

rho
motion

Rho Motion: What to watch in 2023



EV Market

A snapshot of 2022

200%

Highest growth rates in India and ROW at over **200%**

2.8mIn

China adds **2.8 mln** units over 2021, more than triple all other regions

16%

Europe lags with just **16%** growth - lowest of any region

1mIn

First month with over **1 mln** sales

BYD

becomes the largest EV OEM, overtaking Tesla

Tesla

retains top spot for BEVs, becoming first to sell over 1 million in a year

+8

new OEMs enter the market

What to look for in 2023

Our headline figure for 2023 will see EV sales rise to over 14 million units, up from 10.2 million in 2022.

Similarly to 2022, we expect the vast majority of this growth, more than two-thirds of the units added, to come from China as it extends its lead over other regions.

Furthermore, we expect more expansion from China into overseas markets. Most have had a small presence in the European market for some time, however, are only recently expanding sales targeted at the region. NIO now has ten battery swapping stations in Europe and elsewhere BYD has seen its overseas sales increase by 10x in 2022.

EV purchase benefits are being slowly phased out or reduced in some more mature markets. Germany, China, and Norway have seen record sales in December as a pull-forward rush of EV purchases come through before the subsidy reductions and tax introductions. Watching how these fare in 2023 will be a test of the point at which consumers are ready to transition to a mature market.

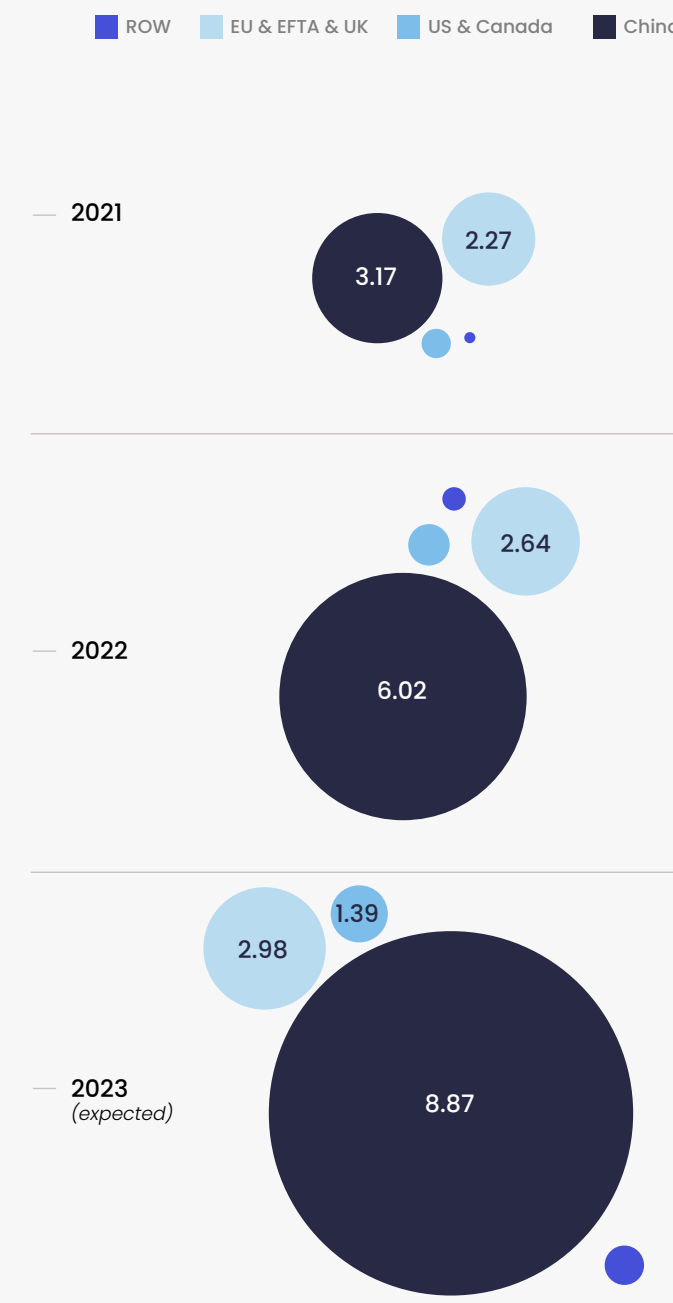
New vehicles will of course make the headlines with popular offerings such as Volvo EX90, Kia EV9 and

Hyundai Ioniq 6 coming to market. Should the Tesla Cybertruck make it to full production it will become the most anticipated launch. It will also cement the arrival of LDVs in the EV market alongside a big ramp up in the F-150 lightning, Rivian R1T and new launches such as the Silverado.

