kcm NETWORK

K C Mehta & Co LLP
Chartered Accountants

kcmLens

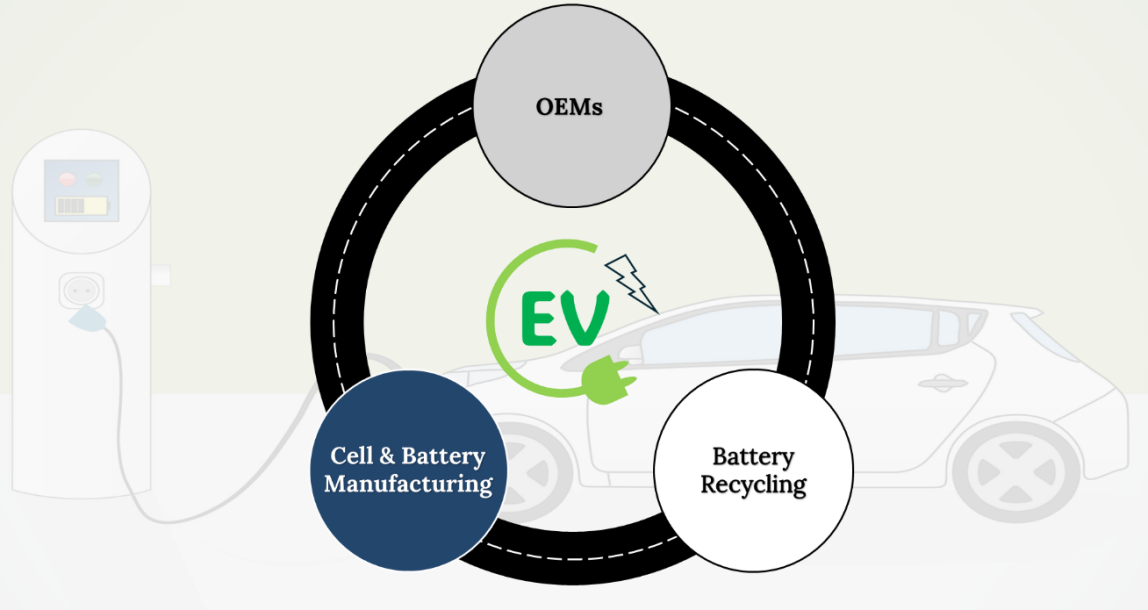
EV Series – Volume 2

Battery & Cell Manufacturing

October 2024

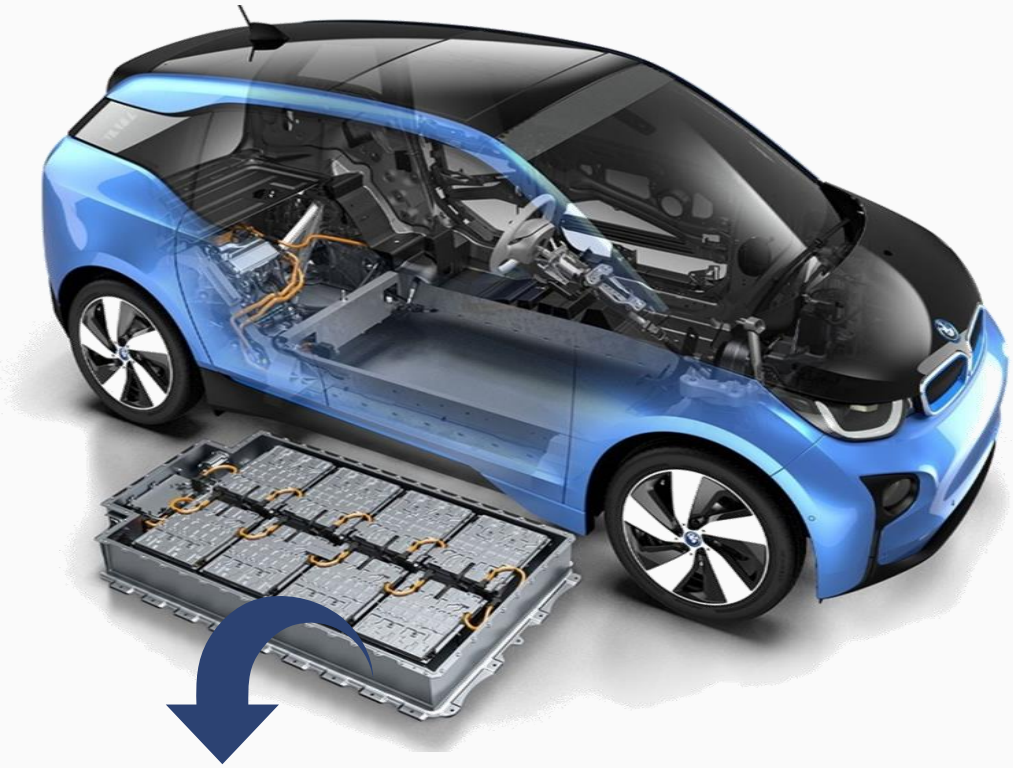
Introduction

kcmLens is a series of publication from KCM, offering sector specific insights. Under this series, we pick one sector, outline the value chain of that sector, and offer a deep dive analysis through the Lens of each segment of the value chain. This publication helps in developing a holistic understanding of the entire sector. The idea is to not only collate insights and updates on a particular sector for the readers, but to also present important takeaways from K C Mehta & Co LLP on that sector.



We launched our first **kcmLens** series, **The EV Series,** in July 2024. The EV series involves analysis of the EV value chain which primarily includes following segments: the Original Equipment Manufacturers (OEMs), the Battery & Cell Manufacturers and the Battery Recyclers (deliberately ignoring mining, extracting, and refining segments of the value chain for focussing on the "EV Loop").

After our first publication on EV OEMs, we are pleased to present the second publication focused on the Battery and Cell manufacturing segment. This publication gives a deep dive into the EV battery – functioning of the battery, various cell chemistries and their KPIs, potential of the Indian market for the same, emerging competitive landscape, government actions, and customer needs.

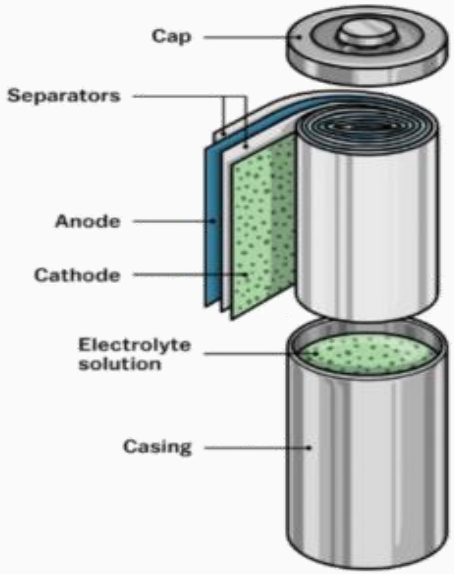


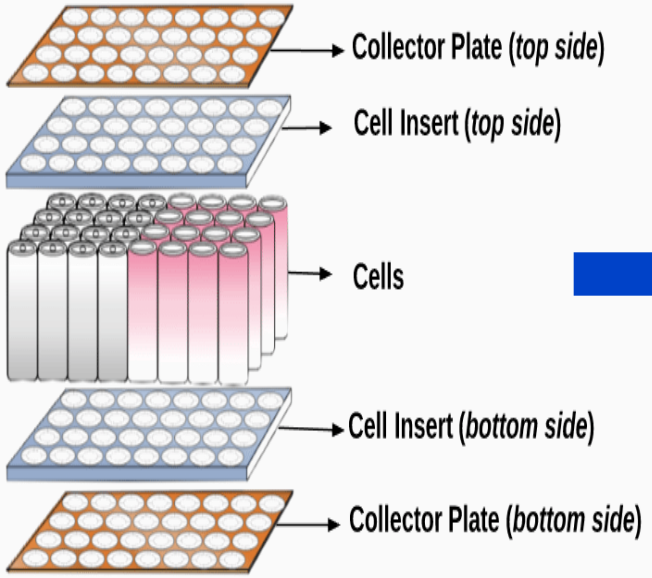
Let's pick up the thread from Series 1, where we explored how the battery plays a pivotal role in shaping the future of Electric Vehicles (EV) in India; as it accounts for almost half the cost of a vehicle! Now, let's shift into high gear and explore the beating heart of the battery and cell industry.

