

Lithium-Ion Battery (LiB) Manufacturing Landscape in India

Market Trends and Outlook

Executive Summary

The Government of India's Make in India initiative, aimed at promoting India as the preferred destination for global manufacturing, has helped industries such as pharmaceuticals and apparel carve a niche. However, when it comes to intermediate industries such as batteries, specifically lithium-ion batteries (LiB), India is still dependent on imports.

Considering that LiBs are in huge demand (~80 per cent) from the automotive industry for electric vehicles (EVs) and India is expected to be the world's third-largest automotive market by 2026,¹ LiB manufacturing requires immediate attention. Add to this the Government of India's target of 30% of new vehicle sales to be electric by 2030 and 34 gigawatts (GW)/136 gigawatt-hour (GWh) of battery storage needed to add 450GW of renewables in India by 2030, according to the Central Electricity Authority (CEA). India is therefore poised to become a key LiB consumer.

This report estimates that the annual capacity addition of LiB for automotive applications will increase from 2.3GWh in FY2021 to 104GWh by FY2030 and for non-automotive applications from 0.3GWh to 12GWh. So, 90 per cent of the total LiB demand will be driven by automotive applications on the back of favourable government policies including Faster Adoption and Manufacturing of Hybrid & EV (FAME) and various state-level EV policies. The demand for LiB in the non-automotive segment will be driven by telecom towers, data centres, and grid-scale renewable energy (RE) integration and rooftop solar (RTS),

**Ninety percent of
the total LiB demand
will be driven by
automotive applications.**

¹ Invest India. [Running in the top gear.](#)

followed in turn by newer applications including materials handling equipment and power tools.

The report also tracks the journey of battery adoption in India – lead-acid (LA) batteries, initially used in automotive and non-automotive applications, were superseded by LiB a few years ago. This was encouraged by the mushrooming of battery pack players from the industry's end with an initial investment in assembly set-up a mere US\$1.3m. In addition, government support allowing 100% foreign direct investment (FDI) and mandating manufacture of battery packs in India increased the growth. The same, however, has not been true for the key component of battery packs – cells. Until now, India was completely dependent on imports of cells from neighbouring countries like China owing to the unavailability of key raw materials and technological know-how. This led battery pack assemblers to bear the brunt of high cell prices, hoarding of cells in the hands of a few Chinese suppliers, availability of lower-grade cells, and non-availability of cells that can withstand higher temperatures specific to India.

**Cell manufacturing costs
in India in 2020 were
the lowest among
the U.S., Europe, even
China and South Korea.**

Identifying this gap, the Government of India has now brought to the fore its focus on manufacturing of cells in India through the likes of the Production-Linked Incentive (PLI). This is expected to bring in huge investments of ~US\$2.2b for a cumulative lithium-ion cell manufacturing capacity of more than 30GWh. There are various compelling reasons for cell manufacturing in India. Cell manufacturing costs in India, as of 2020, were projected to be the lowest (US\$92.8/kWh) when compared with the United States, European nations and even China (US\$98.2/kWh) and South Korea (US\$98.1/kWh). Similarly, India has huge cost opportunities in terms of cheap labour and power (gross monthly minimum wage levels in India in 2019 were US\$65 against US\$217 in China). On the demand side, falling battery prices and initiatives including the FAME scheme are encouraging EV adoption in India. For now, India is likely to import all the raw materials required for cell manufacturing but can lower this dependency by entering into long-term contracts with raw material suppliers or acquiring some assets in mineral-rich nations. Local capabilities are also slated to be built up gradually. Local manufacture of graphite precursor material has already started.

This report also highlights the challenges for the battery pack and cell manufacturing industry in India. End-use customers are wary of the battery pack

and battery management system (BMS) quality offered by local assemblers and hence safety issues arising out of this. Battery pack assemblers find the market unprofitable owing to single-digit EBITDA margins. In addition, cell manufacturing, though a lucrative opportunity, is laced with challenges ranging from unavailability of key raw materials to requirement of huge investments and absence of technological know-how. The report therefore suggests battery recycling as one of the alternate solutions to meet surging LiB demand. It will result in recovery of 90 per cent of lithium, cobalt, nickel, manganese, and graphite and put India on the path to a circular economy.

Overall, however, as India already has huge cost advantages in battery assembly and software-driven BMS capabilities, it can also realise significant benefits through a vertically integrated value chain once lithium-ion cell manufacturing booms. For cell manufacturing and battery pack assembly, the future looks promising in India with the proviso that issues like battery standardization and battery safety issues are addressed and the industry and government work in sync.

Table of Contents

Executive Summary	1
1. Introduction	5
2. LiB Market Size in India	5
2.A LiB Applications	6
3. Key Players in the LiB Market in India.....	10
3.A Planned Investments.....	12
4. Market Drivers	14
4.A Government Policy Initiatives.....	14
4.B No Significant Entry Barriers for Battery Pack Manufacturers	18
4.C Low Manufacturing Costs in India	18
4.D Falling Battery Prices.....	19
5. LiB Manufacturing in India – Current Capabilities & Future Needs	20
5.A Current Manufacturing Capabilities Along the Value Chain	21
5.B Need for LiB Manufacturing in India	23
6. Risks and Challenges	26
6.A For Battery Pack Manufacturers	27
6.B For Cell Manufacturers.....	27
6.C For OEMs	28
7. Conclusion.....	28
8. Annexure	30
About the Authors	33

1. Introduction

The demand for lithium-ion batteries (LiB) in India has been driven by portable applications (consumer electronics like mobiles, laptops, video cameras etc.), stationary energy storage applications, and electric vehicles (EVs). The majority (~80 per cent) of LiB demand is from EVs while 20 per cent is from non-automotive applications (mainly energy storage).

