	Yutong	Yutong Xiaoyu	Zhengzhou, Henan province, China	
Zhidou Electric Vehicle Company	ZD	D2, D2S, D3	Lanzhou, Gansu province, China	Previously Kandi Electric Vehicles & part owned by Geely
Zhongtong	Zhongtong	E-Bus, Solar Bus	Liaocheng, Shandong province, China	
Zhongxing	ZX	Small Tiger EV	Baoding, Hebei province, China	
Zotye	Zotye	L10 PHEV (planned)	Dayi, Hubei province, China	Zotye filed for bankruptcy December 2020
Zotye	Zotye	EV Yun	Changsha, Hunan province, China	
Zotye	Zotye	TT EV	Xiangtan, Hunan province, China	
Zotye	Dorcen, Zotye	G60E, Zhima EV e30	Jintan, Jiangsu province, China	
Zotye	Zotye	E200, E20, FCV E200(planned)	Hangzhou, Zhejiang province, China	
Zotye	Zotye	EV vans	Yongkang, Zhejiang province, China	

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

11. OEMs and Battery Cell Supplier Database

As securing supply of lithium-ion battery cells is becoming critical, OEMs have been expanding and diversifying their battery suppliers to ensure competition and mitigate supply chain shortages. Just a few years ago, an OEM such as Volkswagen relied on single suppliers, such as Samsung SDI for the e-Golf, today it has significantly expanded suppliers, including LG Chem, SK Innovation and CATL, as well as forming partnerships to build its own batteries with Northvolt. Tesla has also expanded its partnerships from working with Panasonic to wider array of suppliers, as well as investing further in building its own batteries and components.

The section identifies, where possible, which battery cell manufacture supplies which OEM. These relationships are not always transparent, and indeed they can vary even by model type. For example, Audi uses LG Chem for its e-tron electric SUV, but Samsung SDI for other variants of it. Nonetheless, a pattern of supply is emerging across the major battery players supplying OEMs.

It is worth noting as well that the leading battery suppliers for the large lithium battery packs that are used in in 'full' electric vehicles (usually around 50 KWh) are quite a different group of companies compared to the smaller batteries used in plug-in hybrids (typically around 10 KWh) and hybrids (around 1 KWh).

Table 11.1 OEMs and Battery Cell Supplier Database

OEM Group	Battery Cell Supplier				
	Electric Vehicles	Mild Hybrid Electric Vehicle	Hybrid Electric Vehicles	Plug-In Hybrid Electric Vehicles	Commercial Electric Vehicles
AIWAYS	CATL				
Alexander Dennis/BYD					BYD
Alfabus					AESC
Aston Martin	Hyperbat (Williams/ Unipart JV)				
BAIC	CATL				Guoxuan High tech
BJEV	CATL				

BMW	Samsung SDI --> CATL, Northvolt	A123 Systems		Samsung SDI	
Bollore	Bollore's own batteries				
BYD	BYD			BYD	BYD
Byton	CATL				
Canoo	n/a (likely Panasonic, Samsung or LG)				
Changan	A123 Systems			A123 Systems	
Chery	A123 Systems			A123 Systems	
Daimler	LG Chem	LG Chem	LG Chem	SK Innovation/ LG Chem	CATL
Detroit Electric	MG Energy Systems				
Dongfeng					Guoxuan High tech
Enovate	ProLogium				
Faraday Future	LG Chem				
FCA (now Stellantis)	Bosch-Samsung SDI partnership		Hitachi Auto-motive Systems	LG Chem	
Fisker	Joining a consortium to secure supply from one of top 5 battery suppliers				

