Q3 2022

rho motion magazine

China automotive on the brink of change

In this issue:

Introduction to the magazine

Adam Panayi
Managing Director, Rho Motion

Hello and welcome to the Q3 2022 issue of the Rho Motion Magazine.

As ever, we have given our analysts an open brief to write an article on anything they have found interesting in the world of the energy transition, and the variety this quarter is quite striking. We would also like to thank our guest contributors: Echion Technologies Ltd, Mitra Chem and Dynapower for their highly informative articles.

The leading three articles in this issue look at China and how the automotive market is developing there. My colleague Will Roberts first addresses the question of legacy and western OEMs operating in China and what risks and opportunities exist from exposure to that market. By contrast our China Research Lead, Yu (Frank) Du, outlines the incredible EV expansion plans of BYD for both the domestic and export markets. Finally, my colleague Jie Xu looks at the role of fuel cell electric vehicles in China, a somewhat overlooked market of which she provides an excellent analysis.

Battery Research Lead, Ulderico Ulissi, takes on the question of sustainability in batteries for EVs in his article, drawing on recent work we have done on life cycle analysis and recycling. Articles from Echion and Mitra Chem outline some of the subtleties around battery selection and how localised investment can change the narrative on Chinese dominance in the market.

The next section of the magazine deals with charging, with input from Dynapower on its solutions for the market plus an illuminating analysis from my colleague Mina Ha on the current structure of the industry. Our Data Manager, Charles Lester, draws on recent work we have done on the subject of bidirectional charging to shed light on the developments in that technology.

The final two articles deal with emerging markets for lithium-ion battery demand, in telecoms and in the construction industry from my colleagues Iola Hughes and Shan Tomouk respectively. Both articles reflect the increasing diversity of end uses and applications beyond EVs. We have again included a high-level overview of the key financial transactions in the space over the last few months which draws on more detailed analysis on our Membership platform. This provides an interesting bellwether for the industry and the uncertainties that the broader macroeconomic and geopolitical landscape pose.

I hope you enjoy the magazine,
Adam

Photo: Ravi Pinisetti

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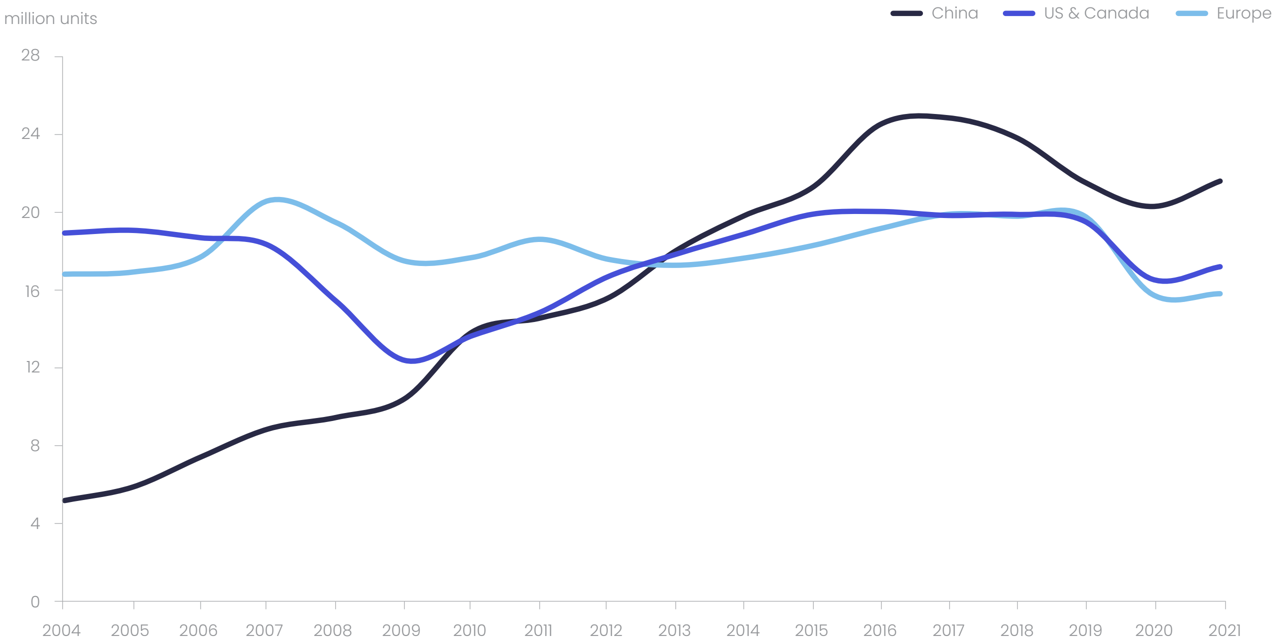
Legacy Auto: Thrive or Dive? China decides

William Roberts
Senior Research Analyst, Rho Motion

Over the past two decades the global passenger car and light duty vehicle market has grown a staggering amount from a little over 50 million vehicles in 2004 to roughly 95 million at a peak in 2017. The last few years have seen a slight decline driven by the global pandemic and supply chain issues which now feel so familiar. This boom was unsurprisingly led by China which in the years to 2017 had a compound annual growth rate in sales of 15%, while the other major markets of Europe and the US saw CAGRs of 0.8% and 0.4% respectively.

Figure 1: Total sales, global top markets, PC & LDV *Source: CAAM, Marklines, Bureau of Economic Analysis, Statistics Canada*



This growth of course led to domestic OEMs volumes growing hugely, SAIC sold 248x the number of vehicles in 2021 as it did in 2004, Geely, Great Wall and BYD also have seen growth in the thousands of percent. However, the top four OEMs in 2021 were not these local giants but the familiar names from Europe, the US and Japan.

VW, General Motors, Toyota and Honda capitalised on this period by bringing their years of internal combustion engine expertise to build quality cars more desirable than local manufacturers were able to produce. This was only possible through joint ventures as the government restricted foreign automakers establishing on their own, meaning the benefit was shared with those local OEMs too. GM with SAIC, VW with SAIC and FAW, Toyota with FAW and GAC, and Honda with GAC and Dongfeng to name a few.

Now, these legacy OEMs have a great deal of reliance on China. VW sold 60% of its vehicles in Europe in 2004, while 13% were sold in China. By 2014 China was bigger than Europe for VW and for five of the eight years since, China has outsold Europe. The story is very similar for GM, China overtook the 'home market' of US and Canada in 2013 and has stayed there ever since.

Figure 2: VW PC sales by major region *Source: OEM annual reports*

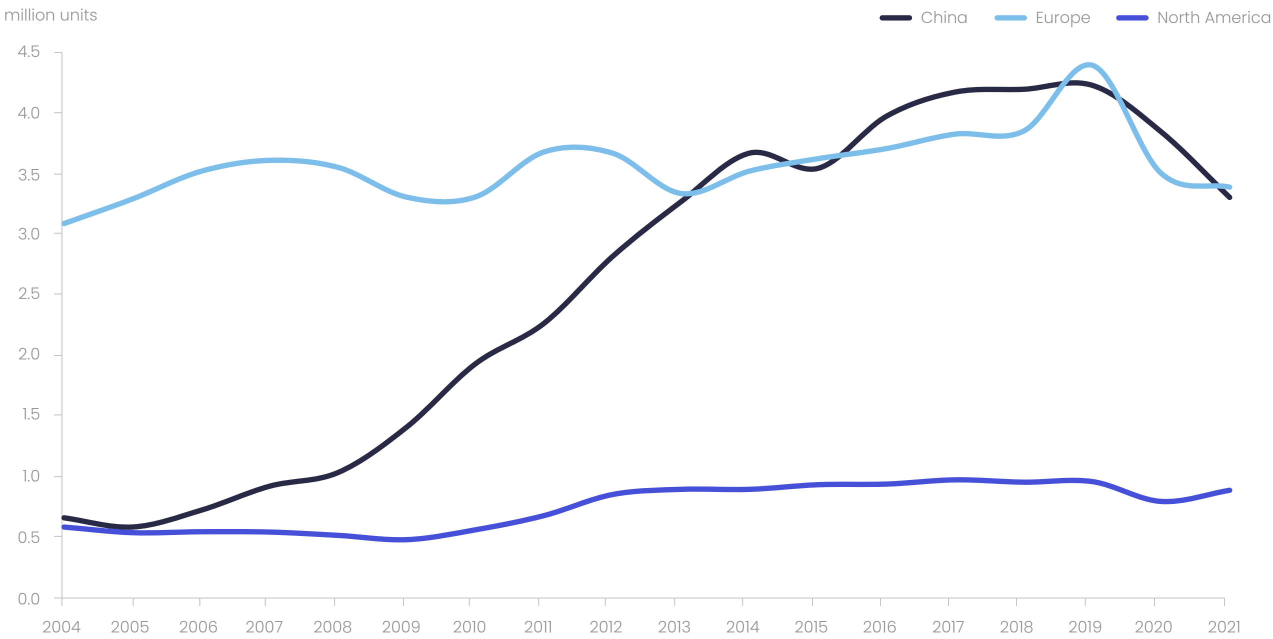
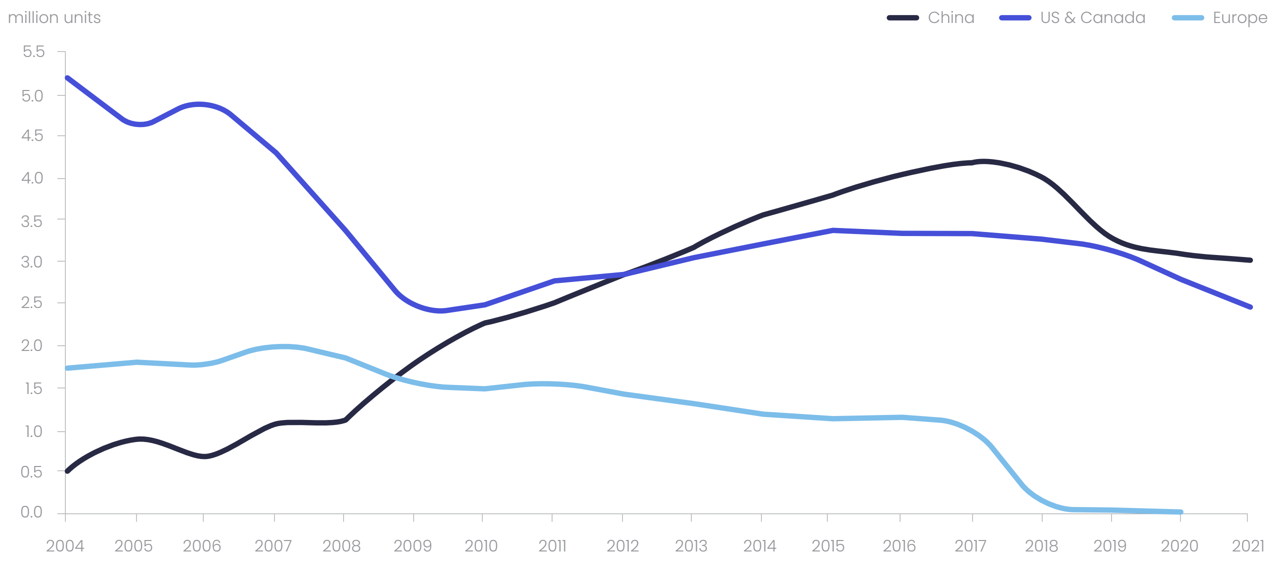


Figure 3: GM PC sales by major region

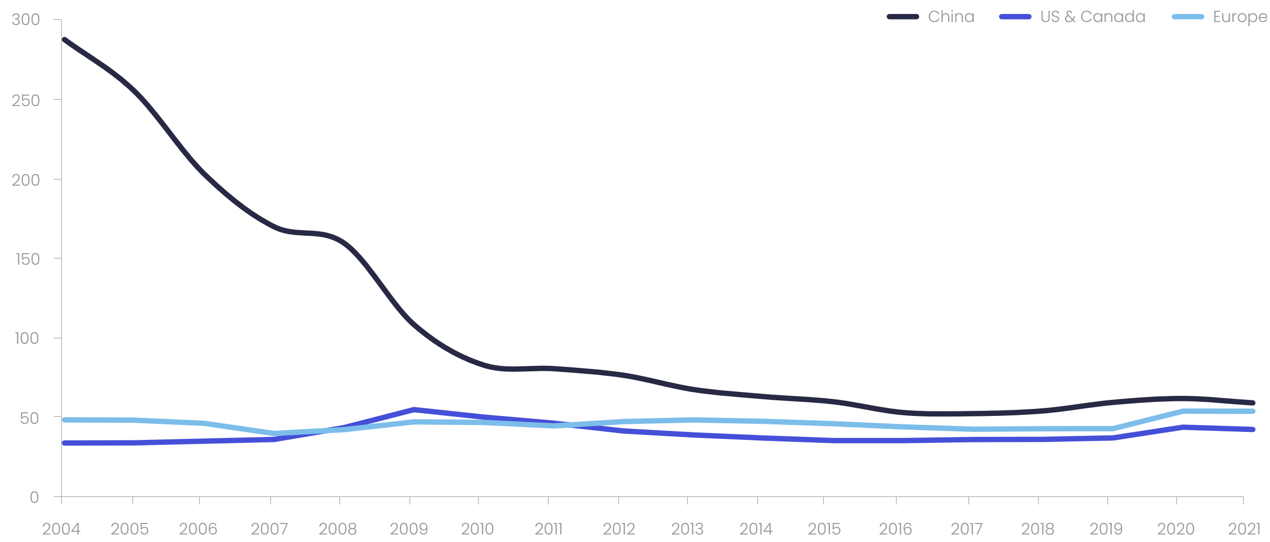
Source: OEM annual reports



It was a no brainer to capitalise on this expansion as unit sales in western markets stabilised thanks to economic growth and urbanisation. The ratio of population to car sales in China also shifted massively in this period from 1 in 287 people purchasing in 2004, ten years later it was 1 in 62, and it has hovered around this level since. The years of astronomical unit growth may well be firmly in the past.

Figure 4: Ratio of population to new car sales

Source: Our World in Data, CAAM, BEA, Marklines

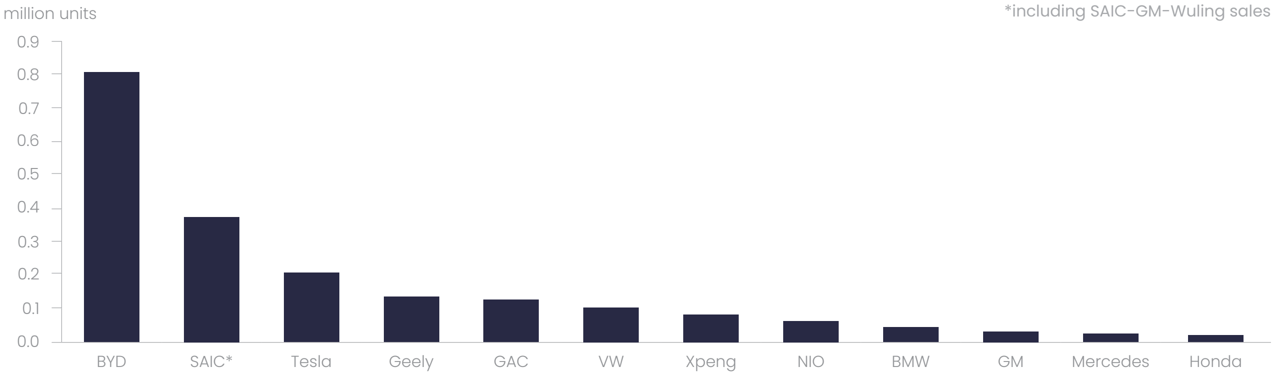


The challenge now pivots to maintaining the share built up over the last two decades. Things are of course changing and the electric vehicle market in China is booming. Year-to-date in 2022 China accounts for 58% of electric vehicle sales and has a penetration of 22%. While legacy OEMs have been sitting happily at the top of the table for ICE sales those domestic manufacturers and multiple start-ups have been working to develop great EVs, not only are they building good cars, but they are also building far more of them than the foreign OEMs are too.

Looking at just EV sales, VW feature only in 7th place, with a 3.5% market share. BYD has so far sold more than eight EVs for every one of VWs in 2022. GM could be seen to be faring better if the extremely popular Baojun and Wuling micro-EV models from its joint venture with SAIC and Wuling are included, however, SAIC are the majority shareholders in this agreement (50.1%, GM 44%) and it also has four other active EV brands under its own name, most of which have more sales than GM's trademarked makes. Toyota and Honda are barely existent in the Chinese EV market each with less than 1% of the market.

Figure 5: YTD EV sales in China, select groups

Source: Rho Motion



Beyond this, start-ups who recognised the huge support in the early days of Chinese EV subsidies have also arrived. XPeng and NIO are bigger than BMW, Mercedes-Benz, Renault-Nissan, Toyota and Honda in EV sales with ambitious plans at home and abroad.

Figure 6: EV market share in China

Source: Rho Motion

BYD	28.6%
SAIC	13.3%
Tesla	7.3%
VW	3.5%
Xpeng	2.9%
NIO	2.2%
BMW	1.5%
GM	1%
Mercedes	0.8%
Honda	0.7%
Others	38.3%

There is of course one western start-up that has recognised the importance of China in the transition to EVs. Tesla sold 320,000 EVs in 2021 in China alone, its Shanghai Gigafactory is its largest by some distance already and has multiple plans for expansion underway, with additional Chinese gigafactories constantly rumoured too. Tesla was able to benefit by not having to enter a joint venture at all, utilising Shanghai's Free Trade Zone rules. This may make it freer to make quick expansion decisions and protect its IP however, legacy auto JVs are well established and should not be a major detraction from expansion either.