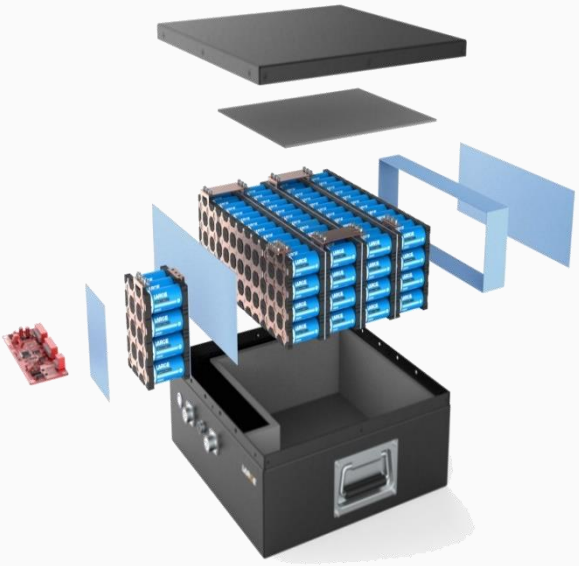
Contents

Grasping the Product

Don't mix up battery and cell... A battery is just an assembly of cells







Cell
A single unit device which converts the chemical energy into electrical energy.

Module
A collection of cells connected in series or in parallel.

Battery Pack
A series of individual modules and protection system organized in a shape that will be installed in a vehicle.

The value of battery assembly is 30% while the value of the cells makes up 70% of the battery pack!

Grasping the Product

Unpacking the cell... what commands the 70% value?

Cathode – Positive electrode

Stores lithium and release lithium ions when battery is charging *(Oxidation).*

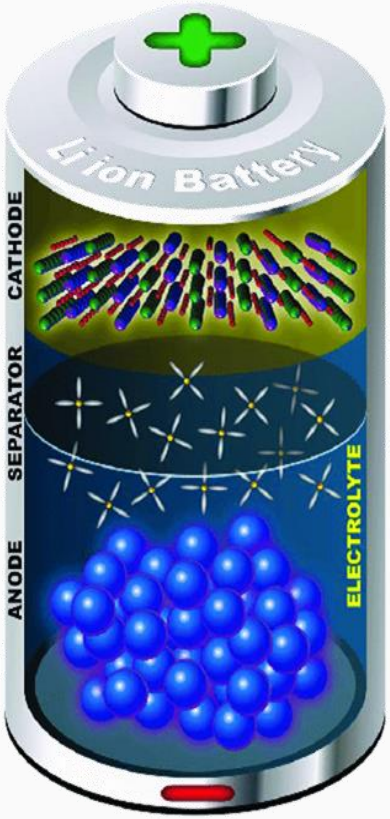
Cathode is usually composed of metal oxides like:

- Lithium cobalt oxide,
- lithium manganese oxide,
- lithium iron phosphate (*LFP*), or
- lithium nickel manganese cobalt oxide (*NMC*).

Lithium batteries are generally named after their Cathode Active Material (CAM).

Separator

It is a plastic material used to separate the positive and negative electrodes and prevents short-circuiting within the cell.



Electrolyte

It enables lithium-ion movement between anode and cathode and composed of lithium salt dissolved in organic solvents.

Anode – Negative electrode

Stores lithium and releases lithium ions when the battery is discharging (Reduction).

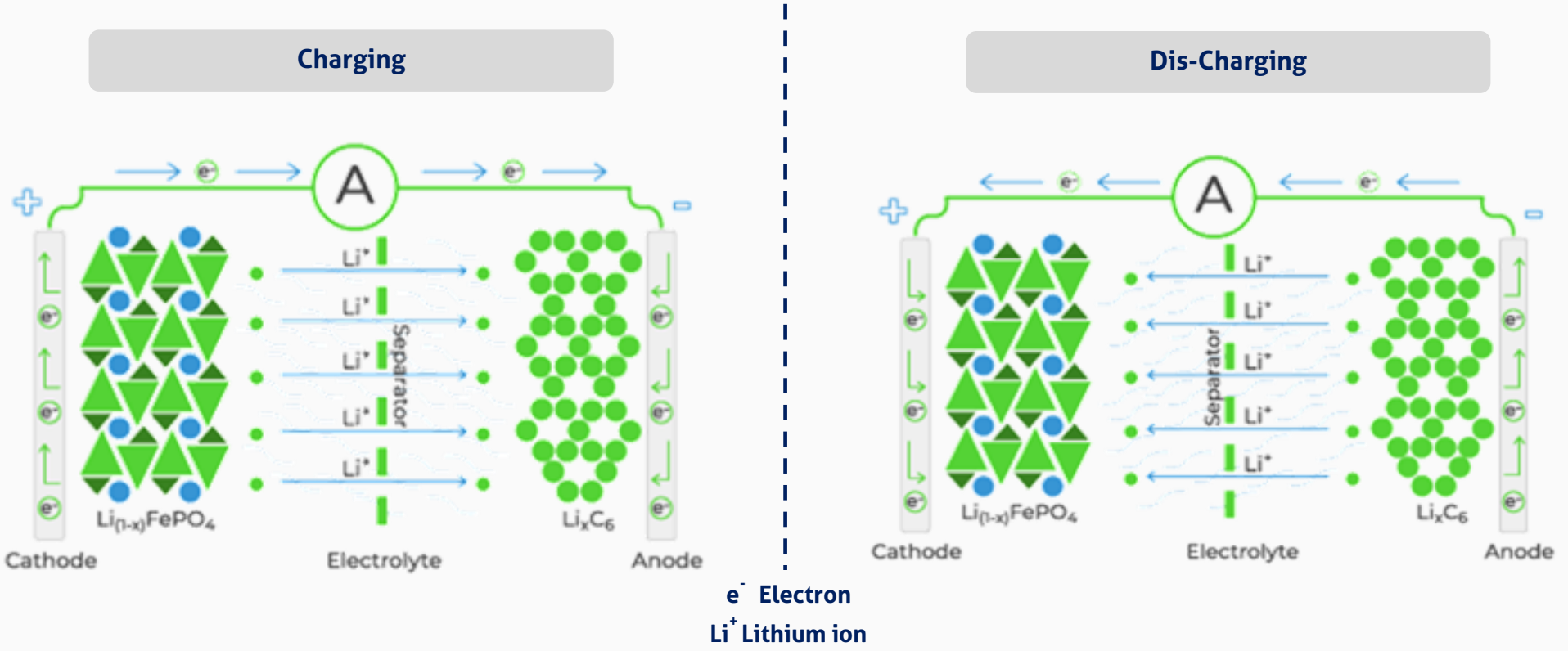
Anode is usually composed from carbon-based material like:

- Graphite
- Silicon, or
- Combination of both

Grasping the Product

Coverage

Lithium generates energy for the battery...



When a device is plugged in for charging, lithium atoms lose electrons and become lithium ions. These ions move from the cathode to the anode, while electrons flow through an external circuit, charging the battery with energy. Whereas during discharging, lithium ions travel from the anode to the cathode, creating a flow of electrons that generates an electric current for the powertrain.

Grasping the Product

Coverage

...making Lithium as the ideal metal for use in various cell chemistries

- Higher energy storage capacity
- Higher voltage and energy output
- Faster charging time
- Safety and stability
- Longer battery life and efficiency
- Compatibility with various cathode materials

Lithium interacts with other compounds to yield energy

Features & Specifications	Lithium Iron Phosphate	Lithium Nickel Manganese Cobalt	Lithium Cobalt Oxide	Lithium Titanium Oxide	Lithium Nickel Cobalt Aluminum Oxide
	LFP	NMC	LCO	LTO	NCA
Energy Density *Amount of energy stored per unit weight*	90-150 Wh/kg	150-220 Wh/kg	150-220 Wh/kg	50-100 Wh/kg	200-280 Wh/kg
Power Density *How quickly a battery can deliver energy*	300-500 W/kg	600-1000 W/kg	300-500 W/kg	1000-3000 W/kg	800-1500 W/kg
Cycle Life *No. of charge-discharge cycles before degrading*	2000-4000	1000-2000	500-1000	5000-10000	1000-2000
Charge and discharge rates *How quickly a battery is charged or discharged*	1C-3C	1C-3C	1C-3C	5C-50C	1C-3C
Thermal Runaway Self-heating state that is controllable	270°C	210°C	150°C	280°C	150°C
Cost per kWh *Manufacturing cost of battery*	8,000 to 12,500	12,500 to 16,500	16,500 to 21,000	25,000 to 33,500	16,500 to 21,000

Takeaway: Globally, markets are transitioning towards lithium-ion based cell compositions such as NMC and LFP, which offer unique benefits. The thermal runaway range and cycle life is higher in LFP batteries, which are robust but heavier. On the other hand, NMC batteries charge faster and have higher energy density, offering a higher range with a small size.

Grasping the Product

What happens in a hot country like India?