Ford	**LG Chem**		**Panasonic**	**Panasonic**	**Panasonic**
Foton					**Samsung SDI**
GAC	**CATL**				
Geely	**CATL**				
Geely / London Electric Vehicle Co.				**CATL**	
GM	**LG Chem, in future Ultium (GM-LG Chem JV)**		**Hitachi Auto-motive Systems**	**LG Chem /A123**	
Great Wall	**Farasis Energy, SVOLT**			**LG Chem**	
Hino					**Toshiba / Primearth EV Energy**
Honda	**Blue Energy (Yuasa, Bosch-Mitsubishi JV), in future CATL**		**Blue Energy (Yuasa, Bosch / Mitsubishi JV)**	**Blue Energy (Yuasa, Bosch / Mitsubishi JV)**	
Hunan Zhongche					**Guoxuan High tech**
Hycan (GAC & Nio JV)	**CATL**				
Hyundai- Kia	**SK Innovation, LG Chem, CATL (for China)**		**LG Chem**	**SK Innovation, LG Chem, CATL (for China)**	
Ikarbus					**Yinlong**

JAC	Guoxuan High-Tech (Gotion Inc.)				
JAC / SOL (VW brand)	Lishen				
Jaguar Land Rover	LG Chem, Samsung SDI (from 2021)			LG Chem, Samsung SDI (from 2021)	
Jinlong					Guoxuan High tech
Joylong					Guoxuan High tech
Kandi Technologies	Lishen, Do-Fluoride, Tianneng				
Karma				A123 Systems	
Kawasaki Tsurumi Rinko Bus Ltd,					Toshiba
Kinglong					Guoxuan High tech
Lamborghini		Super-capacitor			
Lexus	Primearth EV Energy				
London Electric Vehicle Company (LEVC)					LG Chem
Lordstown Motors					LG Chem

Lotus	**Hyperbat (Williams / Unipart JV)**				
Lucid	**Samsung SDI, LG Chem**				
Mahindra	**LG Chem**				
Mazda	**Primearth EV Energy, Panasonic**	**Toshiba**	**Primearth EV Energy**		
Mitsubishi	**Toshiba**			**Lithium Energy Japan Corp. (GS Yuasa-Mitsubishi JV)**	**Toshiba**
Nanjing Golden Dragon					**Guoxuan High tech**
Navistar					**A123 Systems**
Nikola Moor					**Proprietary**
NIO	**CATL**				
Nissan	**AESC Envision, LG Chem, CATL (China)**	**Toshiba**	**AESC Envision, possibly Sunwoda**		**AESC Envision**
Northern Iwate Transport-ation					**Toshiba**
PSA Group (Stellantis)	**LG Chem, CATL (SAFT in future)**		**LG Chem, CATL**	**LG Chem, CATL**	**LG Chem, CATL**
Polestar	**LG Chem, CATL**				
Proterra Inc.					**Toshiba**

Renault	LG Chem				AESC Envision, CATL
Rivian	LG Chem				LG Chem
SAIC / GM / Wuling	A123 Systems, CATL		A123 Systems	LG Chem, A123	
SOL	Tianjin Lishen				
Solaris Bus & Coach S.A,					Toshiba
Sono Motors	Proprietary				
SsangYong	LG Chem				
Subaru			Primearth EV Energy		
Suzhou Golden Dragon					Guoxuan High tech
Suzuki		Toshiba		Sanyo NiMh	
Tata	Tata AutoComp Systems – GS Yuasa				
Tesla	Panasonic, LG Chem, CATL (China), planning in-house cells				
Toyota	Panasonic		Primearth EV Energy	Panasonic	
Via Motors	A123 Systems				
Vinfast	LG Chem-Vinfast JV				

Volkswagen	LG Chem, Samsung SDI and SKI For EU, CATL for China, SKI for North America from 2022, JV with Northvolt			SDI, LG Chem, Panasonic	CATL
Volvo Cars	CATL, LG Chem			CATL, LG Chem	Samsung SDI, CATL, LG Chem
Weltmeister	CATL, LG Chem, Panasonic				
Xpeng	CATL				
Yantai Shuchang					Guoxuan High tech
Yuzong					Samsung SDI, CATL
Zetta	GE Power Technology				
Zhonglong					Guoxuan High tech, CATL
Zotye	Guoxuan High-Tech				

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

12. EV and Hybrid Export Markets Analysis

Global trade of hybrids and electric vehicles is still a relatively small share of vehicle exports and imports. That number will have grown in 2020 with the global increase in electric vehicle sales, and further as more OEMs launch EVs that will be set for export, perhaps most notably in Europe, including Tesla, Volkswagen Group, BMW, Mercedes-Benz and Volvo Cars. China, though not a significant EV exporter as of 2019, is also set for more export growth.