In June this year VW restructured its Chinese business, appointing Ralf Brandstatter to head up the new 'China Board'. This aims to give much greater regional autonomy to and greater decision-making powers. The aim is to turn around a lacklustre start to the ID family of vehicles in the region. In 2021 ex-CEO Herbert Diess said they expected to sell 100,000 of the new EV range of ID vehicles, it managed around 70,000. This year the aim is double that figure to 140,000, despite lockdowns it should now meet this target with over 78,000 sold in the first seven months of this year. Yet with five ID models on sale covering compact and SUV this maybe isn't as high as China's largest vehicle manufacturer should be aiming.

GM, in its 2021 annual report, recognises the risks of holding market share in China due to the emerging technologies and growing production of local manufacturers. Although it plans to improve the offering under its trademarked brands in future with the Ultium platform, the importance of its joint venture activities is also highlighted as key for growth in the market. It has also recently established a new business unit to import 'iconic vehicles' into China, though this will be low volumes.

It was 2010 when the Government in Beijing first expanded its electric vehicle subsidies pilot scheme to six cities, up to $20,000 when combined with some local incentives. The massive subsidy investment that followed lit a fire under domestic industries with the rise of the world's largest battery supplier CATL occurring over the following decade. NIO and Xpeng were founded in 2014, and Berkshire Hathaway bought its stake in BYD in 2008. BMW was one of CATL's first major clients, its high standards helping the battery manufacturer improve. Arguably as some of the biggest players in the Chinese market, western legacy automakers could have noticed the signs and aimed to join in the coming revolution sooner.

Whether or not predicting this future was as easy as it now seems these automotive giants now have a fight to remain relevant in China. The switch to EVs is happening and nowhere on the scale as China. The current big goals to maintain market share in an electrified China are the right thing to have but executing them among the renewed demands of a today's China and stronger competition will be tougher than riding the wave of the last 20 years.

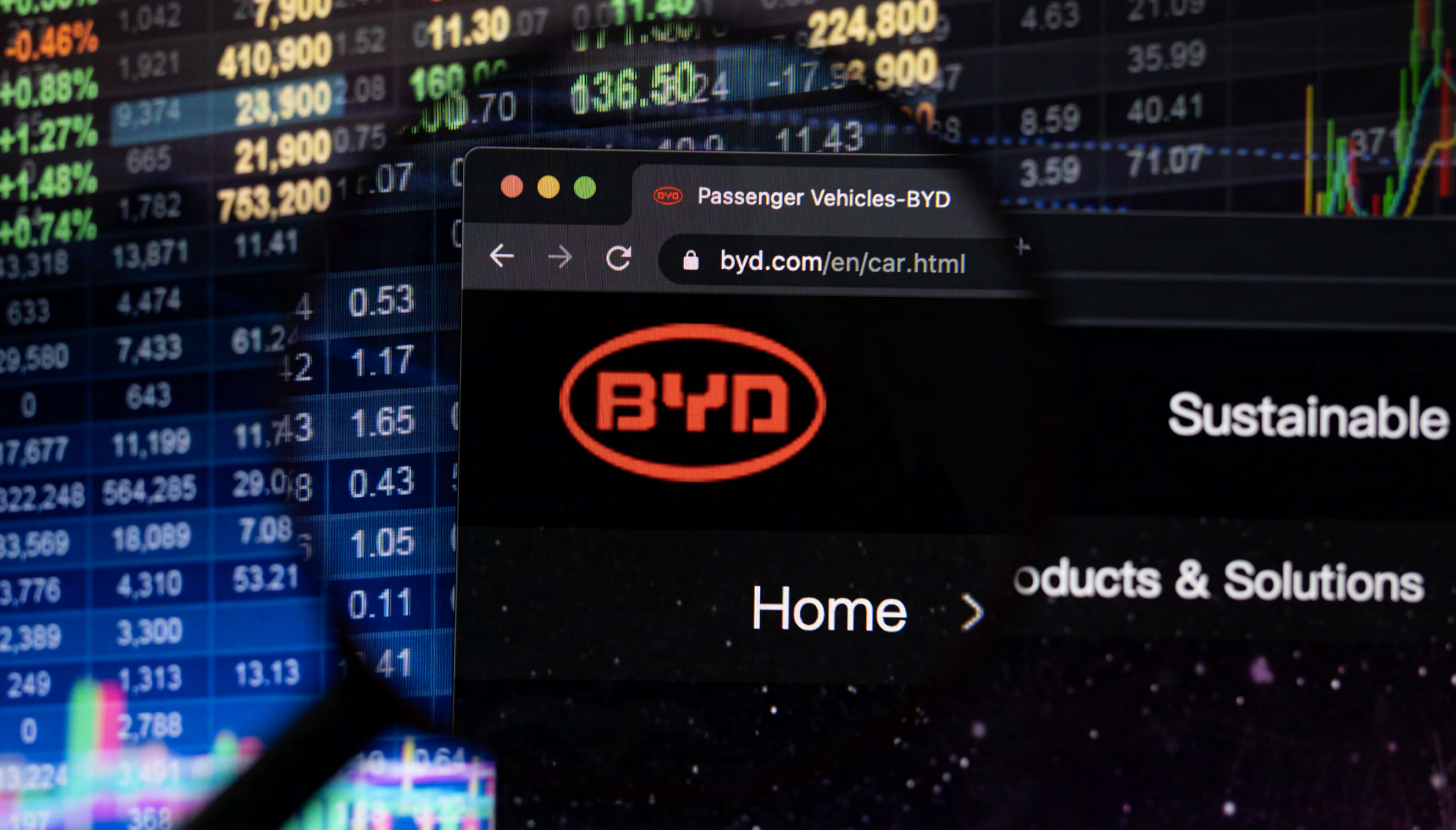


Photo: Adobe Stock

BYD – How Wang Chuanfu is building his electric dream

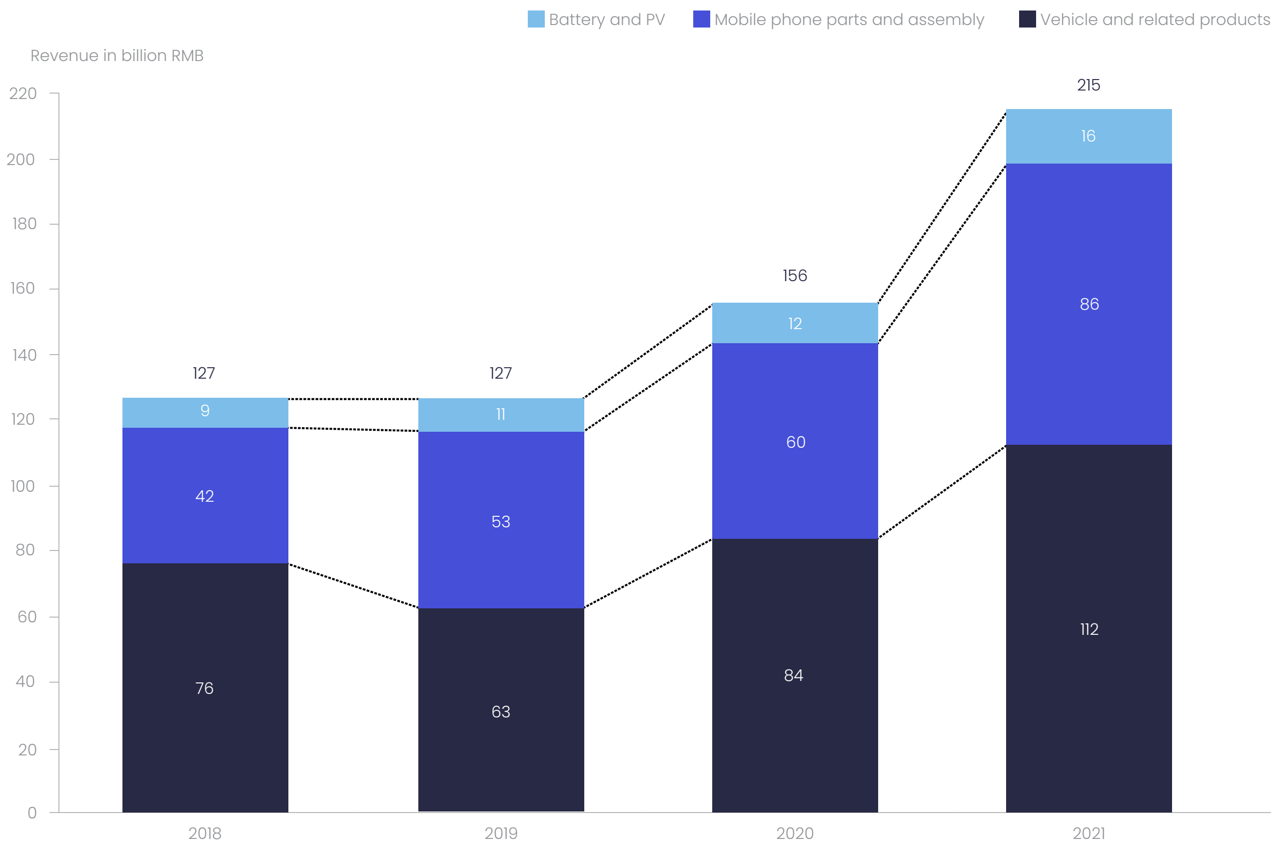
Yu (Frank) Du
China Research Lead, Rho Motion

When it comes to BYD, what is the first thing that comes to mind? Warren Buffet's excellent stock pick, Giant Chinese EV OEM, Fortune 500 company, or extreme LFP advocate? Undoubtedly, BYD is one of the most popular OEMs specialised in BEV and PHEV in China. Despite the impact of lockdowns and supply chain disruption, BYD managed to sell well over 600,000 units of BEV and PHEV in H1 2022, a 168% increase from H1 2021.

After its sales first broke the 100,000 mark in March 2022, BYD's sales have exceeded 100,000 units for four consecutive months and are gradually increasing each month. In July 2022, BYD sold over 162,000 units in one single month. As a comparison, BYD 2020 full year NEV sales are just over 179,000 units. However, new energy vehicles are only part of BYD's industrial empire. According to BYD's 2021 annual report, BYD has invested in over 40 subsidiaries. Figure 1 demonstrates BYD's revenue breakdown by category. This article will provide an in-depth analysis of BYD's industrial investments and strategy.

Figure 1: BYD's revenue by product category 2018-2021

Source: Rho Motion



In 1995, Wang Chuanfu, the founder and CEO of BYD, established BYD Industrial Corporation in Shenzhen, China and began his legendary journey. Initially, BYD's core business was the production of NiCd and NiMH batteries for electronic devices. BYD entered the Electronic Contract Manufacturing (ECM) business several years later and started manufacturing vehicles in 2003 by acquiring Qinchuan Auto. BYD and BYD Electronics was listed on Hong Kong Stock Exchange in 2002 and 2007, respectively. BYD also completed IPO in 2011 on Shenzhen Stock Exchange. Today, BYD is a Fortune 500 corporation operating dozens of companies across three main business sectors – Electronics, New Energy Vehicles, and Renewable Energy.

Electronics business

Electronics business used to be BYD's core business and is still BYD's cash cow today. BYD initially mostly manufactured NiCd and NiMH batteries until it started mass production of lithium-ion batteries in 1998. Because of the 1997 financial crisis, OEMs tried to lower the cost and switched to cheaper BYD batteries from Japanese suppliers. As a result, it only took 3 years for BYD to take almost 40% of global NiCd battery market share. By 2003, BYD had become the biggest lithium-ion battery supplier in the world, supplying mobile phone giants such as Motorola and Nokia.

Now BYD Electronics has become a global leading manufacturing enterprise, providing clients with new material R&D, components, complete product manufacturing, supply chain management, logistic, after-sales service, and other one-stop solutions. BYD electronics is the main manufacturer for iPad in China and a key mobile phone parts supplier to Oppo, Huawei, and Xiaomi. Other than smart phones and PCs, the company also covers wearable and home smart devices, IoT, gaming accessories, drones, telecoms, automotive intelligent systems, robots, and health devices. In August 2022, BYD electronics announced that it has obtained an E-Cigarette Manufacturing License in China and the automated production lines are under construction.

Automobile business

In 2003, Wang Chuanfu decided to enter the automobile industry and acquired Qinchuan Auto. BYD became the second private car manufacturer in China after Geely. However, BYD's automobile business did not take off until the launch of E3 model in 2005 and F3 model in 2006. In 2008, Warren Buffett's Berkshire Hathaway invested USD230 million in BYD for 10% common shares. In 2009, BYD acquired Meidi Bus Manufacturing Company in order to gain the license to manufacture electric buses.

Although BYD Automobile was doing well, Wang Chuanfu had never stopped investing in R&D of EV technologies. In 2006, BYD developed F3e LFP BEV model, its first BEV prototype. In the 2010s, BYD leveraged the support from the government to accelerate the development of its electric buses. By the end of 2017, Shenzhen, the homebase of BYD, became the first large city to operate only electric buses in the world. Out of over 16,000 electric buses registered in Shenzhen, 90% of the buses came from BYD.

Today, BYD Automobile is one of the best-selling Chinese car brands in China. In April 2022, BYD has stopped pure ICE vehicle sales and became the first large OEM that made such commitment. BYD has 8 passenger vehicle plants in China with a total capacity of over 3 million EVs. BYD's commercial vehicles have been delivered to over 50 countries in the world. BYD even has four e-bus factories in US, Brazil, France, and Hungary.

> *Today, BYD Automobile is one of the best-selling Chinese car brands in China. In April 2022, BYD has stopped pure ICE vehicle sales and became the first large OEM that made such commitment.*

BYD energy (PV and ESS)

BYD officially entered the PV business in 2008 and has now mastered the technical aspects of all the key components, including silicon ingots, wafers, cells, and modules. BYD's Brazilian PV production plant was commissioned in 2017 with an annual capacity of 200MW. In April 2022, BYD added a new advanced production line at this facility to increase the capacity to 500MW per year. According to Adalberto Maluf, Director of BYD Brazil, this PV factory has produced over 1.6 million modules in the last five years. In 2021, BYD started mass production of large 210mm wafers with higher efficiency and higher power on the module level.

However, despite all the efforts that BYD has made, its PV business has been relatively slow over the past decade compared to its other business units, especially in the China market. In 2021, BYD's revenue from batteries and PV products accounted for only 7.62% of the group's total revenue. Considering the high demand for the blade batteries, BYD's PV products made a very marginal contribution to the total revenue.

BYD has also invested in battery energy stationary storage (BESS) technology. BYD is an extreme advocate of LFP battery technology, a chemistry well suited to BESS, and is famous for its blade battery (LFP).

Energy storage is increasingly a requirement for renewable projects and BYD has been accelerating the investment in the energy storage space. Similar to BYD's PV business, BYD's focus on its energy storage unit has been overseas markets. However, as the BESS demand in China has grown significantly over the last several years, BYD has shifted the focus domestically and has delivered several large-scale BESS projects in China. As a cell producer as well as a system integrator, BYD can provide an end-to-end renewable energy solution to the clients.

Other key business units of BYD

Outside of the main businesses, BYD has performed vertical integration several times and invested in upstream value chain. Out of the over 40 subsidiaries, FinDreams (Fudi) Battery and BYD Semiconductor are the most famous ones.

FinDreams (Fudi) battery

As the core technology of EV and ESS, Battery has always been one of the main focuses of BYD's R&D. Like Gotion High-Tech, BYD chose Lithium iron phosphate (LFP) battery technology and put its first pack in F3e BEV model back in 2006. For over a decade BYD has gone all out to develop LFP battery technology, from EV battery packs to ESS battery systems. At the early stage, BYD benefited from the government subsidy for electric buses and gained experience with EV batteries. Today, BYD's research focus has shifted to passenger vehicles as the Chinese EV market explodes.

Table 1: FinDream's latest updates on battery projects

Source: Rho Motion

Date	Company	Location (City)	Location (Province)	Capacity (GWh)	Investment (RMB/million)	Status
21/01/2022	BYD	Changchun	Jilin	45		Under Construction
25/02/2022	BYD	Chongqing	Chongqing	20	2,000	Operational
27/02/2022	BYD	Xiangyang	Hubei	30	1,000	Under Construction
31/03/2022	BYD	Yancheng	Jiangsu	15	7,500	Operational
01/04/2022	BYD	Guiyang	Guizhou	10		Operational
03/04/2022	BYD	Taizhou	Jiangsu	22		Announced
27/04/2022	BYD	Wuhan	Hubei	30	10,000	Under Construction
29/04/2022	BYD	Nanning	Guangxi	45	1,400	Under Construction
14/06/2022	BYD	Shaoxing	Zhejiang	15	7,000	Operational
16/07/2022	BYD	Jinan	Shandong	30	10,000	Operational
20/07/2022	BYD	Jinan	Shandong	30	1,000	Under Construction
31/07/2022	BYD	Xi'an	Shanxi	20	1,200	Announced
09/08/2022	BYD	Shaoxing	Zhejiang	15		Announced
15/08/2022	BYD	Yichun	Jiangxi	30	28,500	Announced

BYD's Blade Battery is a patented LFP pack that has been used by all BYD models. In terms of capacity, BYD announced that it aims to reach 600GWh production capacity by 2025.