Supply chain constraints appear to be easing though it remains to be seen whether semiconductor capacity coming online will be the appropriate technology level to abate issues there. Global economic factors and potential recessions in Europe and North America also have the potential to sandbag these markets to some extent.

Finally, a new powerhouse region for EV manufacturing is beginning to emerge in Asia Pacific. South Korea of course leads the way; however new facilities, many from global brands, producing vehicles in Malaysia, Vietnam and Indonesia can lead to a big expansion in sales in the region. In addition, Australia has seen a boom in the latter stages of 2022 as OEMs step up exports, partly due to increased capacity in Europe freeing up vehicles available to send.

2021 – 2023 Passenger car and light duty vehicle unit sales by region (mln)



EV Battery

A snapshot of 2022

Growing battery deployment, continuing to be dominated by LFP.

0.5TWh

2022 battery deployment reached **0.5TWh** across all vehicle classes, 87% y-o-y increase

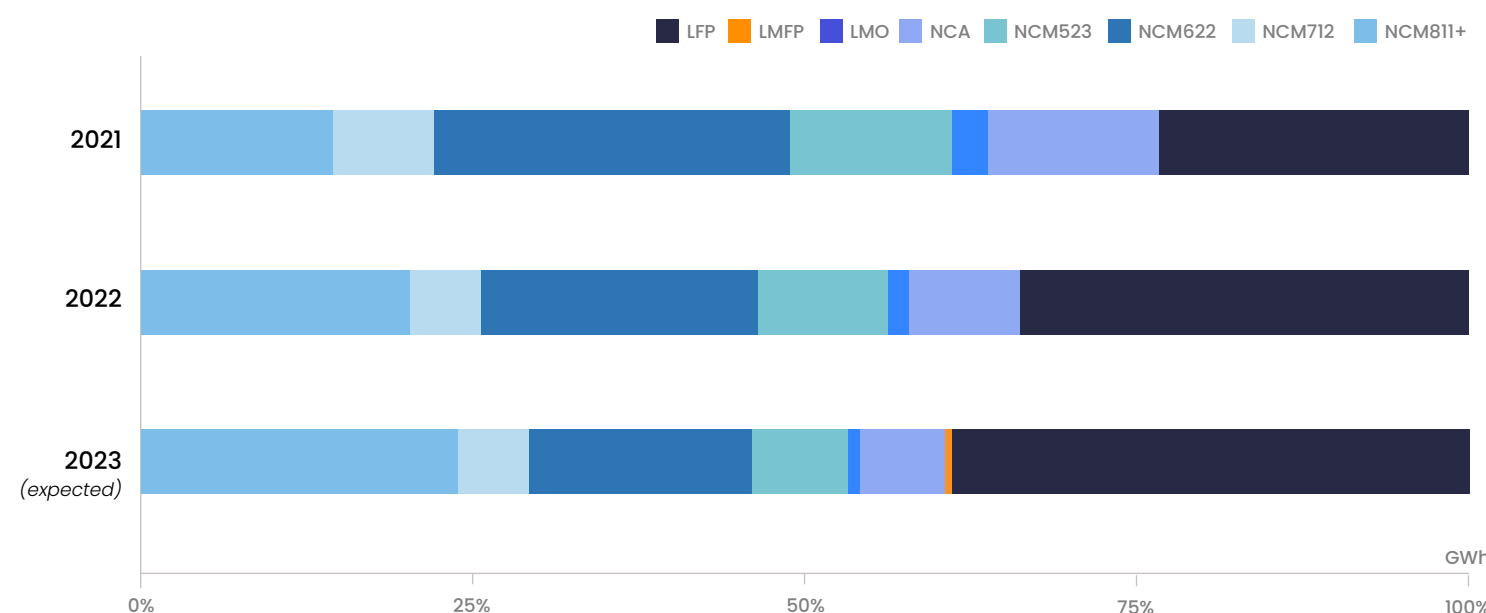
There has been a lot of buzz around sodium-ion in recent months, with plenty of announcements from the likes of HiNa, with the opening of its GWh production facility late last year, a world-first, and others aiming to follow suit with mass production in 2023. There are still limited applications for this chemistry in the EV market, given its significantly lower energy density (~150Wh/kg) compared to lithium-ion (~250-300Wh/kg). However, we expect to see implementation in the 2&3 wheeler markets and lower speed EVs in the coming years. Especially considering second generation sodium-ion cells are expected to reach 200Wh/kg, making them competitive with LFP.