Until a few years ago, the Indian automotive and non-automotive markets were driven by lead-acid (LA) batteries. Players like Exide and Amara Raja ruled the consolidated battery market. However, considering the higher charging efficiency, longer service life, lower weight, and lower maintenance costs of LiB vis-à-vis LA, the Indian telecom and EV markets started using LiBs. Realising the demand potential for LiBs in India, some medium-sized companies started assembling lithium-ion cells locally. These cells are assembled in series/parallel combinations to form a battery module, to be stacked to make a battery pack.

Several small players, including some completely new to the battery sector, soon joined the LiB bandwagon chiefly to serve the mushrooming industry of electric three-wheelers (E3W) and electric two-wheelers (E2W).

Battery packs have been assembled in India for many years and, though cell manufacturing has started, it has not yet been commercialized so cells still are imported. Some companies in India also import pre-assembled battery packs.

Major reasons for the dormancy of India's domestic LiB manufacturing are that key raw materials (lithium, cobalt, nickel) are unavailable, research and development (R&D) on cell technology is inadequate, and large-scale investments are limited. However, amid the ongoing challenges of geo-political tension with China and high logistics cost, and with drivers such as government initiatives for EV adoption and cell manufacturing, the LiB industry is considering cell manufacturing as a serious proposition and is working towards that. It has turned out to be a lucrative opportunity for the existing battery pack players as well as the EV manufacturers/small-scale solar stationary providers and some big players who are completely new to the industry. Suzuki (the parent company of Maruti Suzuki, the largest car maker in India) partnered with global players Toshiba and Denso, while TVS Lucas (automotive component provider) partnered with US-based 24M Technologies for cell manufacturing. Hyderabad's GODI, an entirely home-grown new player, has just produced its first LiB set.

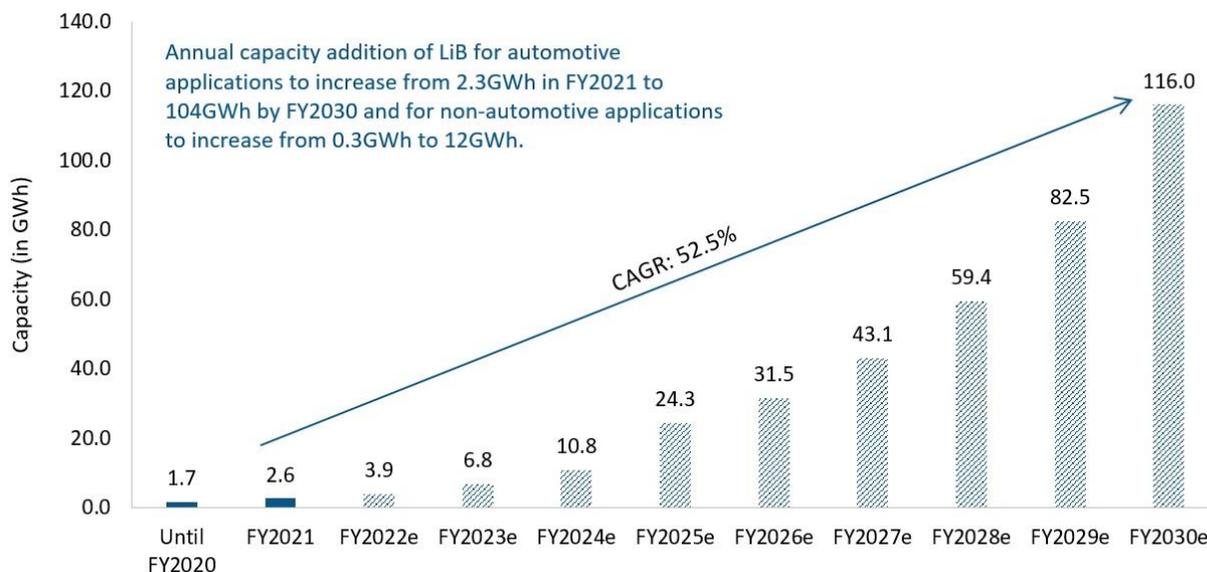
2. LiB Market Size in India

The introduction of LiB has revolutionised numerous sectors, most prominently the EV industry. The adoption of LiB is accelerating in India as depicted in the figure below.

JMK Research estimates that the annual LiB market in India will reach 116GWh in 2030, with EVs accounting for ~90 per cent of the overall market on the back of huge government targets of adding variable renewable energy sources to the grid.

This will lead to higher use of energy storage solutions, a push towards electric mobility and increasing consumer demand for EVs.

Figure 1: LiB Annual Additions in India, GWh



Source: JMK Research.

Assumptions to calculate market size:

1. The total market size includes current and forecast market size for both automotive and non-automotive applications. The non-automotive segment includes grid-scale RE, rooftop solar (RTS), telecom towers, uninterrupted power supply (UPS), solar streetlights, etc.
2. For EVs, the battery size of two-wheelers taken is 2kWh, three-wheelers (e-rickshaw and e-auto) 5kWh and 10kWh respectively, four-wheelers 40kWh and buses 250kWh.
3. Total sale of EVs is estimated to increase from 1.1 million in FY2021 to 17.8 million by 2030.