According to our statistics, BYD has 400GWh capacity planned, under construction, or in operation. So far in 2022, BYD has locked in at least RMB69.6 billion (~USD10 billion) of investment in battery projects over the next few years in China. Table 1 listed BYD's latest updates on battery projects.

However, despite years of experience in the battery sector, BYD did not set up FinDreams Battery Company until 2020. This is considered the preparation step for a spin-off IPO. To further grow, FinDreams must supply more than just its parent company. A spin-off IPO can somewhat assure potential clients that FinDreams Battery is independent and will provide the same product to all clients, including BYD Automobile and Other OEMs.

BYD semiconductor

BYD Semiconductor originated from the restructure of BYD's former microelectronics division, which was established in 2004. As a leading IDM (Integrated Device Manufacturer) company in China, BYD semiconductor is engaged in manufacturing of power semiconductors, control IC, sensors, and other semiconductors. Similar to FinDreams Battery, BYD Semiconductor is pursuing a spin-off IPO and has filed the application to Shenzhen Stock Exchange.

The current focus of BYD Semiconductor is power semiconductors for automobile. For IGBT and SiC, BYD aims to implement IDM model, which will do both design and manufacturing. For Automotive MCU, CMOS, and fingerprint sensor, BYD will pursue Fabless model, which will only design the products. BYD has been supplying IGBT products and SiC MOSFET products to BYD Automobile. In terms of capacity, BYD did acquire a factory previously, but the capacity is unclear. However, it is certain that capacity, especially the SiC capacity, is a bottleneck for BYD. As a result, BYD Semiconductor announced a new project in Jinan, which will be partially funded by the spin-off IPO.

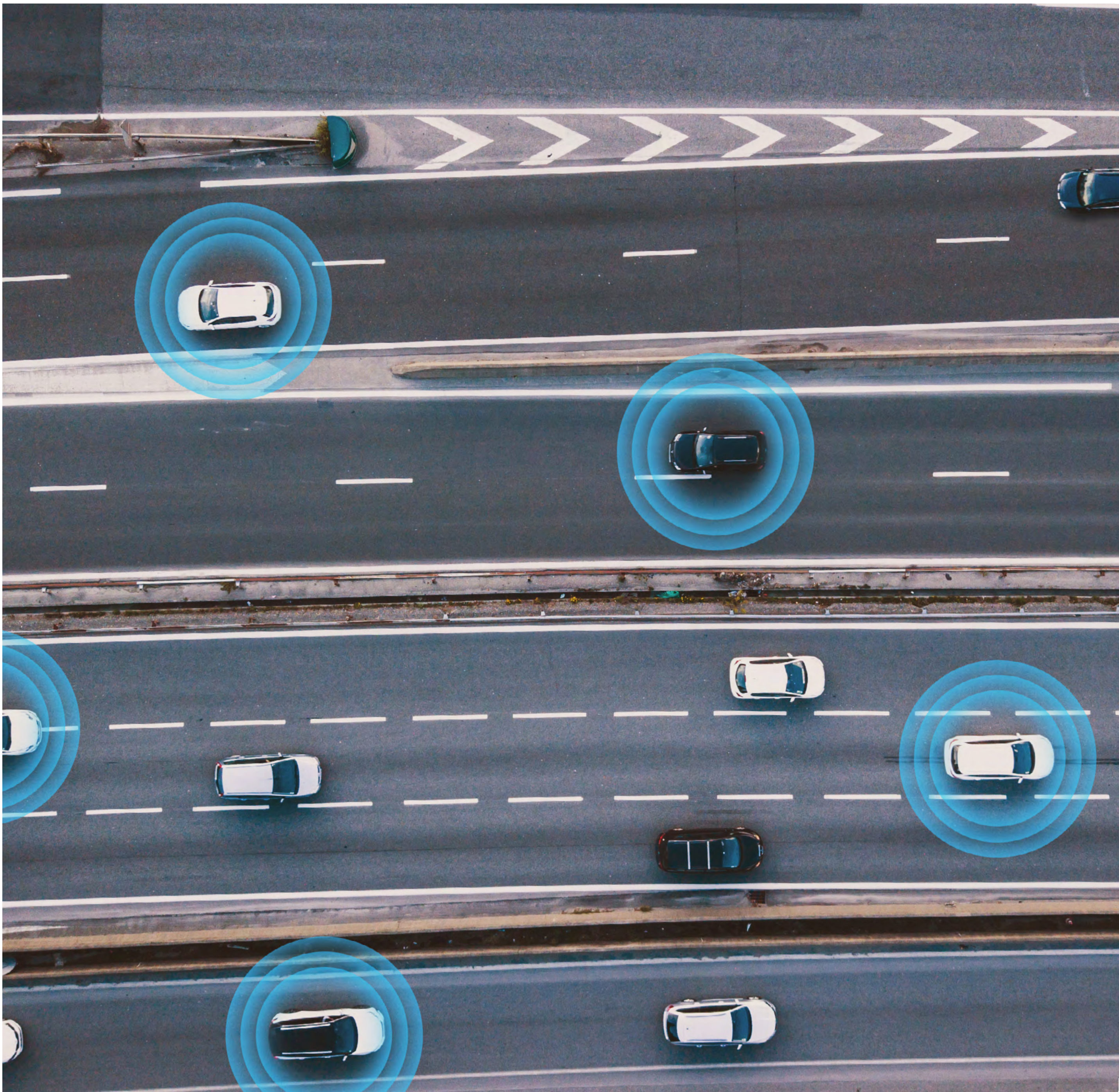
The future of BYD

BYD will continue to invest in a secured supply chain in China and expand to overseas markets. However, Wang Chuanfu's dream is much more than best-selling EV brand in China. BYD is certainly paving its way to become a global leader of energy transition for the future. Rho Motion will continue to update the landing and progress of BYD's projects.

Roadmap of FCEV development in China

Jie (Jessie) Xu
Research Analyst, Rho Motion

Photo: Song_about_summer

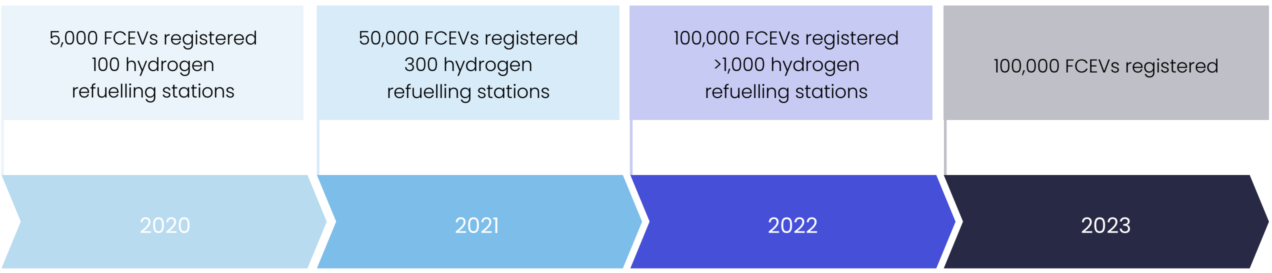


As of April 2022, there are over 6,000 fuel cell vehicles (FCEV) registered in China, taking up 12% of the global total. As of June 2022, China has become home to over 40% of the global hydrogen refuelling stations with 270 stations completed. In 2021, China recognised hydrogen as one of the six focused industries for its 14th five-year plan. Nevertheless, the industry is still in the early stage of development. China's push into FCEVs will be largely policy driven in the short term.

Direction from national and regional legislation

In March 2022, China disclosed its long-term development plan for hydrogen energy, which has identified a target of reaching 50,000 FCEVs registered in China by 2025. Early in 2020, China's Society of Automobile Engineers (SAE) launched the renewable energy and NEV technology roadmap, aiming to reach one million FCEVs registered by 2035. China's Hydrogen Energy and Fuel Cell Industry White Paper in 2020 also expected that China will have 1,500 Hydrogen refuelling stations by 2030.

Figure 1: China's roadmap of FCEVs by 2035 *Source: Rho Motion*

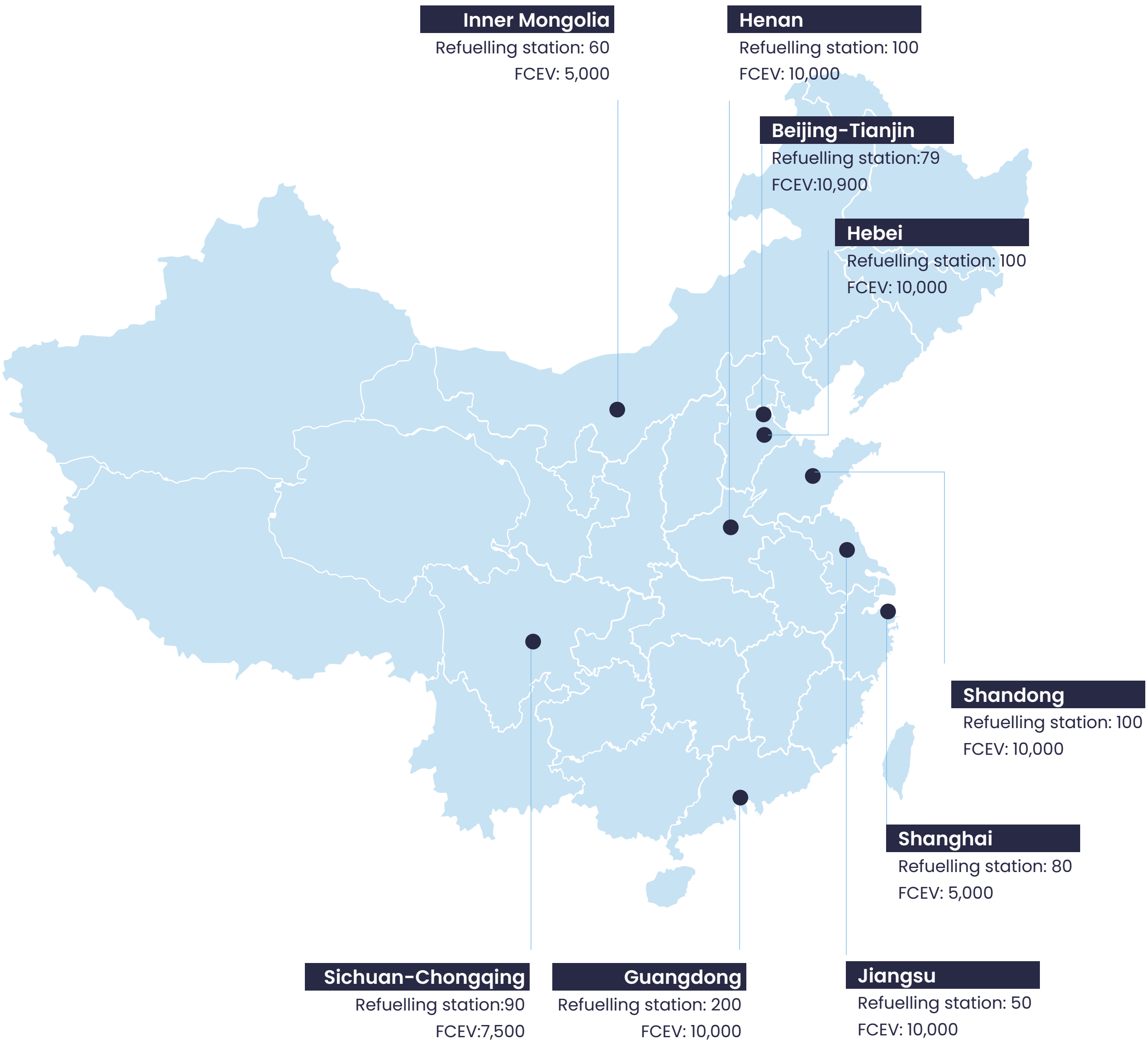


Following the state-run legislation, almost 30 regional governments have established a hydrogen promotion policy, and some disclosed details of their plans in terms of targets for FCEVs and hydrogen refuelling stations during the 14th five-year plan period. For instance, Chongqing aims to work with the Sichuan government to have 1,000 FCEVs registered by 2023 and build 15 stations in the city. Zhejiang plans to promote 5,000 FCEVs in logistics and city public transportation and install up to 50 stations.

In September 2021, Chinese authorities began the demonstrational applications of fuel cell vehicles. Five city clusters were selected as the trial markets: Shanghai, Beijing, Guangdong, Hebei, and Henan.

SAIC, one of the leading OEMs in China, unveiled its fuel cell vehicle plan in 2020. It aims to launch 10 FCEV models and reach sales of 30,000 fuel cell vehicles by 2025.

Figure 2: Regional hydrogen promotion target by 2025 *Source: Rho Motion*



The program will last for four years with additional financial support for the research and development of key technologies. So far, over 40 cities have participated in this state-led demonstration project within the five city clusters. According to the National Energy Administration (NEA), 50% of the hydrogen refuelling stations were built in the five city clusters in 2021. As of April 2022, 5,853 FCEVs have been registered in the five city clusters, accounting for 71.4% of the national total.

The subsidy scheme gives a stronger support

Following the legislation, subsidy also plays an important role in accelerating the development of the FCEVs.

In September 2020, policymakers outlined the revised state-wide fuel cell vehicle subsidy policy and initially applied it to the demonstrational project. The new subsidy identified the standard in terms of different parts of FCEVs, including the rated power ratio between the fuel cell system and the motor, the working temperature of the fuel cell stack, the range, the rated power density, the maximum total mass, and the warranty. Based on the credit-trading system, the current subsidy will be valid until the end of 2023. Below is the subsidy evaluation system of FCEVs in the demonstrational city clusters.

Table 1:

Source: Rho Motion

Fuel Cell Vehicle Category	General Conversion Formula	Subsidy (in RMB)			
		2020	2021	2022	2023
PV	Y=(p-50)×0.03+1	247,000	228,000	209,000	171,000
LD&MD Truck, Medium&Light Bus	Y=(p-50)×0.02+1	208,000	192,000	176,000	144,000
Large Bus(>10m)		364,000	336,000	308,000	252,000
HD Truck(12-25t)	Y=(p-50)×0.03+1	404,000	369,600	338,800	277,200
HD Truck(25-31t)		473,200	436,800	337,700	327,600
HD Truck(>31t)		546,000	504,000	462,000	378,000

Note:

1. Y is the conversion factor. P is the fuel cell's power in kW. In this chart, the subsidy amount is based on the power p=80kW for PV and p=110kW for Bus and Truck.

2. Max credit for FCEV promotion and application is 15,000 points. One point will be awarded approximately RMB100,000 in principle.

3. The credit standard of awards is 1.3 points/unit for 2020, 1.2 points/unit for 2021, 1.1 points/unit for 2022, 0.9 points/unit for 2023. In terms of HD trucks, when the fuel cell system rated power is above 80kW, the maximum design total mass of 12-25 tons (including 25 tons) will be calculated by 1.1 times, 25-31 tons (including 31 tons) will be calculated by 1.3 times, above 31 tons will be calculated by 1.5 times.

In terms of the refuelling station construction, several cities and provinces have released the regional subsidy, which will be granted based on the capacity of the station and is capped at RMB20 million.

OEMs are engaging in the development of FCEVs

In H1 2022, China has produced over 1,500 FCEVs and achieved sales of 1,400 units, taking up 80% and 90% of the market share in 2021. Following the legislation and subsidies, OEMs are now more focused on fuel cell technology and accelerating their plans for fuel cell vehicles.

SAIC, one of the leading OEMs in China, unveiled its fuel cell vehicle plan in 2020. It aims to launch 10 FCEV models and reach sales of 30,000 fuel cell vehicles by 2025.
In January 2022, SAIC started the operation of its fuel cell HD truck plant in Inner Mongolia, with a capacity of 10,000 FCEVs.

Another state-owned OEM, Great Wall Motor (GWM), also announced that it will invest RMB3 billion in R&D of fuel cell systems and aims to become the third largest fuel cell vehicle manufacturer by 2025.

Foton Motor, one of the biggest bus and truck manufacturers in China, aims to promote 15,000 FCVs by 2025 and 200,000 FCVs by 2030 through its subsidiary Zhilan Automobile.

Conclusion

After the disclosure of the 14th Five-Year plan, China's energy transition plan has become much clearer. As one pillar of China's energy strategy, the hydrogen and fuel cell industry will gain more attention and attract capital investors. With the experience of developing BEV, the government will pursue a similar path to achieve the target. However, the key challenges are still the heavy initial investment from the hydrogen supply and the refuelling network and the high unit price of FCEVs.

Energy Transition Tracker

Q3 2022

Our Energy Transition Capital Tracker provides an analysis of energy transition related companies going public through IPO or a merger with a SPAC each month, the full report is made available as part of our Membership. Below we provide a summary of the highlights over the last three months.

In June 2022, three companies went public successfully. Polestar completed its SPAC merge with Gores Guggenheim Inc. and is now traded at NASDAQ under ticker "PSNY". Ruitai New Material went public through an IPO and is now listed on Shenzhen Stock Exchange. Phoenix Motor closed its IPO deal and the stock started trading on 8th June 2022.