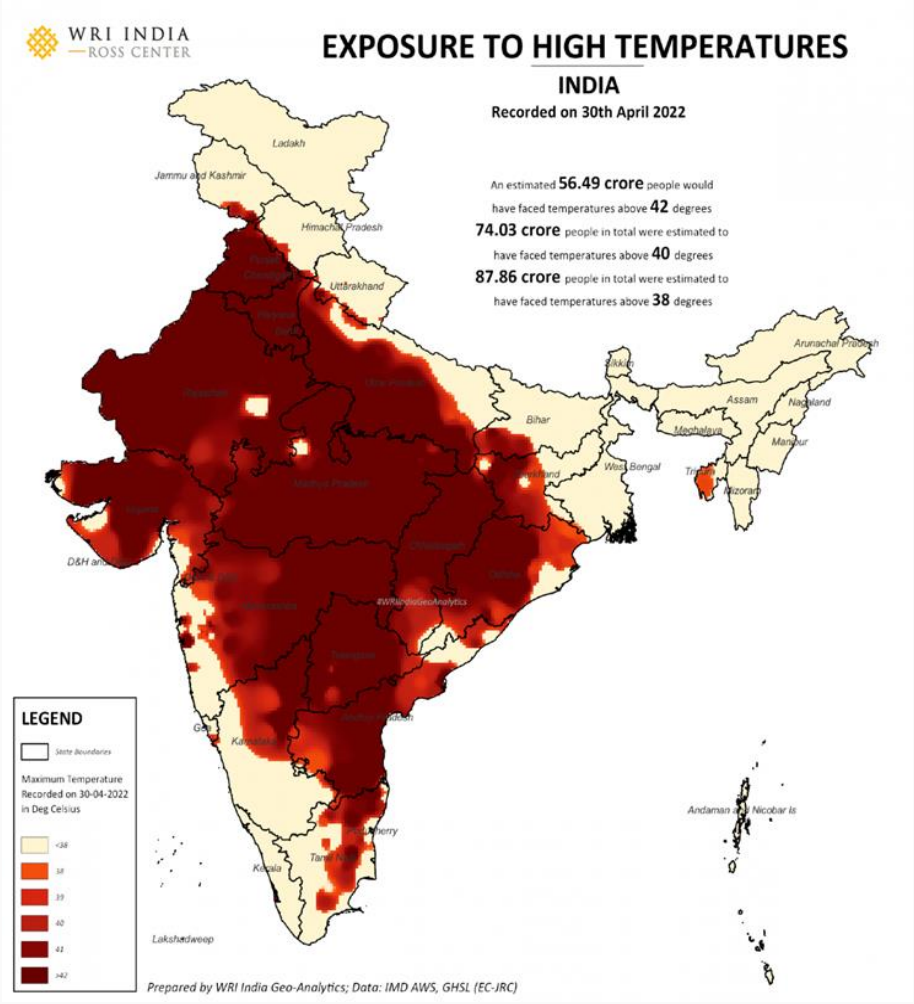
The adoption of lithium-ion batteries (LiBs) in India gained significant momentum when Reliance integrated them into its telecom towers, utilizing both LFP and NMC battery chemistries.

NMC couldn't withstand the high temperature requirements of ~45-50°C and hence caught fire. LFP could sustain, and it became the most preferred chemistry type for the said purpose.

Thermal stability in NMC batteries is lower than that of LFP batteries and therefore LFP batteries would have a longer life and will be relatively safe in a hot country like India.

Takeaway

This would mean that either the OEMs would have to provide for a cooling system or Thermal Management System to manage the above risk; or the battery should be manufactured with Phase Change Materials or Thermal Barriers which can absorb the heat from the battery.



Grasping the Product

Lithium is popular but Sodium & Zinc are now emerging

Sodium and Zinc, both are abundant on earth and therefore, unlike Lithium (a rare metal), the extraction & processing cost is low, leading to lower battery cost.

However, with energy density lesser than that of lithium-ion batteries, sodium ion batteries are often considered a potential player in grid storage but possibly less so in transport, where higher range is a key requirement.

China, however, has managed to increase the energy density of Sodium ion batteries to 160-170 Wh/Kg, which is more than the average density of LFP batteries!

Takeaway

It's likely that the EV industry will adopt a multi-battery approach. Lithium-ion batteries will continue to dominate the market for the near future. However, with evolving technology and R&D effort, sodium-ion and zinc batteries may pose a serious challenge to the dominance of lithium-ion batteries.

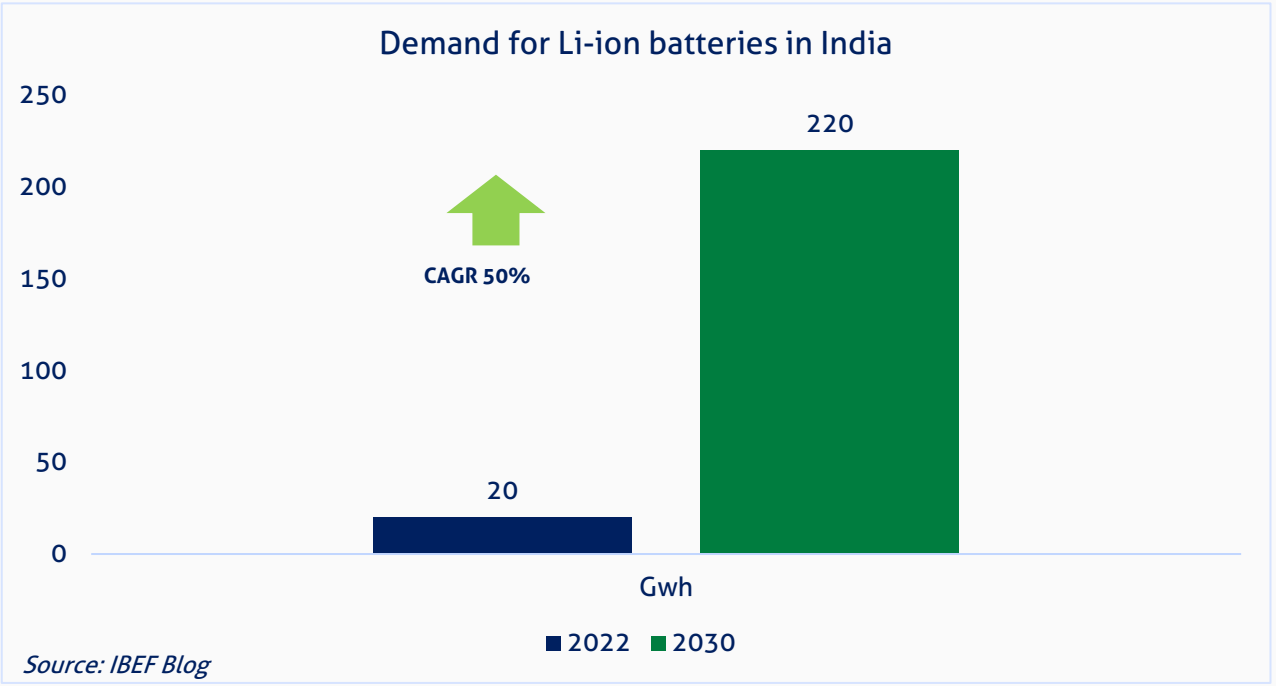
Feature	Lithium-ion	Sodium-ion	Zinc
Energy density	High	Lower	Lower
Cost	High	Lower	Lower
Safety	Good	Better	Better
Charging speed	Moderate	Faster	Moderate
Lifespan	Good	Shorter	Shorter

Understanding the Market

Trickle-down effect of the EV surge on Battery Market

The accelerating adoption of EVs in India, as observed in Series 1, will profoundly impact the demand and production of EV batteries and components over the coming years.

The ripple effect can be observed in the lithium-ion (Li-ion) battery market in India with the demand expected to grow at a CAGR of 50% by 2030.