2.A LiB Applications

Currently, the end-use applications creating demand for LiB include the following:

Automotive

LiBs have become an integral part of the EV ecosystem. The Government of India has set a target of electrifying 30 per cent of private cars, 70 per cent of commercial vehicles, 40 per cent of buses, and 80 per cent of two- and three-wheelers by 2030.² Add to that, the creation of favourable policies by the central government such as the Faster Adoption and Manufacturing of Hybrid & EV (FAME) scheme Phase-II (FAME-II), which offers incentives to EV buyers to boost EV adoption in India.

² The Hindu. Aim to have 30% of 2030 car sales as EVs. October 2021.

- Currently, about ~85 per cent of E2Ws in India operate on LiB.
- Only 10 per cent of E3Ws use LiB. The remainder run on LA batteries.³
- Electric cars and electric buses (E-buses), on the other hand, only use LiB.

Non-Automotive

LiBs are expected to play a crucial role in other applications. As demand for variable renewable energy sources such as solar and wind keeps growing, there will be an increasing need to store the excess energy to improve the flexibility of these sources. And LiBs are preferred due to their higher charge/discharge rates and higher cycle life. With Reliance's mobile towers using ~100 per cent LiB and other telecom operators also rapidly adopting LiBs in their towers, the demand for these batteries is bound to increase. All new data centres in India have shifted to LiBs for power backup instead of LA batteries, further increasing demand.

The non-automotive market, presently dominated by the telecom segment, is represented by lithium iron phosphate (LFP) in terms of battery chemistry. LFP batteries are based on a prismatic form factor for large storage applications, and cylindrical cells for small storage applications of below 1 kilowatt hour (kWh) such as solar streetlights.

Some of the major applications in the non-automotive segment are:

Telecom Towers

The primary reason for telecom tower companies to adopt LiB is to minimize diesel-use amid economic and environmental pressures. Theft of diesel generators in some regions has led telecom companies to look for generator-free options. Further, advent of 5G technology will require mini-towers and hence mini-cells, which will require small battery packs that fit in smaller spaces and are easily replaceable. Lithium-ion cells can offer that solution.

The increasing number of towers will require fresh LiB installations. Secondary demand will arise due to LiBs that will need to be replaced by 2025 in towers that were installed before 2019.

Uninterrupted Power Supply (UPS)

The UPS market in India is expected to grow by ~10 per cent y-o-y on the back of simultaneous growth in demand for power vis-à-vis the availability. The growing demand for digitization along with increasing requirement for power backup in the commercial and industrial sectors is expected to drive this. The highest demand for UPS is expected to be from healthcare and data centre applications.

At about half the size and less than a quarter of the weight of LA batteries, as well as having a higher cycle life of 2,500 compared to ~300 for LA technology, LiBs are regarded as the batteries of the future.

³ Stakeholder Consultation.

Grid-scale Renewable Energy Integration (RE)

Batteries are expected to play a major role in increasing the flexibility of RE systems. As of March 31, 2021, India has installed about 30 megawatts (MW) of solar with 19.27MWh of grid-scale battery storage projects, according to JMK Research. This includes a 10MW/10MWh solar+battery storage project in Delhi and a 20MW/8MWh solar+battery storage project in Andaman & Nicobar Islands.

The grid-scale battery storage market in India is still a few years away. The high cost of LiBs is more apparent in this market owing to large-scale energy storage requirements.

Nevertheless, with the ongoing pace of RE capacity addition in India, the scope for LiB-based grid-scale storage continues to widen. To “flatten” the varying RE-integrated power supply curve to ensure stability of the grid, it is necessary to have a reliable battery energy storage system (BESS) that can store surplus renewable power and later, inject firm power into the electricity network. Solar and wind projects in India now require ever-increasing amounts of battery storage to meet the generation needs of multiple peaks during the day.

The power utilities’ concern for grid balancing and security will drive the demand for BESS-supported RE projects, with the objective of firming-up RE power.

Many new RE tenders issued in India are now either for **peak power supply or round the clock (RTC) power generation**. In all such tenders, storage is imperative to maintain the capacity utilization factor (CUF) requirement of the plant.

- In September 2019, a solar tender of 1200MW was awarded to manage peak power supply for nine hours per day (morning peak 6-9am and evening peak from 6-12pm), at a peak tariff of Rs6.3/kWh (USD0.09/kWh). The annual CUF requirement for the tender is 41%.
- In April 2020, an **RTC tender of 400MW** with storage for an annual CUF requirement of 80% was awarded.
- Auctions were also concluded for another significant **RTC II tender of 2,500MW of RE+thermal**.
- Apart from peak power supply and RTC tenders, recently Solar Energy Corporation of India (SECI) also awarded a big 100MW solar with 120 MWh battery storage in Chhattisgarh to Tata Power.⁴

With the need for an assured RE-integrated power supply bound to grow significantly in the future, lithium-based BESS will become critical in this market segment.

⁴ PV Magazine, [Tata Power awarded India’s largest solar and battery storage project](#), December 2021.

Rooftop Solar (RTS)

A vast majority of operational distributed (On-site/Rooftop) solar-plus-storage projects utilize the LA battery system as their storage component. LiB technology has only emerged recently in the distributed solar market.

In light of restrictive measures by many state-run utilities on net-metering and electricity banking in the grid, which essentially restrict the “buying” and “storing” of surplus energy, there are increasing opportunities for the rooftop solar-plus-BESS market.