The top table for electrified vehicle exports looks likely to be more fluid compared to ICE vehicles. Japan, Germany and the US were the largest exporters in 2019, however Japan's ranking was mostly because of the many Toyota, Honda and Mitsubishi hybrids manufactured in Japan – and relatively few plug-in hybrid and full electric vehicles.

While Germany has been relatively balanced between EV, plug-in and hybrid exports, the US has been third overall driven mainly by its EV exports – for which it was the largest exporter – and that has been down in large part to Tesla. While Tesla continues to increase output, it is also notably expanding its global footprint, having already launched production in China and set to start production in Germany.

The relatively low volumes have up to now also meant that smaller manufacturing countries have ranked higher for EV trade. Belgium, for example, was the second largest exporters of EVs in 2019, thanks mainly to production and export of the Audi e-tron SUV. Volvo Cars' recent launch of the XC40 Recharge EV will give Belgium a boost as well. Sweden, meanwhile, has been the third largest global exporter of plug-in hybrids thanks to a wide range offered by Volvo.

However, the larger automotive nations are likely to rise further up the ranks. OEMs in Europe are ramping up production of EVs quickly, with a raft of launches set from Volkswagen Group, BMW, Daimler, Porsche and indeed Tesla's new German plant. China, meanwhile, has seen EV exports rise to Europe, including Polestar and MG, as well as Tesla and BMWs. Other European brands including BMW Mini, Smart and Renault/Dacia are planning EV exports from China, while Chinese startups like Nio and Xpeng are targeting European markets in particular.