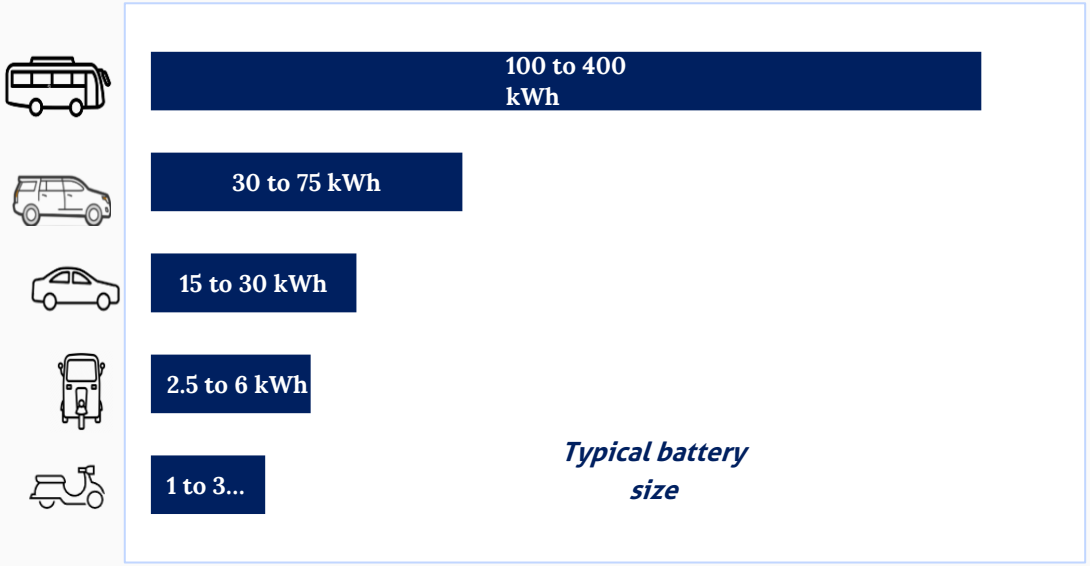
Source: IBEF Blog

Watt-hours (Wh) is a unit of energy that represents the amount of power, a battery can provide for a number of hours. E.g. A 10 Wh battery can provide 10 watts of power for 1 hour or 5 watts of power for 2 hours. Kilowatt-hours (Kwh) is 1000 Watt-hours and Gigawatt-hours (Gwh) is 1000,000 Kwh.

Understanding the Market

Coverage

In the current EV market; LFP is dominant, but NMC is catching up!



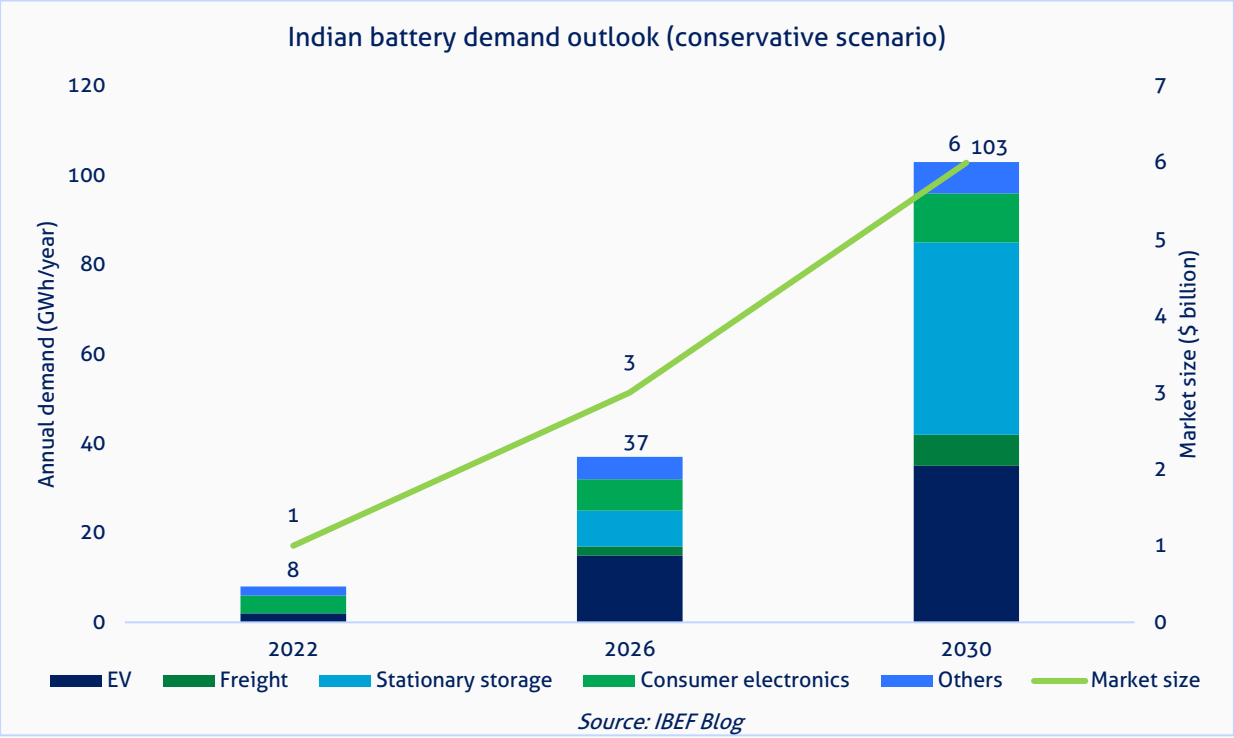
	Company	Batteries used	No. of vehicles sold in FY24	Average kWh	Total GWh	Market share in 4W/2W
4W	Tata Motors	LFP	66,927	33	2.21	90%
	MG Motor	LFP	13,286	33	0.44	
	Mahindra & Mahindra	NMC	6,663	36	0.24	
		Total	**86,876**		**2.89**	
2W	Ola	NMC	3,26,443	3	0.97	83%
	TVS	NMC	1,82,959	2	0.41	
	Ather	NMC/NCA	1,08,872	3	0.31	
	Bajaj	NMC/NCA	1,06,990	3	0.32	
	Ampere	LFP	55,057	2	0.09	
		Total	**7,80,321**		**2.11**	
		LFP EV penetration			**~2.74**	
		NMC EV penetration			**~2.26**	

Takeaway: LFP batteries are ideal for applications with more space and higher life expectancy requirements, such as in electric four-wheelers and traction applications. Conversely, NMC batteries are preferred for applications where space is limited but high energy density is crucial, such as in electric two-wheelers (E2W).

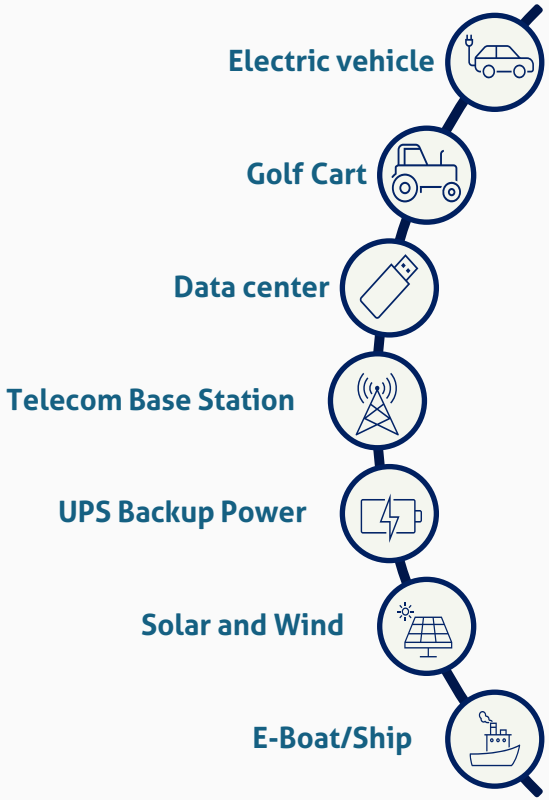
Understanding the Market

Coverage

EV will be a major contributor... but not the only one!



Source: IBEF Blog



Takeaway: It is observed that battery usage in stationary storage is about to explode in the next 6 years and would be the major contributor to battery demand in 2030. However, with only 7.5% households in India currently owning a 4W, EVs alone can create ~100 Gwh of battery demand in the coming years as this number grows! However, this would require the right set of measures by the Government, and timely execution by OEMs.

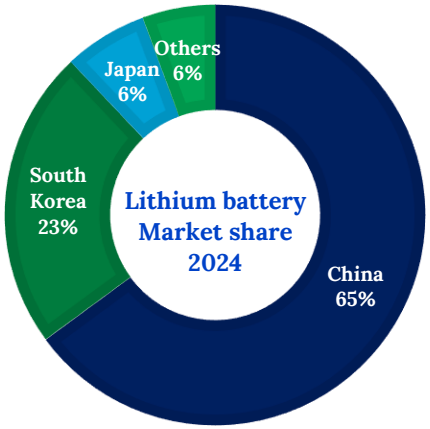
Competitive Landscape

Coverage

China leads the way, despite limited natural reserves!

