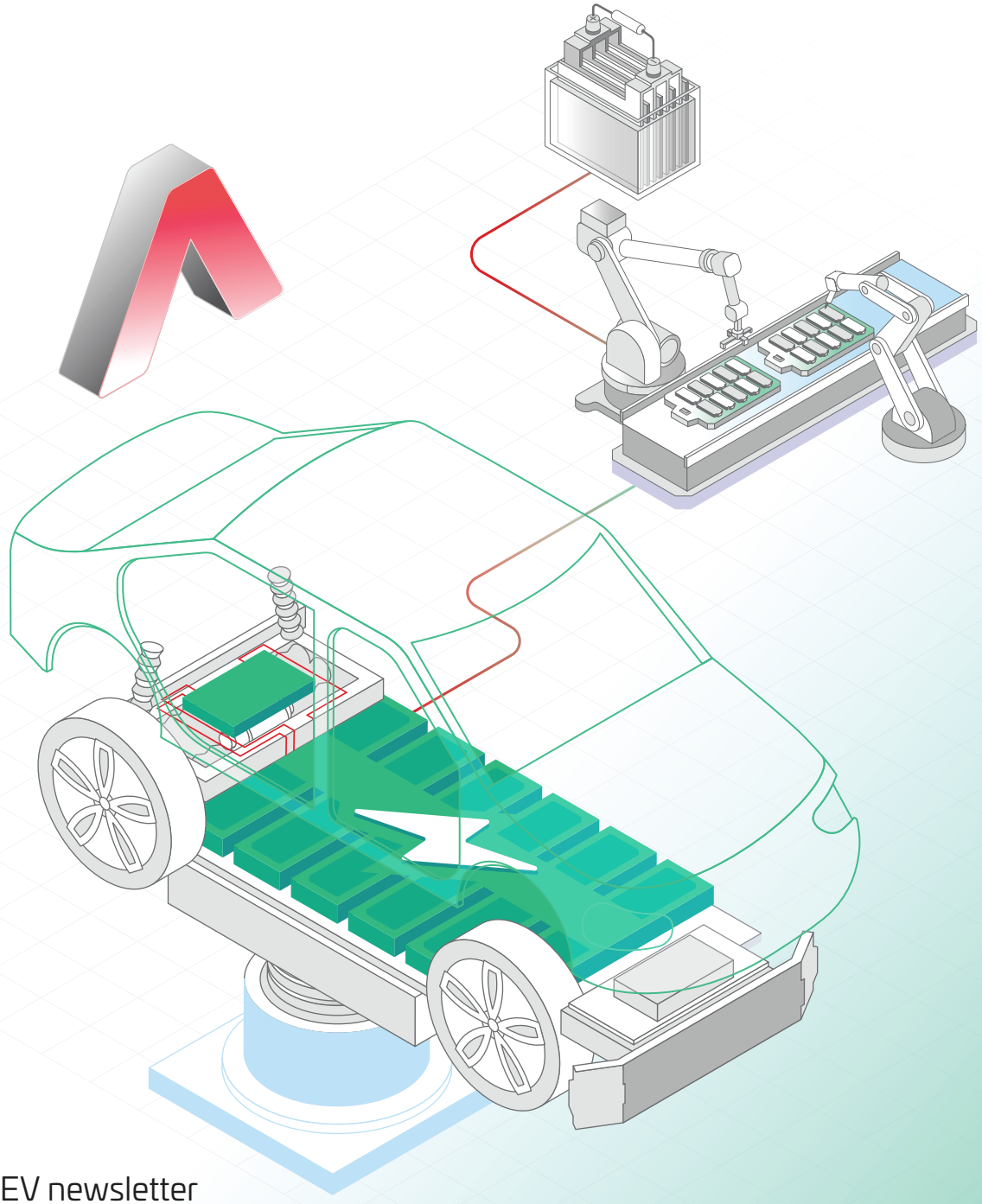
Avendus
Next is the only level

India EV Landscape

Ground up battery manufacturing not far from reality



Quarterly EV newsletter

January 2022

TABLE OF CONTENTS

Executive summary

The demand for electric vehicles (EVs) is witnessing non-linear growth in India, driven by customers' realization of cost parity and other benefits of EVs. A shift in the mindset of leading auto and ancillary companies in India is clearly visible as they join the race with EV-focused start-ups. This momentum has made Indian EV players rethink their business strategies. They are fast realizing that just importing EV parts and assembling them in India is not going to sustainably create value for them. With increasing scale, opportunities of creating value by focusing on manufacturing EV components locally are becoming lucrative. These opportunities in the EV component space are not just attracting existing companies in the ecosystem, but several companies in the conventional automotive segments and other segments are also showing strong interest and are formulating plans to enter this space.

Battery is the most critical component of an EV. With India lacking key resources for local manufacturing – battery technology, access to raw materials, skilled labor for manufacturing and capital – companies are carefully evaluating the position they would like to take in the battery value chain and are planning to scale up in a phased manner.

Globally, progress in the battery space has been much faster. On one hand, current battery giants are focusing on scale, with plans of setting up multiple gigafactories to gain a competitive advantage. On the other hand, several new entrants are focusing on advanced battery solutions based on potentially superior, differentiated technologies. With a massive potential global market opportunity, investors are rewarding innovators in this space with premium valuations.

In this quarterly newsletter, we provide an estimate of the total market opportunity for batteries in the next few years with respect to different vehicular segments in India. We provide an overview of the future plans of all the key companies that are planning to venture into this space and discuss the factors that will provide a competitive advantage in this space. We also analyze the correlation between battery prices and EV adoption.

In this newsletter, we also cover the current and potential demand-supply dynamics of the global EV battery manufacturing space. We analyze the key challenges of conventional Li-ion technologies and explore areas of development in the advanced battery solutions space. At the same time, we provide an update on the status of some of the alternative energy storage technologies coming up in the market.

Together with this, we take a look at the key EV models launched, highlight recent developments with respect to various stakeholders and cover key transactions in the Indian EV sector over the past few months.

Increased traction in the EV space translating into higher interest in battery manufacturing

India has witnessed an unprecedented traction in the EV space in the last few months. EV sales have been at an all-time high, the central and state governments are sharpening their EV policies, companies are announcing dedicated investments for the EV segment, and investors are looking at the space with a different lens and considering larger investments. Some of the key highlights of these developments include India clocking monthly EV sales of 50,000 vehicles across segments for the first time in December-2021 (21% growth over November-2021 despite post-festive season slowdown), Tata Motors raising USD 1 bn for its EV division from TPG and ADQ, making it the largest transaction in India in the EV segment till date, and the Government of India's announcement of multiple production-linked incentive (PLI) schemes with a total outlay of INR 450 bn+ with specific focus on the EVs. Continued interest on the demand side is expected to put pressure on companies to strengthen their supply chains. Battery, being the most critical component that constitutes about 30-50% of the cost of the vehicle, is thus garnering significant attention. Li-ion batteries used in EVs in India are currently largely imported (either as cells or battery packs). However, there are several challenges associated with the use of imported batteries.

CHALLENGES IN USING IMPORTED BATTERIES

1. They are not customized for the vehicle
2. They are not customized for Indian conditions (especially, running in high temperatures and harsh road conditions)
3. Battery imports are subject to higher duty structure
4. Necessitates higher working capital and logistics costs for Indian EV OEMs

INR 450 bn+

Outlay in multiple PLI schemes announced by the government with focus on the EV segment

50,000

India's EV sales in December 2021 alone across segments

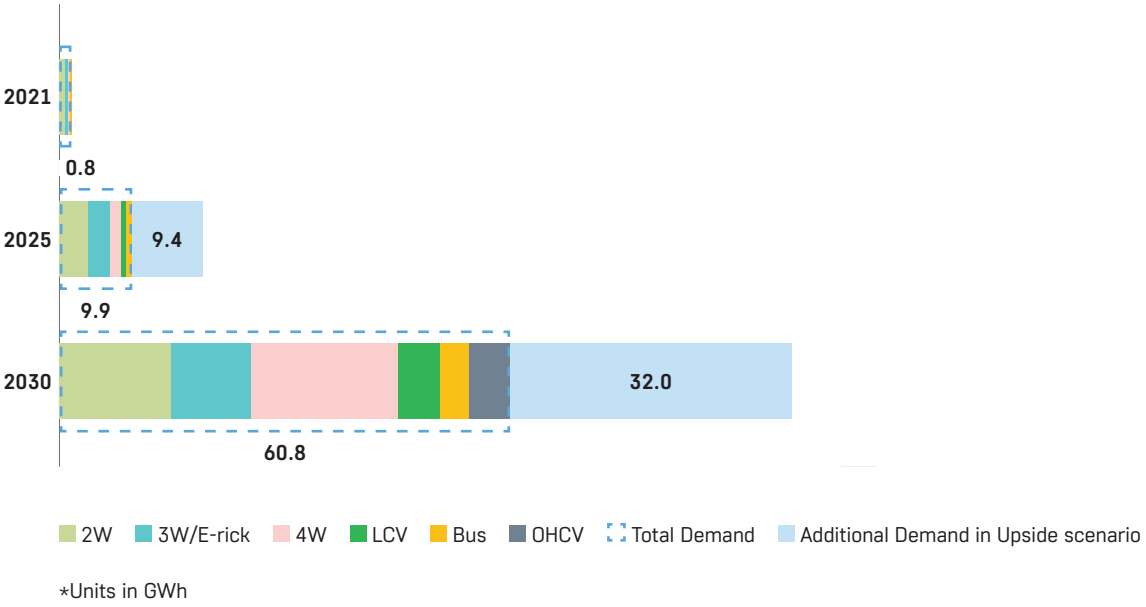
To overcome some of these challenges, OEMs prefer to make the battery pack in-house or are looking for a tie-up with a domestic battery company. This is leading to the emergence of several companies in India with plans to establish their positions in the battery manufacturing space. In the near term, due to multiple constraints, the cells are expected to be imported. However, several companies are planning to invest in cell manufacturing in India in the medium to long term, and this part of the value chain is also expected to get localized eventually.

Projected demand for batteries in India

EV adoption in India will grow exponentially over the next decade, and multiple tailwinds are clearly visible in the market. The adoption trajectory will vary between various vehicle segments and will be driven by four key factors – Policy, Battery Prices, Charging Infrastructure and Supply Chain Localization. Battery is the core of EVs, and electrification across vehicle platforms will create a massive demand for batteries in India.

EXHIBIT 1

Projected battery capacity demand in India for e-mobility



*Units in GWh

HOW THE EV BATTERY DEMAND IS EXPECTED TO SHAPE UP IN INDIA?