33%

LFP accounted for **33%** of battery deployment, up from 23% in 2021

Throughout 2022, we saw solid-state (SS) developers making announcements of key milestones towards commercial implementation into EVs. Mercedes-Benz-backed Prologium aim to have its first SS gigafactory operational by Q2 of 2023. While QuantumScape has begun shipping prototypes to automotive customers. We can expect to see continued progress in this area in 2023 but unlikely to see in EVs in mass production until at least 2024, as promised by Dongfeng Motor.

EV battery deployment by cathode chemistry



What to look for in 2023

We expect to see LFP growth to continue into 2023, with production still to come primarily from China. There are plans for LFP production outside of China to begin, albeit at a small scale, with larger projects not expected to come online until earliest 2024.

Established LFP cell producers are now looking to commercialise the next generation of the chemistry, by doping with additional transition metals to increase energy output, commonly referred to as LMFP. With launches this year from CATL with its LxFP product, M3P, and SAFT targeting for its LMFP launch also.

NMx is another cobalt-free chemistry to watch in the coming year, with currently only SVolt producing. There are plans from it and other manufacturers to commercialise in 2023.

Looking into anodes, silicon is increasingly being used as an anode additive in high-performance EVs. We can expect the weighted average of silicon within the battery to increase this year, as more advanced silicon materials will allow increase stability whilst maintaining the advantage of increased capacity. Supported by strategic investments by OEMs into advanced silicon developers.

EV Charging Market

A snapshot of 2022

2022 has highlighted the importance of legislation in supporting the development of charging infrastructure.

40%

In 2022, the total number of public chargers increased by **40%** across the EU, EFTA & UK, US & Canada and China, with a **49%** increase in public fast chargers

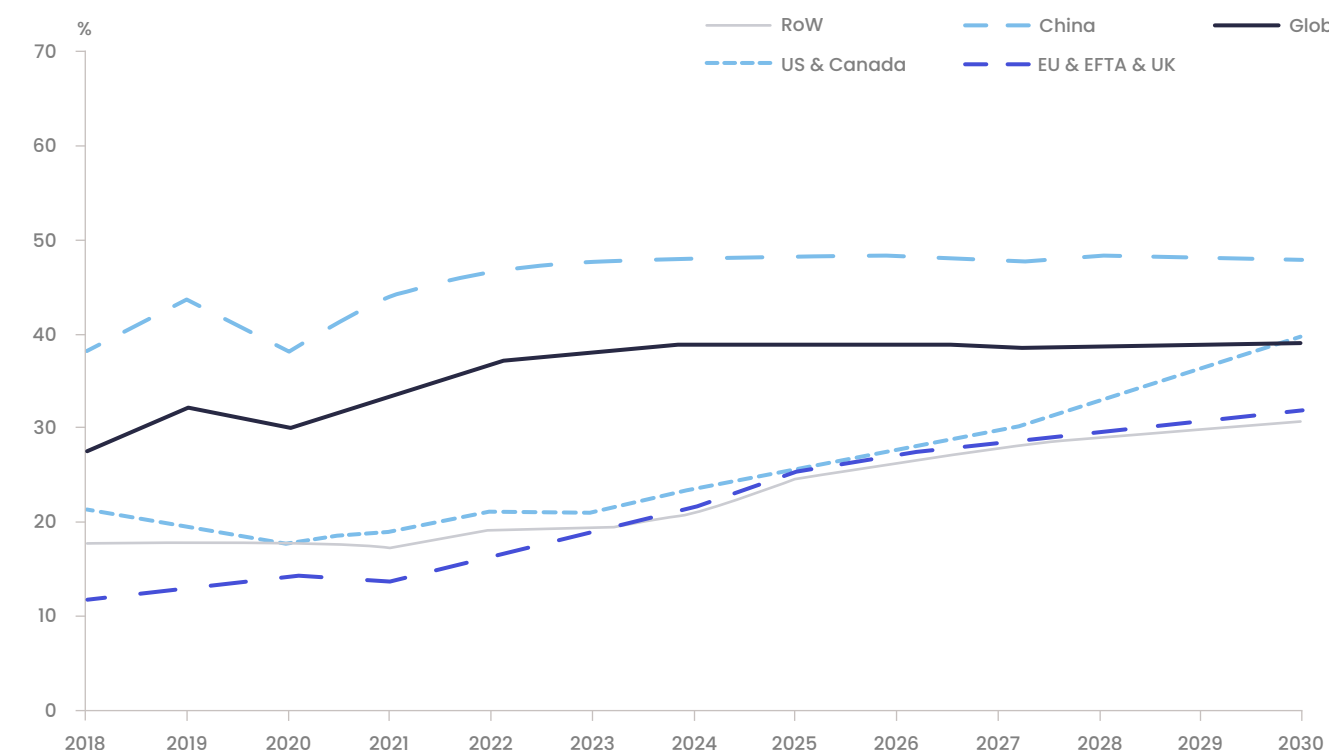
95kW-111kW

The global sales weighted average maximum BEV charging speed increased from **95kW to 111kW** from January to November 2022