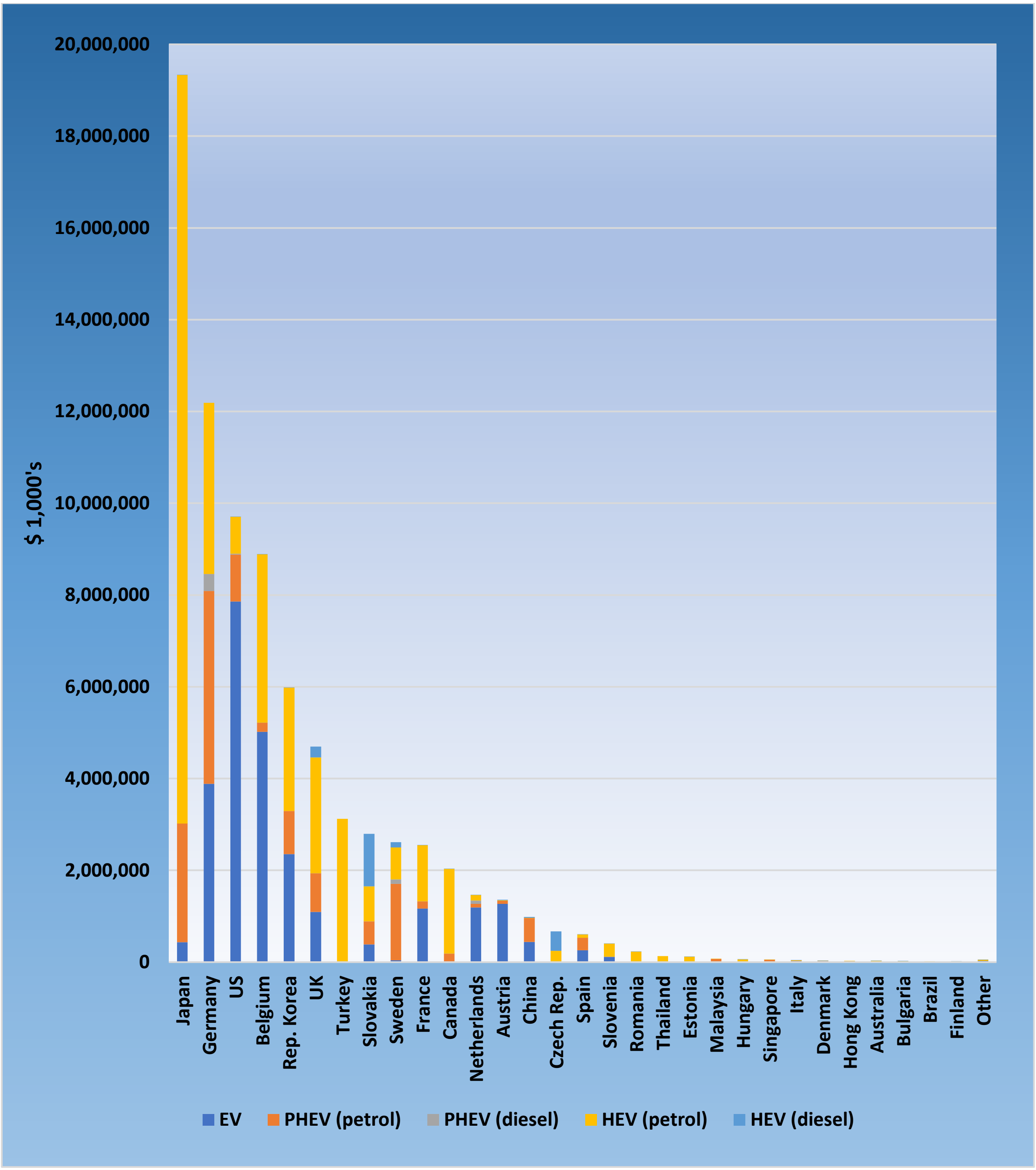
Exporting electric vehicles may not happen in as large a volume as they do for ICE vehicles, however. Heavier vehicles bring higher shipping and logistics cost, and in some cases added complexity (although not as significant as with batteries, see appendix). The high cost of production and components, however, will also likely encourage more OEMs to localise EV production. It is likely that as battery plants and capacity increase, OEMs will be produce EVs on a highly regional strategy. The Volkswagen Group, for example, will soon be building EVs on its MEB platform alone across seven plants in Germany, Czech Republic, China and the US.