A/

The EV battery demand in India is expected to reach about

10 GWh by 2025 and 60 GWh by 2030

which is equivalent to a USD 5.5 bn market opportunity in 2030

B/

Early EV adoption in India is expected to be led by 2Ws and 3Ws, and these segments will constitute

~70% of overall EV battery demand in 2025

C/

The larger vehicle segments are expected to grow rapidly post 2025, with contribution from these segments expected to be

~50% by 2030

D/

In an optimistic EV adoption scenario, the projected demand could be additional 10 GWh in 2025 and additional

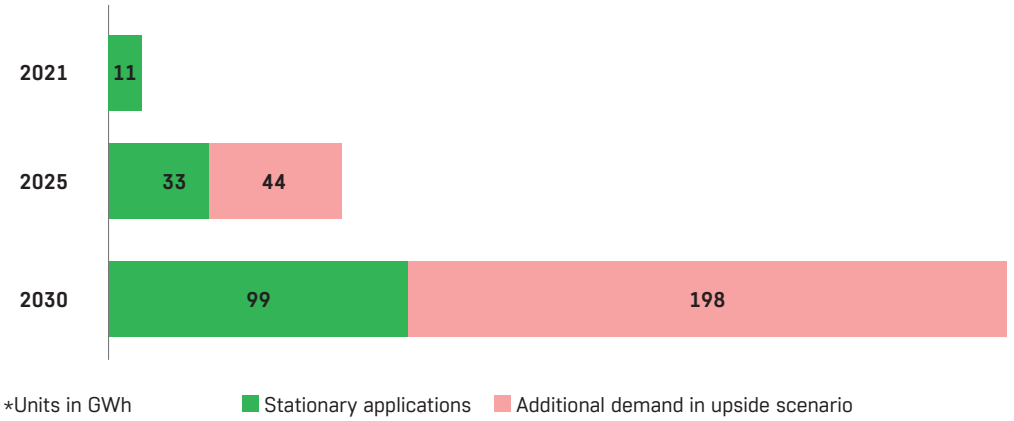
30 GWh in 2030

USE OF LI-ION BATTERIES FOR STATIONARY USE CASES

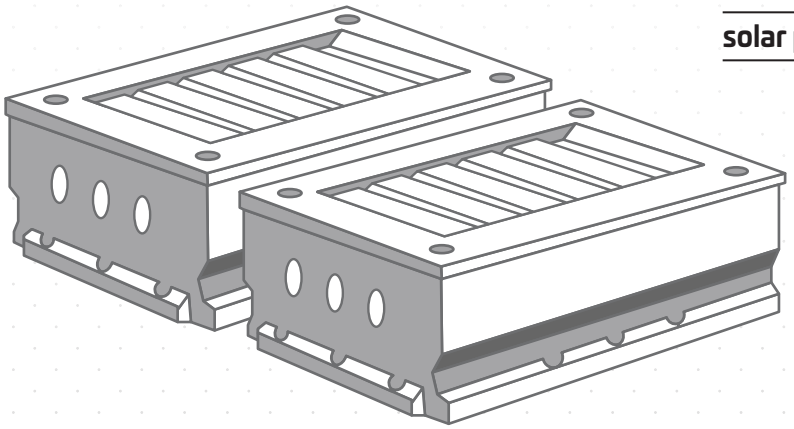
A sustainable and cleaner mobility solution can only be realized if electrification is complimented by a large-scale shift to renewable energy generation. India has set a target of 450 GW renewable power generation by 2030 from the current levels of about 100 GW. Any such large-scale renewable power generation requires battery storage capabilities, as the grid cannot directly handle the intermittency of power generation. Li-ion batteries offer an economical storage solution and the coming decade will see a huge demand for storage application for round-the-clock solar projects. For a 450 GW generation capacity, and assuming 3-5 hours of storage for 20-50% of the capacity, India will need about 300-1,000 GWh of battery storage capacity by 2030. Exhibit 2 below captures the projected battery storage capacity demand in India for renewable integration.

EXHIBIT 2

Projected battery capacity demand in India for stationary applications



Li-ion batteries offer an economical storage solution, and the coming decade will see a huge demand for storage application for round-the-clock solar projects



300-1,000 GWh

India's projected battery storage capacity by 2030 to meet renewable energy generation target of 450 GW

Current battery manufacturing scenario in India

Key current and potential players in EV battery value chain in India

Battery manufacturing has attracted the attention of several industry players, including companies which have not been in traditional battery manufacturing or in the automotive space. To attract large investments, the Government of India has announced a PLI scheme earlier this year for advanced cell chemistries with an outlay of INR 181 bn. At the current demand level, battery players in India are rightly focusing more on the pack + electronics side of the value chain of batteries. The foray into cell manufacturing is expected to happen once the domestic battery demand reaches a critical mass around 2024-25.

TABLE 1: KEY CURRENT PLAYERS IN THE INDIAN BATTERY ECOSYSTEM

Company	Description	Focus area in Battery Value Chain	Capacity/ Investments Planned	Location	Battery Type/ Chemistry/ Material Targeted	Strategic/JV Partnership/ Investment
Amara Raja	Set up a new business unit, 'Energy SBU', to focus on EV and green technologies. Plans to venture into Li-ion battery manufacturing space in the next 5-7 years	Cell, Battery Packs	USD 1 bn investment in 5-7 years for a 10-12 GWh battery manufacturing plant	Tirupati (Andhra Pradesh)	Li-ion	Log9 Materials, InoBat Auto
Exicom	Currently caters to telecom and mobility applications by manufacturing battery packs. Plans to venture into cell manufacturing going forward	Cell, Battery Packs	-	-	Li-ion	-
Greenfuel Energy Solutions	Manufacturer of CNG kits is now also focusing on the EV segment with battery packs manufacturing. Plans to cater to both e-mobility and stationary applications	Battery Packs	Invested INR 210 mn in the EV division	-	Li-ion (NMC, LFP)	-
Ipower Batteries	Manufactures Li-ion battery packs for Gemopai, Benling India, Okinawa Autotech, etc. Serves several EV 2W makers in the country using battery cells it imports from Japan, South Korea and China	Battery Packs	Set up capacity to produce 500 packs per day with INR 1 bn investment	Kundli (Haryana)	-	-
Log9 Materials	Developed High Power Cells (HPC) which can provide a long life higher charging and discharging speed and are extremely safe in wide operating temperature range. Targetting to cater commercial 2W/3Ws initially and then expand to LCVs, 4Ws, buses and stationary applications	Cell RM, Cell, Battery Packs	Plan to set up a pilot facility in FY23 for a multi-purpose assembly line for HPC and Supercapacitors. Going forward, it plans to set up a giga battery manufacturing facility with a strategic partner.	Bengaluru	Li-ion	Amara Raja, Petronas
Nexcharge (Exide - Leclanche)	Started assembling battery packs in India and will look to enter cell manufacturing as the ecosystem develops	Cell, Battery Packs	Have invested INR 25 bn to set up a 1.5 GWh battery assembly facility	Ahmedabad (Gujarat)	Li-ion (LFP, NMC)	Exide Industries (75%), Leclanche (25%)
TDSG (AEPPL) (Suzuki Denso Toshiba JV)	JV between TOSHIBA Corporation, DENSO Corporation and Suzuki Motor Corporation to manufacture and supply Li-ion batteries to Maruti Suzuki and other exports customers	Cell, Battery Packs	INR 50 bn investment to manufacture 30 mn cells with more than 1 GWh capacity in the next 5 years	Ahmedabad (Gujarat)	Li-ion	Toshiba Corporation (50%), Denso Corporation (40%), Suzuki Motor Corp (10%)

Cell RM Cell Battery Packs Vehicles

Low Focus Medium Focus High focus

Factors that will provide an edge to a battery manufacturer in India

Battery manufacturing with in-house cell manufacturing is a significantly capital-intensive business. Setting up large giga-scale facilities requires about USD 60-100 mn/ GWh of capital investments. Additionally, securing a stable raw material supply is going to be a significant challenge for Indian companies, given the limited availability of resources in India. Thus, venturing into cell manufacturing in the short term will not be feasible for Indian companies. With demand for batteries expected to increase significantly in the latter part of the decade, with the inflection in retail and large vehicle segments, companies should focus on developing a complete ecosystem suitable for cell manufacturing.

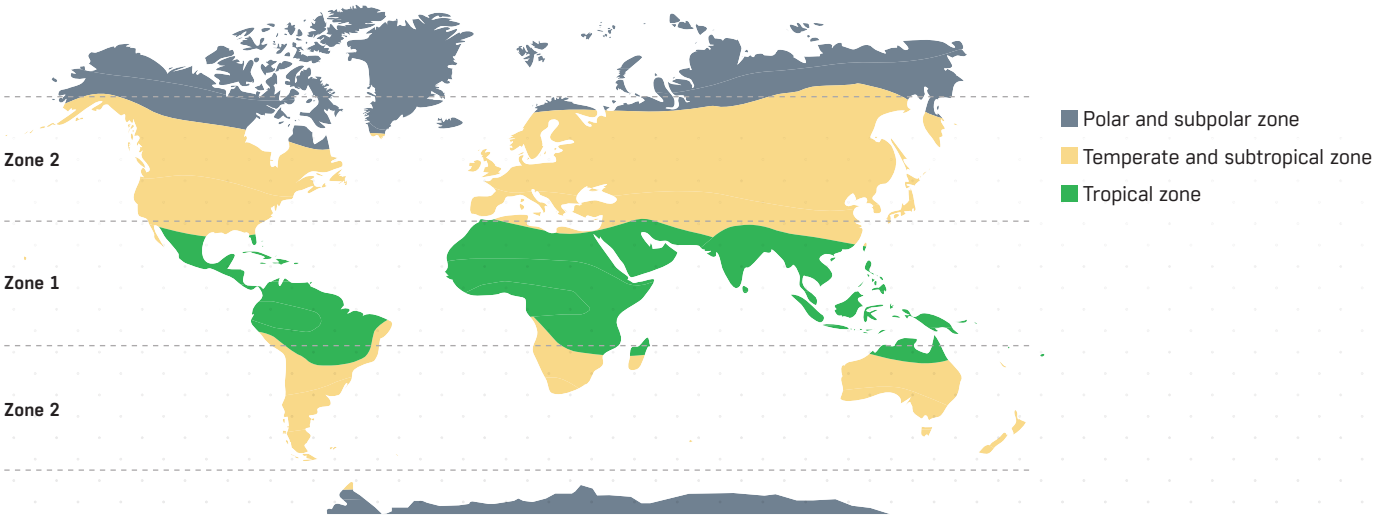
CRITICAL FACTORS COMPANIES NEED TO FOCUS ON WHILE EVALUATING THEIR ENTRY INTO THE BATTERY MANUFACTURING SPACE IN INDIA