The EV charging market gained significant momentum in 2022 as governments strive to avoid infrastructural bottlenecks to EV adoption growth. The speeds of public chargers deployed are also shifting as manufacturers begin future proofing for evolving vehicle capabilities. An increasing number of models capable of fast DC charging, in addition to the development of 800V platform architectures, is fueling a push toward higher-speed charging networks.

In the US, 2022 saw a promising increase in production capacity as multiple new facilities from manufacturers such as Tritium, Flo and Wallbox came online, with further projects from ABB and SK Signet in development. The growth in fast charging was primarily driven by an expansion of legislation to support infrastructural development. In November 2022, the House of Representatives passed the USD1.2 trillion infrastructure bill, which included USD7.5 billion in funding to aid in the construction of 500,000 charging stations across the country by 2030. USD5 billion of this will be provided over the next five years via the National Electric Vehicle Infrastructure (NEVI) Formula Program. The establishment of the Inflation Reduction Act also introduced incentives and subsidies of up to 30% for select installations of charging stations.

Share of fast charging (>22kW) in EV charging split by region, 2018-2030



What to look for in 2023

In 2023, manufacturing capacity in the US is expected to continue to expand as companies look to take full advantage.

Unsurprisingly, the shift towards faster public charging is set to continue, particularly in the US and Europe, as both regions look to close the gap on China. Manufacturing capacity is also expected to increase strongly, with a growing emphasis on high-speed commercial vehicle charging. Increased consolidation in the market is also likely as the current fragmentation seen across the charging infrastructural chain will struggle to endure as regional markets mature.

Legislation will remain a key driver for infrastructural development. The success of the US infrastructure bill and NEVI Program in supporting charger manufacturing is sure to inspire the European Parliament to implement similar subsidies and incentives in the near future.

Battery Recycling

A snapshot of 2022

2022 saw increasing investments of existing recyclers in expanding battery recycling capacities across regions while new entrants through joint ventures or acquisitions entered the market.

78%

China accounted for 78% of battery recycling pre-treatment recycling capacity in 2022

Global battery recycling pre-treatment capacity reached 1.5 million tonnes of recycling inputs in December 2022, with China taking up around 78% of the share.

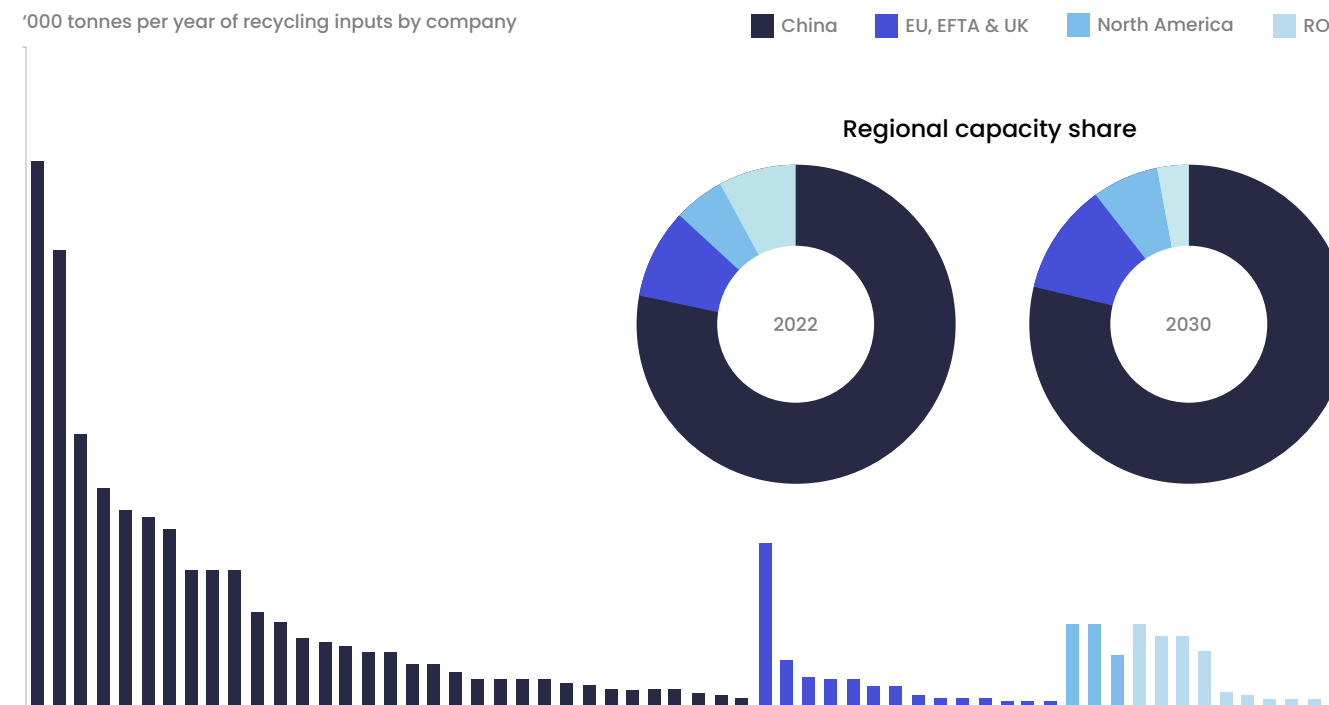
Large growth was seen in China in November 2022 as the government announced a new batch of the 'Whitelist', which is battery recycling and reuse companies authorised by the Ministry of Industry and Information Technology.