Also in June, six companies announced their plans to go public. Tianqi Lithium's application to be listed on HKSE has been approved by the authority. Weltmeister Motor has filed IPO application to HKSE. Sunwoda will spin off its EV battery business, which will start the IPO process in 2023/24. Wanrun New Energy and Power New Energy have filed IPO application to the Shanghai Stock Exchange. Hunan Yuneng has filed IPO application to the Shenzhen Stock Exchange.

In July 2022, the China-Swiss Stock Connect, which links the Swiss Stock Exchange, the Shenzhen Stock Exchange, and the Shanghai Stock Exchange, was officially established. Four companies were listed on SIX Swiss Exchange through the new scheme, including GEM, Gotion High-Tech, and Shanshan Group. In July, SungEel HiTech, Tianqi Lithium, and HSC Corporation also went public via traditional IPO in Korea, Hong Kong, and Shanghai, respectively.

In August there have been several delays to the IPO process of several companies, due to the volatility of the equity market and the uncertainty of the global economy. CALB's IPO, potentially the largest by far in 2022 in the Hong Kong market, was slightly delayed due to the postponed listing hearing. Plentitude Energy, a spin-off IPO from Italian energy giant DEO, and Vinfast, the first Vietnamese EV OEM, have both confirmed that their IPO will be postponed. Recently less companies than usual have announced plans for an IPO, with the exception in the China market.

Despite the overall market concern, most companies under our watch have not made further announcements. In August, two companies closed their IPO deals – Forza X1 and NeoVolta.

Company	Company Area	Transaction type	SPAC	Date
June 2022				
Tianqi Lithium	Battery Materials	IPO	-	Q3 2022
Wanrun New Energy	Battery Materials	IPO	-	Q3 2022
Sunwoda	Battery	IPO	-	2023
Power New Energy	Battery Materials	IPO	-	H2 2022
Hunan Yuneng	Battery Materials	IPO	-	H2 2022
NeoVolta	ESS	IPO	-	H2 2022
SungEel HiTech	Recycling	IPO	-	H2 2022
Freewire	Charging	IPO	-	Q4 2023
ProLogium	EV	IPO	-	Q4 2023
Vinfast	EV	IPO	-	Q1 2023
Phoenix Motor	EV	IPO	-	10/06/2022
Ruitai New Material	Battery Materials	IPO	-	17/06/2022
Polestar	EV	SPAC	Gores Guggenheim Inc.	24/06/2022
July 2022				
Next e.GO Mobile	EV	SPAC	Athena Consumer Acquisition Corp.	Q4 2022
SolarMax Technology	ESS	IPO	-	Q1 2023
Georgina Energy	Hydrogen & Fuel Cells	IPO	-	Q4 2022
Xinte Energy	ESS	IPO	-	Q1 2023
Huadian New Energy	ESS	IPO	-	2023
EVE Energy	Battery	IPO	-	Q3 2022
Sunwoda	Battery	IPO	-	Q3 2022
GEM	Recycling	IPO	-	29/07/2022
Shanshan Group	Battery Materials	IPO	-	29/07/2022
Gotion High-Tech	Battery	IPO	-	29/07/2022
Tianqi Lithium	Battery Materials	IPO	-	13/07/2022
HSC Corporation	Battery Materials	IPO	-	13/07/2022
SungEel HiTech	Recycling	IPO	-	28/07/2022
August 2022				
Senior Material	Battery Materials	IPO	-	Q3 2022
SinoHytec	Hydrogen & Fuel Cells	IPO	-	Q1 2023
High Power Technology	EV	IPO	-	Q4 2022
Power New Energy	ESS	IPO	-	Q1 2023
Leap Motor	EV	IPO	-	Q4 2022
Vinfast	EV	IPO	-	2023
Charge Amps	Charging	IPO	-	2023
CALB	Battery	IPO	-	Q4 2022
Dragonfly	Battery Materials	IPO	-	2023
Livewire	EV	SPAC	AEA-Bridges	2023
Next.e.GO Mobile	EV	SPAC	Athena Consumer Acquisition Corp.	Q4 2022
NeoVolta	ESS	IPO	-	30/07/2022
Forza X1	EV	IPO	-	12/08/2022

Rho Motion's Energy Transition Capital tracker tracks companies going public through an Initial Public Offering (IPO) or special purchase acquisition companies (SPAC), SPACs are blank cheque companies designed to bypass the traditional IPO process.

Pre Merger/IPO
Post Merger/IPO

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A one-size battery does not fit all

Ben Ting
Chief Commercial Officer, Echion Technologies LTD

Photo: dezign56

The growth of passenger EVs is driving global demand for lithium-ion batteries. To address the range anxiety and upfront costs concerns associated with this market, OEMs have long prioritised the need to increase energy density and lower the $/kWh of their batteries. It is only expected then that many of the innovations seen in lithium-ion batteries target these concerns.

However, with such focused attention to the passenger EV market, are we neglecting the needs of other important markets and applications? Markets and applications such as public transportation, mining and minerals, industrial supply chains and logistics, and not to mention, energy storage systems. These heavy-duty or high-duty cycle applications are either large carbon emitters today or are new opportunities well-placed to help achieve the net-zero targets of countries and organisations.
A common need across these markets is to address "productivity anxiety" and "total cost of ownership anxiety". In this light, a one-size battery developed for the passenger EV market does not fit all. Sure, the performance space of batteries optimised for passenger EVs overlaps with the needs of subsegments of these markets. However, to provide greater coverage for non-EV markets, we require something different, something bespoke and something more sustainable.

As a developer of new, innovative battery anode materials, the opportunity to target these non-EV markets is appealing for three reasons:

1. There is great interest from industrial, commercial, and public-service end-users and operators to electrify. If electrification solutions deliver better productivity and economics, adoption will occur.
2. Despite being significantly smaller than the passenger EV market (for example, in terms of demand in forecasted GWh/year), these non-passenger EV markets are still sizable.
3. Active materials innovation "lifts all boats". In other words, innovations at the cell, module, BMS and system levels can still be utilised, in some cases to greater effect.

Public transport authorities around the world are examples of the first point.

Though financial incentives and grants fuelled early adoption of battery electric buses, improvements in productivity, air quality, and total cost of ownership observed from subsidised operations are driving more operators to make the switch when possible. In many cases, making the switch has been mandated through net-zero goals, such as Deutsche Bahn's commitment to becoming carbon neutral by 2040. This will result in approximately 3,000 rail vehicles and 26,000 buses substituted with Zero-Emission alternatives (approx. 7 million tonnes of CO_2e) (Source: DB)

In less-subsidised private industries such as mining, the acquisition of Williams Advanced Engineering by Australian miner Fortescue Metals Group was a pivotal move to develop a viable solution to electrify haul truck operations. Other global miners are also well into their journey of finding electrification solutions for their fleets.

This brings us to the second point. The potential size of industrial markets is significant enough, and they are accessible, meaning healthy returns for those who can provide solutions.

Beyond performance and costs, achieving sustainability is a core objective of battery electrification.

Illustration: Petovarga

As one of the organisations developing innovative new battery chemistries and active materials, Echion understands the requirements for industrial transport markets. Echion's XNO® anode material enables OEMs and end-users to eliminate many of the compromises they currently face by adapting passenger EV battery technology. These include:

1. Removing the risk of dendrite formation under fast-charge conditions, resulting in enhanced cell safety.
2. Maintaining long cycle life, even under fast charge and discharge, deep cycling, and high and low temperatures.
3. Maintain higher energy densities under fast charging and discharging conditions.

In industrial applications safety is a crucial factor – it matters most to users and passengers. It also has implications for the reputation of manufacturers and OEMs. XNO® delivers unrivalled levels of safety as it is an inherently stable material. In nail penetration tests for example, fully charged XNO® cells do not result in thermal runaway. Achieving this safety at a material level can simplify the design of modules and packs, potentially lowering the cost of meeting the safety standards for industrial and commercial applications.

If a battery can last longer before replacement, then a substantial improvement in $/kWh/cycle is achieved. This is a key component of the total cost of ownership (TCO). In independent testing, we have recorded performances of more than 12,000 cycles, and cell manufacturers using XNO® are targeting 20,000 cycles in certain designs.

For industrial applications, fast charging means less downtime and more efficient operations. For typically EV batteries, fast charging means reduced life of the battery. However, with XNO®, you can combine fast charging with long cycle life and bring not just productivity benefits, but low TCO benefits too.

Beyond performance and costs, achieving sustainability is a core objective of battery electrification. Environmental standards in battery production and their subsequent use will be scrutinised and meeting the regulatory requirements of individual markets will be essential. If not, clean end products could result in dirty supply chains. Cell manufacturers will be looking for materials that best meet those standards.

Echion, and our supply chain is committed to delivering a sustainable future. In one example, XNO® has been assessed in a recent study by Ghent University to have less CO2 than LTO anodes by a factor of two – bringing a major benefit for customers who are ready to fulfil their environmental, social and governance commitments.

Now is the time to focus on the battery electrification needs of the industrial, commercial, and public sectors. After six years of dedicated research and development, Echion is demonstrating the effectiveness of XNO® as a proven solution to many of the requirements and frustrations these industries face. Work with us to deliver sustainable electrification for these key markets.

Powered by XNO®
means a battery to
decarbonise the
toughest applications
Today's Lithium-ion batteries struggle to deliver the combined power, safety, capacity and lifetime required to cost-effectively electrify heavy duty applications. Echion's unique XNO® anode material takes high performance lithium-ion batteries to a new level achieving the lowest total cost of ownership and highest productivity.
Join our growing network of XNO® technology developers and end-users today.
Get in touch to find out more:
Ben Ting, Chief Commercial Officer
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Echion Technologies

Photo: Petair

Sustainable batteries for EV propulsion

The need for standardised sustainability assessments

Ulderico Ulissi
Battery Research Lead, Rho Motion

In the last few months, we have seen the impact of increasing energy prices on the western economy. Several factors have contributed to the current crisis, threatening western manufacturing competitiveness. The most discussed is the ongoing conflict in Ukraine, with European countries facing severe headwinds due to over-reliance on Russian gas imports. Another complex issue to quantify is the effect of climate change.

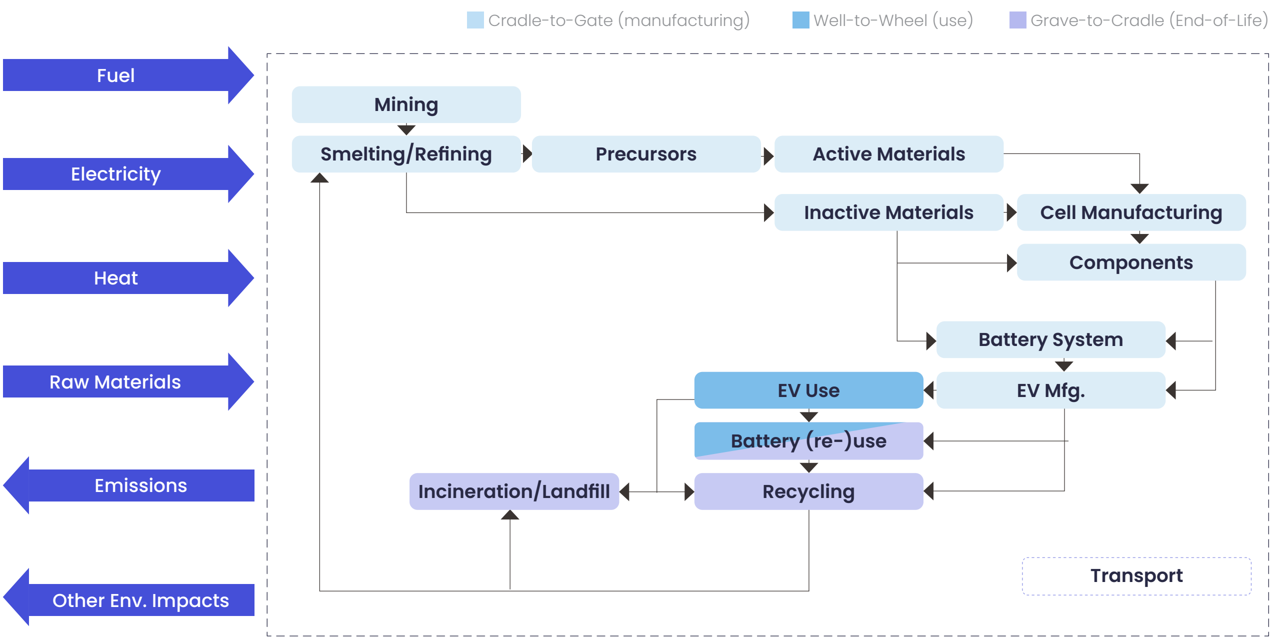
As discussed by the head of the European Space Agency, Josef Aschbacher (Hepher, 2022), climate change is causing a series of unprecedented heatwaves, wildfires, and draughts worldwide. These are affecting power plants, which are running at reduced efficiency, and also impacting other human activities. Consequences are visible in China, highlighting how climate change is a global issue (*'It's Getting Extremely Hard': Climate Crisis Forces China to Ration Electricity*, 2022).

Tackling climate change and understanding the underlying risks is a complex task, as outlined by the IPCC in a recent report (P.R. et al., 2022). Because of this, it will likely become more important to quantify a product's or process' sustainability. The industrial sector has been developing sustainability assessment methods for a long time. Despite this, there is still no consensus on how to carry out these studies. A recent study (Pihkola et al., 2017) supported by the European Commission has identified over 100 different tools being employed for sustainability assessment, some developed in-house by prominent industry players and others publicly available. For example, one of the most common methods, called Life Cycle Assessment (LCA), is far from comprehensive, as it disregards economic, social and technical impacts. Moreover, the methodology is still not harmonised despite being documented at a national and international level, e.g., in several ISO standards.

Sustainability assessment of electric vehicles

Despite its shortcomings, the LCA is widely employed in the industry. Performing a sustainability assessment for an electric vehicle is complex, primarily due to the battery. This is due to several reasons. We discussed in our Q1 issue how the value chain is long and complex, dominated mainly by Chinese players. The complexity is further evidenced by a schematic of the typical system boundaries, reported in Figure 1.

Figure 1: LCA System boundary for an electric vehicle (EV), cradle-to-cradle, including re-use (2nd Life) *Source: Rho Motion*



When reviewing publicly available studies, we realised a lack of data regarding a wide range of pollutants. Other environmental indicators, such as resource depletion, ecosystem toxicity and quality, and impact on human health and society, are also seldomly reported. There is also a lack of clear descriptions of emissions and strategies at vehicle end-of-life. Moreover, with the value chain still far from being developed outside of China, Cradle-to-Cradle approaches, i.e., from mining to recycling, generally lack information. These analyses often use preliminary or assumed data. A lack of consensus between different studies is further evidenced by Table 1. Here we show a summary of the typical values found in the literature for the "Cradle-to-Gate" phase, which is the one having the highest and most measurable impact on emission.

Table 1: Summary of Cradle-to-Gate emissions estimated in different studies and models. Values are presented in kilogram of CO_2 equivalents emitted per kWh of battery manufactured. Data from "The Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies" (GREET) Model by the Argonne National Laboratory and from the "International Council on Clean Transportation" (ICCT) are reported as reputable benchmarks. Data for $LiFePO_4$ (LFP) and $LiNi_aCo_bMn_cO_2$ (NCM).

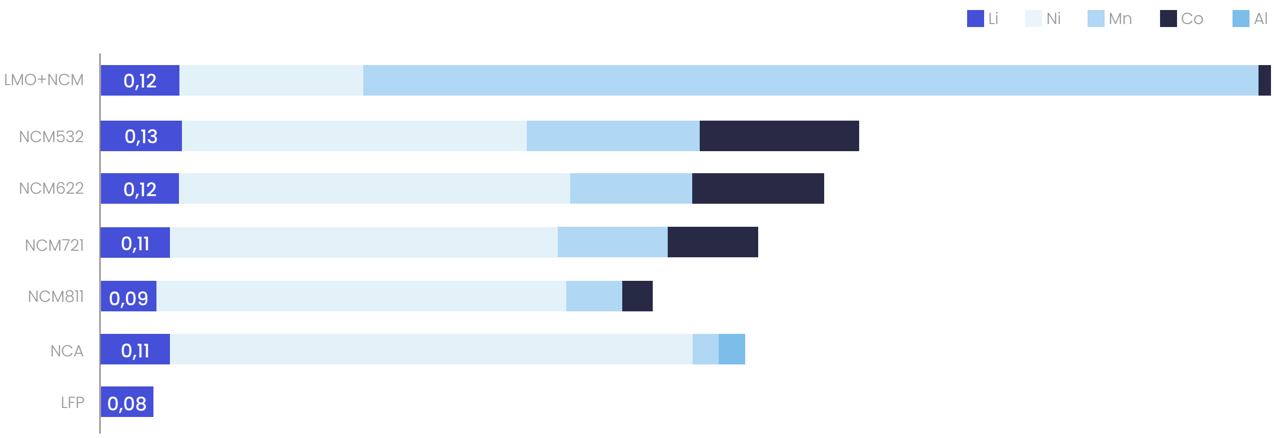
Source: Rho Motion

	GREET	ICCT (2021)	ICCT (2022)	VW ID.3	Polestar, Volvo	Tesla	Academic studies
LFP (kg_{CO2e}/kWh)	35-37	34-55					50-350, typically in the range of 100
NMC (kg_{CO2e}/kWh)	70-80	53-68	60	62	80-90	No value clearly reported	

The data suggest a lower environmental impact of LFP for producing an equivalent amount of kWh of batteries, possibly due to several factors. One of the most significant sources of uncertainty and contributing factors is the amount of material in a battery. Our recent analysis, based on teardown data and calculations, and supported by several academic studies (Lai et al., 2022; Sun et al., 2022), do suggest that LFP is, as of today, a more environmentally friendly source of energy storage. Batteries contain a lower amount of elemental lithium per kWh of a battery cell, as evidenced by Figure 2, and require less lithium for manufacturing (e.g., lower lithium losses during manufacturing).