In the diesel replacement sub-segment, distributed solar-plus-storage has a potential of ~100GW (which is equivalent to the latent capacity of diesel generators in India).

Consumer Electronics

The increasing use of LiBs in smartphones, laptops, and elsewhere is driving LiB growth across the globe. Historically, consumer electronics have dominated the battery market, guiding innovation in technology design and configurations. Projected growth for consumer electronics is not as high as EVs, yet the Indian appliances and consumer electronics market is expected to double in the next two to three years, reaching Rs2 trillion (US\$27b), according to Consumer Electronics and Appliances Manufacturers Association (CEAMA).⁵ Given the linear dependence of consumer electronics on LiBs, these batteries have a major role to play in realising these projections.

Material Handling Equipment

In India, the concept of automated MHEs or Automated Guided Vehicles (AGVs) is new and its acceptance has picked up in the last couple of years. The COVID-19 pandemic demanded safety and contactless operations while also leading to a shortage of manpower, which in turn created scope for AGVs. In addition, the pandemic changed the consumer buying behaviour, triggering massive online purchasing. This provided a fillip to already booming e-commerce and led the Indian e-commerce giants to introduce robot-based sorting technologies including AGVs.

Power Tools

LiBs are used in bandsaws, drills, and crimpers. The strengths of LiB for power tools include ease of use, longer run times, flexible charging, and fewer short circuits. In addition, the battery will not discharge if stored for an extended period.

To serve the power tool applications, LiBs have been modified to operate at high discharge rates. So, while the standard LiBs have 1C or even lower discharge rate, high-power LiBs typically possess 10C or higher C-rate.⁶

⁵ Business Standard. [Appliances, consumer electronics industry to touch Rs 2 trn worth: CEAMA](#). October 2021.

⁶ The charge and discharge current of a battery is measured in C-rate.

3. Key Players in the LiB Market in India

Of the total cost of LiBs, cells account for 65 per cent, the battery pack 15 per cent, BMS 15 per cent, and the balance being the outer box.⁷ To date, battery pack and associated BMS manufacturing have entirely dominated the space in India. Indian manufacturers are able to produce most of the sub-components that go in a battery pack viz-a-viz copper harness, terminal, non-reactive glue, and outer casing, while thermal pads still need to be imported. Similarly, BMS and outer box are also primarily supplied by the Indian battery pack assemblers only. However, since India does not have BMS manufacturing components, it sources pre-programmed protection circuit board (PCB) from China and undertakes printing in India.

The LiB pack manufacturing market in India is fragmented and comprised of numerous active players including Coslight India, Okaya, Exicom, followed by Trontek, Amptek, Cygni, Grinntech, Lohum Cleantech, Pure EV etc.

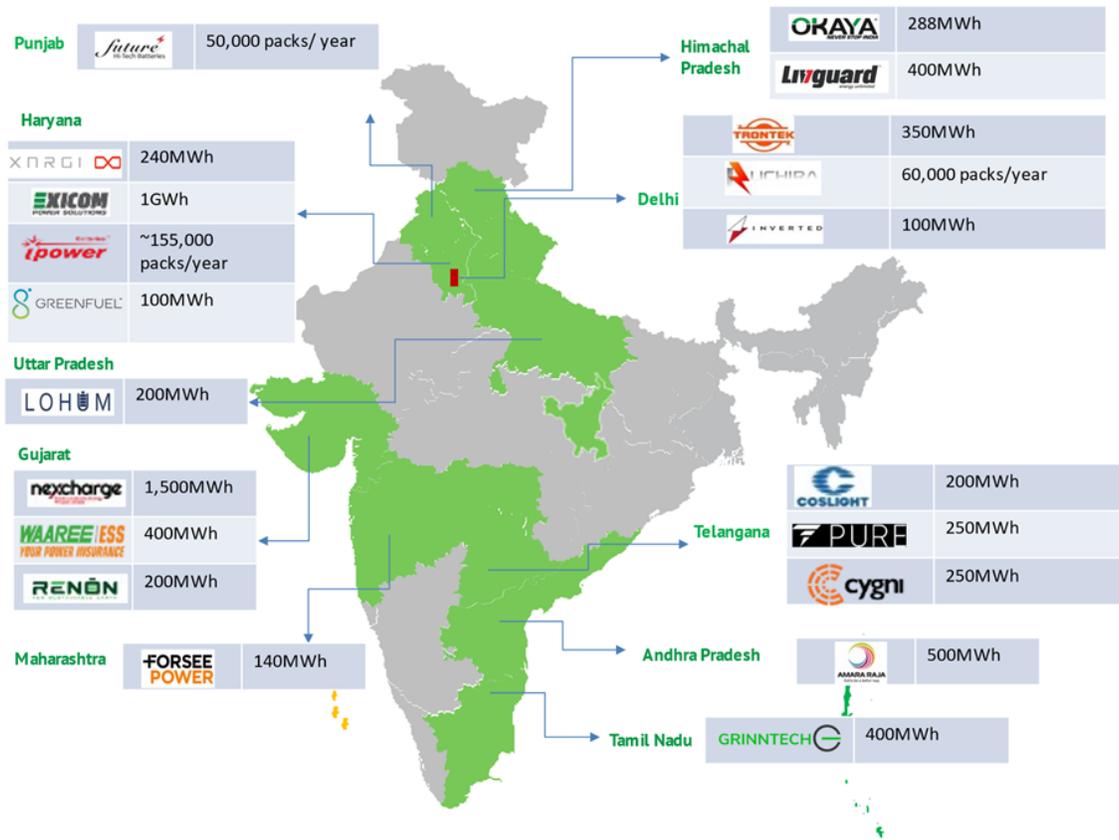
- In terms of battery chemistry, the LiB pack industry has been serving E2W and E3W OEMs as well as stationary markets with a mix of LFP and Nickel Manganese Cobalt (NMC) batteries. While NMC is used in E2Ws and e-cars, LiB-based E3Ws are powered by LFP-type cells. In addition, Indian E2W OEMs like Okaya have increasingly used LFP in their new models. However, EVs worldwide primarily use NMC chemistries. China, an exception, sticks with LFP chemistry for its e-buses, e-bikes, and cheaper cars (refer Table 1 in Annexure).
- The majority of players have been serving both the EV and stationary markets with LiB packs with prismatic form factor, owing to its ease of assembly and better volumetric efficiency (i.e., more energy in smaller size) when compared to cylindrical cells.