We saw an increasing number of battery recycling companies expanding overseas due to transport costs and safety issues. Legislation was a key driver supporting the recycling industry in 2022, with the likes of the US Inflation Reduction Act of 2022 (IRA) requiring a minimum percentage of the value of critical materials sourced within the region, and the EU Battery Directive.

1.5mIn

Tonnes of global recycling capacity at the end of 2022

Regional battery recycling pre-treatment capacity by company in YTD December 2022



What to look for in 2023

In 2023, overseas expansions are expected to accelerate mainly driven by new legislation, together with investments in building closed-loop supply chains

Looking to 2023, China is expected to remain dominant while investments in battery recycling capacity in Europe, North America, and Asia are expected to increase. The global battery recycling market will continue to expand with government supports, in particular in the US, and new entrants including EV OEMs, battery producers, or battery recycling technology providers.

Overseas expansions are expected to continue in 2023 as new regulations for battery recycling in Europe, which are set to enter into force in the short or medium term, are expected to be tightened. Asian companies with post-treatment technologies are highly likely to enter the European markets as the region currently lacks black mass processing capacity.

Investments in establishing battery closed-loop supply chains through acquisitions, joint ventures, or partnerships are expected to continue in the coming year as companies try to secure sales and lower costs in cathode material production by using recycled battery-grade materials. As for China, its closed-loop supply chain currently remains largely within the country as the battery recyclers focus on domestic expansions. Expansions to the US market seem limited due to the IRA, but there would be companies expanding elsewhere through partnerships such as CNGR Advanced Material and Huayou Cobalt.

Battery Storage

A snapshot of 2022

The BESS market more than doubled in 2022, driven by strong Chinese and US markets.

80GWh

of BESS installed globally in 2022 across the grid and behind-the-meter market

75%

of lithium ion BESS installed in 2022 was LFP

Policy around the BESS market began to take form, in the US through support from the Inflation Reduction Act, in China through state-level guidance and provincial storage mandates, and less strong but emerging in Europe through the likes of REPOWER EU.

Lithium ion BESS demand continues to outpace other battery technologies, with total market share in 2022 at 77% across the grid and BTM market, with lead acid retaining a declining share of close to 50% of the BTM market.

2022 was the year of LFP, with LFP cathode market share exceeding 75% of lithium ion BESS installed globally across the grid and BTM in 2022, up from close to 50% in 2021. In China this is more significant with LFP representing over 90% of lithium ion BESS installed. From China we also witnessed a draft proposal for an NCM and Na-S ban that will have implications not only for China but global technology trends.

Alternative battery technologies continued to gain support as supply chains start to be established and players look to move from pilot projects to commercial. The first sodium ion BESS installations began to emerge this year largely at the pilot scale in China and the behind the meter market elsewhere. In 2022, there has been some significant development in flow batteries in China, especially the vanadium flow battery technology. With the largest, at 400MWh entering operation.

What to look for in 2023

In 2023 we can expect to see strong growth once again in the BESS market, driven by both number of installations and an increased average project size in the grid market.