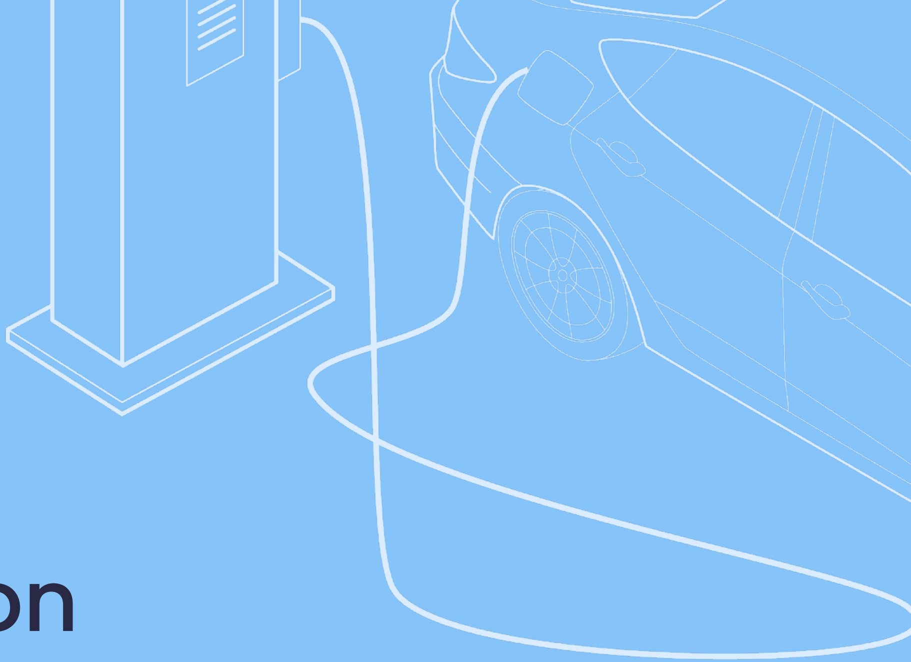
Figure 2: Kilogram of metal contained in a kWh of battery cell for different chemistries, based on cathode active material content. The electrolyte has a negligible contribution. The pre-lithiation requirement is considered constant and not computed.

Source: Rho Motion



Performing an accurate LCA at the pack level is undoubtedly more challenging, particularly when considering the latest cell-to-pack technologies, as both chemistries continue to evolve. New battery packs have announced energies of up to 180 Wh/kg (CALB LxFP) and 250 Wh/kg (CATL NCM-based Qilin), which will also affect the well-to-wheel phase. This is mainly influenced by several, vehicle and regional specific factors, but it is strongly influenced by vehicle curb weight. A small battery with a high energy per kilogram (Wh/kg) could enable cars with a lower energy consumption during the use-phase.

Finally, LCA for batteries at end-of-life have limited data inventories. LFP has lower economic value in terms of raw materials. With a potentially longer cycle life and an appetite for this chemistry in stationary storage applications, LFP will likely be developed to excel in second-life applications. This could further dilute their impact by extending product lifetime. Our initial data analysis does also suggest that recycling LFP requires a lower amount of energy and resources. This is an aspect we will further develop and discuss during the coming months, as we build our modelling on NCM and LFP batteries. In the meantime, further discussion on this topic is needed. As a critical takeaway, there is an urgent need to develop harmonised tools for environmental assessment, which are not limited to calculating a CO_{2e} value.



Rho Motion Consultancy and Advisory Services

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Rho Motion provides bespoke consultancy and advisory services, based on our clients' needs covering the EV and battery supply chains in the following areas:

- Competitor analysis
- Market entry strategy
- Business appraisal and strategy
- Battery chemistry and technology evaluation
- Techno-economic modelling
- Technology strategy
- ESG circular economy
- PFS/DFS

Our clients are diverse, global players and our research is relied upon in bankable feasibility studies, preliminary economic assessments and public finance raising including IPOs and debt issues.

Photo: Mitra Chem

Historic US investment in battery materials can upend the global supply chain and shift the balance of global power

Mitra Chem

Vivas Kumar
Founder and CEO, Mitra Chem

The United States has long fought to be "energy independent". The theory holds that by controlling our energy supply, we could break free from dependence on unfriendly dictators to power our nation. The war in Ukraine and the resulting spike in energy prices show the risks and damage of over-dependence on risky energy sources.

Simply producing our own fuels is no longer enough in the age of electrification. The energy supply chains, especially those for electrification technologies, are far more complex. More importantly, these supply chains are dependent on a wider array of technologies and components to generate, store, distribute, and recharge lithium-ion batteries.

As we all know, shifting from carbon-based combustible fuels to electricity stored and delivered by batteries is not as simple as plugging a cord into the wall. Building the components and materials of the battery cell is a complex, laborious, and time-consuming process that today is almost totally controlled by companies producing in China for global consumption.

The Biden Administration and Congress have now taken long overdue action to ramp up domestic production and distribution of battery product materials with the passage of two important laws:

1. The Inflation Reduction Act (IRA), which provides tax credits only to those EVs that meet rigorous requirements for domestic-produced content inside battery cells

2. The Bipartisan Infrastructure Law (BIL), which includes $3.16 billion in grants to make more batteries and components in America and bolster the domestic supply chain.

These actions will have an immediate and significant impact to strengthen the U.S. global market position and restore U.S. leadership in the fight against climate change. It also marks the first time that the US government has implemented the full triumvirate of actions needed for a massive industry build-up that we need: policy, legislation, and most importantly, funding.

Our company, Mitra Chem, is focused on three core goals that directly align with the core pools of federal investment:

- Shifting the Western electric vehicle and energy storage industries' battery portfolio towards better, safer, cheaper iron-based battery cathodes.

- Accelerating by >90% the lab-to-market timeline for a portfolio of battery materials through a proprietary machine learning advantage.

- Building production capacity in the USA to offset production asset overconcentration in China.

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We are poised to answer the government's call to action and positioned to leverage this historic investment to help support the national effort to accelerate electrification in the fight against climate change.

In addition, this moment is a tremendous opportunity for the United States to invest in our innovators who were at the forefront of battery materials technology. The most prominent type of iron-based cathode, Lithium Iron Phosphate (LFP), was invented in the West, and would be the ideal product to industrialize at scale with this significant government investment.

> *The 20th Century's balance of power was defined by the control of the production and distribution of oil.*

Photo: Mitra Chem

China currently dominates the global battery market, accounting for the vast majority of all cathode material production (the critical component of manufacturing batteries). Recent reports suggest this market position will continue to increase. In addition, current nickel-rich and cobalt-rich battery products favored in the West are too dependent on specialty chemicals sourced from China.

The reports are clear that China sees building its battery production capabilities to sell into Western markets as a strategic imperative. As such, Chinese companies aided by government backing have been willing to invest billions of dollars to strengthen their position. In a time of increasing geopolitical tensions and continued COVID-driven supply chain disruptions, dramatically reducing our dependence on a single supply chain failure node, especially in a country that has continued to increase its brazen rhetoric against the West, is a national security and economic necessity.

With the passage of the IRA and the BIL, companies building the American battery supply chain have real and transformative opportunities to leverage new funding, tax credits, and other regulatory benefits included in the bill to help scale up operations.

Individual companies cannot build this supply chain alone. Downstream partners must step up: build this industry together with commercial commitments and testing and qualification priority to deploy these technologies in the ecosystems as fast as possible. Provide the purchase guarantees to drive further capacity growth onshoring from players across the entire supply chain. The market need is clear, and the time to act and build is now.

The 20th Century's balance of power was defined by the control of the production and distribution of oil. Control of new energy supply chains, batteries chief among them, will define the 21st Century. We must continue to build faster and work closer together to control our energy future and lead in the fight against climate change.

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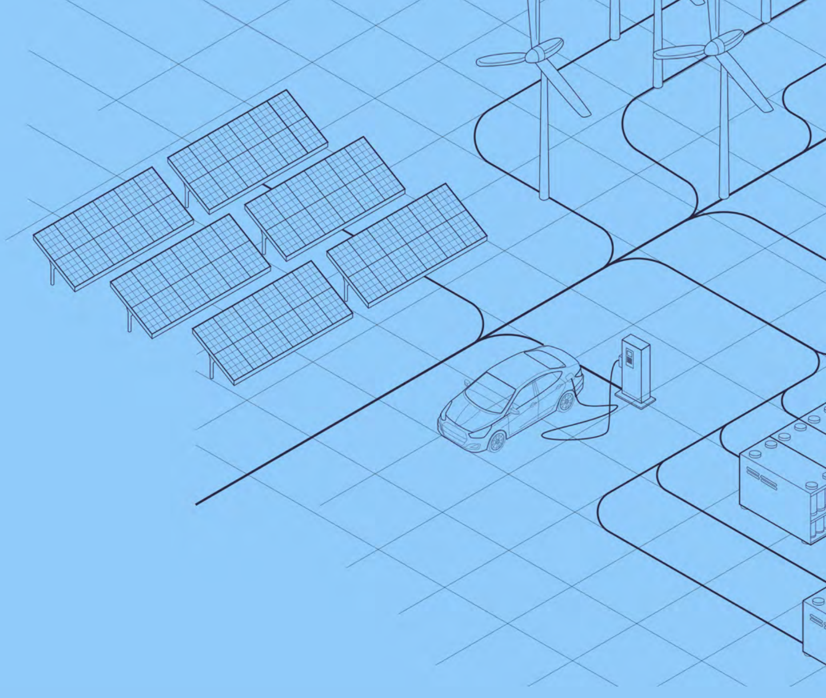
Battery Demand Service



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The Battery Demand Service combines all our battery outlooks and assessments in one place.

	Pro	Plus	Premium
Battery Demand Service: Outlook Excel file • Updated in line with outlook report releases	✓	✓	✓
EV & Battery Quarterly Outlook PDF and Excel File • Quarterly releases	✓	✓	✓
Hybrid EV Quarterly Outlook PDF and Excel File • Quarterly releases	✓	✓	✓
Battery Energy Stationary Storage Outlook PDF and Excel File • Quarterly releases	✓	✓	✓
Fuel Cell Electric Vehicle Outlook PDF and Excel File • Annual releases	✓	✓	✓
Electric 2&3 Wheeler Outlook PDF and Excel File • Annual releases	✓	✓	✓
Electric Micro Mobility Outlook PDF and Excel File • Annual releases	✓	✓	✓
Portables Battery Outlook PDF and Excel File • Annual releases	✓	✓	✓
EV Battery Chemistry Monthly Assessment PDF and Excel File • Monthly releases		✓	✓
Battery ESS Monthly Assessment PDF and Excel File • Monthly releases		✓	✓
EV & Battery Monthly Database Excel File • Monthly releases			✓

Photo: Blue Planet Studio

System coupling options for EV charging

DYNAPOWER
POWERING A CLEANER PLANET

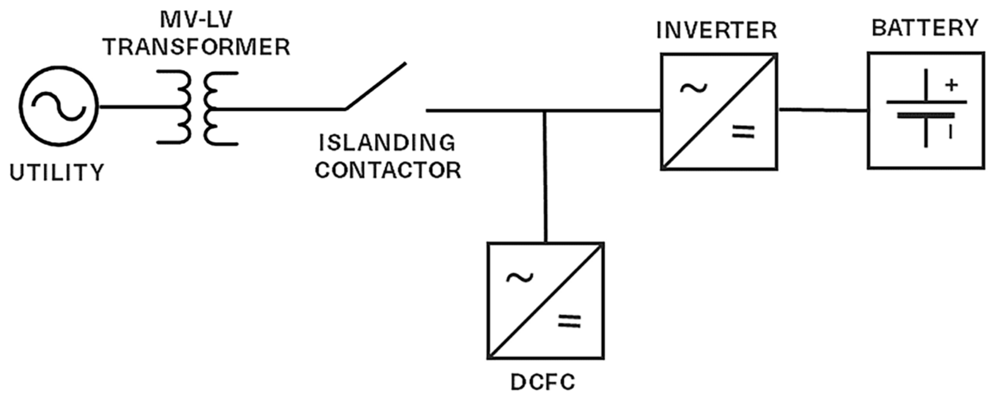
John Springer
Segment Manager, e-Mobility

Below compares AC and DC coupled energy storage configurations for DC fast charging (DCFC) and highlights the benefit of creating microgrids utilizing Dynamic Transfer to protect both charging and critical loads. Coupling energy storage helps mitigate the challenging effects of installing chargers within the existing grid infrastructure at points of grid weakness. That is, chosen locations for DCFC may not be satisfactory to support the increased demand on the grid without supplemental site power. Overcoming these challenges is possible, but at a dramatic increase in cost with additional considerations ranging from utility upgrades, demand charges, and unacceptable times to implementation.

AC coupled configuration

Current DCFC installations being deployed require a 3-phase AC input. This topology has been used in other applications–specifically the C&I sector–for quite some time. As a behind-the-meter application, this can provide several different services for the end user to reduce operational costs as well as provide a backup power source.

Figure 1: Standard AC coupled configuration *Source: Dynapower*



Several known advantages include reduction in infrastructure costs through the battery's power offset at the point of interconnection. This includes reduction of peak demand charges along with peak-shaving strategies, voltage and frequency support including microgrid modes, and Dynamic Transfer as explained in further detail below.

DC coupled configuration

The future of DC fast chargers will likely be true DC/DC fast chargers tied to a common DC bus. Including DC coupled battery storage provides the same benefits of AC coupled systems with the additional benefit of higher efficiency.

Figure 2: DC coupled configuration *Source: Dynapower*

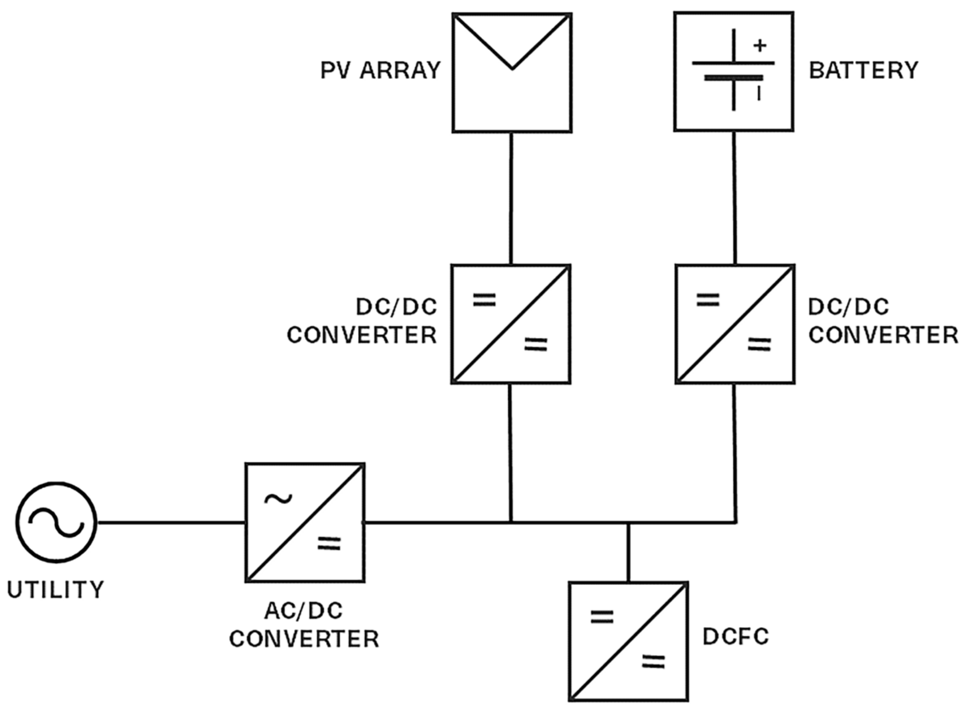
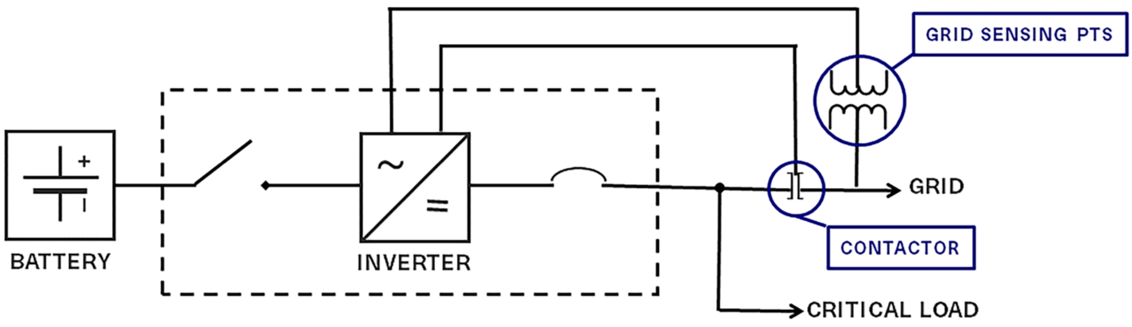


Figure 3: Typical dynamic transfer configuration *Source: Dynapower*



Less relevant for consumer home charging activity, DC/DC will have a great effect on fleet charging as vehicle battery capacity increases and the dwell time required cannot accommodate inexpensive and ultimately underpowered L2 charging systems. Offering a DC solution through a common bus will increase the available power, future proof the design, reduce pedestal size, and provide increased efficiency–especially as it relates to onsite generation which will be required in many locations.