Table 12.1 Top 30 Electric and Hybrid Vehicle Exporting Countries 2019

HS Code Type	870380 EV	870360 PHEV (petrol)	870370 PHEV (diesel)	870340 HEV (petrol)	870350 HEV (diesel)	Total XEV (all variants)
Japan	$431,470k	$2,588,951k	$17k	$16,315,948k	$63k	$19,336,449k
Germany	$3,885,103k	$4,200,662k	$374,583k	$3,730,496k	-	$12,190,844k
US	$7,858,135k	$1,025,244k	$18,345k	$802,390k	$7,442k	$9,711,556k
Belgium	$5,017,975k	$198,311k	$791k	$3,672,757k	$884k	$8,890,718k
Rep. Korea	$2,353,736k	$939,425k	-	$2,690,724k	$55k	$5,983,940k
UK	$1,096,333k	$837,637k	$987k	$2,524,478k	$236,865k	$4,696,300k
Turkey	-	-	-	$3,124,196k	-	$3,124,196k
Slovakia	$383,252k	$507,773k	$22k	$761,767k	$1,140,847k	$2,793,661k
Sweden	$38,443k	$1,666,162k	$96,854k	$700,938k	$114,113k	$2,616,510k
France	$1,165,716k	$157,095k	$501k	$1,225,421k	$1,849k	$2,550,582k
Canada	$3,079k	$180,740k	$339k	$1,846,548k	$83k	$2,030,789k
Netherlands	$1,191,949k	$78,880k	$73,865k	$117,182k	$9,771k	$1,471,647k
Austria	$1,268,625k	$67,532k	$2,447k	$7,800k	$16,853k	$1,363,257k
China	$438,082k	$522,937k	$15k	$8,754k	$14,262k	$984,050k
Czech Rep.	$3,258k	$9,483k	$149k	$235,622k	$419,936k	$668,448k
Spain	$259,671k	$269,440k	$1,417k	$73,888k	$3,898k	$608,314k
Slovenia	$112,967k	$4,410k	$117k	$286,346k	$104k	$403,944k
Romania	$1,069k	$5,629k	$325k	$220,431k	$1,088k	$228,542k
Thailand	-	-	-	$129,075k	-	$129,075k
Estonia	-	-	-	$122,262k	$361k	$122,623k
Malaysia	$93k	$73,657k	-	$648k	-	$74,398k
Hungary	$6,860k	$5,978k	$424k	$46,750k	$4,948k	$64,960k
Singapore	$1,551k	$52,967k	$48k	$1,635k	-	$56,201k
Italy	$22,024k	$7,184k	$186k	$11,328k	$3,539k	$44,261k
Denmark	$15,265k	$7,438k	$2,972k	$4,368k	$336k	$30,379k
Hong Kong	$18,355k	$5,813k	-	$6,804k	-	$30,972k
Australia	$1,873k	-	$160k	$25,633k	$367k	$28,033k
Bulgaria	$309k	$6,494k	$215k	$12,990k	$2,017k	$22,025k
Brazil	-	-	-	$18,567k	-	$18,567k
Finland	$5,444k	$5,110k	-	$4,891k	$1,758k	$17,203k
Other	$27,627k	$2,177k	$1,715k	$19,440k	$4,193k	$47,227k
Totals	**$25,176,794k**	**$10,838,178k**	**$576,477k**	**$22,434,129k**	**$1,985,569k**	**$61,003,222k**

Source: International Trade Centre (ITC), Automotive from Ultima Media

Figure 12.1 Top 30 Electric & Hybrid Vehicle (X)EV Exporting Countries 2019 ($ 1000's)



Source: International Trade Centre (ITC), Automotive from Ultima Media

13. Automotive Battery Re-Use and Recycling Companies

The issue of what happens to a vehicle's lithium battery after its useful life is an increasingly important question. Considering the emission and resource impact of battery production, this is of course an important environmental concern. However, it will also likely be a strategic supply strategy.

As OEMs ramp up volumes in the race to electrification, recycling and reuse will be important to avoid shortages of some metals such as cobalt, nickel and manganese. In the long run, the percentage of lithium-ion batteries and materials that can be recycled and re-enter the value chain will be important.

Generally, the lifetime of an automotive vehicle battery is intended to be at least 8-10 years. It is only considered to be beyond its useful life when its capacity reduces to 70% or below original levels. However, that does not mean that the battery is of no-value and must be recycled, as there are also other uses that the battery might have outside the vehicle.

13.1 Re-using EV Batteries for A Second Life

The performance of the battery will eventually drop below an acceptable level for a critical application such as an EV, where weight, size and performance are major issues. However, the battery can still have a useful second life for many years in other applications.

Some OEMs, such as Nissan and BMW, has re-used batteries in production operations, such as powering automated guided vehicles or forklifts. But batteries are also used in small scale or local level power storage in domestic and commercial buildings for back-up power, or in remote locations where there is no mains power.

Batteries could also be combined in large quantities for grid or utility scale energy storage applications. These achieve 'load levelling' or smoothing of the output of inherently fluctuating renewable energy sources such as photovoltaic solar panels and wind turbines to create a more consistent input to the electricity networks and are thus vital components in making renewable energy sources viable.

By re-using batteries in this way, not only does it moderate the price of electricity from the grid, but it also effectively reduces the environmental impact of the battery's original manufacturing process by extending the battery's useful life.

There is also a financial factor. Repurposing batteries means that they will hold considerable value for reuse rather than going straight to recycling.