Policy support will have a big impact this year, with BESS projects in US now eligible for the investment tax credit as of January 1st 2023, increased support from a number of European countries, and strong motivation from the government to boost economy via new infrastructure in China.

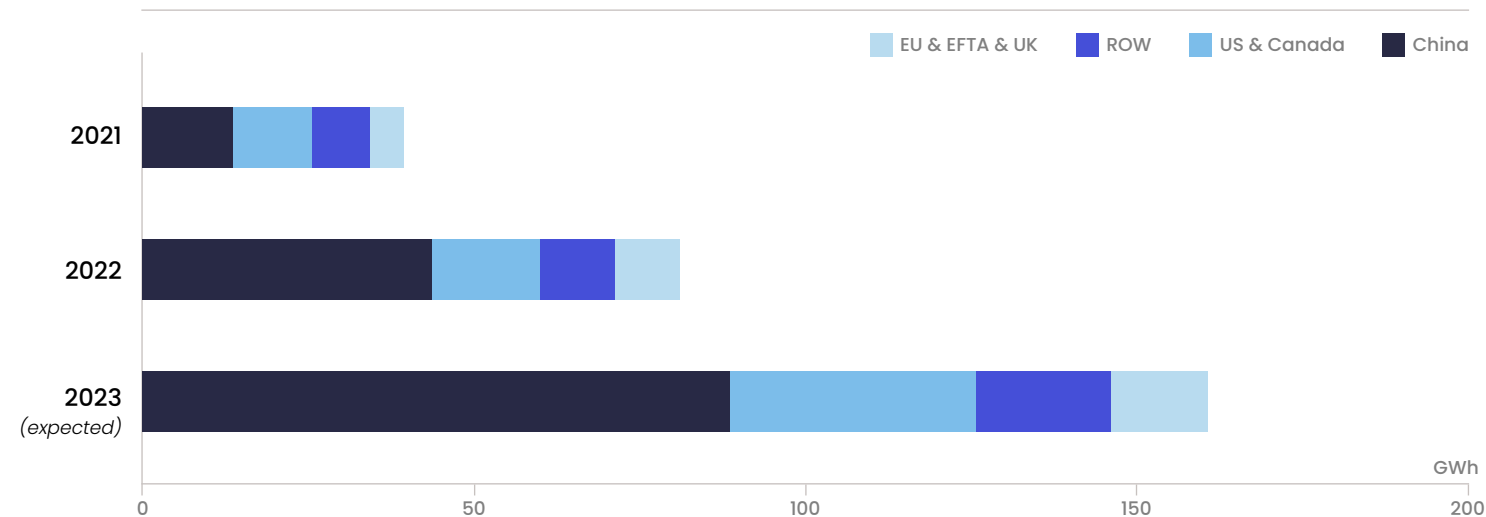
In the supply chain we can expect to see an increased localisation of manufacturing, as players look to sure up supply outside of China as well as enter the US market in order to access tax credits. This trend has begun to emerge in the second half of 2022, with European player accelerating investment in the US market, for example Freyr and Kontrolmatik.

LFP will continue to take centre-stage, with increased commitments and capacity plans. This comes in two

forms with cell manufacturers emerging dedicated to BESS applications, such as Freyr in Europe and Cornex New Energy in China. And through large scale offtake agreements from system integrators and developers, as they look to secure supply, CATL's recent offtake agreements with developer Gresham House and integrator FlexGen.

Diversification of chemistries will be a bigger part of the picture this year, as sodium ion and flow battery supply chains establish. Both chemistries will continue the move from a pilot to commercial stage, driven by developments in China. At the end of 2022, two 1GWh vanadium flow battery energy storage stations were announced. Additionally the first large scale (60MWh/30MW) sodium-ion battery storage station is due to come online in June 2023 in Anhui, China.

2021 – 2023 Installed BESS capacity (Grid & Behind the Meter)



EV Motors & Systems

A snapshot of 2022

2022 has shown us how progression in the EV Motors and Systems market is really starting to kick off.