Dynamic transfer advantages

To reduce risk associated with potential service interruptions, Dynamic Transfer technology utilizing a bi-directional utility-interactive inverter and configured batteries to create a shunt-connected uninterruptible power supply (UPS) can be implemented. The inverter autonomously, and generally seamlessly, transitions from grid-tied operation to microgrid mode. The inverter also manages the seamless transition back to grid-tied operation upon return of utility service. Additional benefits of this configuration include:

- Facility power from the utility does not flow through the inverter or battery and inverter losses are only incurred when the system is in active use (less aux losses).
- The battery can be charged from renewables or other on-site generation, facilitating energy time-shifting, self-consumption of PV, and extending the effective duration of the battery by prioritizing renewable consumption over battery energy consumption in microgrid mode.
- The battery can discharge to the grid, facilitating peak shaving to reduce demand charges, energy arbitrage, and a host of ancillary grid services that can generate revenue.

> *The future of DC fast chargers will likely be true DC/DC fast chargers tied to a common DC bus. Including DC coupled battery storage provides the same benefits of AC coupled systems with the additional benefit of higher efficiency.*

In a rapidly evolving space, there are numerous developing strategies to address efficiency, increase speed of adoption and improve economics. The need for these solutions is very real and not everyone has accounted for considerations which, made in the short-term, may not have the mid to long term impact which was originally intended. Please reach out if you wish to explore your unique challenges and arrive at solutions to meet your goals.

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Charging & Infrastructure

Our EV Charging and Infrastructure research provides flexible and dynamic analysis on both the current state of the market and the technological and commercial outlook for the sector

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Global EV Charging Outlook

Our Global EV Charging Outlook provides an electric vehicle market analysis of the current and planned technologies at both the vehicle and charger level, and profiles the major players in the market and their relative competitive position and plans for the future. The report can be customised to cover as many or as few countries or regions as needed.

EV Charging Monthly Assessment

The assessment provides an analysis of the maximum charging capacity of global and regional passenger car and light duty vehicle sales and fleets, as well as a fleet energy demand.

EV Charging Monthly Database

Our EV Charging database with model-by-model sales and analysis of vehicle charging capabilities and battery pack size and chemistry.

Our Charging & Infrastructure market analysis is delivered in flexible, dynamic formats that can be customised for the user.

Find out more, contact us +44 (0) 203 960 9986, info@ rhomotion.com

Photo: iaremenko

Evolving EV charging market structure

Mina Ha
Senior Research Analyst, Rho Motion

The EV charging market is undergoing consolidation with increasing investments in acquisition activities in 2022. This trend is expected to continue in the US and Europe while China has passed the consolidation phase.

Global EV charging infrastructure has been expanding on the back of rising demand for electric vehicles and government funds. The global public EV charging market increased by 34% y-o-y to 1.7 million public EV charging points in 2021 on the back of strong EV sales. The growth is expected to continue in 2022, reaching 2.6

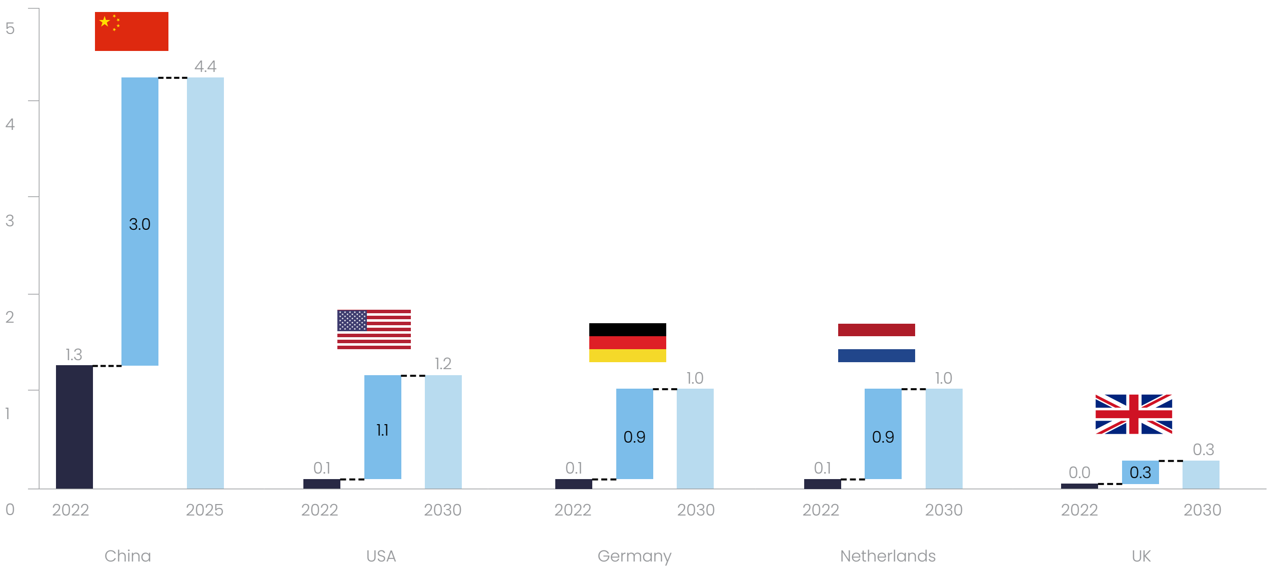
million public charging points despite weaker EV sales due to COVID-19 lockdowns in China combined with global EV supply chain issues.

National EV charging point targets in major markets including China, Germany, the Netherlands, and the US indicate significant expansions across the regions in the coming years. In February 2022 China confirmed it would build a nationwide EV charging network to meet its demand of 20 million EVs by 2025. Local authorities also have their own roadmaps and subsidy policies for EV charging infrastructure in China. Based on 23 provincial targets announced to date, China aims to install 4.4 million EV charging points by 2025, the largest expansion amongst all regions.

In Europe, the Netherlands currently has the highest number of public EV charging points at around 72,000 as of August 2022. The Dutch government aims to have one million public charging points and 800,000 residential charging points by 2030, by providing incentives through the Environmental Investment Allowance (MIA) and the Random Depreciation of Environmental Investments (VAMIL) schemes.

In the US there are around 126,000 public charging points installed as of 1st September 2022, 80% of which are slow chargers with up to 22kW charging speed. The US House of Representatives passed a $1.2 trillion infrastructure bill in November 2021, USD7.5 billion of which will be used in building 500,000 EV charging stations nationwide by 2030.

Figure 1: EV charging market growth is expected to accelerate on the back of national EV charging point targets *Source: Rho Motion*



Notes: China EV charging target is the sum of 23 provincial targets announced to date. The provinces include Beijing, Hubei, Hunan, Shaanxi, Hainan, Sichuan, Guangdong, Anhui, Chongqing, Shanghai, Henan, Shandong, Jiangsu, Hebei, Guangxi, Zhejiang, Gansu, Inner Mongolia, Yunnan, Guizhou, Heilongjiang, Liaoning, and Ningxia.

The US EV charging target is calculated by multiplying 2.5 with 500,000 EV charging stations. The multiply factor is an average number of charging points per charging unit based on the country's EV charging data for the period January 2022 to May 2022.

EV charging manufacturers and networks are scaling up their operations to meet the increasing demand. For example, BP Pulse aims to expand its public EV charging network, operating 100,000 charging points globally by 2030, including 16,000 charging points in the UK by 2030. It recently announced a joint venture with Spanish utility company Iberdrola for 11,000 fast chargers to be installed in Spain and Portugal with an investment of USD1 billion. Shell also plans to operate 500,000 charging points by 2025 and 2.5 million by 2030 globally through various partnerships and joint ventures. It recently announced partnerships with BYD and Genesis Motor Europe.

Investment in acquisitions have been increasing as a way to expand their market share this year. In January 2022, ABB increased its stake in Chargedot to 80% to further strengthen its market presence in the Chinese market and it also acquired an additional 50% stake in US-based

InCharge Energy, following a 10% stake acquired in 2020. Also in January, Mer acquired the UK-based EV charging network Elmtronics to expand its market share in the UK. Mer expects to expand its EV charging services for fleets and workplaces in which Elmtronics is specialised.

Acquisition activities continued in the second quarter of 2022 with Florida-based EV charger producer Blink Charging acquiring the UK-based EV charging network Electric Blue (EB Charging) in April. Blink Charging has deployed over 30,000 charging points globally and through this acquisition, it entered the UK charging market adding over 1,150 chargers from EB Charging. In June 2022, Blink Charging announced that it agreed to acquire the US-based EV charging infrastructure solution provider SemaConnect for USD200 million. Through the acquisition, Blink Charging is expected to double its EV charging network with an additional 13,000 Level 2 and DC fast EV chargers and 3,800 site host locations. In the same month, US-based EV charging network EV Connect was acquired by French energy management and automation company Schneider Electric. In July, Shell España SA acquired a Spanish EV charging operator Cable Energía to accelerate its expansion in Spain and Portugal, adding 80 charging points of Cable Energía to Shell's network.

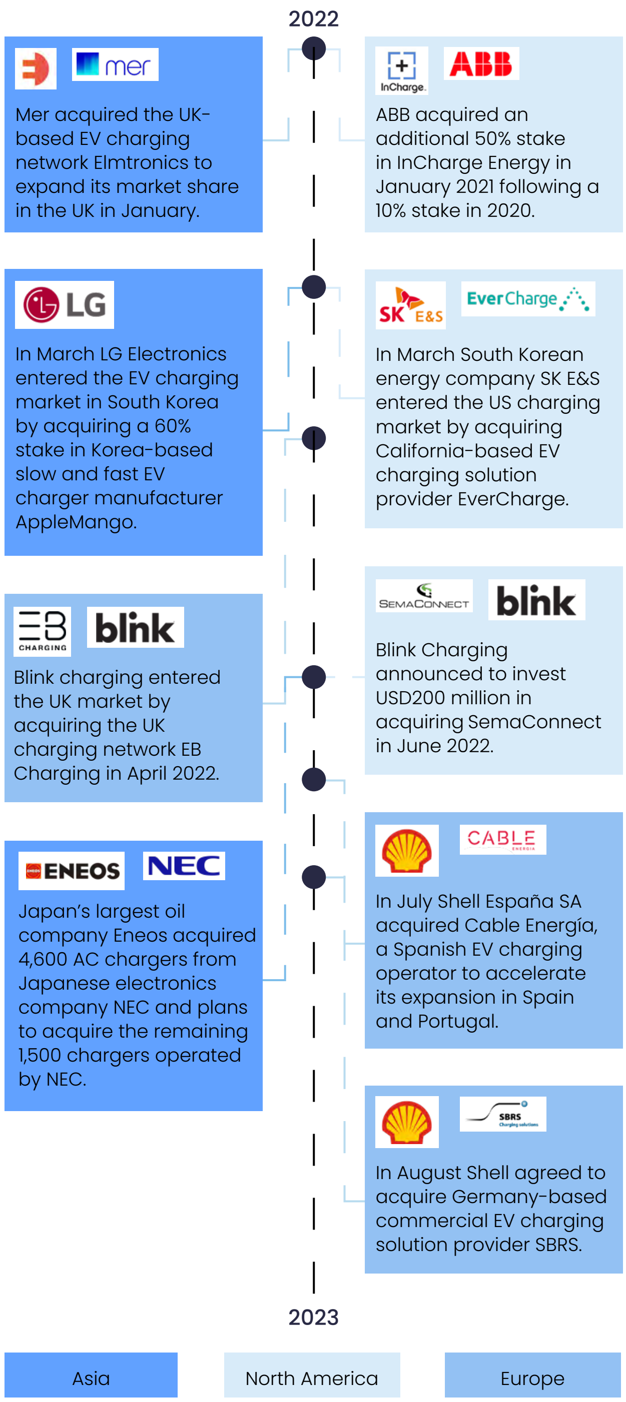
New entrants, mainly energy companies, that have financial stabilities and established infrastructure and networks, have been entering the EV charging market by acquiring existing EV charging networks with experience in operations and/or production.

In March 2022, South Korean energy company SK E&S entered the US charging market by acquiring California-based EV charging solution provider EverCharge. Founded in 2014 and headquartered in the San Francisco Bay Area, EverCharge mainly produces Level 2 EV chargers and currently operates 4,600 EV chargers primarily installed in large buildings in the US and Canada. LG Electronics also entered the EV charging market in the same month by acquiring a 60% stake in Korea-based slow and fast EV charger manufacturer AppleMango, with GS Energy acquiring the remaining 40% stake. LG Electronics plans to build an EV charger production line at the LG Digital Park in the city of Pyeongtaek, Korea by the end of 2022. It expects to expand its EV charging sites in partnership with GS Energy which has plans to turn its gas stations into EV charging stations. In June, Japan's largest oil company Eneos entered the EV charging market with a plan to install 10,000 fast chargers by 2030. It recently acquired 4,600 AC chargers from Japanese electronics company NEC and plans to acquire the remaining 1,500 chargers operated by NEC.

Figure 2: Existing EV charging networks and new entrants expand their market share via acquisitions

Source: Rho Motion

Announcements on acquisitions in EV charging market in 2022



Increasing investment in acquisition activities are expected to continue globally, consolidating the EV charging market as the competitive and fragmented market experiences rapid growth. The trend is likely to be more prominent in the US and Europe compared to China where the top five EV charging networks, Start Charge, YKC Charging, Teld, State Grid and China Southern Power Grid, account for 78% of the domestic market after passing the consolidation phase.

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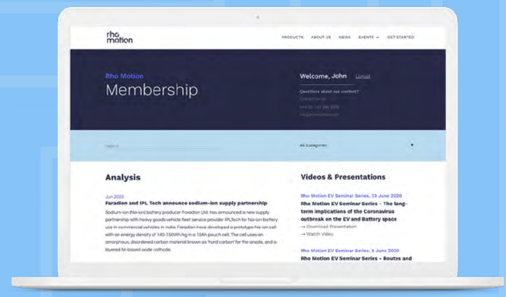

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Photo: drotik

The role of bidirectional charging and V2G technology in the EV ecosystem

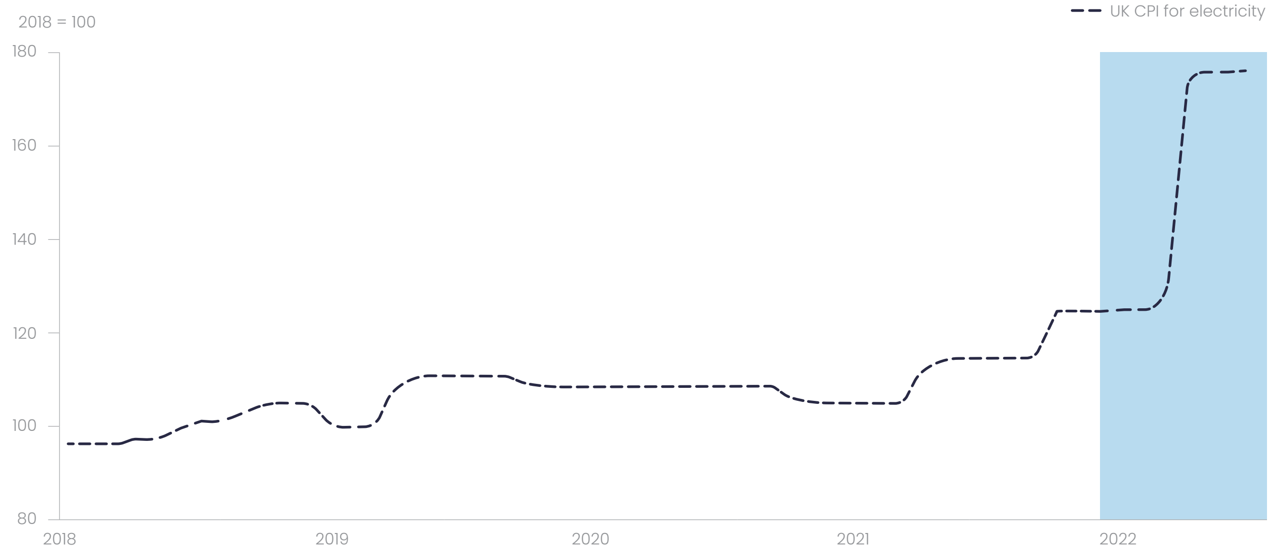
Charles Lester
Data Manager, Rho Motion

As energy prices soar across Europe and North America it is critical that reducing energy consumption and increasing renewable energy is key to a sustainable future. Battery Energy Stationary Storage (BESS) offers a solution to store renewable energy and alleviate pressure on the grid during peak demand. And now, bidirectional charging and V2X applications have opened another avenue for EV owners.