Table 13.1 Examples of OEMs Re-Using EV Batteries in Other Applications

OEM	Re-Use and Second life
Audi	Energy storage test installation at EUREF research campus, Berlin 'Audi Brand Experience Centre' at Munich airport uses old Audi EV batteries for energy storage
BJEV	EV-charging, backup power
BMW	Grid-scale energy storage, EV-charging BMW re-purposes EV batteries at many global plants
BYD	Grid-scale energy storage, backup power
Changan	Backup power
Daimler	Grid-scale energy storage, C&I energy storage
General Motors	Remanufacturing
Great Wall Motor	Backup power
Honda	Renewable energy storage partnership in Europe with Societe Nouvelle d'Affinage des Metaux (SNAM)
Hyundai	Grid-scale energy storage, C&I energy storage
Renault Nissan Mitsubishi	C&I energy storage, EV-charging, residential energy storage, grid-scale energy storage Nissan-Sumitomo Corporation JV with 4R Energy Corporation for re-use or less critical applications such as forklifts, golf carts and streetlamps Energy storage project with Smarthubs/Connected Energy in West Sussex, UK Energy storage project with Advanced Battery Storage in Douai, France Nissan repurposes batteries at North American facilities
PSA	C&I energy storage
SAIC	Backup power
Toyota	C&I energy storage, grid-scale energy storage (NiMH)
VW Group	C&I energy storage
Volvo	Residential energy storage Energy Storage project with Volvo Buses in partnership with Stena Recycling subsidiary Batteryloop Energy Storage with Volvo Buses and Stena Fastigheter

Source for all tables and figures in this section unless noted otherwise: Automotive from Ultima Media

13.2 Recycling Automotive Batteries

In an ideal battery supply chain, batteries will move through their useful lifecycles and then in a 'closed loop' to recycling, from which raw materials are extracted and fed back into the production of new battery components. That would make the production process more environmentally friendly and also reduce demand on the supply chain for raw materials as battery volumes ramp up.

However, the recycling of lithium-ion batteries is a relatively new and emerging industry. Much of the recycling landscape is primarily in Asia, for example, which means that most batteries used in other markets will need to be sent to Asia for processing. China accounts for more than two-thirds of all recycling facilities handling the roughly 100,000 tonnes of batteries currently being recycled. South Korea is second with around one-sixth of global recycling. The industry is otherwise highly fragmented with a 'long tail' of many other smaller players attempting to enter this burgeoning market.

However, these figures are inexact and fluid due to the nature of how lithium-ion battery recyclers stockpile them for recycling for when metals prices are more favourable. That leads to fluctuations in recycling activity and the share across regions.

Table 13.2 Leading Automotive Battery Recycling Companies

Company	Location
Green Eco Manufacturing Resource (GEM)	Shenzen, China
Hunan Brunp Recycling Technology	Hunan Province, China
Quzhou Huayou Cobalt New Material	Quzhou, China
Ganzhou Highpower Technology	Shenzen, China
Guangdong Guanghua Sci-Tech	Guangdong, China

Table 13.3 Other Lithium-Ion Battery Recycling Companies

Company	Plants
ACCUREC Recycling	Mülheim, Germany, Krefeld, Germany
AEA Technology	Sunderland, UK
AERC Recycling Solutions	Allentown, Pennsylvania, US, West Melbourne, Florida, US, Richmond, Virginia, US
AkkuSer Oy	Nivala, Finland
American Manganese	Surrey, British Columbia, Canada
Anhua Taisen Recycling Technology Co.	Hunan province, China