Even though the industry is unorganised, it has existing capacities of nearly 5.5GWh (refer Figure 2), a figure expected to double in the next 18-24 months. Companies like Coslight India and Pure EV will primarily serve their captive EV units with the planned battery capacities, while others will continue serving EV and stationary storage clients.

The following graph shows the existing capacities and geographic spread of some of these key battery pack manufacturers.

⁷ Stakeholder consultation.

Figure 2: Existing Capacities of LiB Battery Pack Manufacturers



Source: Industry News Articles, Interview Insights, JMK Research.

Note: Other prominent players include Pastiche Energy Solutions (P) Ltd. (Panchkula, Haryana), Fusion Power Systems operating under the 'Amptek' brand (Gurugram, Haryana; New Delhi), CTech (IMT Manesar, Haryana), Maxvolt (Noida, Uttar Pradesh) Vision Mechatronics (Pune, Maharashtra) and Aqueouss (Delhi).

As Figure 2 shows, investments in battery manufacturing are concentrated in the northern region. The southern region has fewer investments, with Amara Raja and Grinntech the only big players followed by Coslight India for its telecom clients.

Gujarat shows promise, with huge capacity installations by companies like Exide-Leclanché, Waaree, etc. The state is home to India's first cell manufacturing project by Toshiba Denso Suzuki Lithium-Ion Battery Gujarat Private Limited (TDSG). ReNew Power and Tata Chemicals have plans to enter the battery manufacturing and cell manufacturing domains respectively. Tata Chemicals has bought land in Dholera, Gujarat, though at the time of writing no decision had been taken regarding battery/cell manufacturing.

In the south, Tamil Nadu, which until now had only Grinntech, has planned capacity of ~2,000MWh in the coming years.

Eyeing huge progress in the battery pack manufacturing segment, the government

and industry alike relish the next step of value chain, cell manufacturing. In fact, the industry has already witnessed the manufacture of cells by TDSG and homegrown battery manufacturer GODI.

- **TDSG:** The JV has earmarked a ~Rs49 b (\$690m) corpus to build its lithium-ion battery manufacturing plant in Gujarat’s Hansalpur spread over five years to 2025. The JV already invested Rs12.1bn (\$170m) in the first phase (2018-20) of production and plans to manufacture 30 million LiB cells per year by 2025, with a production capacity of more than 1GWh. The cells, with LTO as cell chemistry, will primarily be exported, say industry sources.
- **GODI:** The company, set up in 2019, has a manufacturing capacity of 100MWh and plans to scale this up by building a 5GWh factory within the next three years. GODI announced its plans of setting up supercapacitor and LiB cell manufacturing facilities in India in July 2021, producing the first batch of commercial grade NMC 21700 Li-ion cells in January 2022. The cells, meant for use in E2W, E3W, and electric four-wheelers (E4W), will soon be available for testing and validation to OEMs and bulk deliveries are expected in late 2022.

3.A Planned Investments

Nearly US\$1800m investments are already planned by leading players in the LiB manufacturing space in India. Key announcements by various players include:

Table 1: Key Planned Investments in the Indian Battery Manufacturing Space

Company	Investment (in US\$m)	Planned Capacity	Plant Location
Qmax Ion Private Ltd	660	500MWh	Thiruporur, Chennai
Coslight India	330	240MWh	Una, Himachal Pradesh
Ruchira Green Earth	260	120,000 packs per annum	Haryana
Power Global	240	1,000MWh	Greater Noida, Uttar Pradesh
Li Energy	130-200	1,500MWh	Thondi, Tamil Nadu
Cygni Energy	130	750MWh	Hyderabad, Telangana
Pure EV	N/A	2,400 MWh	Telangana
Forsee Power	N/A	1,000MWh	Pune, Maharashtra

Source: Industry News Articles, Interview Insights, JMK Research.

Note: ReNew Power has announced a plan to invest Rs40,000m (US\$526m) for a LiB plant.

Existing battery pack manufacturers like Amara Raja and Exide, which are also the top lead acid battery manufacturers in India, have already announced their plans to start lithium-ion cell manufacturing.

The lucrative cell manufacturing business is not just attracting India’s existing battery manufacturers but also companies from automotive component

manufacturing, like Lucas TVS and Denso, and automobile manufacturing, like Suzuki Motor Corporation, the parent of Maruti Suzuki, the largest carmaker in India.