Increasingly, EV owners have the option of Vehicle-to-Everything (V2X) technology. This includes Vehicle-to-Load (V2L), Vehicle-to-House (V2H), and Vehicle-to-Grid (V2G). The initial vehicles introduced with this technology were the Mitsubishi Outlander PHEV and Nissan Leaf BEV using a CHAdeMO charging port. Many more OEMs have introduced bidirectional technology, including Ford with the F-150 Lightning and Hyundai with its Ioniq 5, and more have committed, including the likes of Volkswagen, Volvo, and Tesla.

Figure 1: UK monthly CPI for electricity, 2018 = 100

Source: ONS, Rho Motion



Most EVs have unidirectional charging capabilities. To utilise V2G you need a bidirectional charger and a compatible EV. A bidirectional charger can both draw energy into the vehicle's battery and also send energy back. V2L allows energy to be drawn from the battery to use externally, like for appliances. For example, the Ioniq 5 can exert up to 3.6kW of power to help charge electrical appliances. V2H uses the vehicle's battery to charge the home, for instance during peak electricity prices or a blackout. V2G technology can send back electricity to the grid to help stabilise the grid and earn profit for the consumer.

Most EVs that have this technology do so through the CHAdeMO port. However, as the CHAdeMO charging port gets phased out, bidirectional charging technology will mostly be through a CCS port.

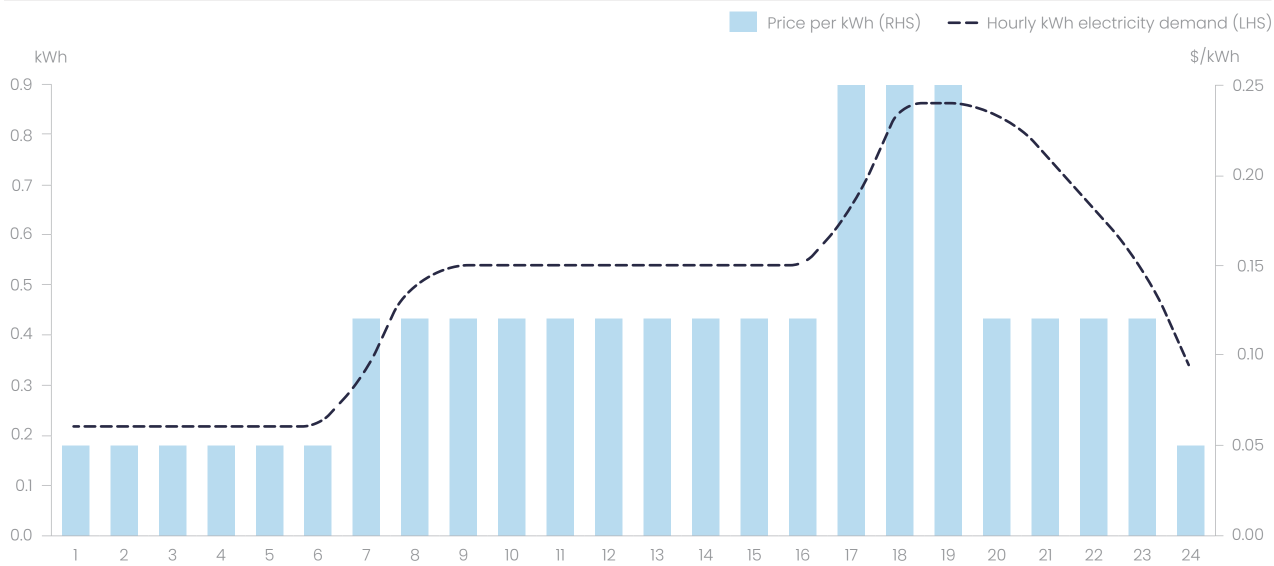
Benefits of bidirectional charging

Grid stability

One of the main benefits for the government or utility companies is the ability to manage the grid. During peak hours, which are typically 7-10 in the morning and between 5-9 in the evening, the cost of electricity is higher as demand is higher, and therefore more energy needs to be purchased. With V2G technology, an EV owner can purchase cheaper off-peak electricity during the night and use it within the household during peak times to therefore reduce their energy bill. In addition, an EV owner can sell the energy back to the grid during peak times at a higher price than they purchased it and therefore make money.

Figure 2: Example of daily consumption and varying tariffs based on electricity demand

Source: Rho Motion



This is both beneficial to the consumer and the utility company as pressure is relieved from the grid. Legislation can play a key role in grid stability. For example, in the UK, from July 2022, all EV chargers sold have to have smart charging capabilities. This is not bidirectional technology but it can be seen as a step toward and prerequisite to help understand how the technology can work. Key features of smart charging in the UK include; being able to set the time when the charging commences, and a randomised 15-minute function so not all EVs are being charged at the same time.

Blackouts

Blackouts and electricity disturbances occur more often in regions with poor grid connection or areas with natural disasters. Whereas a BESS system offers backup power, an EV battery utilising a bidirectional charger can offer both a cheaper alternative to those who own an EV and a larger energy source. The average daily household energy consumption in Europe can be anywhere between 5-40kWh depending on the country. With a 60kWh EV battery, you will therefore be able to run your house for between 1.5-12 days. This is assuming the normal level of electricity consumption, but it is more likely a consumer will be limiting their consumption during an electrical outage.

In addition, many regions on the West Coast in the USA are prone to natural disasters, for instance, California, and V2H would have a greater benefit than the lesser impacted regions.

Renewable pairing

An increasing number of homes are looking toward a self-sustaining energy source to power their home, and this will likely be more pronounced as energy prices rise.

A key complement to solar energy at the home is the ability to store the energy when it is not being used, otherwise, you lose the energy entirely. You can store the electricity with a home energy storage system, for instance, the Tesla Powerwall which has a 13.5kWh battery. Alternatively, you can use your EV battery as the ESS by purchasing a bidirectional charging system.

In Germany, around 70% of households that install solar energy also purchase a battery system. As the number of EVs with bidirectional charging capabilities grows, more consumers may look towards the growing technology. Bidirectional charging can seem like the perfect technology to help reduce net energy consumption, reduce reliance on the grid, and bring down energy costs. However, it does not come without its challenges.

What are the challenges?

Consumer confidence

It may be difficult to understand the benefits of V2X technology in some applications. For instance, many consumers may prefer their existing diesel generator as a backup power rather than an EV battery. There will be questions, such as: When is the best time to charge and discharge? What if my car is not at home? Would a BESS system be better? What about the lifetime of my battery? As pilot schemes grow and more data is collected from schemes, such as the UK's smart charging, there will be more information to help develop the role of V2X technology.

For the condition of the battery, it is true that the more you discharge and recharge the more you degrade the battery. This may be of concern to many consumers. However, a large portion of the vehicle fleet in western Europe is corporate and business. In the UK, around half of new vehicles sold this year have been corporate and business and half have been private. Without full ownership of the car and battery, you are less likely to worry about degradation.

Cost

Like with solar panels, many people install them with an expected payback period in mind. This is similar to bidirectional charging which can currently cost between USD3-5,000 for the equipment.

Legislation

In most national EV charging strategies, bidirectional charging and V2X technology have mostly been mentioned as a future opportunity. However, by 2025, we expect most EU countries, and the UK, to come up with an approach to how V2G can operate and benefit the region.

Overall, there is still a lot to prove with V2G technology and the magnitude of the benefit to the grid. There are many pilot projects underway and it will become more apparent over the next few years the direction governments plan to take this technology for V2G applications. For consumers, there is certainly a trend towards a self-sustaining energy source, which will only be accelerated by rising energy costs.

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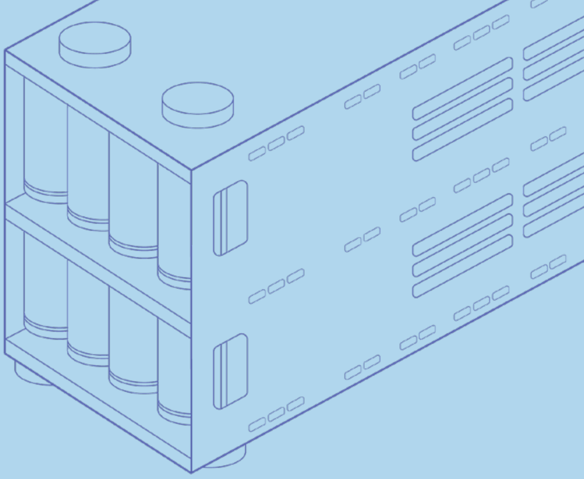

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Photo: Yanawut Suntornkij

Telecoms towers and the trend towards batteries

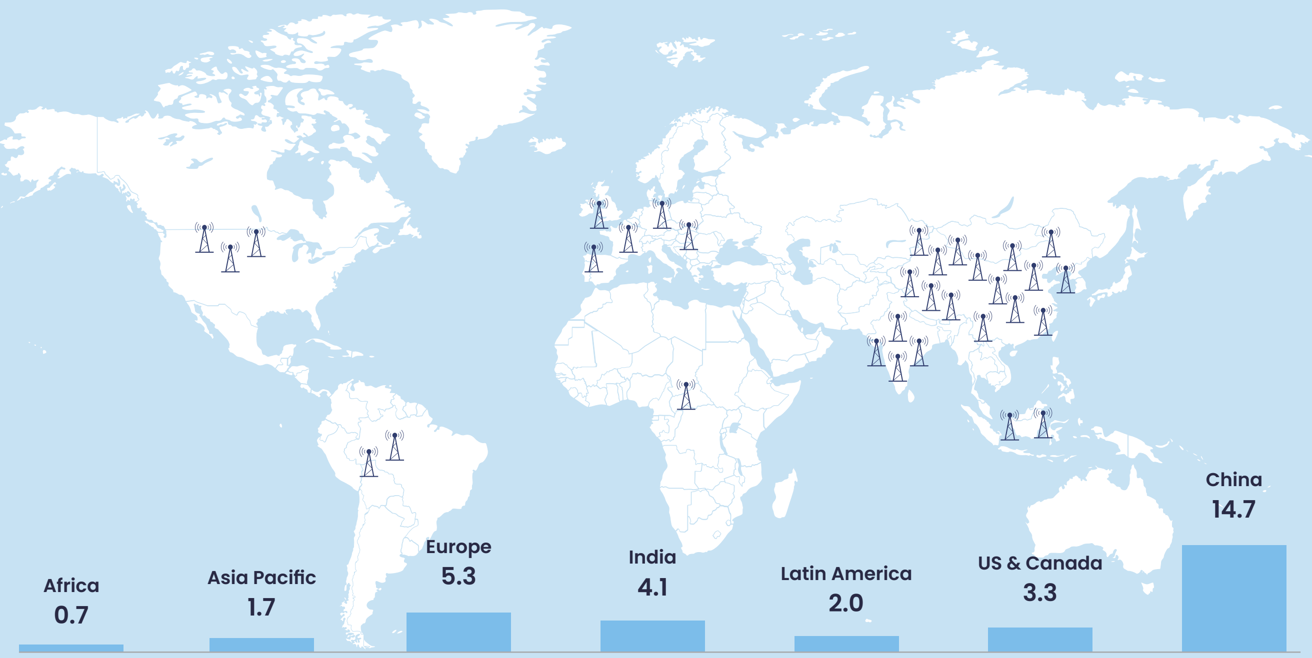
Iola Hughes
Research Manager, Rho Motion

Telecom towers form a backbone to society as we know it, the typically tall structures are designed to support antennas for telecommunications and broadcasting and require back up electrical power to maintain a good network.

The first telecom towers emerged at the start of the 20th century, and now number over four million globally. China dominates the market, with over 2 million towers, a result of a 2003 national level project requiring 95% of remote mountainous areas to be covered with communication signals at a fee no higher than those placed in urban areas. Elsewhere, the number of towers is increasing, driven by the roll out of 5G and a greater want for connectivity. Tower Companies (TowerCos) are increasingly looking to batteries to meet their back up power requirements.

Chart 1: Telecom towers by region

Source: Rho Motion



Global demand for lithium-ion batteries

The battery energy stationary storage (BESS) market has seen significant growth over recent years, as the falling costs of batteries, increasing number of applications batteries can meet and, the growing pressure to adhere to environmental, social & governance (ESG) provides the stimulus for this expansion and will continue to for at least the next decade.

The stationary storage market can be split into two broad categories, grid (front of the meter) and behind the meter. As the world looks to decarbonize its electricity grid and countries step up their climate actions, the use of BESS is set to play an increasingly important role in the energy transition. Changes in electricity generation and supply is having a knock-on effect on the structure and future of the electricity grid, driving the need for stationary storage. Grid scale storage covers batteries with capacity ranging from tens to thousands of megawatt-hours. This ranges from small scale commercial and industrial applications, to large scale batteries that support the grid by balancing renewables, mitigating grid congestion, and preventing blackouts.

Behind the meter storage is interconnected behind the utility meter of commercial, industrial, or residential customers, with a wide range of use cases from energy

Chart 2: BESS applications can be split into two broad categories: grid and behind-the-meter

Source: Rho Motion

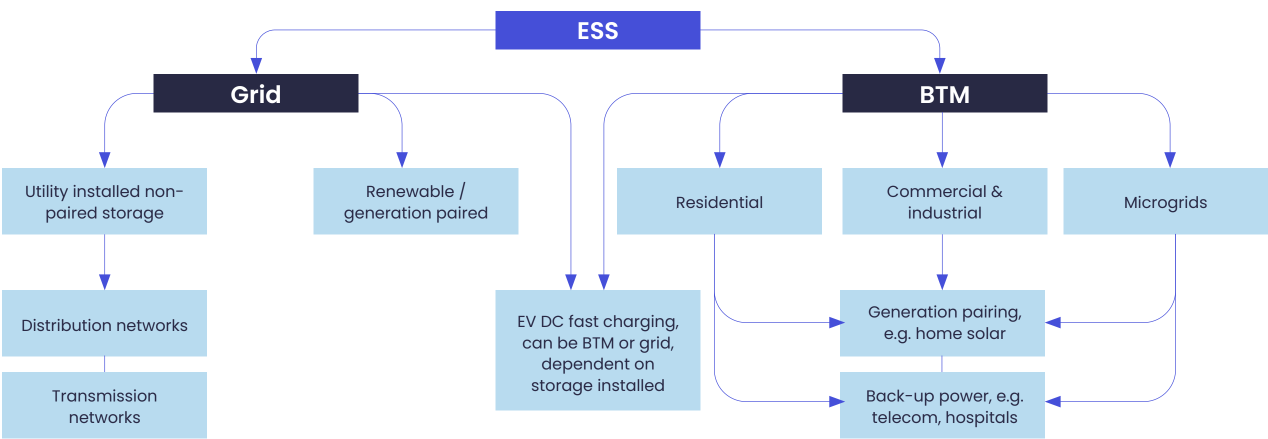
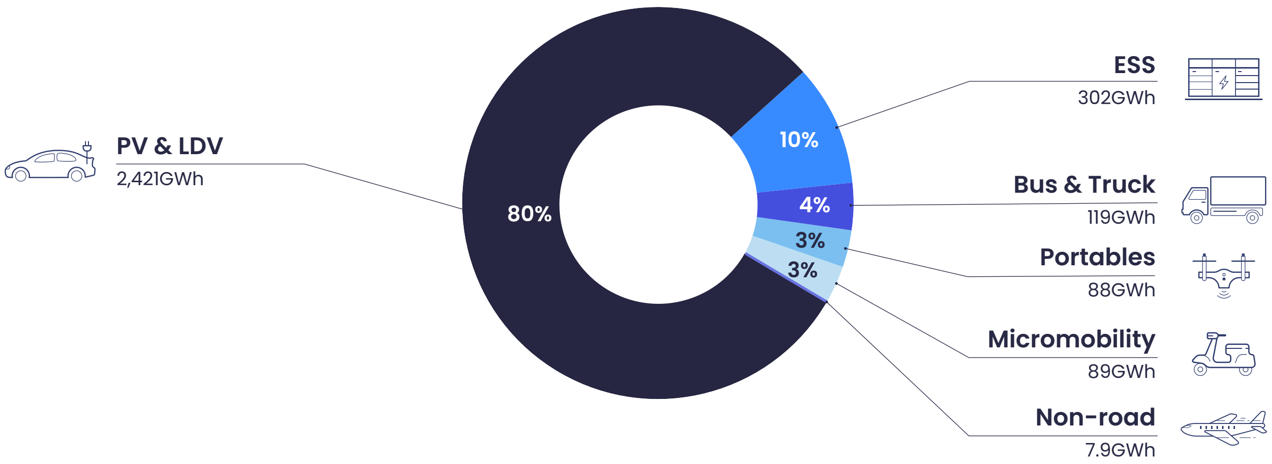


Chart 3: Global Battery Demand for Lithium-ion Batteries is Projected to exceed 3TWh in 2030

Source: Rho Motion



arbitrage to back up power. Batteries' roles within the behind the meter market have been gaining pace across multiple sectors, from the solar and storage market to EV fast charging, microgrids and, of course, telecoms.

Not only is the telecoms market set to compete with the wider BESS market for batteries, but it also forms a part of the battery demand picture, competing with applications from electric vehicles (EV) to portable devices such as laptops. We project that global demand for lithium-ion batteries will increase from 0.4TWh in 2021 to 3TWh annually by 2030, with over 80% of the demand coming from the EV market and the BESS market set to take the second largest share.