BASF	BASF, Eramet, and SUEZ have partnered as part to develop a closed loop recycling process for lithium-ion batteries
Batrec Industrie	Wimmis, Switzerland
Battery Recycling Made Easy	Cartersville, Georgia, US
Battery Resourcers	Worcester, Massachusetts, US
Battery Solutions	
Dowa Eco-System Co.	
Duesenfeld	Wendeburg, Germany
Ecobat	
Eramet-Valdi	Commentry, France
Euro Dieuze Industrie-SARP	Dieuze, France
Fortnum	Harjavalta, Finland Ikaalinen, Finland
Ganfeng Recycling Technology Co	
Ganfeng Lithium	Mexico
Glencore International	Sudbury, Canada, Rouyn-Noranda, Canada Kristiansand, Norway
Green Technology Solutions	Blacksburg, South Carolina, US
G&P Batteries	Darlaston, UK
Hydro-Northvolt, supported by government enterprise Enowa	Joint venture for a pilot plant in Fredrikstad, Norway
International Metals Reclamation Company (INMETCO)	
Johnson Matthey	
JX Nippon Mining and Metals Co.	
Li-Cycle Corporation	Kingston, Ontario, Canada Eastman Business Park, New York, US
Lithion Recycling Inc.	
Metal Conversion Technologies	
Neometals	Ontario, Canada
Nippon Recycle Center Corporation	Osaka, Japan, Aichi, Japan, Miyagi, Japan
Northvolt	Vasteras, Sweden
OnTo Technology	
G&P Service	
Raad Solar-=Mahindra Electric	
Raw Materials Company Inc.	

Recupyl	Grenoble, France, Singapore
Retriev Technologies Inc.	Trail, British Columbia, Canada, Baltimore, Ohio, US, Anaheim, California, US
Sitrasa	
SNAM	Saint Quentin Fallavier, France
Sony Electronics Inc. - Sumitomo Metals and Mining Co.	
Tata Chemicals Limited	
Tes-Amm Singapore Pte Ltd	
Tesla	Nevada, US
Umicore	Wickliffe, Ohio, US Hoboken, Belgium Olen, Belgium
Urecycle Group Oy	
VW	Salzgitter, Germany
Ziptrax	

14. Conclusions: Local, Strategic Supply

The global environmental and regulatory push, especially in Europe, China and likely increasingly in North America, will drive rapid electric vehicle growth over the next decade. This increase requires a commensurate ramping up of battery gigafactory capacity and the wider lithium-ion battery supply chain across regions.

There is a lot at stake. Without enough battery cell capacity, major automotive producing countries risk falling behind in the race for electrification. Without a well-developed and secure battery supply chain, EV production will ultimately be over dependent on supply from a limited number of countries, mostly in Asia. As the current semiconductor shortage demonstrates, that would leave manufacturers and economies vulnerable. This is not just an economically strategic issue, but arguably one of national security, just as energy supply has been.

With the battery comprising as much as 30-40% of the vehicle cost, OEMs and suppliers could also see their existing control of technology and production threatened, with new competitors and market entrants liable to gain share. But the opportunity is also so huge as to require investment, technology and capacity from all stakeholders – with many likely to profit as well.

There are a number of key takeaways from this report:

The Battery Supply Chain Will Become Increasingly Local

As volumes ramp up, manufacturers and suppliers are investing in regional battery production capacity, with the EU currently set to see the most significant growth in cell capacity. Huge investments are also set for China, which already dominates EV battery production. At the strategic level, governments and regulators are pushing to localise battery supply chains both to ensure the security of supply as well as to gain from the economic value and compensate for the loss of industry and jobs built around internal combustion engine powertrains. The EU has set a roadmap of sustainability of raw material production and energy used in battery manufacture. In the US, the Biden administration's recent executive order to review supply chains, including EV batteries and semiconductors, is a clear example of how seriously governments are taking the issue of supply chain disruption and security.

OEMs Will Seek a Diversity of Cell Suppliers

As EV volumes ramp up, leading automotive OEMs are increasingly moving away from single sourcing agreements with battery cell suppliers to a more flexible, multi-sourcing model across a mix of suppliers, and in some cases joint ventures and investments to build cells and components in house. This diversification is another feature of securing supply, but also being able to maintain competition, cost and quality. If one supplier suddenly makes a technological step forward, for example, an OEM can switch or vary suppliers.