13mIn

electric motors deployed in EVs in 2022

37%

EV Dedicated platforms used for **37%** of EV sales

4%

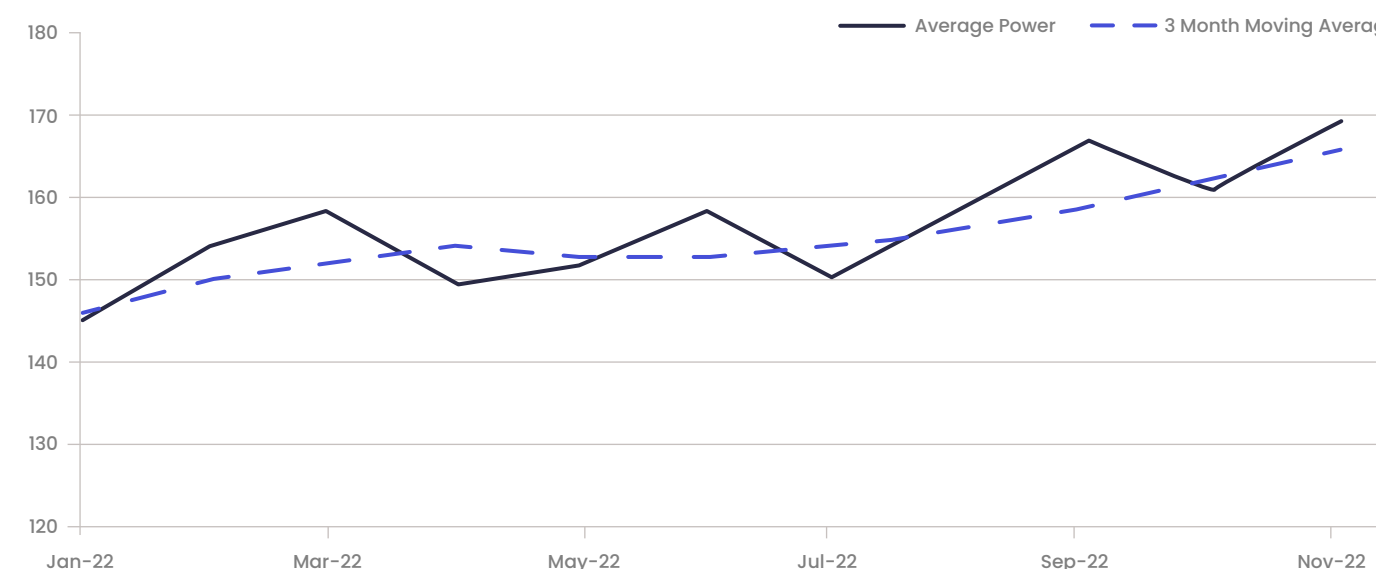
Just **4%** of vehicles sold use 800V or higher architecture

While battery development continues to remain the focus of EV advancement, behind this OEMs, Tier 1 automotive suppliers, electronics companies, semiconductor manufacturers big and small and of course motor suppliers have been making big strides and big plans for the coming few years.

We saw a range of new technologies in 2022, Koenigsegg presented its new Raxial Flux design, fitting 250kW of power in a 30kg package. Renault and Valeo agreed to collaborate on the next generation EESM design, an important magnet free technology. On stator windings, we were introduced to the new continuous wave winding concept firstly from Lucid and now Schaeffler too, unlocking more hairpin winding potential.

One metric that continued to shock through 2022 was our Electric Vehicle Power tracker. This has risen a massive 20kW over the course of the year without sign of slowing down. The average vehicle power in November 2022 was 169kW. Factors driving this are more motors per vehicle, now 37% of vehicles have more than one, compared to 27% two years ago. Also, more SUVs, 57% of motors deployed in 2022 were in SUVs.

Rho Motion EV Power Tracker, 2022



What to look for in 2023

In 2023 Silicon Carbide will really start to enter the frame. So far the proportion of models using the tech is still small but with SiC specialists such as STMicro, Wolfspeed, Onsemi all looking to expand both production and product offering and every powertrain system developer looking to **800V demand for this semiconductor will begin to move more quickly.**

Diversification of the Permanent magnet supply chain is also getting started. Separation and processing facilities in Belfast and Hull are underway, a new magnet manufacturing facility in Estonia has funding and Critical mineral strategies from Canada, Australia,





The EU, The UK and more are looking to develop this supply chain in their own back yard. Expect more announcements from OEMs looking to partner up on this critical material.

Rho Motion: What to watch in 2023

Click on the products below for more details.