Following the announcement of the revised PLI ACC scheme, the likes of Adani Group, Larsen and Toubro Ltd (L&T), Bharat Heavy Electricals Ltd. (BHEL), and Reliance Industries Ltd., with interests in diverse fields and no previous experience in battery manufacturing, have also shown interest in investing in cell manufacturing in India. The only concrete plans shared to date are for Reliance's gigafactory in Jamnagar, Gujarat, the group having invested in Ambri Inc, an energy storage company based in Massachusetts, U.S.

Analysing the data available currently, India will witness investments of Rs160 billion (~US\$2.2bn) for a cumulative lithium-ion cell manufacturing capacity of more than 30GWh. Given the Indian Government's target of reaching a cell manufacturing capacity of 50GWh by 2030 and the incentives under the PLI ACC scheme for the same, Reliance's plans can greatly aid in achieving the target.

Planned Investments & Capacities of Lithium-ion Cell Manufacturers

- Lucas TVS & 24M Technologies, Inc.: Indian auto-components manufacturer Lucas TVS has partnered with US-based 24M Technologies to manufacture semi-solid cells based on 24M's technology near Chennai, Tamil Nadu at an investment of Rs25bn (US\$343m). The 10GWh capacity plant will be built in two stages and cell production is expected to begin in the second half of 2023.
- Amara Raja: will invest Rs74bn (US\$1bn) for a 10-12GWh facility under the ACC PLI Scheme over five to seven years.
- Exide: plans to set up a greenfield multi-gigawatt lithium-ion cell manufacturing facility in India to participate in the ACC PLI scheme.
- C4V: CCCV LLC (C4V), a US-based LiB technology company signed an MoU with the Karnataka government, to build a cell manufacturing gigafactory, with an investment size of Rs40.15bn (US\$538m). The company plans to set up a 5GWh plant, with work expected to begin in early 2022.
- Greenko Group & ChargeXO: battery manufacturer ChargeXO and renewable energy firm Greenko plans to invest Rs20b (US\$276m) in about 100 acres in the Mahabnagar energy park of Hyderabad, Telangana to build a cell manufacturing unit.
- Li Energy: renewables and energy storage outfit plans a pilot line of 150MW of LFP cells, eventually scaling up to 5GWh.

Further up the value chain, Epsilon Advanced Materials Private Limited (EAMPL) has plans to manufacture synthetic graphite (which serves as anode material in cells) as well as far-sighted plans to manufacture cathodes. EAMPL is already manufacturing bulk carbonaceous mesophase – anode precursor material that goes

into synthetic graphite – with a capacity of 2,500 tonnes per annum, and it had planned to expand to 15,000 tonnes by the end of 2021. It has received orders for its anode precursor material from two leading anode makers in Japan and China. EAMPL will be the first company in India to have initiated manufacturing of synthetic graphite of ~40,000 tonnes with plans for investment of Rs20,000m (US\$271.4m).

Some other key investments, where more than one step of the value chain is involved, include:

- Lohum Cleantech has announced plans to invest Rs3,000m (US\$40.2m) in a 1GWh battery pack plant and a recycling plant. In addition, the company is planning to set up a smaller recycling unit in Kandla, Gujarat.
- Grinntech will expand its existing Ambattur, Chennai-based facility with 400MWh for LiBs and BMS with lead time of three months.
- Li Energy purchased 125 acres of land in Thondi, Tamil Nadu for the development of a Special Economic Zone (SEZ) and lithium-ion manufacturing facility. It plans to set up a lithium-ion prismatic battery assembly and pack line with an annual capacity of 1.5GWh in early 2022. Phase-2 will include LFP cell manufacturing up to 5GWh.

4. Market Drivers

The Indian battery manufacturing market is making great strides on the back of policy initiatives introduced by the central and state governments and the inherent low-cost manufacturing advantages offered in India, which are discussed in the following sections.

4.A Government Policy Initiatives

4.A.1 Central Level

The Government of India has set an ambitious target for 2030: 30 per cent of new vehicle registrations to be electric⁸ and 450GW of renewables. To address this, it has focused its efforts on developing the value chain for the most important component of a battery, i.e., cells, and is encouraging local manufacturing of lithium-ion cells.

- In the same vein, the Indian Government doubled import duty on lithium-ion cells to 10 per cent from April 2021.
- The PLI ACC scheme announcement to encourage domestic production of cells is also a step in that direction. Lucas-TVS/24M Technologies has announced plans to start commercial production of lithium-ion cells by the second half (H2) of 2023, while TDSG, the joint venture (JV) between

⁸ CSE. [India's policies and programmes on electric vehicles are "a case of missed opportunities"](#), says CSE. September 2021; IEA. [EV30@30 Campaign](#). June 2021.

Toshiba, Denso, and Suzuki started commercial production of cells in December 2020. GODI also recently announced it is manufacturing the first batch of commercial grade NMC 21700 Li-ion cells at its facility in Shamshabad, Hyderabad.