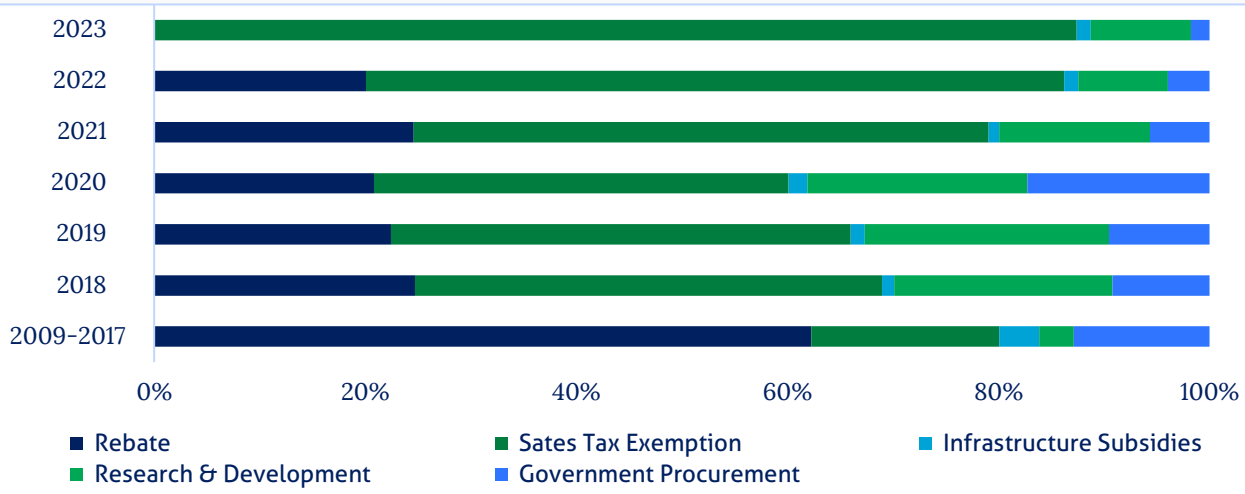
Although China is not a majority owner of any of the key metals required for battery manufacturing (except some rare elements used in the magnets for electric motors), it is the global market leader for EV batteries and has managed to create huge dependence of other major economies on Chinese imports through early recognition of opportunities, massive investment in technology and capacity, strategic trade partnerships, and control over the supply chain. Chinese companies bought mines in different countries (Australia, Chile, etc.), and gained substantial control over the supply chain of raw materials for cell manufacturing.

Further, the Chinese government has taken substantial measures to push the industry with extensive support policies and subsidies that extended to over $230.9 billion between 2009-2023.



Source: Mint

The nature of Chinese government support to EVs has changed



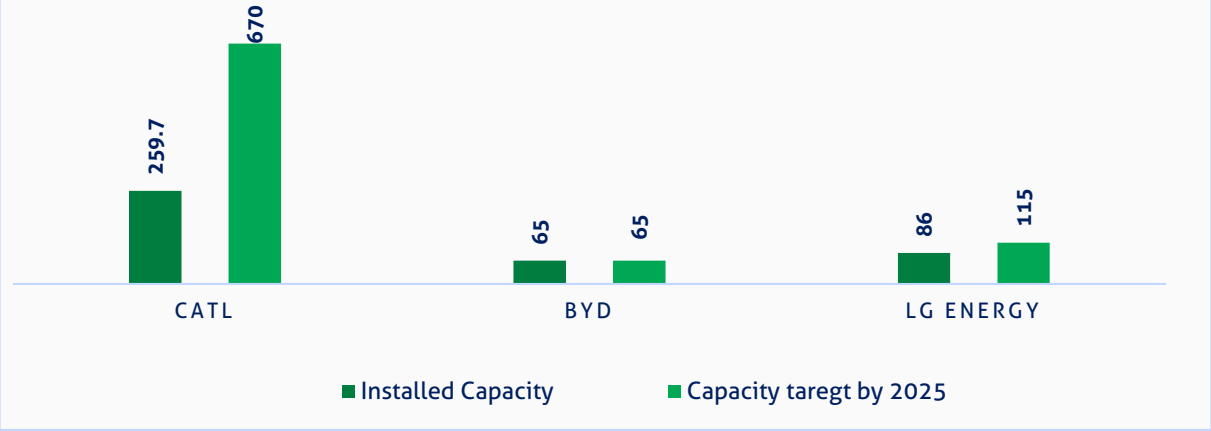
Source: Center for Strategic and International Studies

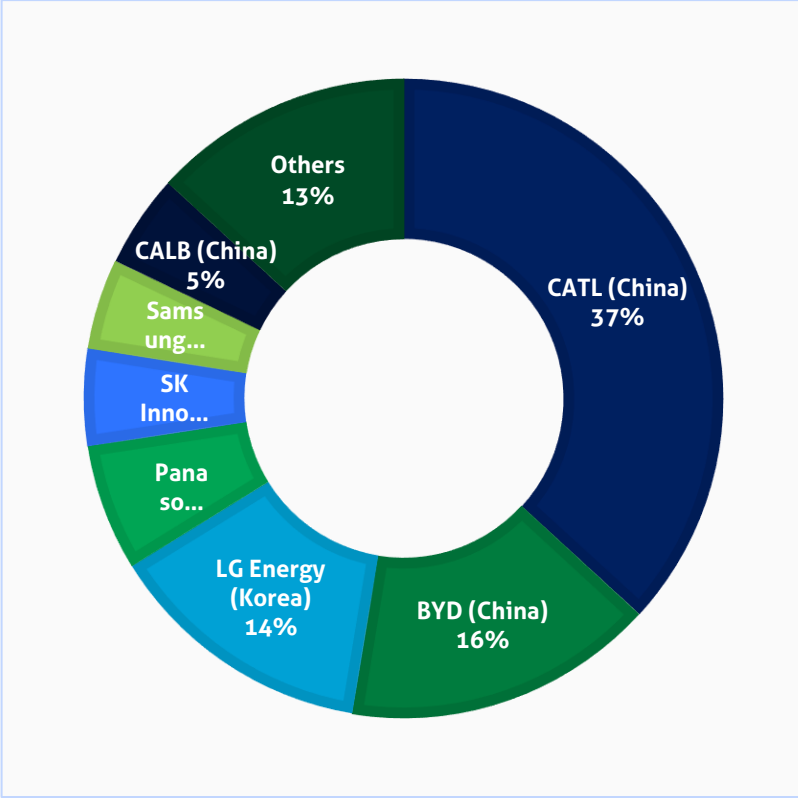
Competitive Landscape

CATL, a Chinese company is the world leader in cell manufacturing

CATL dominates the global EV battery market for 7 years. Its market share is more than the combined market share of the 2nd and 3rd biggest player i.e. BYD and LG Energy respectively. CATL was able to get to this position because:

1. It was ambitious enough to build gigantic capacities. CATL has 4x installed capacity than BYD, its immediate competitor and they aim to increase by ~2.5 times making it 10x of BYD.
2. It put emphasis on technology and products by investing around $440 million in R&D. It focused on innovation and made the most lucrative products ahead of its peers. It made a battery with a range of 1,000 km on a single charge, developed commercially viable sodium ion battery, and most recently – developed superfast charging LFP battery which charges in 10-minutes with a range of 400 km.





Competitive Landscape

Competitive Advantage to China through Overcapacity?

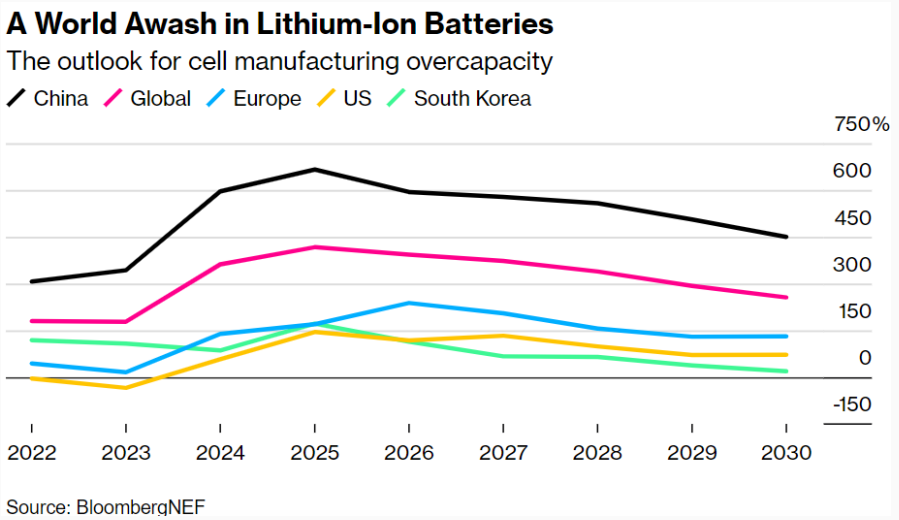
In 2023, China's dominant players including CATL produced 747 Gwh of battery cells while only 387 Gwh was installed into final products. This overcapacity in China's cell manufacturing industry coupled with a slowdown in EV sales caused sharp decline in the prices of batteries.