1/

CHEMISTRIES THAT ARE MORE SUITABLE FOR INDIAN CONDITIONS

Battery research and technology development have largely been happening in USA, Europe and China, and the technologies are built for the respective operating conditions (ambient and road conditions). Indian companies need to target technology solutions that are suitable for hotter climatic conditions and usage patterns in India. **Companies can either develop new chemistry solutions suitable for Indian conditions or optimize the existing chemistries to offer more reliable performance in the Indian conditions.**

Challenges in using same battery technology solution across the globe



Zone	Average Temperature	Dominant Vehicle Types	Usage Pattern
Zone 1: Tropical zone	30-50 °C	2W, 3W, SCVs, Small / Budget Cars	Used for shorter distances in harsh road conditions
Zone 2: Temperate and subtropical zone	10-30 °C	Large / Premium Cars, SUVs, Heavy Commercial Vehicles	Used for longer distances in developed road conditions

2/

SOLUTIONS BUILT FOR SEGMENTS

Different segments or use cases of batteries have different requirements. For example, 2W/3W batteries have power density constraints, limiting their charging speed. On the other hand, long-haul vehicles require large capacities to travel long distances and have weight constraints. While stationary applications for renewable energy can have flexibility with space, they require a long life and cost-effective solution. Thus, targeting various segments with the same battery solution may not be effective. **Companies need to focus on developing solutions to address specific use cases and resolve key pain points.**

3/

CELL TO PACK INNOVATION

Cell to pack assembly offers ample scope for battery companies to create differentiating solutions that can translate into improved reliability, safety and user experience. **Innovations around cooling architecture, telematics and battery management system (BMS) can help companies offer superior products and optimize the value of their products to customers.**

4/

BACKWARD INTEGRATION FOR RAW MATERIALS AND RECYCLING OF BATTERIES

Key raw materials currently used for manufacturing batteries and companies providing these materials are non-existent in India. Thus, companies will need to secure access to a sustainable supply of these raw materials. **Backward integration into raw material supply either by setting up own facilities or developing partnerships with companies in these segments will be critical for long-term sustainability.** Developing a circular economy by venturing into raw material recycling will also significantly reduce dependencies on external partnerships and the burden on the supply chain going forward. Choice of chemistry can address this issue at the root by eliminating dependence on elements like Cobalt and Nickel.

Developing a circular economy by venturing into raw material recycling will significantly reduce dependencies on external partnerships and the burden on the supply chain going forward

Battery price reduction will lead to inflection points in various EV segments

Reduction in battery prices is a crucial driver for large scale EV adoption. At the same time, critical demand mass is important for economies of scale to bring in operating efficiencies.

FACTORS THAT PLAY A KEY ROLE IN THE REDUCTION OF BATTERY PRICES GLOBALLY:

CHANGES IN CELL CHEMISTRIES:

a. Reduction of rare and expensive material (such as Cobalt) from batteries. e.g. NMC chemistry has slowly graduated from a 1:1:1 composition (of Nickel, Manganese and Cobalt) to 6:2:2 to 8:1:1.

b. Elimination of such materials by using alternative cell chemistries like LFP, LMO, etc.

SCALE OF OPERATIONS:

a. Larger facilities offer significant capex efficiency

b. Large-scale operations are also critical for operating cost efficiencies

c. Scale is also critical for companies to establish supply chain control and lock-in demand

DEVELOPMENTS IN SUB-COMPONENTS:

a. Innovations in cell-level sub-components, such as separators, electrolytes

b. Innovations in cell-pack assembly in terms of electronics, cooling systems, etc.

In addition to these global factors, the increasing scale of demand in the Indian market and localization of the battery value chain within the country will play a crucial role in reducing the gap between global battery prices and landed battery prices in the Indian market.

EXHIBIT 3

Projected global and India battery prices with inflection points for different vehicle segments in India

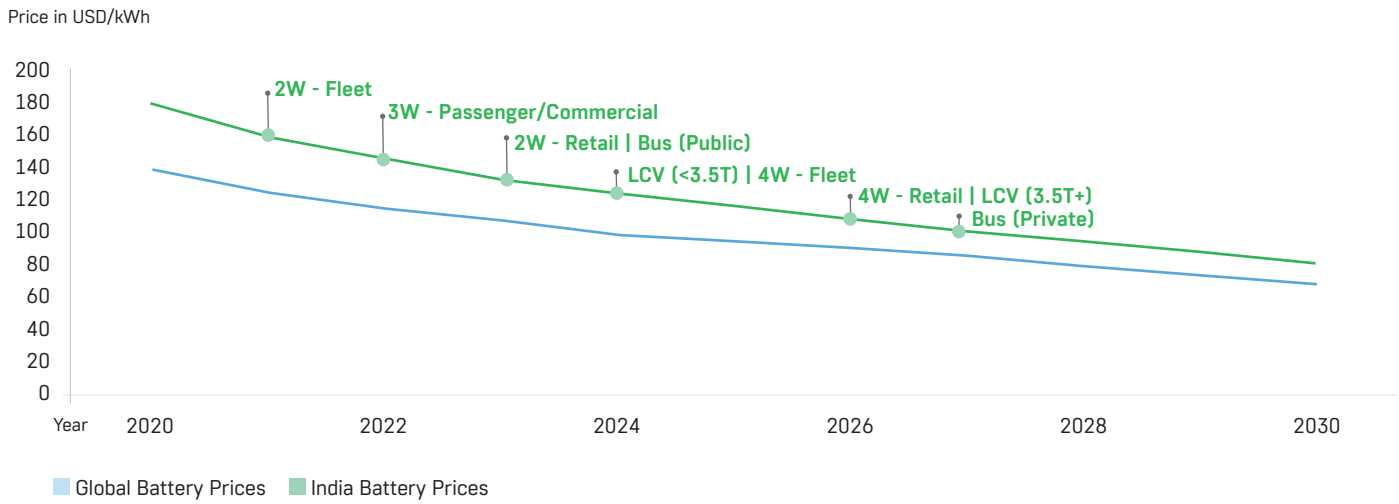


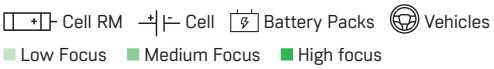
TABLE 2: OTHER PLAYERS TAKING POSITIONS IN THE BATTERY ECOSYSTEM

Company	Description	Focus area in Battery Value Chain	Capacity/ Investments Planned	Location	Battery Type/ Chemistry/ Material Targeted	Strategic/JV Partnership/ Investment
Adani Group	Announced its plan to set up a Li-ion battery manufacturing complex. Also announced plans to venture into the Green Hydrogen space. Looking to invest USD 20 bn over the next decade to focus on renewable energy		-	Gujarat	Li-ion	-
Ather Energy	Manufactures battery packs in-house for its vehicles by importing cells from other countries. It has set up a plant to manufacture 120K battery packs per year		400,000 battery packs annually in the next plant	Hosur (Tamil Nadu)	Li-ion (NMC)	-
ATL (Amperex Technology Limited)	Plans to manufacture batteries largely focusing on smartphones and 2W/3W segments in the e-mobility space. In Aug 2020, it acquired a parcel of land in Haryana for the same		Invest INR 70 bn in the next few years to set up a manufacturing facility	Haryana	Li-ion (Polymer electrolyte)	-
C4V	Signed an MoU with Karnataka govt to set up a manufacturing facility in the state. Focusing on advanced battery chemistries and is planning to set up plants leveraging these technologies		5 GWh with investments of INR 40 bn	Karnataka	Li-ion (Conventional, Solid State)	-
Epsilon Advanced Materials	Plans to manufacture synthetic graphite which is used to manufacture anode material for Li-ion cells. Looking to get its material qualified with global cell manufacturers to bag large orders in the space		1,00,000 TPA of synthetic graphite anode	-	Graphite anodes	-
Godi Energy	Focus on setting up a giga-scale facility for cell manufacturing in India. Looking to also focus on other technologies like Sodium ion cells and supercapacitors in parallel		Plans to set up a 5 GWh facility in the next 5 years	Hyderabad	Li-ion (NMC, LFP), Na-ion	-
Greenko Energy	Plans to invest in battery storage business that will cater to applications for both EVs and power grids		USD 1 bn investment to set up a giga facility	Mahbubnagar (Telangana)	Li-ion	ChargeXO
Li Energy	Looking to set up a vertically integrated facility for battery manufacturing. Have purchased land in Tamil Nadu to start building a facility		Plans to invest INR 7.5 bn in the next 4 years to set up a 1 GWh integrated facility	Thondi (Tamil Nadu)	Li-ion (LFP, NMC)	-
Livguard Energy	Largely focused on assembling battery packs for stationary, 2W and 3W applications		Invested USD 20 mn to set up a battery assembly facility	Manesar (Haryana)	Li-ion	-
Lohum	Plans to create circular economy by operating in both manufacturing and recycling of Li-ion batteries in India. It plans to cater 2W/3W and stationary applications through its manufacturing facility		Plans to set up 3 GWh integrated Li-ion manufacturing and recycling facility by 2022-23	Greater Noida (Uttar Pradesh)	Li-ion	-
Lucas TVS	Plans to set up a giga facility leveraging 24M's semisolid technology platform and plans to install capacity in two stages		Initial investment of INR 25 bn. Plans to have a 10 GWh facility after 2 phase expansion	Chennai (Tamil Nadu)	Li-ion (Semisolid electrolyte)	24M Technologies
Manikaran Power	Set up a battery raw material (Lithium Hydroxide) manufacturing facility by importing Lithium ore from Australia		USD 300 mn for 20,000T (Lithium Carbonate equivalent) facility	Gujarat	Lithium Hydroxide	Neometals (Australia)

Cell RM Cell Battery Packs Vehicles

Low Focus Medium Focus High focus

Company	Description	Focus area in Battery Value Chain	Capacity/ Investments Planned	Location	Battery Type/ Chemistry/ Material Targeted	Strategic/JV Partnership/ Investment
Ola Electric	Currently, manufactures battery packs for its vehicles at its integrated facility in Karnataka. Going forward, it will look to partner with other players to venture into cell manufacturing		-	Krishnagiri (Tamil Nadu)	-	-
Power Global	Setting up a 1 GWh facility in India to target retrofitting of conventional 3Ws		USD 25 mn for 1 GWh facility over the next 2-3 years	Noida (Uttar Pradesh)	Li-ion	-
Reliance Industries	Plans to set up a Li-ion battery manufacturing complex in Jamnagar. Looking to diversify its business with high focus renewable segment. Its energy storage plans are also largely for grid integration		Plans to invest INR 750 bn in clean energy. Investment in giga factory to be a part of it	Jamnagar (Gujarat)	Li-ion	Ambri Inc, Faradion
Tata Chemicals	Plans to set up a giga facility to cater e-mobility and stationary applications. Identified a place in Gujarat to set up the facility and commence pilot manufacturing		~2 GWh in phase-1 with investment of INR 8-10 bn. Phase 2 capacity of 10 GWh with INR 40 bn investment	Dholera (Gujarat)	Li-ion	-
Triton	US-based, solar panel and battery engineering firm plans to use its EV division to produce electric cars along with batteries in India		Plans to invest INR 21 bn to set up a facility to produce over 50K vehicles	Telangana	Li-ion	-



Company in focus

LOG MATERIALS

Company Facts

HQ : Bangalore
Founded in: 2015
Founders: Akshay Singhal, Kartik Hajela, Pankaj Sharma

Business

USP: Focuses on material to cell to pack level technologies

TECHNOLOGY FOCUS:

1/

RAPID CHARGING BATTERIES

These batteries provide superior performance solving for 3 key challenges currently faced by the users:

a. Rapid charging from 0% to 100% in 15 minutes for 2Ws and in 35 minutes for 3Ws, solves for high vehicle downtime due to slow charging
b. Long cycle life of 40,000+ cycles solves for multiple battery replacements during a vehicle's life
c. Operability in a wide temperature range of -30 °C to 60 °C solves for high safety risk in Indian conditions

2/

SUPERCAPACITORS

These high-power storage systems can cater to applications like Metro, Electric Rail, etc.