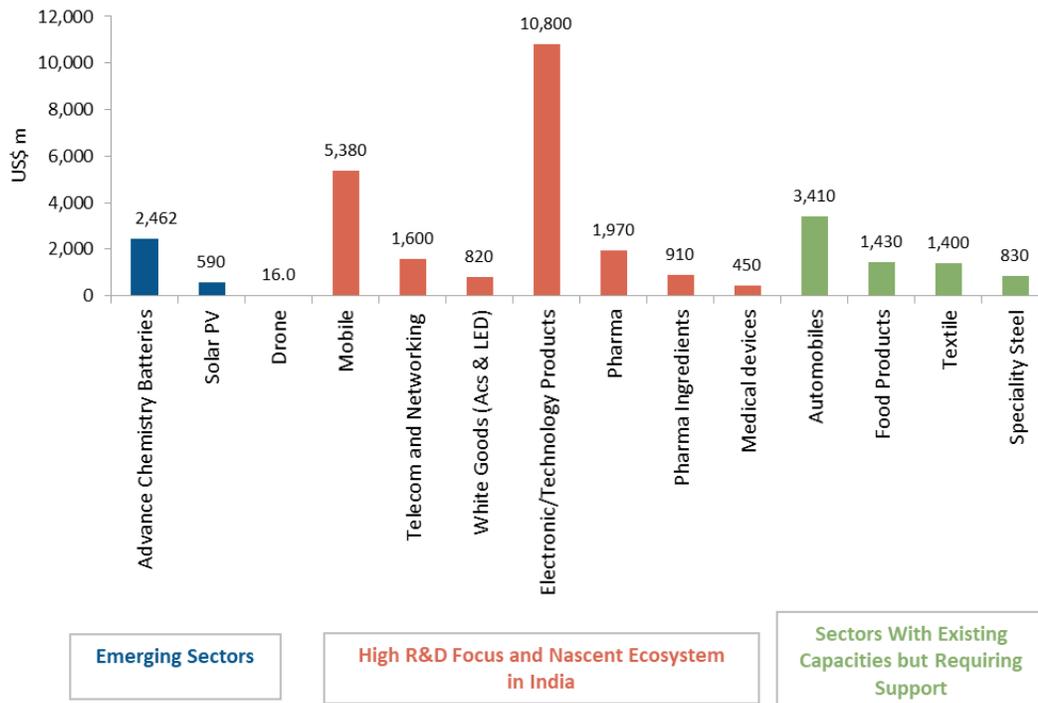
The government had already introduced measures to encourage manufacturing of battery packs in India.

- It trebled import duty on assembled battery packs to 15% from April 2021.
- Similarly, the requirement for EV manufacturers to assemble the traction battery packs locally to gain FAME-II incentives led to the proliferation of battery pack assemblers in India.

Production Linked Incentive (PLI) Scheme

The PLI scheme, introduced by the Government of India, offers incentives in 14 key sectors (including drones). This includes financial allocations of Rs181,000m (US\$2,461.6m) for Advanced Chemistry Cell (ACC) batteries under the National Programme for Advanced Chemistry Cell (NPACC) and Rs259,380m (US\$3,410m) for automobiles and auto components with an emphasis on promoting local manufacturing.

Figure 3: Fund Allocation Under PLI



Source: Press Information Bureau, Government of India.

The Government of India expects huge investments of over Rs450,000m (US\$6,120 m) for the planned 50GWh capacity under the PLI ACC scheme.⁹ The scheme will help in achieving manufacturing capacity of 50GWh of ACC and 5GWh of “niche” ACC.

The process of bidding has already started under the PLI ACC scheme. A total of 10 companies submitted their bids for ~130GWh on 14th January 2022 under ACC for which Request for Proposal (RFP) was released by the Ministry of Heavy Industries (MHI) on 22 October 2021. The 10 bidders are:

	Reliance New Energy Solar Limited
	Hyundai Global Motors Company Limited
	Ola Electric Mobility Private Limited
	Lucas-TVS Limited
	Mahindra & Mahindra Limited
	Amara Raja Batteries Limited
	Exide Industries Limited
	Rajesh Exports Limited
	Larsen & Toubro Limited
	India Power Corporation Limited

The government has set a subsidy limit at Rs2,000/kWh (US\$27.2/kWh). To apply for incentives, the following criteria must be adhered to:

- Each selected ACC battery storage manufacturer will have to commit to set-up an ACC manufacturing facility of minimum 5GWh-capacity.

⁹ PIB. Cabinet approves Production Linked Incentive scheme “National Programme on Advanced Chemistry Cell Battery Storage”. May 2021.

- The beneficiary firms will have to achieve a domestic value addition of at least 25 per cent and incur the mandatory investment Rs2,250m/GWh (US\$30.6m) within two years (at the Mother Unit Level). Firms must attain 60 per cent domestic value addition within five years, either at the Mother Unit, in case of an Integrated Unit, or at the project level, in case of “Hub & Spoke” structure.

The incentive will be disbursed over a period of five years. It will be paid out on the basis of sales, energy efficiency, battery life cycle, and localisation levels. ACC battery storage manufacturers will be selected through a transparent competitive bidding process.

An important point to note is that, according to a notification issued by the Department of Heavy Industry, the incentives will only be offered for cell manufacturing and not for conventional battery pack assembly as such activities are already taking place in the country.

FAME-II Scheme

The demand incentive for E2W has been increased by 50 per cent to Rs15,000/kWh (US\$205.7/kWh) of battery capacity as of June 11, 2021. So, an E2W with a 1kWh-battery will receive an incentive of Rs15,000 (US\$205.7) while one with a 3kWh battery pack will be eligible for an incentive of at least Rs45,000 (US\$617.1), given its ex-factory cost is over Rs100,000 (US\$1,371.3) and below Rs150,000 (US\$ 2,056.1). In addition, the limit on this incentive was doubled to 40 per cent of the ex-showroom price. This will result in the slashing of E2W prices by a considerable margin. The end result is expected to be an increase in production of such E2Ws and hence more demand for batteries.