The price of LFP battery cells dropped by 51% last year. Average LFP battery cell price in China is $53/kWh as compared to global average of $95/kWh.

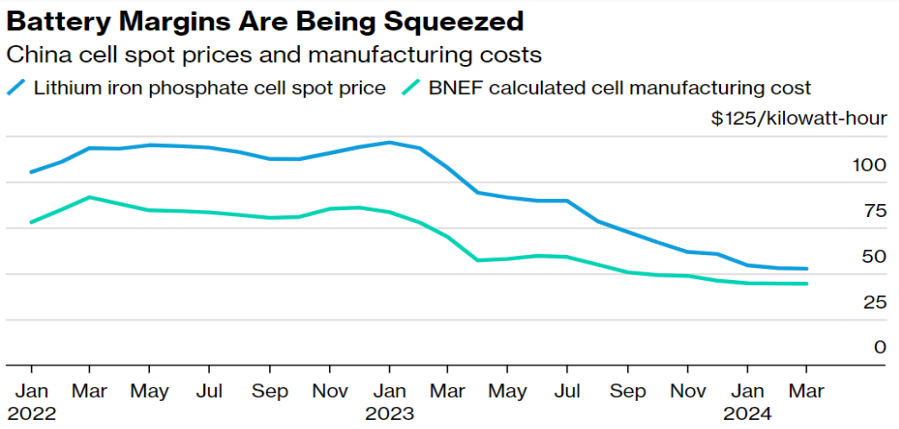
With falling prices and squeezing margins, it has become extremely difficult to compete for the existing battery players in US & Europe.

Takeaway:

Reduced battery prices would certainly help in reducing the upfront costs of EVs and thereby improve volumes for EV OEMs but would pose a big challenge for India's upcoming battery ecosystem. To give a context, manufacturing cost in India for same battery cell is $100/kwh which is almost double the Chinese price!



Source: BloombergNEF



Source: BloombergNEF
Note: The cell mentioned here is in prismatic format and excludes taxes. LFP spot price comes from the ICC Battery price database. Estimated cell manufacturing cost is for LFP cells and uses the BNEF BattMan cost model.

Competitive Landscape

Coverage

Despite the Chinese lead, India kicks off cell manufacturing ...

Jamnagar, Gujarat

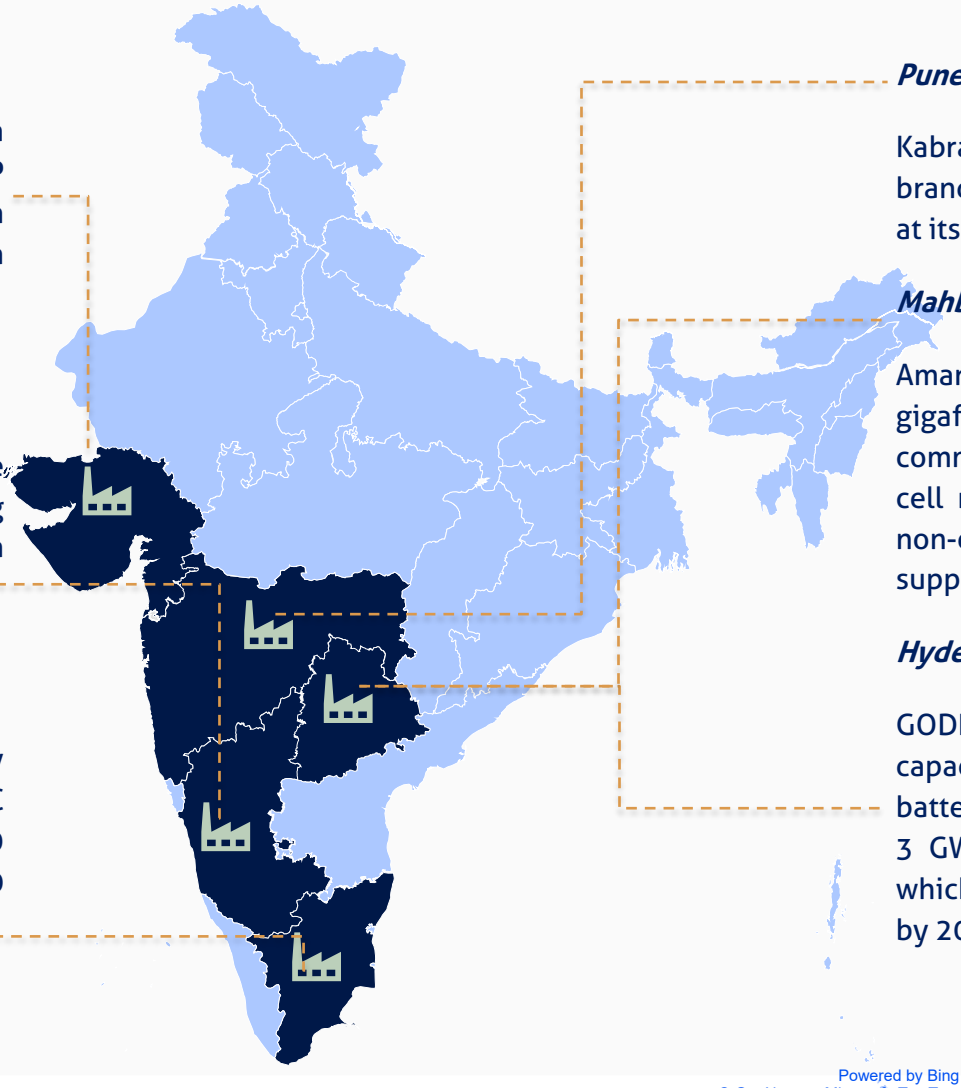
Reliance Industries have acquired Lithium Werks to set up a gigafactory for **LFP** battery cells with a capacity of 30 GWh in Jamnagar. It plans to start production with installed capacity of 50MWh by 2026.

Bangalore, Karnataka

Exide Industries has also started with the establishment of its gigafactory fo making LFP battery cells with capacity of 12 Gwh in Karnataka.

Chennai, Tamil Nadu

Ola Electric has set up its gigafactory which has started production of NMC battery cells with initial capacity of 4680 cells and the same is expandable to 20 GWh in Chennai, Tamil Nadu.



Pune, Maharashtra

Kabra Extrusion Technic, under the BATTRIXX brand, produces NMC & LFP type battery cells at its gigafactory at a capacity of 2GWh.

Mahbubnagar, Telangana

Amara Raja has laid foundation of its gigafactory with 16GWh capacity and started commercial pilot plant for LFP & NMC battery cell manufacturing. It has already signed a non-exclusive agreement with Ather to supply the batteries.

Hyderabad, Telangana

GODI India is setting up a gigafactory with a capacity of 12.5 GWh to make LFP & NMC battery cells and Allox Advance Materials with 3 GWh capacity to make LFP battery cells which is expected to be expanded to 10 GWh by 2030.

Competitive Landscape

With veteran battery makers ramping up capacities

Exide Industries Ltd has recently invested a significant sum of ₹ 75 crores in Exide Energy Solution Ltd (EESL) which is its wholly owned subsidiary, totaling its investments to ₹ 2652 crores. EESL is engaged in the manufacture and sale of Lithium-ion cells, modules and packs. It has also entered a non-binding MoU with Hyundai and KIA.

Tata Chemicals in collaboration with ISRO has signed an MoU to start transferring ISRO's lithium-ion cell technology with an investment of **₹13,000 crores** in Gujarat. They will initially start with the production of **LFP** battery cells.

Amara Raja Energy & Mobility Ltd had planned to invest close to **₹ 9,000 crores** in the upcoming decade to setup its Gigafactory in Mahbubnagar, Telangana, with initial investment being between ₹ 1,500 to ₹ 2,000 crores to kickstart the Gigafactory.

Smaller players have started to tap into the Indian opportunity

OLA Electric recently raised funds amounting to ₹ 5,500 crores from fresh issue out of which 22.3% will be utilized towards the expansion of capacity of the cell manufacturing plant from 5GWh to 6.4 GWh.

International Battery Company (IBC), a maker of rechargeable NMC battery cells has secured funding of $35 million which will be used to set up gigafactory in Bengaluru and will start production by 2025. The new facility is part of IBC's plan to achieve a production capacity of 10 GWh by 2028.

Cygni Energy has raised $12.5 million to set up a NMC battery cell manufacturing facility in Telangana with capacity of 1.2 GWh. Currently the installed capacity is 250 MWh.

Nsure Reliable Power Solutions has announced an investment of ₹ 1,000+ crores to enter LFP battery cells manufacturing in Bengaluru, Karnataka. The plant will have an initial production capacity of 1 GWh which will be expandable to 5 GWh.