3/

ALUMINUM FUEL CELLS

These can store large amounts of energy and can be useful in applications like long-haul mobility and stationary applications

END USER SEGMENTS:

Commercial E-mobility (2W, LCVs and SCVs, 4W) and Stationary Use Cases

FUTURE PLANS:

Scale to 20 GWh of battery capacity by 2030

Investment details

Capital Raised: USD 14 mn

Investors

Surge (Sequoia Seed Fund), Amara Raja, Exfinity, Petronas, AC Ventures

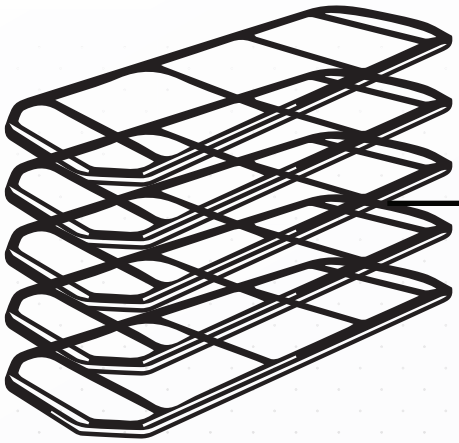
Advanced battery technologies globally are unlocking electrification potential for several niche markets

Global scenario in the traditional Li-ion space

Battery production capacities along with decline in battery prices are going to play a critical role in the continual rise in EV adoption.

The pace of electrification in China, USA and Europe has been faster than expected. A combination of reduced battery prices, policy directives with focus on cleaner mobility and availability of good product options has accelerated the global EV transition. This is leading to a much faster rise in demand for batteries globally. Battery production capacities along with battery prices are going to play a critical role in the continual rise in EV adoption.

Li-ion battery production capacity globally has increased from around 250 GWh in 2018 to about 700 GWh in 2021. With significant announcements by most battery manufacturers – both incumbents and new entrants – the capacities are expected to rise to over 2,000 GWh by 2025. Global players cumulatively have plans to build about 80 new giga factories in the coming five years. Battery capacity production has largely been concentrated in China, accounting for about 75% share in 2021. This is primarily because of higher emphasis by the Chinese government on EVs from an early stage and a strong supply chain developed by companies in the region. With faster EV growth in Europe and actions taken by the EU to reduce dependence on Chinese suppliers, the proportion of Europe in total battery capacity is expected to increase going forward. However, China will continue to dominate the overall battery market.



2,000 GWh+

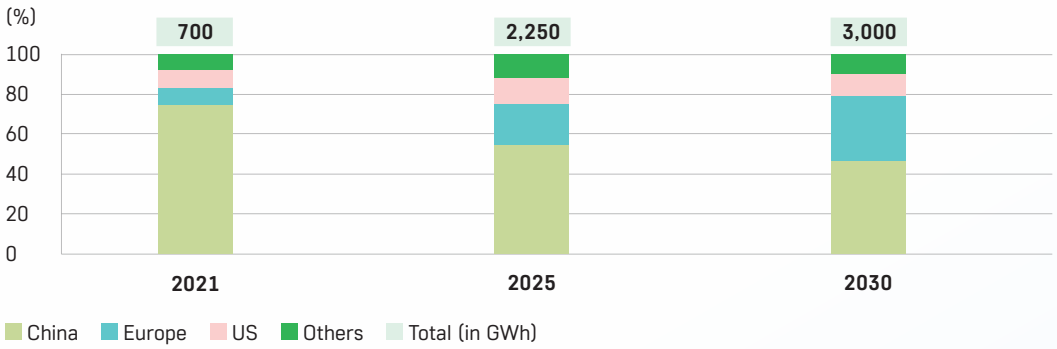
Projected global Li-ion battery production capacity by 2025

~3,900 GWh

Projected global demand for batteries by 2030

EXHIBIT 4

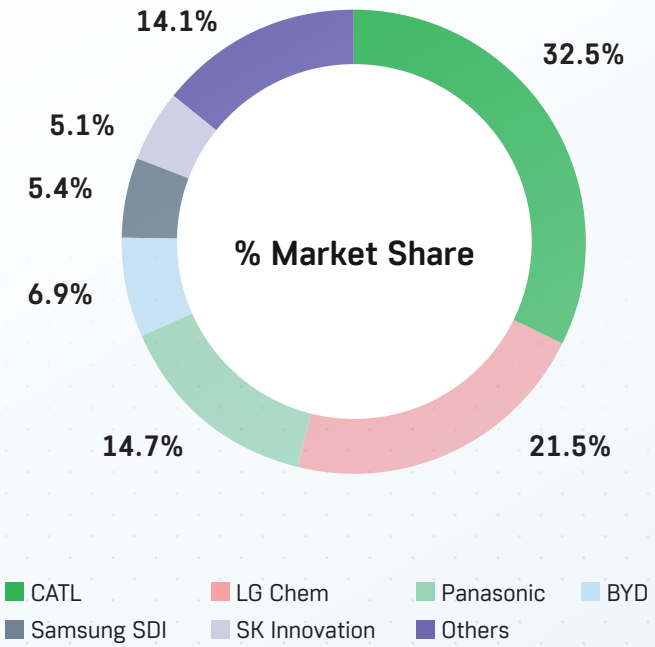
Current and projected global battery manufacturing capacity split by geography based on announcements from the companies



Note: The above figures are based on current announcements by the companies

EXHIBIT 5

Current global battery manufacturing market share



Source: Statista

Global demand for batteries is expected to reach ~3,900 GWh by 2030. Additional announcements and investment plans are required from companies to meet the demand, considering significant execution risk. An increase in EV adoption is also contingent on the decline in battery prices driven by technological developments in battery chemistries and increase in scale. So, progress on the battery front is key for increase in EV adoption.

The global battery cell manufacturing market is currently dominated by six major players. These players, with their large expansion plans, will continue to be prominent players. But with rapid developments and the potential to address the demand-supply gap in the future, new entrants are expected to enter this market, making it more fragmented. Several new battery companies have grown rapidly in the recent past, including the likes of Gotion, Phylion, C4V, Northvolt, etc.

Problems associated with conventional Li-ion battery technologies

Innovation in battery chemistry is one of the key success factors for upcoming companies in the battery market.

Traditional Li-ion technology has multiple drawbacks and is not optimal for all applications. Some of the key challenges are the following:

1/
CHARGE TIME
Traditional Li-ion chemistries have limitations around the rate at which they can be charged. These batteries cannot be charged at more than 1-2 C, without having a degradation in their cycle life.

2/
RANGE
With a maximum energy density of 200-280 Wh/kg, traditional Li-ion batteries are constrained with short ranges. Having a longer range would increase the weight of the vehicle, thus reducing its efficiency.

3/
SAFETY
Traditional chemistries with slightly higher energy density like NCA, NMC, etc. are more prone to safety risks of thermal runaway at higher temperatures, especially in harsh ambient conditions in countries like India.

4/
LIFE
Traditional Li-ion batteries generally have a cycle life of 1,000-3,000 cycles. These cycles are further reduced with usage outside of standard conditions or operating procedures. Thus, there is need for battery replacement multiple times within a single life of a vehicle.

5/
SUSTAINABILITY (RM SOURCING, LIFE CYCLE EMISSIONS)
Traditional Li-ion batteries heavily depend on certain rare elements like Lithium, Cobalt, Nickel, etc. These elements are concentrated in certain regions, creating an imbalance across geographies. Additionally, mining and processing of these elements have a significant amount of carbon footprint upfront, so the benefits of these batteries are not realized until they have been used for many kilometers.

Upcoming advanced battery solutions

Advanced battery technologies are trying to resolve some of the challenges associated with conventional technologies and cater to relevant use cases.

There are many ways in which companies are trying to develop advanced battery solutions. Companies are largely working on addressing challenges with respect to the various sub-components of cells (anode, cathode, and electrolytes) to enhance the batteries. Companies with strong technology proposition and are on an advanced development stage have a high potential for disrupting the current market. Thus, they are commanding significantly premium valuations. These companies may not have short-term revenue potential, but they are being valued on the revenue potential many years down the line. Some of the advanced battery solutions that have progressed from early stages and are being actively developed are presented below:

LI-ION BATTERIES WITH SILICON ANODE

DEVELOPMENT STAGE

CONCEPTUAL | EARLY STAGES | ACTIVE DEVELOPMENT | **ADVANCED STAGES** | COMMERCIALIZATION (2023)

100%

Replacement by Silicon could lead to improvement in energy density of batteries by 40-50%

Concept: For conventional Li-ion technologies, the current bottleneck is the significantly lower capacity of anode as compared to cathode. To bridge this gap, there is significant development happening in anode technology across the globe. The most feasible and near-term commercializable idea is to replace Graphite, used as anode, with Silicon. The theoretical capacity of Silicon is 3,600 mAh/g, which is almost 10x that of Graphite. Thus, 100% replacement by Silicon could lead to improvement in energy density of the batteries by 40-50%. Currently, Silicon materials are already being used along with Graphite, but only in smaller quantities (<5%) due to significant challenges related to its use.