EV & BATTERY

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-  EV & Battery Quarterly Outlook
-  EV Battery Chemistry Monthly Assessment
-  EV & Battery Monthly Database
-  Hybrid EV & Battery Quarterly Outlook



ENERGY STATIONARY STORAGE

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-  BESS Quarterly Outlook
-  BESS Monthly Assessment
-  BESS Monthly Database



BATTERY RECYCLING

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-  Battery Recycling Quarterly Outlook
-  Battery Recycling Capacity Database

EV MOTORS & SYSTEMS

-

-  EV Motors & Systems Quarterly Outlook
-  EV Motors Monthly Assessment







CHARGING & INFRASTRUCTURE

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-  EV Charging Quarterly Outlook
-  EV Charging Monthly Assessment
-  EV Charging Monthly Database
-  EV Charging Commodity Demand Outlook

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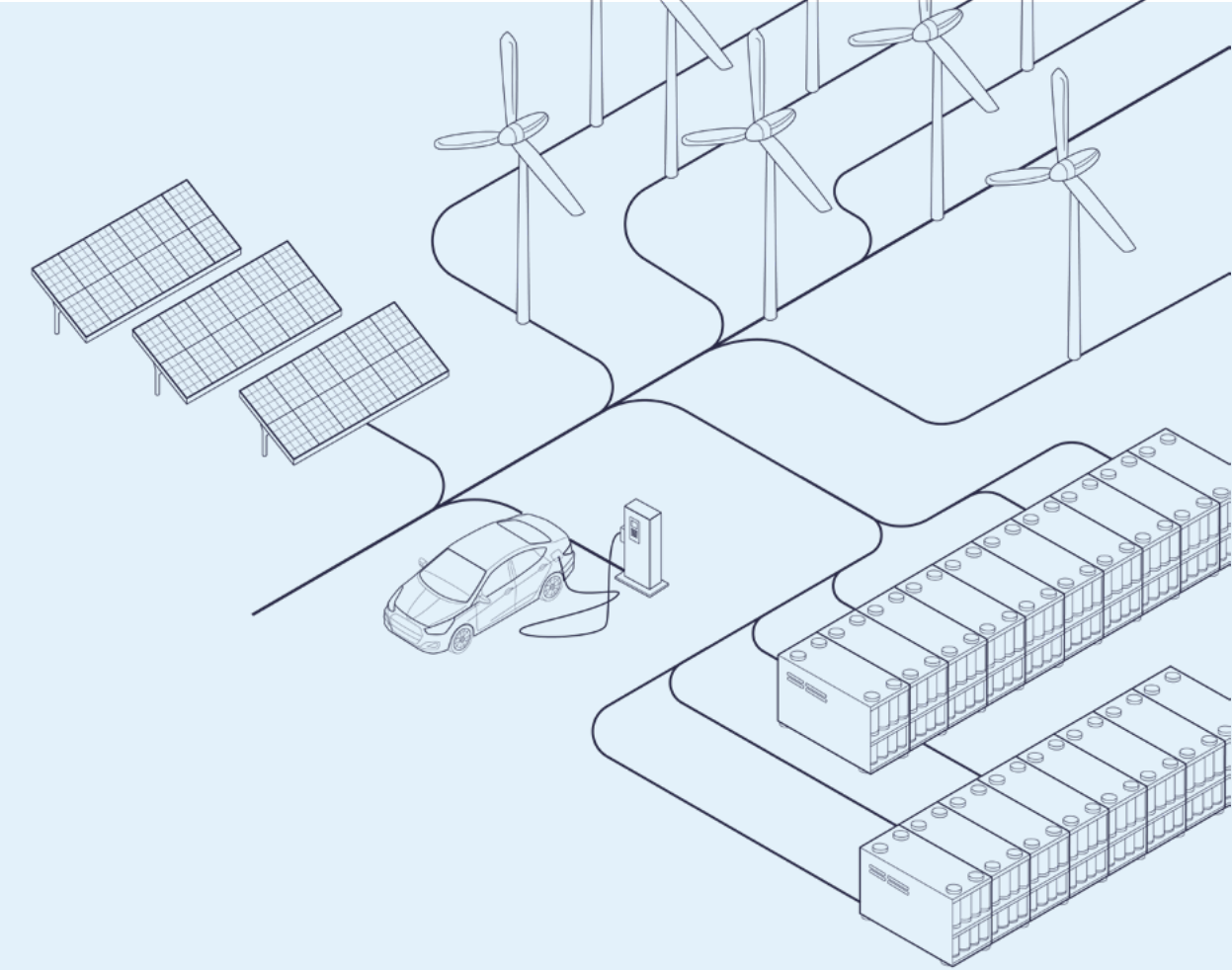
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-  Electric 2 & 3 Wheeler Outlook
-  E-Micromobility Outlook
-  Portables Battery Outlook
-  Battery Cell Cost Model
-  NRMM Battery Outlook

BATTERY DEMAND SERVICE

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-  Battery Demand Service



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