Competitive Landscape

New entrants also forming strategic alliances to get a jumpstart

Munoth Industries Ltd is setting up India's maiden lithium-ion cell manufacturing unit with a total investment of ₹ 799 crores and has signed a technology agreement with China based manufacturer **Tainjin Lishen Battery Joint Stock Co.** with an initial capacity of 250 MWh.

TDS Lithium-Ion Battery Gujarat is set up by Suzuki (50%), Toshiba (40%) and DENSO (10%) in Hansalpur, Gujarat to manufacture **LTO** battery cells.

Lucas TVS and **24m Technologies** have come together to set up a Gigafactory in Chennai with a target capacity of 10 GWh in two phases for manufacturing **both LFP and NMC** battery cells.

Li Energy has set up a **LFP** battery cell manufacturing and signed an MoU with Guidance Tamil Nadu and 2 Gwh of capacity would become operational by December 2024.

What India needs: Government support & Risk Appetite

As one can see from the Table, India's EV OEM market is heavily dependent on China and Korea for their battery needs. India's OEM customers are price conscious and therefore falling battery prices in China, is only going make OEMs move towards Chinese battery players.

In such scenario, India's upcoming battery cell manufacturing would need serious government support in the form of timely PLI incentives and anti-dumping duty on low-cost Chinese batteries to make the India made battery cells competitive and lucrative.

It must also be noted that battery technology is continuously evolving, with newer, more efficient chemistries being developed. There is a lot of scope for innovation for battery makers. In such a scenario, Indian battery players must develop the risk appetite to invest heavily in R&D and create a highly efficient battery technology which can help OEMs differentiate their EVs in the competitive Indian market.

	Company	Batteries used	Company supplying battery cell	Source Country
4W	Tata Motors	LFP	Gotion, Octillion	China
	MG Motor	LFP	Shanghai Advanced Traction Battery Systems, Gotion, CATL	China
	Mahindra & Mahindra	NMC	Farasis	China
2W	Ola	NMC	LG Chem	Korea
	TVS	NMC	LG Chem	Korea
	Ather	NMC/NCA	LG Chem	Korea
	Bajaj	NMC/NCA	Gotion	China
	Ampere	LFP	LG Chem	Korea

What Government is doing and must also do

Union Budget 2024-25 *exempted customs duties* on lithium, cobalt and nickel (for cathode manufacturing) and *reduced duty to 2.5%* on graphite (for anode manufacturing). However, it also extended concessional customs duty on import of Li-ion cells till March 2026,

The Government on 12th May 2021 approved PLI Scheme for manufacturing of Advanced Chemistry Cells (ACC) in the country with a budgetary outlay of ₹ *18,100 crore*. The scheme envisages to establish a competitive ACC battery manufacturing set up in the country for *50 GWh*.

In March 2022, the first round of the ACC PLI bidding concluded and three players - Reliance New Energy, Ola Electric Mobility and Rajesh Exports were allocated a total capacity of 30 GWh.

Takeaway:

What the Govt must also focus on is incentivizing R&D in battery technology. Collaboration between Deep tech startups in battery technology and veteran battery players must be encouraged. Further, they should also ensure availability of skilled workforce by arranging contests and challenges in various educational institutions across India.

Critical Mineral	Old Rate	New Rate
Natural Graphite	5%	2.5%
Cobalt Ores and concentrates	2.5%	Nil
Cobalt Oxides	7.5%	Nil
Cobalt Hydroxides	7.5%	Nil
Commercial Cobalt Oxides	7.5%	Nil
Lithium Oxide and Hydroxide	7.5%	Nil
Chlorides of Nickel	7.5%	Nil
Sulphates of Nickel	7.5%	Nil
Lithium Carbonates	7.5%	Nil

What OEM customers need?

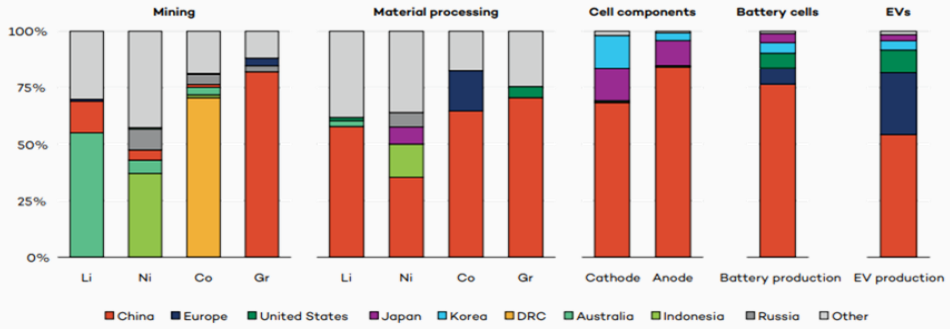
A steady supply of batteries

Indian battery players would need to offer additional value to their OEM customers in order to compete with the Chinese batteries. A reliable & faster supply chain would be one such value that can be offered.

In one such instance, Mahindra had collaborated with LG Chem for supply of battery cells; however, LG Chem discontinued the relevant chemistry and couldn't supply the required quantity to Mahindra. This resulted in the delayed launch of Mahindra's flagship XUV400 model taking away their competitive advantage. Eventually, Mahindra discontinued its relationship with LG Chem.

Further, OEMs operate on Just-in time basis. Since lithium-ion battery cells are not available in India and just in time delivery from China is not possible, working capital cycle has shot up for Indian OEMs, causing lot of inconvenience. Local manufacturing and supply of battery cells can be of real value to Indian OEMS in such case.

Geographical distribution of the global EV battery supply chain*



Li=lithium, Ni=Nickel, Co=Cobalt, Gr=Graphite, DRC=Democratic Republic of Congo

Exclude cell component value; calculation based on NITI Aayog (2022).

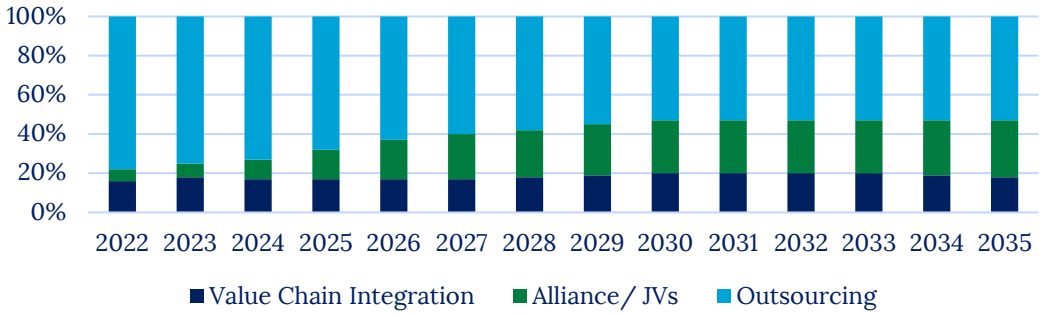
Adaptability to changing technology and chemistry

As discussed, Mahindra had ordered NMC 532 Cathode chemistry cells from LG Chem for its XUV400 model. However, LG Chem discontinued the 532 chemistry and Mahindra had to delay the launch of XUV400. Mahindra couldn't use any other chemistry since XUV400 was conceived to work with that chemistry.

This instance shows that OEMs need to maintain continuous communication with battery cell manufacturers to keep updated about the changing technology. Better chemistry and technology would have a direct impact on efficiency of EV and consequently on the sale volumes. As the graph shows, more OEMs would move towards Alliance/JVs, to not only maintain the supply but also ensure continuous flow of information on the battery technology.

However, Outsourcing remains dominant, and that is where local manufacturing of battery cells can address this very need of the OEMs. With a shared culture, language & place of origin, Indian battery players can have an edge in creating an atmosphere of trust and dialogue with Indian OEMs.