CHALLENGES

A/

Expansion and contraction:

Silicon anodes expand by about 3x when charged and shrink back to normal levels when discharged. Repeated swelling and shrinking causes the Silicon anode to fracture and degrade rapidly.

B/

Lower first charge efficiency:

Significant proportion of Li-ions are permanently trapped inside the anode during the first charge, which impacts the overall efficiency of the cell.

C/

Unstable surface electrolyte interface (SEI) film:

Repeated fluctuations in the size of the anode make the SEI film unstable and thicker, which leads to poor battery performance.

CURRENT STATUS:

Companies are exploring a variety of structures to control the volume expansion of cells. They are also working with certain binders and additives to help them with this problem. A few companies have been successful at the prototype stage and are looking to deploy them in niche applications like premium wearables and smartphones. With increase in scale, these companies expect them to be deployable in EVs in the coming years.

TABLE 3: COMPANIES WORKING ON SILICON ANODE TECHNOLOGY

Company	Country	Innovation	Current Status/Future Plan	Raised to Date (USD mn)	Last Round Valuation/ Latest Market Cap (USD mn)	Strategic Partnerships
Sila Nanotechnologies	USA	The company's innovative battery chemistry uses Silicon in its cell's anode instead of Graphite. It has created a coating around Silicon that can have the expansion and contractions inside the coating without causing side reactions outside it. It provides a battery with up to 20% more energy density than conventional Li-ion batteries	Plans to manufacture anode material and have capacity of 100 GWh by 2025	934	3,300	Diamler
ENOVIX	USA	It uses 100% active Silicon anode. The company overcame most of the challenges of Si-anode with unique 3D design of cell and process improvements like pre-lithiation. It has increased energy volume density to reach 900 Wh/l (from current levels of 700 Wh/l)	Started manufacturing battery cells from its first automated factory in Fremont, California. 1-yr away from commercialization. Plans to have 35 GWh by 2025	534	2,771	-
StoreDot	Israel	Its battery replaces Graphite in anode with semiconductor nanoparticles (Germanium) through which Li-ions can pass more quickly and easily. The company would switch to Silicon later this year. It uses a flexible self-healing polymer in anode that absorbs the contractions and expansions. It also plans to provide 5 minutes fast charging to 100%	Currently at a technology development stage. Plans to commercialize Silicon based batteries by 2024 and then move to solid state batteries by 2028	226	1,500	-
Amprius	USA	Developed a porous, amorphous nanowire structure for Si-anode that it claims to reduce swelling to less than 30% and eases stresses associated with expansion and contraction. It has led to an increase in energy density and thus in range of vehicles	Awarded contract by US army to develop 100% silicon anode cells in the next 18 months	67	530	Airbus
Enevate	USA	It has developed a hard film where Silicon is stored, to be used as anode. It provides higher energy density, faster charging (5 minutes for 80%) and is safer compared to conventional Li-ion technology	Commercialization expected by 2022	192	501	-

Source: CapIQ, Pitchbook; Latest Market Cap as of 14th January, 2022

SOLID STATE

DEVELOPMENT STAGE

CONCEPTUAL | EARLY STAGES | **ACTIVE DEVELOPMENT** | ADVANCED STAGES | COMMERCIALIZATION (2025)

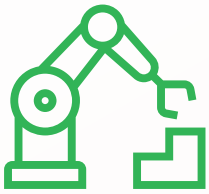
Concept: Lower safety of the batteries has always been a critical issue. To address this issue, significant investments are being made by companies on temperature management. One of the main reasons of safety risk of batteries has been the presence of highly flammable liquid electrolytes. Solid State batteries replace the liquid electrolytes used in the cells with solid-state material. This itself doesn't improve the performance of the batteries significantly, but it makes them stable at higher temperatures and enables experimentation with advanced anode materials. The solid state materials largely being experimented with are ceramics, glasses, or sulfides. All these materials have some drawbacks, and the companies are attempting to overcome the same.

CHALLENGES

A/

Interface issues:

Due to the presence of solid-solid internal interfaces, there is lower conductivity, resulting in potential limitations on current density. Additionally, mechanical instability, resulting from cycling of batteries, can result in undesired reactions at the interfaces, leading to poor performance.



B/

Redesign existing manufacturing processes:

Mass production and manufacturing of solid state batteries is quite complex. Current manufacturing processes need to be significantly redesigned to incorporate usage of solid state electrolytes.

CURRENT STATUS:

Companies working in this area are largely developing their proprietary electrolytes. Some companies are leveraging this switch in electrolyte to overcome some of the challenges of using other advanced technologies like Li-metal and Silicon anodes. Companies are also looking towards this development to improve safety, thus lowering the cost of the battery by reducing costs on active thermal management systems.

TABLE 4: COMPANIES WORKING ON SOLID STATE TECHNOLOGY

Company	Country	Innovation	Current Status/Future Plan	Raised to Date (USD mn)	Last Round Valuation/ Latest Market Cap (USD mn)	Strategic Partnerships
QuantumScape	USA	It is using an inflamable and non-combustible ceramic electrolyte with high dentride resistance for electrolytes. It increases energy density up to 300-400 Wh/kg and volume density up to 1,000 Wh/l. It also enables fast charge upto 80% in <15 minutes by eliminating lithium diffusion bottleneck at anode and increases battery life by eliminating capacity loss at anode interface	Expected commercial production by 2024. Ramp up to 90 GWh by 2028	1,412	8,739	Volkswagen
Prologium	China	It uses a proprietary technology to produce solid state electrolyte cells. It uses conventional anode and cathode. Though cell cost will be same as liquid pack costs, the overall battery will cost 70% of the liquid batteries due to savings on thermal management. By using 100% Si anodes by 2025, the company plans to increase energy density to 900 Wh/l	Plans to set up 1-2 GWh plant in 2022	426	~2,500	NIO
Solid Power	USA	Uses Sulfide based electrolyte for high conductivity and Li-ion stability. It enables the company to produce cells with energy densities of 440 Wh/kg and 930 Wh/l. It also provides <20 minutes charging with 1,000+ cycles for battery life	Electrolyte produced is currently used to feed pilot cell line; commercial production expected by 2024	806	1,433	Ford, BMW
Ionic Materials	USA	It uses advanced polymers as separators and makes batteries extremely safe by eliminating liquid electrolyte. It has also developed a highly desirable co-extrusion manufacturing process which has potential for massive capital savings	Plan to commercialize the technology with A123 Systems in the coming 1-2 years	85	112	A123 Systems

Source: CapIQ, Pitchbook; Latest Market Cap as of 14th January, 2022

LI-METAL

DEVELOPMENT STAGE

CONCEPTUAL | EARLY STAGES | **ACTIVE DEVELOPMENT** | ADVANCED STAGES | COMMERCIALIZATION (2026)

Concept: In the battery research, the emphasis has always been on achieving higher energy density to overcome range limitations. Amongst several ideas, using Li-metal as anode has always seemed plausible. Lithium has a very low redox potential of -3.04V and very high theoretical capacity of 3,862 mAh/g. Successfully developing cells with Li-metal anodes could result in cells with energy densities of 550+ Wh/kg.

For cathode, current chemistries like LFP, NCA, NCM, etc. can be used. Advanced cathodes can be experimented with to further increase energy density, as usage of Li-metal would have resulted in debottlenecking of the capacity on the anode. However, due to a few key challenges, development of this technology has not yet reached advanced stages.

CHALLENGES

A/

Dendrite formation:

Lithium tends to form dendrites on the anode. These dendrites, growing overtime, may pierce the separator and cause short circuiting. This is the key reason of cycle life decay and safety risks with Li-metal anode.

B/

Corrosion of Anode/Dead Lithium:

Li-metal has the potential to form unstable SEI with electrolyte that leads to repeated breaking and forming of SEI during cycling. This results in generation of dead lithium and loss of electrolyte, thereby resulting in poor performance.

CURRENT STATUS:

Companies working in this area are trying to identify ways to solve the biggest challenge of dendrite formation. Leveraging physical strength/properties of solid-state electrolytes, developing in-house proprietary hybrid electrolytes, using technology and software to monitor dendrite growth formation, designing processes to reduce uneven deposition of Lithium, etc. are some of the methods that companies are attempting. Development of this technology may lead to a step jump in energy density, thus bringing down costs significantly for mass EV adoption.

TABLE 5: COMPANIES WORKING ON LI-METAL TECHNOLOGY

Company Name	Country	Innovation	Current Status/Future Plan	Raised to Date (USD mn)	Last Round Valuation/ Latest Market Cap (USD mn)	Strategic Partnerships
SES (Solid Energy Systems)	USA	Uses novel battery design and software to monitor dentride growth. It also uses proprietary electrolyte composition to address safety issues. Its Apollo batteries are expected to have the following specifications: Energy densities of 417 Wh/kg and 935 Wh/l, life around 800 cycles and 15 minutes fast charge	Plan of commercialization in 2022-23. Also, plans to complete a 1GWh facility by 2024 and 10 GWh by 2025; and further expansion to 30 GWh by 2028	521	3,600	GM, Hyundai
Sion	USA	It performs optimization of its protected lithium anode (PLA) and uses advanced electrolyte formulations to overcome challenges. Its Licerion batteries are expected have energy densities of 400 Wh/kg and 810 Wh/l. It is also expected to provide 80% charge in 15 minutes with ~800 cycles of life	Plans to license the technology; to continue to focus on technology	70	-	-

Source: CapIQ, Pitchbook

OTHER KEY BATTERY TECHNOLOGIES AND ENERGY STORAGE SYSTEMS

Apart from the battery developments mentioned, there is ongoing research on using technologies to solve for specific problems related select segments or conditions.

Innovations in battery space are also being targeted towards specific segments like 2W/3W, long-haul mobility, stationary energy storage systems, etc. or specific operating conditions like extreme climatic conditions, high usage applications like commercial applications, etc.

Some of the select technologies that are actively researched in this category include:

1/

LTO

In this technology, instead of graphite, Lithium Titanite Oxide is used as anode. With significantly superior physical properties of LTO anode, it has a much longer life of over 15,000 cycles. It also allows for significantly faster charging and discharging with its high power density and can work in harsh ambient conditions of -30 °C to 60 °C. These properties make it one of the most suitable chemistries for the regions present in the tropical belt (India, Africa, Latin America, etc.). Higher costs of LTO and lower energy density are the only challenges that prevent it for being used widely for mobility applications.

2/

SODIUM-ION BATTERIES

In this technology, energy is stored by transfer of Sodium ions. Several Sodium compounds are being experimented as cathodes. For anodes, hard carbon has been found useful. It is mainly being researched to overcome sustainability challenge related to conventional Li-ion batteries. Sodium, unlike Lithium is abundantly available and is fairly distributed across the world. Basis the prototypes developed, these batteries are expected to have a longer cycle life and higher charge/discharge rates. However, lower energy and volume density are expected to limit its usage to stationary applications.