Batteries Are Not Commoditised

There is considerable competitive advantage to be had by developing and commercialising a specific battery technology. That is because, for now, at least, lithium-ion batteries are far from being commoditised. There are multiple chemical formulations that make for differing price and performance propositions, including for battery cost, range and charging. OEMs will consider these factors depending on product and even regional strategy when choosing a particular battery type and supplier. Carmakers are also investing billions more into their own battery research and development, hoping to gain advantages in electrification.

OEMs Want to Have More Control of the Battery Supply Chain

It is no coincidence that many OEMs and other stakeholders in the EV value chain are looking at vertical integration of key operations – including establishing in-house operations to manufacture battery cells and getting more involved in upstream processes. OEMs including GM and Volkswagen have followed Tesla's example in establishing joint ventures with cell suppliers to produce cells – possibly even to commercialise supply to other OEMs. Tesla is aiming to develop and produce its own in-house cells even beyond those it makes with Panasonic. Gaining visibility and control of the supply chain can be a competitive advantage both in coordinating volume ramp up as well as in preparing for and responding to supply chain disruption.

Tesla is also leading a charge – in ambition and strategy, at least – to take more control upstream, including directly mining minerals like lithium, as well as encouraging technologies that reduce or eliminate the use of cobalt or even nickel. Price spikes in mining such materials have caused OEMs to look more carefully at the upstream supply chain, in some cases taking a more active role in procurement, too.

Ethical Supply Chains are Strategic Supply Chains

As well as controlling costs and supply, OEMs are examining upstream supply chains more carefully to monitor emissions, fair trade and labour practices. The extraction of rare minerals and the energy used during battery production are increasingly under the scrutiny of environmentalists, regulators and consumers. Carmakers such as Volvo Cars, BMW and Daimler are demanding that cell and raw mineral suppliers conform to strict environmental and labour standards. Partly for this reason, manufacturers are also exploring ways to reduce or phase out cobalt, which has notorious supply and labour issues from the DRC.

Battery Packs Can Be as Important as Cells

Battery performance is not just down to the cell, but how the battery modules and packs are combined both in hardware and software integration, for example through battery management systems. The overall battery integration process is becoming increasingly important for OEMs, as in some cases such packs could gain more range and better performance even when using the same cell supplier. As such, the lines are increasingly blurring between battery cell supplier and module pack assembly. In response, some cell suppliers have developed 'cell-to-pack' technologies to optimise this process with the goal of reducing battery prices below $100 per KWh.

Lithium-ion Batteries May Not Be the Only Solution – But They Will Be Key

The rise in electric vehicle demand looks increasingly to be as sure a bet as possible, thanks to the heavy regulatory push and massive OEM investment in EV development. However, the dominance of lithium batteries is not 100% certain. Certain technologies such as lithium-sulphur and solid-state batteries, hydrogen fuel cell, or even a left-of-field technology could upend the current trajectory of lithium-ion battery demand. Breakthroughs in faster charging times – or business models that depend less on them, like battery swaps – could further reduce the need altogether for such expensive batteries.

These risks could undermine the investment going into the global battery supply chain, including the many gigafactories currently in the pipeline, as well as the host of cell processing, battery pack assembly and integration across hundreds of facilities. However, while not every battery manufacturer is likely to achieve its stated GWh capacity ambitions, the demand and capacity requirement for lithium-ion battery is still very likely to rise further over the next decade. New technologies and alternatives will be important, too, but rather than sweeping away the lithium-ion supply chain, they are more likely to be part of an increasingly diversified electric powertrain strategy.

Electrification Is the Key to Keeping Automotive a Pillar Industry

It would not be an overstatement to say that the next decade of transition towards electrification will be the most profound in the automotive industry's history. The environmental implications are immense. At the same time, the business opportunities are vast for an industry currently worth some $3 trillion, and which still plays such a key role in many countries' prosperity, individual freedom and personal mobility. The success of the battery supply chain will be pivotal in both the automotive industry's transformation and maintaining its role as a pillar industry.

Appendix

A. Credits

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