Lithium Ion battery cell sourcing strategy in India (2022-35)



Source: S&P Global Mobility

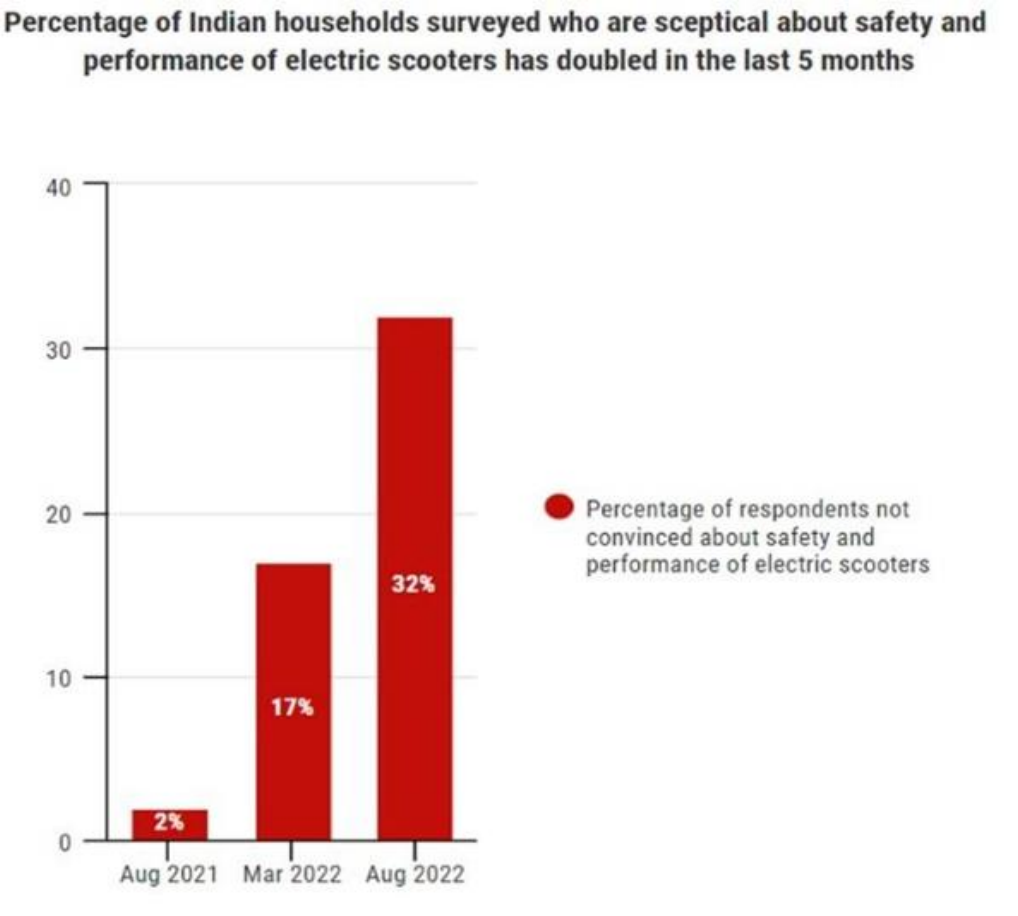
What OEM customers need?

Confidence of consumers by offering safe vehicles

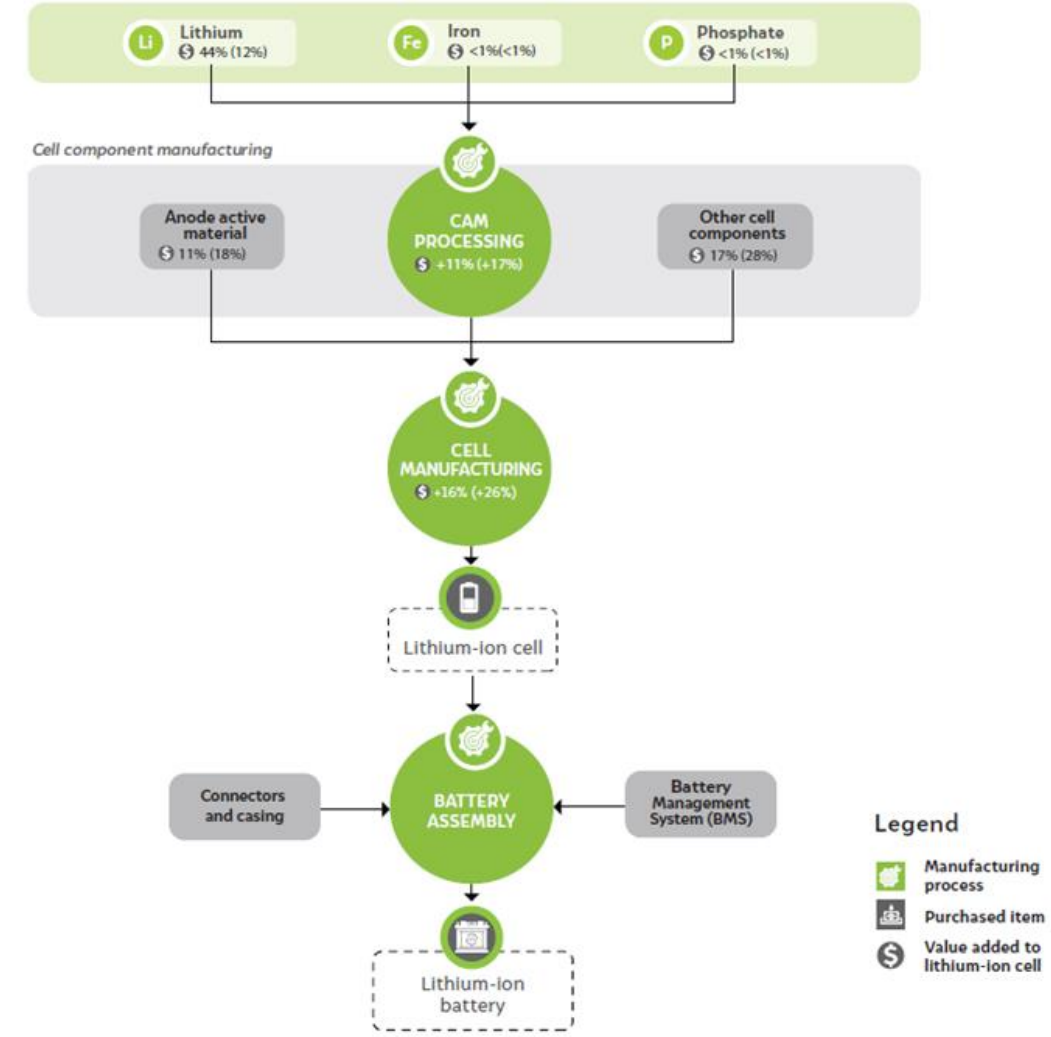
In a survey carried out in 2022, it was found that 32% of the respondents were unsure about safety of EVs. Just a year before only 2% respondents had such doubts. This was on account of number of EV fire incidents that took place in early 2022. Consumer behavior is extremely fickle and therefore OEMs would want to ensure the safety of their vehicles.

As we discussed earlier, certain EV chemistries if exposed to higher temperatures can lead to thermal runaway, causing fire. The cell manufacturers must ensure that the batteries supplied to Indian OEMs have the appropriate cooling systems to avoid the thermal runaway.

But more importantly, another problem lies in ill-designed modules and packs. Many aspiring battery assemblers are trying to get into assembly, despite not having the expertise of sophisticated thermal engineering. These new players use cello tape and screw drivers to make modules & packs, leading to badly assembled battery packs. Hence, cell manufacturers must ensure that they supply their cells to the right battery assembler, to provide best quality and extremely safe batteries to their OEM customers.



What drives the value of a battery cell



Source: Author's analysis, BatPaC 5.0, Shanghai Metals Market (SMM n.d.) ,CellEst 2019

We saw that lithium forms a crucial part of a cell and how it interacts with other compounds to produce energy. The chemistry decides the efficiency of the cell and ultimately drives the value. Hence, it is important to go further upstream the value chain and understand the cell components industry including the battery recycling industry – See you in the next publication, **EV Series #3**...!

About kcmLens

kcmLens is a special publication prepared by the Strategic Advisory team at K C Mehta & Co LLP. This publication is intended to provide deep dive into the value chain of a particular industry. The idea is to provide the reader an end-to-end understanding of a particular industry through the Lens of each segment of the value chain of that industry. This would act as a ready reference for professionals, who seek to understand their client's business and as an update document for business leaders for tracking recent developments in their industry.

Locations

Ahmedabad
Arpit Jain
Level 11, Tower B,
Ratnaakar Nine Square,
Vastrapur,
Ahmedabad - 380 015
Phone: + 91 79 4910 2200
arpit.jain@kcmehta.com

Bengaluru
Dhaval Trivedi
4/1, Rudra Chambers, First Floor, 4th Main, B/W 8th & 9th Cross Road, Malleshwaram, Bengaluru - 560 003
Phone: +91 99983 24622
dhaval.trivedi@kcmehta.com

Mumbai
Bhadresh Vyas
315, The Summit Business Bay, Nr. WEH Metro Station, Gundavali, Andheri East, Mumbai – 400 069
Phone: +91 22 2612 5834
bhadresh.vyas@kcmehta.com

Vadodara
Milin Mehta
Meghdhanush, Race Course, Vadodara - 390 007
Phone: +91 265 2440 400
milin.mehta@kcmehta.com

Independent Member
kcm NETWORK