3/

SUPERCAPACITORS

These energy storage systems do not rely on chemical reactions. They store potential energy electrostatically within them. These have high power density, but have limitation on their energy density. Thus, they can either be used in applications that require a large amount of power in a short timeframe, like train, or can be combined with batteries to create hybrid supercapacitors solution to target e-mobility applications.

4/

FUEL CELL SYSTEMS

Key research areas in fuel cells are metal-air fuel cells and hydrogen fuel cells. These can store large amounts of energy and thus have high potential in long-haul mobility and stationary applications. Development of metal-air fuel cells is in early stages with a limited number of companies focusing on it. However, hydrogen fuel cells have been gaining significant traction with developments on hydrogen economy. Details on it have been covered in the next section.

TABLE 6: OVERVIEW OF SOME OF THE COMPANIES MAKING INROADS VIA ABOVE MENTIONED TECHNOLOGIES

Company	Country	Product Innovation	Future Plan	Strategic Partnerships
Log9 Materials	India	Working on large scale commercialization of high power battery technology that offers rapid charging, long life and safe operations. Plans to leverage competency in Graphene to manufacture supercapacitors which can cater to high power applications. It has also successfully developed prototypes of products using Aluminum fuel cell (AFC) technology	It plans to achieve annual sales of 20 GWh of high power batteries, 500 MW of AFC and 20 MWh of supercapacitors by 2030	Amara Raja, Petronas
Skeleton	Estonia	Provides ultracapacitor solutions for automotive, grid, industrial and transportation applications using its patented technology of 'curved graphene'. It has capabilities of manufacturing ultracapacitors that have higher flexibility and can take different shapes	It currently has a capacity of 1 mn supercapacitors which it plans to expand to 4 mn and then 10 mn in 2 phases over the next 5-10 years	Marubeni Group
Phinergy	Israel	The company works on developing Aluminium-air technology. With this technology, energy density can increase upto 8,000 Wh/kg. This has a strong potential in long-haul mobility and stationary applications	Conducting pilots for various applications like backup storage for telecom towers, renewable energy storage, long-haul storage, etc. It looks to commercialize its products for a few of these use cases in the near term	IOCL
Form Energy	USA	The company leverages Iron-air technology to store energy in cost-effective manner for stationary applications. It works using a process the company calls “reversible rusting” in which the battery charges and discharges by converting iron back and forth into rust	Aims to reduce the system cost to 20 USD/kWh which is ~1/10th of the cost of the Li-ion technology	ArcelorMittal

Source: News articles, Investor presentations

Prospects of a hydrogen economy

The current energy economy is largely based on hydrocarbons. The larger vision of a hydrogen economy is to replace hydrocarbons with hydrogen. Unlike hydrocarbons, when hydrogen is burnt as fuel, no CO_2 is produced. Thus, hydrogen economy can be used for decarbonization. Use of hydrogen fuel cells instead of batteries in EVs is one of the many applications of hydrogen economy.

HYDROGEN SPACE IS SEEING MASSIVE TRACTION IN THE GLOBAL MARKET, ESPECIALLY IN USA

The technology to produce hydrogen using electricity (Electrolyzers) and the technology to produce electricity using hydrogen (Fuel Cells) has started making economic sense only recently. There is a lot of optimism, especially in the USA market, with respect to innovators in the hydrogen space.

TABLE 7: SELECT COMPANIES WORKING IN THE HYDROGEN SPACE

Company	Country	Focus Area/Stage/Commercialization Target	Current Market Cap (USD mn)	EV/FY25 Revenue
Plug Power	USA	• Integrated company with plans to manufacture electrolyzers, produce and distribute hydrogen. Aims to target commercial fleet vehicles, stationary power and aerospace applications • Had planned to set up 3 Plants in 2021 and 13 plants by 2025 which will produce 500 TPD of Hydrogen	13,510	4.5x
Ballard	Canada	• Operates in the fuel cell manufacturing domain. Largely targets medium and heavy duty applications • Commercialized for select applications like buses and trucks. Aims to achieve ~USD 5 bn revenues by 2030 with 20% global market share	3,274	7.3x
ITM Power	UK	• Operates in electrolyser manufacturing space • Aims to expand production capacity to 1 GW by 2022 and 5 GW by 2025	2,834	5.9x
Nel	Norway	• Manufacturers electrolyzers that produce hydrogen • Aims to bring down costs to be able to produce hydrogen at USD 1.5/kg by 2025	2,254	5.0x
Fuel Cell Energy	USA	• Turnkey solutions for design, installation and maintenance of the fuel cell systems • Aims to focus on service business and expand geographically in Asia, Europe, Middle East and the US	1,771	5.3x

Source: CapIQ, News Articles; Latest Market Cap as of 14th January, 2022

Fuel Cells vs Batteries

Fuel cells are inherently less efficient than batteries because it involves conversion of electricity to hydrogen and then hydrogen to electricity. However, fuel cells can address the range and charge time anxiety related to batteries. The cost of hydrogen generation and cost of fuel cells need to reach a critical level (like batteries did between 2010-2020: USD 1,000/kWh-USD 150/kWh) before the commercial use cases of fuel cell electric vehicles (FCEVs) can make sense.

TABLE 8: PROJECTED COSTS OF HYDROGEN AND FUEL CELLS AT GLOBAL LEVEL

	2021	2025	2030
Hydrogen (USD/kg)	4-6	3-4	2
Fuel Cell Cost (USD/kW)	1,200	900	500

Note: Fuel cell cost mentioned is estimated cost for a Bus FCEV

Fuel cells can potentially be most useful for heavy-duty long-haul mobility. These applications cannot be electrified using batteries since the dead weight of the battery becomes unfeasible for operations. Most players presented in Table 7 are focused on such heavy EV applications.

Establishing the complete ecosystem around hydrogen generation, transportation and supply are challenging tasks and we will have to wait and see how the story unfolds. In a nutshell, fuel cells are not a threat to batteries, at least over the next decade, especially in small EV platforms where they might never be able to beat batteries.

The cost of hydrogen generation and cost of fuel cells need to reach a critical level before the commercial use cases of FCEVs can make sense

FCEVs in India

The Indian automobile market is dominated by small vehicle platforms like 2W/3W/4W/LCVs. FCEVs are unlikely to make economic sense in these segments in the next decade. Long range buses and trucks can potentially see electrification in India via FCEV technology. Currently, companies are largely focusing on setting up green hydrogen plants in India to manufacture hydrogen.

FCEVs are still at a very nascent stage in India. A limited number of players are exploring this space to create component level/vehicle level solutions in India.

TABLE 9: SELECT INDIAN COMPANIES AND THEIR PLANS FOR THE HYDROGEN SEGMENT

COMPANY	DEVELOPMENT IN HYDROGEN SEGMENT
Reliance	Outlined a 1-1-1 vision to bring down the cost of hydrogen to under USD 1 per 1 kg in 1 decade. To achieve this, it plans to setup an electrolyzer factory to produce green hydrogen. Plans to have a fuel cell factory to manufacture fuel cells for e-mobility applications
Adani	The Group will invest USD 20 bn over the next decade in renewables. The Group aims to become one of the largest producers of green hydrogen globally
NTPC	Plans to set up India's first green hydrogen fuelling station in Leh, Ladakh. It is also looking to set up a pilot project for blending hydrogen for use in city gas distribution. It plans to build a 5 MW green hydrogen plant going forward
IOCL	Plans to build a green hydrogen plant at its Mathura refinery in Uttar Pradesh. It is also working on technology to develop hydrogen-spiked compressed natural gas, or H-CNG to run buses
KPIT	It is working along with Counsil of Scientific and Industrial Research (CSIR) to build prototypes of fuel-cell run vehicles. It plans to venture into manufacturing of FCEVs for mobility segment going forward
JSW Group	JSW Future Energy has entered into a strategic agreement with Australia's Fortescue Future Industries (FII) for potential projects related to the production of green hydrogen
GAIL	It has announced setting up of 10 MW hydrogen plant in the coming 12-18 months to complement its natural gas business
L&T	L&T entered into a partnership agreement with Renew Power to together work on hydrogen projects in the coming months. They together plan to invest USD 2 bn in the space
ACME Group	It plans to invite bids for setting up of 25 kW green hydrogen based pilot project in Leh. It also plans to set up a green hydrogen and ammonia plant in Rajasthan

Source: News articles

Latest news on EVs – Recent developments and transactions

New EV launches

VEHICLE NAME	OEM	LAUNCH MONTH	STARTING PRICE ('000 INR)	BATTERY CAPACITY (KWH)	MAXIMUM RANGE (KM)	TOP SPEED (KMPH)
One-Moto Electa	One-Moto	Dec-21	199	3.2	150	100
Okaya Faast	Okaya Electric	Dec-21	90	4.4	200	65
e-Ashwa EasyGoPlus	e-Ashwa Auto	Dec-21	88	1.8	110	55
e-Ashwa Cutie	e-Ashwa Auto	Dec-21	63	1.4	70	45
Earth Energy Glyde SX	Earth Energy	Dec-21	74	3.9	150	25
EeVe Soul	EeVe India	Dec-21	140	4.4	120	60
Bounce Infinity E1	Bounce	Dec-21	69	1.9	85	65
Boom Corbett 14	Boom	Nov-21	90	2.3	100	65
Boom Corbett 14-EX	Boom	Nov-21	130	4.6	200	75
Darwin D5, D7, D14	Darwin	Nov-21	68	NA	120	NA
Greta Harper, Evespa, Glide, Harper ZX	Greta	Nov-21	60	NA	100	NA
Ampere Magnus EX	Ampere	Oct-21	69	2.3	121	50
Enigma Cafe Racer	Enigma	Oct-21	NA	3.6	140	136
Aventose S110	Aventose	Oct-21	85	2.0	100	60
Mahindra Treo (Passenger) EV	Mahindra Electric	Dec-21	209	7.4	130	55
Omega Seiki Rage + Rapid EV	Omega Seiki	Nov-21	359	6.0	90	50
Euler Hiload EV	Euler	Oct-21	350	12.4	151	45
BMW iX xDrive40	BMW	Dec-21	11,590	76.6	425	200
BYD e6	BYD	Nov-21	2,916	71.7	415	130
Porsche Taycan	Porsche	Nov-21	15,000	79.2	431	230
Porsche Turbo	Porsche	Nov-21	20,800	93.4	452	260
Porsche Taycan Cross Turismo 4S	Porsche	Nov-21	17,000	93.4	452	240
Mini Cooper SE	Mini India	Oct-21	5,000	32.6	270	150

E-2Ws E-3Ws E-4Ws

'Starting Price' includes central level subsidy benefits and excludes state level benefits.