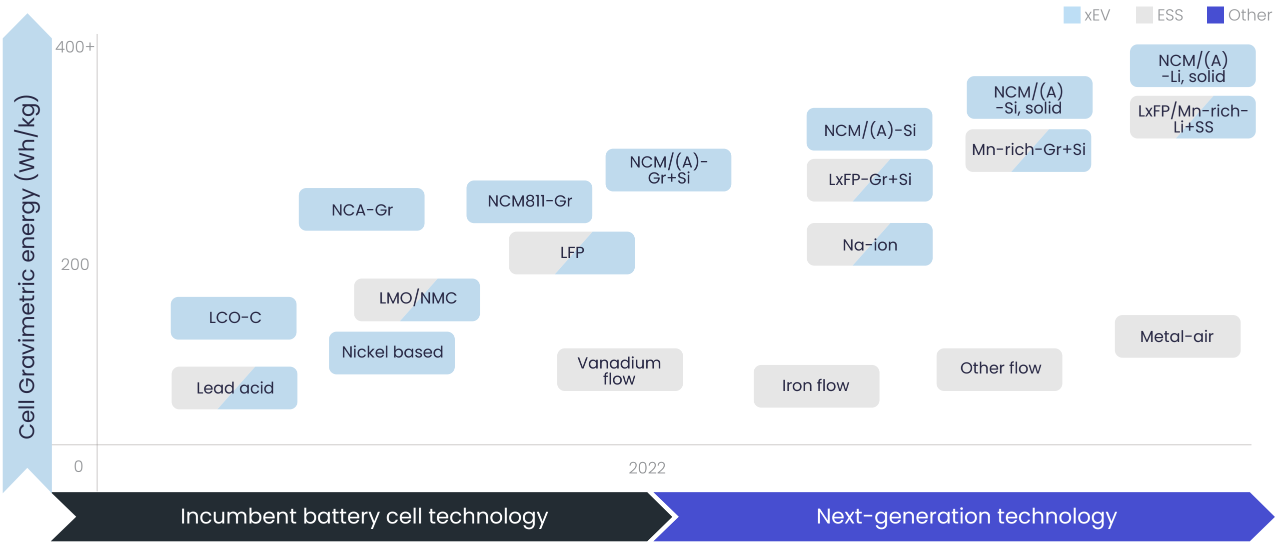
Investment and technology advancements from the EV space

The following chart shows the position of current state of the art lithium-ion chemistries, as well as competing battery technologies, including the incumbent technologies such as lead acid and next generation technologies such as sodium ion. Lead acid has historically been well placed to meet the needs of the telecoms, UPS and data centre markets, but is losing market share due to lithium-ion technology.

The lithium-ion battery market has rapidly evolved over the last decade, driven by greater flexibility and ease of installation for batteries compared to traditional energy storage (e.g., PHSS), and more broadly by the falling costs due to increased capacity build-out to meet demand from the automotive sector. The BESS market has benefited from this with most players initially making use of surplus EV batteries. More recently however we have seen a shift, battery manufacturers are looking to technologies that are best suited for stationary storage applications, and choices are no longer being made based on availability. Similarly, we have seen a ramping up of cell manufacturers both moving into and building out technologies specifically for the BESS space.

Chart 4: Battery development timeline

Source: Rho Motion



The result of this shift has been a change in cathode chemistry for lithium-ion batteries towards lithium iron phosphate (LFP) over nickel cobalt manganese (NCM). Despite LFP batteries offering lower energy density than NCM, the big driver here is around safety. Over recent years a number of battery fires have occurred at NCM BESS projects, mostly notably the Victoria Big Battery fire in Australia in 2021 and several BTM fires in China and Korea. These events have motivated developers, system integrators and cell suppliers to look towards a battery with a lower risk of thermal runaway. Another driver central to chemistry choice is cost, batteries for BESS need to minimise initial cost in order to generate revenue, with LFP batteries being more competitive here.

Other technologies offer a future potential solution as demand grows across the lithium-ion space, with sodium ion, redox flow, zinc, and metal air batteries all being explored, most of these at early stage of development. Sodium-ion been explored as a potential cheaper alternative to lithium-ion in the past decade, as highly volatile and rising lithium-ion raw materials commodity prices are leading to demand for low-cost, alternative chemistries. The technology is considered a good lower energy, low cost "drop-in" alternative. This means that industry is focusing on technologies that would require limited CapEx to adapt lithium-ion battery cell and pack manufacturing equipment to produce sodium-ion.

Manufacturing at scale will require the creation of new value chains which can differ substantially from lithium-ion. This will require new anode and cathode active materials, as well as battery grade sodium salts and inactive cell components. This cell chemistry doesn't require copper current collectors, and can benefit from good calendar life, with a few suppliers suggesting that it can be stored at a fully discharged state, increasing cell safety.

Building out this supply chain will take time, however, HiNa Technology is currently leading, with a world first 1MWh ESS project installed in Taiyuan, China, and 1 GWh of planned cell manufacturing for 2022. Additionally, battery giant CATL announced its first-generation sodium-ion battery in 2021 and aims at establishing a supply chain by 2023.

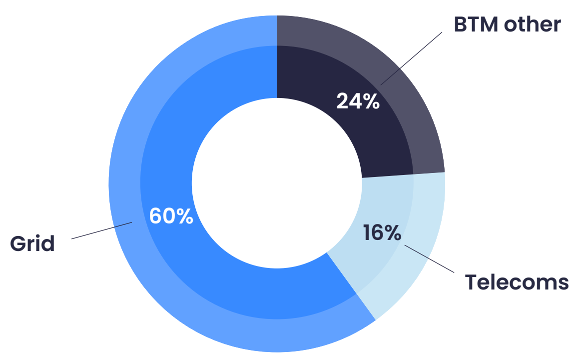
Batteries in Telecoms

Telecom towers require a form of backup power to keep them running during any disruption to the electricity grid. For regions with a poor electricity grid backup power is even more important, this has historically been met by diesel generators. TowerCos in these regions are increasingly looking to batteries instead in order to improve their ESG credentials.

For battery backup this market is currently dominated by lead acid. Lithium-ion batteries, in particular LFP, are increasingly replacing lead acid batteries and diesel generators in telecom networks. The comparative higher energy density of lithium-ion compared to lead acid, as well as the cost reductions lithium-ion batteries have benefited from over recent years make them suitable to higher power requirements from 5G and 4G towers compared to their earlier counterparts. As well as this shift, a greater need for more base stations, due to a lower signal range, as networks are upgraded to 5G means the need for back-up power is increasing further.

By 2030 we anticipate the telecoms market will represent over 15% of battery demand of the overall BESS market. TowerCos are set to build out their networks globally, make larger commitments to improving climate goals and begin to investigate new revenue streams for their batteries, such as energy arbitrage.

Chart 5: BESS Market Battery Demand in 2030 *Source: Rho Motion*



*Rho Motion's **BESS Quarterly Outlook** and **BESS Monthly Assessment** provide up to date insight into all developments in this space. The assessment provides analysis of project announcements, updates, and commissions, tracking the development of key battery stationary storage metrics over time, as well as monthly news and market updates. Our outlook provides long-term outlooks for battery demand and battery chemistry, by application and region, based on robust and informed methodologies.*

Photo: Danist Soh

Electrification in construction

Shan Tomouk
Senior Research Analyst, Rho Motion

As governments and OEMs continue to target emissions reduction through electrification, it is also interesting to consider periphery transport sectors. One such sector that holds potential for the switch to electric is that of the construction industry.

Although non-road mobile machinery (NRMM) vehicles in the construction sector are not a major contributor to total GHG emissions (accounting for less than 2% of CO2 emissions), there are other issues to consider. In the United States, NRMM vehicles account for approximately 70% of fine particulate matter (PM2.5) and 25% of NOx pollution from mobile sources. This is especially important for urban construction projects, in which managing particle and noise pollution is becoming increasingly important for securing contracts.

In looking at the potential for electrification, it is useful to split construction transport into two categories: on-road and non-road.

On-road vehicles aid in the transport of materials, concrete, equipment and personnel to and from construction sites. Although vital in the operation of a construction project, they can be somewhat separated from the argument on the basis that in most cases, they are comprised of standard HDV trucks that are adapted for construction use cases. We have already begun to see the electrification of trucking across all regions, with long-standing players such as Volvo Trucks, Scania and MAN all developing electric truck offerings. In contrast, non-road machinery remains in the early stages of development, with questions remaining over viability. Within this market, several obstacles remain:

Cost of ownership

As with other forms of electric vehicles, both OEMs and consumers currently face higher up-front costs due to steep battery prices. Although the overall trend for cost/kWh is on the decline, sharp fluctuations as seen in 2021 and 2022 have introduced some concern. Lower operating costs through fuel savings will help BEV construction vehicles to reach TCO parity with traditional diesel-powered machines, although how quickly that point arrives is heavily dependent on use-case and vehicle type.

Battery size requirements

Another perceived obstacle is the notion that construction vehicles would require exceptionally large battery packs that, under current prices, would be unviable to pursue. While this may be true for heavy-duty construction vehicles, there are a range of smaller-scale vehicles that would not require audaciously large packs. Additionally, construction equipment is often operated at low speeds, allowing for a high-torque output from even a relatively modest electric motor. Battery pack sizes for new light excavators range from as small as 20kWh to 50kWh.

Legislation

Given the focus on the passenger vehicle market, legislation for electrification in the construction industry has been limited. Although regional targets for total emissions and pollution reduction are in place, electrification-specific policy is lacking. This is likely to change in future, however, as newly developed models become more available in the market and stricter legislation becomes achievable.

Another perceived obstacle is the notion that construction vehicles would require exceptionally large battery packs that, under current prices, would be unviable to pursue.

Charging infrastructure

Perhaps the most significant obstacle is that of charging solutions. For urban construction projects, this is not so much of an issue. Urban areas have ample access to power and charging facilities. In contrast, for rural or large-scale construction projects, which are usually farther out and use heavier-duty vehicles, more creative solutions, such as microgrids or battery swapping, will have to be explored to adequately cover fleet charging.

Current Viability

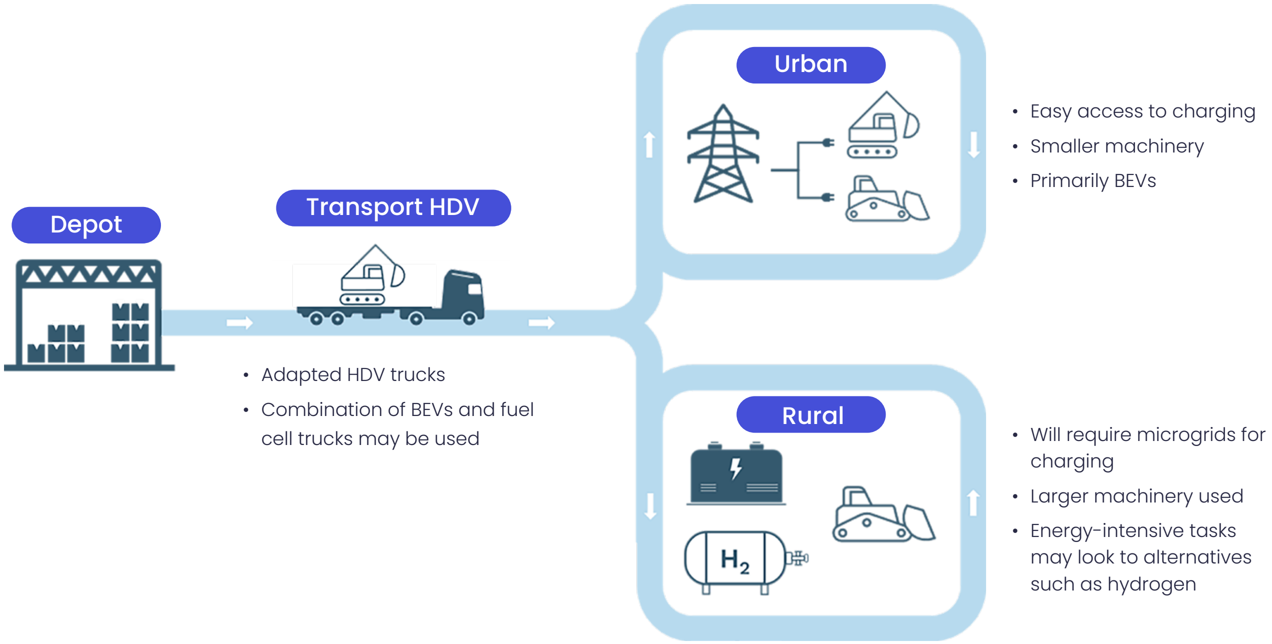
Despite the various challenges outlined, it could be argued that electrification in some subsectors could be viable already. Urban construction projects, particularly at smaller sites with less space, could benefit strongly from new electric light excavator offerings. Volvo Construction Equipment, for example, are this year releasing a variety of smaller machines capable of operating up to 5-8 hours at a time.

Within an urban environment, construction companies need not worry about access to charging points or mains power, allowing for easy overnight/out of hours charging. A switch to BEVs would also allow companies to significantly reduce NOx and other particulate emissions, as well as reducing noise pollution.

Although upfront costs are likely to be higher, long term fuel savings will allow for a lower TCO over time. Electric machines are also significantly less complex than ICE vehicles, allowing for easier and cheaper maintenance. This is particularly helpful in the construction industry given high levels of dust and sand exposure.

Figure 1: Electrification of construction

Source: Rho Motion



With all this in mind, it is likely that we will see the urban construction sector electrify far sooner than larger-scale rural projects. The latter will require multiple developments in the space. Firstly, battery packs will have to come down further in price given the larger sizes that would be required for moving heavy machinery. This is especially true given the introduction of "hybrid" large-scale machinery, in which a diesel-fueled electric motor powers the machine system and regenerative braking in the arm is converted back into electrical energy via a supercapacitor. The result is a significant increase in efficiency and savings which will make a full switch to BEV offerings harder to justify.

With respect to charging solutions, large-scale construction projects will have to develop on-site facilities that can offer fast charging for larger packs. One such solution is off-grid chargers or microgrids. The development of this portable storage is already underway with companies such as Northvolt conducting pilot studies with adapted construction machinery. Another option would be to introduce battery swapping capabilities for small and medium machinery, allowing for longer continuous operation. Mini excavators to trial battery swapping in the construction sector are currently in development by Honda and Komatsu.

Hydrogen to the rescue?

At the very extremities of size and energy-intensive tasks in construction, BEVs may prove to be unviable. The necessary pack sizes and charging capabilities that would be required for electrifying large-scale excavators and loaders would be far above what is currently on the horizon. To date, prototypes for small-medium duty electrified dump trucks have used batteries as large as 700kWh. For heavy or ultra-heavy duty construction vehicles such as loaders or dump trucks, pack sizes would need to be significantly larger.

There is then an argument to be made for the development of fuel cell technology for certain use cases. Although fuel cell technology has struggled to compete with the BEV revolution, it may serve a purpose in plugging in some of the remaining gaps for adoption.

In the HDV truck market, OEMs are investing heavily in fuel cell development for long-haul and highly energy intensive use cases. Companies such as Daimler Truck and Volvo Trucks have commenced pilot schemes to test fuel-cell truck prototypes. Given the investment in this industry, it is likely that we will see technology trickle down into the construction industry. In the long-term, hydrogen has the potential to solve some of the key obstacles surrounding the size and weight of large-scale construction machinery, helping to complement future BEV fleets.

The construction market will be covered in further detail in our upcoming NRMM report, which will breakdown electrification prospects across construction, mining, agriculture and more.

Battery Recycling Outlook

Our Battery Recycling Outlook provides a long-term outlook for global scrap material available for battery recycling. The outlook is presented by region, battery chemistry and feedstock and covers end-of-life EVs, battery manufacturing scrap and end-of-life energy stationary storage.

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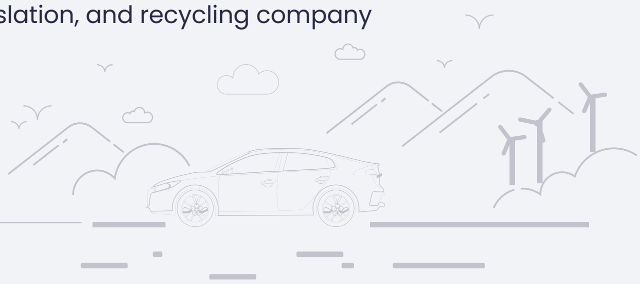
Our forecast provides long-term outlooks for the following:

- GWh of BEV and PHEV scrap material available for battery recycling by feedstock, battery chemistry and region to 2040
- Tonnes of black mass available for battery recycling by feedstock, battery chemistry and region to 2040
- Battery recycling technologies
- Battery recycling OEM profiles
- Battery recycling legislation

The battery recycling market is gaining traction as EV value chains evolve toward long-term sustainability goals amid future raw material shortages and environmental, social, and governance (ESG) concerns.

The outlook provides an in-depth analysis of the current and future battery recycling market in aspects of the market dynamics, technologies, and key drivers. The report can be used as a tool to understand how the market grows at global, regional, and country levels on the back of EV demand, legislation, and recycling company strategies.



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When

26 Sep 2022
9AM – 5PM

Where

Museum of the City of New York,
1220 Fifth Avenue, New York

Program

Scan the code below to see the **Conference Program.**

Find out more, contact us +44 (0) 203 960 9986, info@ rhomotion.com

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