Recent news

CATEGORY	MONTH	TITLE	DESCRIPTION
Policy	Dec-21	Goa launches Electric Mobility Promotion Policy to promote EV adoption	The state government will provide subsidy to the buyers of e-vehicles, and set up charging infrastructure. The policy also includes incentives on EV manufacturing, waiver of road tax up to five years applicable to all classes of e-vehicles registered in Goa. The plan is to set up charging infrastructure at every 25 km on highways
	Nov-21	Delhi govt launches single window clearance, subsidy for e-2W charging points	Delhi government will charge only INR 2,500 to install private chargers for light EVs, including 2W/3Ws at malls, apartments, hospitals, and such other places in the city. The government will offer a subsidy of INR 6,000 to the first 30,000 applicants for the installation of EV chargers in the city
	Nov-21	Odisha government announces full tax exemption for EVs, registration fee waiver	The Odisha government has announced full exemption of motor vehicles taxes and registration fees on EVs in the state. The exemption will be applicable till December 31, 2025. The step has been taken in an attempt to encourage faster adoption of EVs
	Oct-21	NHAI targets EV charging stations at every 40-60 km on national highways by 2023	NHAI plans to cover around 40,000 km of national highways with charging stations by 2023, with almost 700 stations coming up over the next two years. The charging stations will be a part of wayside amenities to be developed by private concessionaires along greenfield expressways as well as existing highways that are being expanded
	Oct-21	Maharashtra government signs MoU worth INR 28 bn to set up EV production unit	Maharashtra Industrial Development Corporation has signed a strategic MoU with UK-based Causis E-Mobility, to set up an EV production unit in Talegaon, near Pune. Under the MoU, INR 28+ bn investment will be made and 1,250 jobs will be created. Following this, the company has also planned to set up a battery giga factory in the state
	Oct-21	Maharashtra government to buy only EVs for its use from April 2022	Maharashtra government announced that all government departments in the state will opt only for EVs if they need to procure new vehicles from April 2022. To encourage the use of EVs, government envisages to have charging stations at petrol pumps and parking lots of housing societies/single buildings
Charging Infrastructure	Dec-21	ElectriVa to install EV charging stations at 100 locations in Delhi	Electric vehicle Charging startup ElectiVa has bagged the contract for installing and operating 100 EV charging stations in Delhi. The contract has been awarded by the local urban bodies in Delhi. The company has already finished the work of installing 10 charging stations
	Dec-21	Tata Power Delhi Distribution (TPDDL) installs over 1,400 EV chargers in Delhi-NCR	With EV adoption picking up pace in Delhi, power discom TPDDL has boosted charging infrastructure by installing over 1,400 chargers across the city and neighbouring towns in the national capital region. The charging configuration is primarily deployed as per the nearby traffic movement and business potential
	Dec-21	Honda Motors sets up battery-sharing service subsidiary in India	Honda Motors has set up a battery-sharing service subsidiary in India with a capital of INR 1.3 bn. The new subsidiary will offer battery sharing service for small mobility segments, which will accelerate the penetration of EVs, and will also provide technical support to OEMs
	Nov-21	Nupur Recyclers to set up 200 EV charging points, battery swap stations	Nupur Recyclers, a metal scrap processing and recycling company announced its foray into the EV sector in India. The company will set up 200 EV charging points and several battery swapping stations in association with EVI technologies. The company will offer a battery exchange facility for e-2Ws/e-3Ws and charging facilities for e-4Ws
	Nov-21	Bounce and Park+ to set up 3,500 battery swapping stations	Mobility firm, Bounce, and Park+, an app for car users, have announced the entry into a strategic partnership to strengthen the EV ecosystem across the country by setting up over 3,500 battery swapping stations across 10 cities in India. This will be available at locations like residential societies, key parking spaces, malls, corporate offices, etc

CATEGORY	MONTH	TITLE	DESCRIPTION
	Nov-21	Omega Seiki, Charzer partners for setting up EV charging stations	Bengaluru-based EV charging infrastructure startup Charzer has joined hands with EV maker, Omega Seiki Mobility, to set up a network of 20,000 EV charging stations across India in the next two years. Charzer will deploy the charging stations across geographies where Omega Seiki Mobility clients will operate
	Nov-21	Hero Electric ties up with Charzer to set up 100K EV charging stations	Hero Electric has joined hands with Bengaluru-based EV charging startup Charzer to install 100K charging stations across the country over the next three years. The startup will deploy Kirana Charzer across Hero Electric dealerships to ease charging facility availability for consumers
	Nov-21	CESL inks MoU with Marriott International to develop EV charging units	With the aim to boost EV adoption by strengthening charging infrastructure across the country, CESL has signed an MoU with Marriott International to construct and operate EV charging infrastructure in the hotels managed, licensed and franchised by them and their affiliates in India
	Nov-21	Oil PSUs to set up 22,000 EV charging stations in the next 3-5 years	IOCL, the country's largest state-controlled refiner by capacity, will set up EV charging facilities at 10,000 fuel outlets over the next three years. BPCL said it will set up 7,000 charging stations over the next five years while HPCL has plans for 5,000 charging stations
	Oct-21	Jio-BP launches its first Mobility Station in Mumbai	Reliance Industries and BP's joint venture, Reliance BP Mobility Limited (RBML), launched their first Jio-BP branded mobility station at Navde, Navi Mumbai. Jio-BP will also set up a network of EV charging and battery swap stations at these Mobility Stations and standalone locations or Mobility Points.
	Oct-21	BP and Piaggio join up to accelerate EV revolution across Europe, India and Asia	BP and Piaggio Group plan to work together to develop and roll out a comprehensive set of services for the rapidly growing number of e-2Ws and e-3Ws across Europe and Asia. The partnership is aimed to develop integrated services such as EV charging, battery swap service stations, and vehicle leasing
	Oct-21	Log9 Materials partners with Fortum India to Develop EV charging infra	Bengaluru-based Log9 Materials has partnered with the Indian subsidiary of Finnish clean energy company Fortum to deploy public fast chargers for e-2Ws and e-3Ws in the country. The partnership will be for a duration of at least 24 months and can thereafter be mutually extended both in terms of period and scope. The vision is to make Log9's InstaCharging mainstream for EVs in India
	Oct-21	Magenta and BSES Sign MoU to Deploy EV Charging Solutions in Delhi	Magenta, an India based charge point operator (CPO) company, will be deploying innovative EV charging solutions in collaboration with BSES Rajdhani Power Limited and BSES Yamuna Power Limited. BSES has been forging partnerships to promote e-mobility in the national capital, and has also partnered with Charge+Zone to roll out EV charging stations in Delhi
	Oct-21	eBikeGo to install one lakh smart charging stations in India	eBikeGo, a smart e-2W mobility platform, has announced that they will be installing 1 lakh smart IoT-enabled charging stations in seven Indian cities. The charging stations will be installed at every 500 m in major cities. It offers pre-determined recharge plans as per user's demand and has an integrated payment mechanism

CATEGORY	MONTH	TITLE	DESCRIPTION
EV OEMs	Dec-21	Earth Energy plans to invest INR 1 bn in two years as EV demand rises	EV maker Earth Energy is looking to invest around INR 1 bn in the next two years in the EV business. The investment will go into ramping up production, technology and R&D infrastructure among others. The company plans to raise through institutional as well as strategic investors besides PE players
	Dec-21	Omega Seiki Mobility joins hands with IGDTUW to set up centre of excellence, R&D centre	EV maker Omega Seiki Mobility has partnered with Indira Gandhi Delhi Technical University for Women (IGDTUW) to set up a centre of excellence and R&D centre. Under the alliance, the company will work with the IGDTUW students on design, simulation, testing, prototyping and production of automotive components and full vehicle development for EVs, battery packs and telematics
	Dec-21	Bajaj Auto to invest INR 3 bn in EV manufacturing facility in Pune	Bajaj Auto will set up an electric vehicle manufacturing facility at Akurdi in Pune with an investment of INR 3 bn. The facility will have the capacity to produce 500K EVs per annum and will cater to both domestic and exports markets. The facility will spread over half-a-million square feet area and will employ around 800 personnel
	Dec-21	HOP Electric signs pact with Rajasthan govt to set up EV manufacturing unit in Jaipur	EV maker HOP Electric has signed an initial pact with the Rajasthan government to set up an EV manufacturing plant in Jaipur with a capacity to produce 1.8 lakh vehicles per annum. The company is also exploring similar possibilities in other states it plans to invest around INR 1 bn in these facilities
	Dec-21	Hero Electric ties up with HDB Financial Services for retail financing	Hero Electric has tied up with HDB Financial Services, to offer easy financing options for the purchase of electric scooters. The collaboration will enable customers to avail hassle-free loans with minimum documentation. The financing option will be available to Hero Electric customers across its widespread network of over 700 dealerships
	Dec-21	Hero Electric joins hands with Log9 Materials for InstaCharging battery packs	Hero Electric has joined hands with Bengaluru-based advanced battery technology company Log9 Materials to offer latter's InstaCharging battery packs for its EVs. The integration of Log9's RapidX batteries will fully charge the Hero Electric's e-2Ws within 15 minutes
	Dec-21	Olectra Greentech to set up India's biggest e-bus factory with 10,000 units capacity	Olectra Greentech, India's largest manufacturer of electric buses, is setting up the country's biggest e-bus factory with a capacity of 10,000 units near Hyderabad. The new facility is spread over 150 acres and to be set up with an investment of more INR 6 bn
	Dec-21	Omega Seiki Mobility to invest USD 200-300 mn in electric light commercial vehicle business	Omega Seiki Mobility is investing USD 200-300 mn in the e-LCV business with plans to roll out e-trucks in various payload capacities in the domestic market by this fiscal end, for the logistics sector. The company has been carrying out the R&D work for the last four years to build e-trucks in Korea
	Dec-21	Euler Motors partners with MoEVing to supply 1,000 e-3W cargo vehicle	EV maker Euler Motors has bagged an order for 1,000 units of its recently launched HiLoad e-3W cargo vehicle from MoEVing, which plans to deploy these vehicles across India. Euler HiLoad already has an order lineup of 3,500+ vehicles within 1 month of its launch, including orders from Flipkart, BigBasket and Udaan
	Nov-21	Omega Seiki launches Rage+ Rapid e-3W vehicle powered by Log9 InstaCharge battery	Omega Seiki Mobility, in partnership with Log 9 Materials has launched India's fastest charging e-3W cargo vehicle Rage+ Rapid EV. The vehicle comes along with a INR 1 lakh buy-back guarantee within 5 years after the purchase, a first-of-its-kind offering in Indian EV market. Additionally, the vehicle offers a 6-year battery warranty and 'InstaCharge on Demand', a mobile application based EV charging service
	Nov-21	Ather Energy to set up its second plant in Tamil Nadu	E-2W maker Ather Energy announced that it is setting up a second plant adjacent to its existing facility at Hosur in Tamil Nadu that will take up its total manufacturing capacity to 4,00,000 units a year from 1,20,000 at present. It will invest INR 6.5 bn over the next five years to increase its production capacity and improve operational efficiency

CATEGORY	MONTH	TITLE	DESCRIPTION
	Nov-21	TVS Motor signs MoU with Tamil Nadu govt to invest INR 12 bn in EVs and future technologies	TVS Motor would invest INR 12 bn in future technologies and EVs over the next four years. The investment mainly aims at the design, development of new products and capacity expansion in the EV space
	Nov-21	eBikeGo acquires rights to manufacture Velocipedo in India	eBikeGo has acquired the manufacturing rights for smart electric trike Velocipedo from Torrot, a leading Spanish automotive company. The Velocipedo is claimed to be the world's first smart electric trike to offer a range of 200 km on a single charge and it has a top speed of 95 kmph
	Oct-21	Ather Energy acquires rights to AiKaan's OTA platform	Smart electric scooter maker Ather Energy has obtained the rights to AiKaan platform from its OTA (Over-The-Air) partner, AiKaan Labs. AiKaan has worked with Ather Energy since inception to develop the OTA solution and deploy all OTA updates on Ather electric scooters. OTA enables its Ather 450 product line to be up-to-date with its software upgrades and feature offerings
Battery	**Dec-21**	Attero to invest INR 3 bn to ramp up Li-ion battery recycling capacity to 11,000 tonnes	E-waste recycling firm Attero is planning to invest INR 3 bn in a bid to increase its existing Li-ion battery recycling capacity by 11 times to 11,000 tonnes by the end of 2022. According to the market estimates, India generates more than 50,000 tonnes of Li-ion battery waste every year
	Nov-21	Power Global partners Rap Eco Motors to supply eZee swappable Li-ion battery tech	US-based clean energy and mobility products startup Power Global, which has a battery production plant in Greater Noida, announced a strategic partnership with Hyderabad-based e-3W manufacturer Rap Eco Motors to supply its eZee swappable Li-ion battery technology for 50,000 EVs over the next 5 years
	Nov-21	Epsilon Advanced Materials partners with C4V to supply synthetic anode material	Epsilon Advanced Materials, a subsidiary of Epsilon Carbon, has joined hands with US-based C4V for the development and qualification of large-scale supply of synthetic anode material to support C4V's domestic supply chain vision to establish a giga factory in India
	Oct-21	Power Global to invest USD 25 mn to set up battery infra facility in India	Power Global plans to invest around USD 25 mn to set up a Li-ion battery manufacturing unit and battery swapping infrastructure in India over the next 2-3 years. The company is also targeting to retrofit around 8 lakh existing conventional 3Ws in India for conversion into electric versions
	Oct-21	Exponent Energy to offer rapid charging solution for e-CVs	Bengaluru-based Exponent Energy has developed a battery pack and charging station led E-pack and E-pump that together claims to deliver a 0-100% rapid charge within 15 minutes for all commercial vehicles, irrespective of the number of wheels. It uses affordable Li-ion cells and delivering a warranty of 3,000 charging cycles
EV Customers-B2B	Nov-21	Chartered Speed to provide e-bikes powered by Adani electricity	Chartered Speed, one of India's leading surface mobility company, has announced that it will deploy over 2,000 e-bikes and 200 EV charging stations in Mumbai in the next 3-6 months. These e-bikes will be powered by Adani electricity and aimed at providing sustainable last-mile delivery solutions. The e-bikes can be accessed by delivery partners of all e-commerce, food aggregators and delivery platforms
	Oct-21	BluSmart to expand electric fleet with 3,500 Xpres-T EVs, signs MoU with Tata Motors	BluSmart Mobility, which offers an all-electric ride-hailing service, has signed an MoU with Tata Motors for expanding their fleet across Delhi-NCR. As a part of this MoU, Tata Motors will deliver 3,500 XPRES-T EVs to BluSmart Mobility
	Oct-21	FM Logistic India to deploy 500 EVs in 4 years for last-mile delivery	FM Logistic India, a 3PL service provider, is planning to deploy 500 EVs in the next 4 years for last-mile delivery. Along with last mile deliveries, the company is also looking at managing the supply chain within a city with EVs. The company is also partnering with startups to locate charging points for their EV fleet

Recent transactions

DEAL DATE	TARGET	EV SUBSECTOR	INVESTORS	DEAL SIZE (USD MN)	DEAL TYPE
Dec-21	Faradion	EV Battery	Reliance New Energy Solar	134	M&A
Dec-21	Inobat Auto	EV Battery	Amara Raja Industries	11	Strategic Investment
Dec-21	MoEVing	EV Aggregator	Individual Investors	5	PE/VC/Angel
Dec-21	Ultraviolette Automotive	OEM E-2W	TVS Motor Company, Zoho Corporation	15	PE/VC
Dec-21	OLA Electric	OEM E-2W	Temasek Holdings, Edelweiss Financial Services, IIFL Finance, VSS Investco and Individual Investors	53	PE/VC
Dec-21	Exponent Energy	EV Battery / Charging Infrastructure	3one4 Capital, YourNest VC, AdvantEdge Partners	5	PE/VC
Dec-21	Charge+Zone	Charging Infrastructure	Venture Catalysts	10	PE/VC
Nov-21	Simple Energy	OEM E-2W	Salarpuria Sattva Group, Athiyas Group and Individual Investors	21	PE/VC
Nov-21	Euler Motors	OEM E-Cargo	QRG Investments and Holdings, ADB Ventures, Blume Ventures, Inventus Capital, Jetty Ventures, Kailash Trust	10	PE/VC
Nov-21	3EV Industries	OEM E-3W	Undisclosed	2	PE/VC
Nov-21	ElectricPe	Charging Infrastructure	Blume Ventures, Micelio Fund and Individual Investors	3	PE/VC
Nov-21	Battery Smart	Charging Infrastructure	Orios Venture Partners, Blume Ventures, Baring Private Equity, Green Frontier Capital and Individual Investors	4	PE/VC
Oct-21	Emotorad	OEM E-2W	Individual Investors	3	PE/VC/Angel
Oct-21	Sun Mobility	Charging Infrastructure	Vitol Holding	50	Strategic Investment
Oct-21	Tata Motors EVco.	OEM E-4W	TPG Capital, ADQ	1,000	PE/VC
Oct-21	Log9 Materials	EV Battery	Petronas Ventures	2	PE/VC
Oct-21	Twenty Two Motors	OEM E-2W	Bounce	5	M&A
Oct-21	KWh Motors	OEM E-2W	Capita India, LetsVenture and Individual Investors	2	PE/VC
Oct-21	Blu-Smart Mobility	EV Aggregator	BP Ventures, Mayfield India, 9Unicorns, Survam Partners	20	PE/VC
Oct-21	Zypp Electric	EV Aggregator	9Unicorns, Anthill Capital Ventures, Dholakia Ventures, RiSo Capital	7	PE/VC

Contact

Koushik Bhattacharyya

EXECUTIVE DIRECTOR
E-mail : koushik.b@avendus.com
Mob : +91 99676 06839

Amol Deorukhakar

ASSOCIATE VICE PRESIDENT
E-mail : amol.deorukhakar@avendus.com
Mob : +91 80972 50652

Sumit Agarwal

ASSOCIATE
E-mail : sumit.agarwal@avendus.com
Mob : +91 80743 40782

Rohit

ASSOCIATE
E-mail : rohit@avendus.com
Mob : +91 96481 07705

Disclaimer

This document is being furnished to you by Avendus Capital Private Limited for itself and its affiliates strictly on a confidential basis.

The document is for informational purposes only and should not be regarded as an offer to sell, or offer for subscription, or as a solicitation of an offer to buy the securities or other investments mentioned in it. This information profile has been provided to its recipient upon the express understanding that the information contained herein, or made available in connection with any further investigation, is strictly confidential and is intended for the exclusive use of its recipient. It shall not be photocopied, reproduced and/or distributed to others at any time without prior written consent.

This document is neither a prospectus nor an invitation to subscribe to securities or other investments. Nothing in this document is intended to constitute legal, tax, securities or investment advice, or opinion regarding the appropriateness of any investment, or a solicitation for any product or service. The information herein is subject to change without notice. Avendus Capital Private Limited does not represent that any information, including any third party information, is accurate or complete and it should not be relied upon without proper investigation on the part of the investor/s.

Neither Avendus Capital Private Limited nor its affiliates nor any of its officers or employees accept any liability whatsoever for any direct or consequential loss arising from any use of this publication or its contents. The recipient of the material should rely on their own investigations and take their own professional advice. While we endeavor to update on a reasonable basis the information discussed in this material, there may be regulatory, compliance, or other reasons that prevent us from doing so.

Investments in securities/equity related instruments are subject to market risk. These risks could be security specific or market specific and arising from company, industry, political, economic (both domestic and global), etc, factors. Investor/s should carefully read all disclosure documents before investing and shall not make Avendus Capital Private Limited and/or its associates/employees liable for any risks/losses pertaining to any product/scheme offered by them from time to time.

Past performance does not indicate the future performance of any current or future fund or strategies advised or managed by Avendus Capital Private Limited or its affiliates.

Distribution of this document in some jurisdictions may be restricted or prohibited by law and regulation, and accordingly recipients of this document represent that they are able to receive it without contravention of any unfulfilled registration requirements or any other legal or regulatory restrictions. Recipients of this document in such jurisdiction should fully inform themselves about and observe all applicable legal or regulatory requirements and Avendus Capital Private Limited and its affiliates, directors, shareholders, managers, officers, employees, agents and advisors, do not accept any liability to any person in relation thereto.

For the purposes of distribution within the United Kingdom, this communication is exempt from the financial promotion restriction in Section 21 of the Financial Services and Markets Act, 2000 relating to the communication of an invitation or inducement to engage in investment activity on the grounds that it is made to those persons falling within the following Articles of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005, as amended: Article 19 (Investment Professionals) and Article 49 (High Net Worth Companies). Any investment to which this communication relates is only available to investment professionals and high net worth companies

If you have received this document and you are not the person for whom it is intended, you should not rely on this communication or act on it.

Avendus offices

MUMBAI

BENGALURU

DELHI

KOLKATA

AHMEDABAD

PUNE

LONDON

NEW YORK

HYDERABAD

SINGAPORE