100% FDI Permitted

The Government of India has encouraged new global players by permitting 100 per cent foreign direct investment (FDI). Meanwhile, no entry barriers exist for domestic players interested in the battery pack/BMS segment.

4.A.2 State-announced Incentives Under EV Policies

States are also promoting battery manufacturing with various incentives to build a complete ecosystem to drive this segment. When designing their EV policies, some states have announced incentives specifically for EV battery manufacturing/assembly.

The green-shaded cells in the table below indicate the state provides battery manufacturing incentives/initiatives.

Table 2: State-level Battery Manufacturing Incentives

State	Capital Subsidies	Tax Exemptions and Interest Subsidies	Land Development Incentives	Battery Recycling Initiatives
Andhra Pradesh				
Delhi				
Karnataka				
Kerala				
Madhya Pradesh				
Maharashtra				
Meghalaya				
Odisha				
Punjab				
Tamil Nadu				
Telangana				
Uttar Pradesh				

Source: State EV Policies, JMK Research.

Note: For detailed state-level incentives and announcements, refer table 6 in the annexure.

4.B No Significant Entry Barriers for Battery Pack Manufacturers

Apart from the government push via various policy measures and incentives, numerous other factors are leading to huge influx of investments, including:

- The initial investment to set up a battery pack manual assembly is as low as Rs100m (US\$1.3m) which is one of the reasons for the keen interest of so many players entering the market.
- The assembly of most of the battery packs in India is on manual and semi-automated assembly lines (Ola Electric’s automated line is the exception). This does not require capabilities and investments pertaining to Industry 4.0.
- The BMS in the battery packs must be of good quality but for now is not governed by any standards in India. Once a manufacturer procures cells and PCB design from a reliable source, the assembly of cells into modules and further into packs and BMS build-up is not difficult.

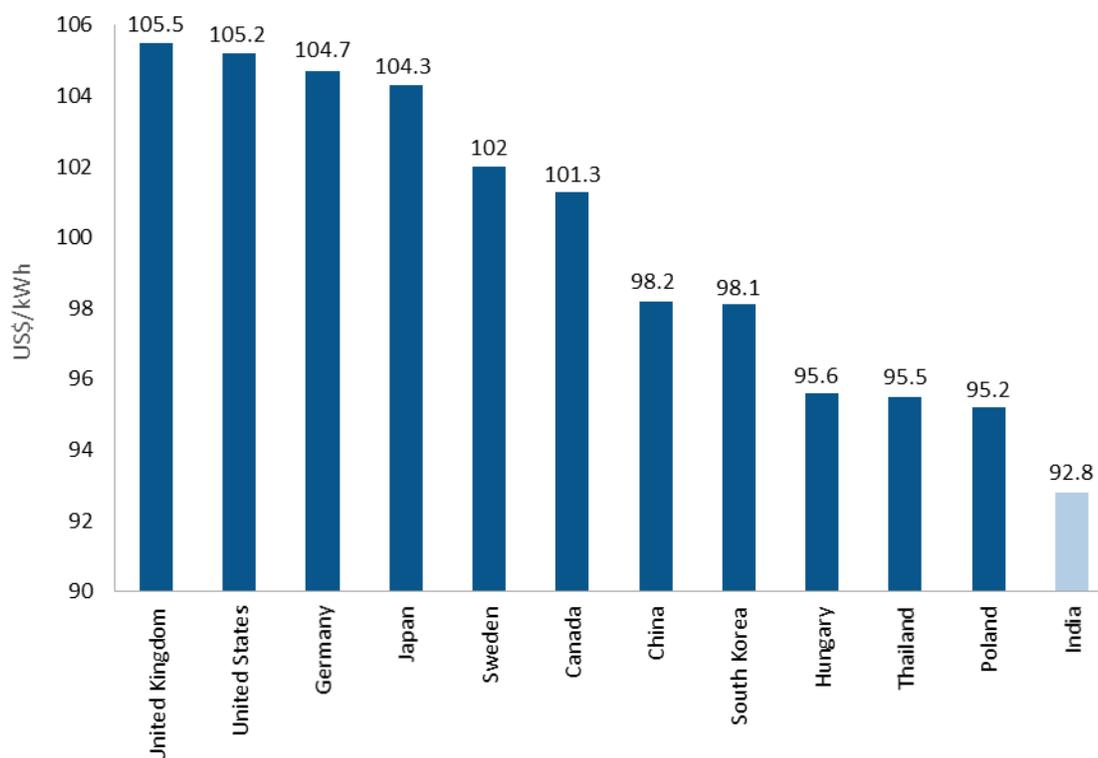
All these advantages are drawing players that do not have any prior experience in battery manufacturing, among them small solar stationary providers and E2W manufacturers.

4.C Low Manufacturing Costs in India

An analysis done by Bloomberg New Energy Finance (BNEF) indicates that India is already the lowest cost country for manufacturing NMC pouch cells and the subsidies promised under the PLI ACC scheme could further reduce costs to

US\$65/kWh. Land, labour, and utility costs are what determine the difference in manufacturing costs around the regions. Given that gross monthly minimum wage levels in India in 2019 were US\$65 against US\$217 in China and annualized real minimum wage growth over a period of 2010-2019 was 3.9% in India against 6% in China, India can achieve cost competitiveness with its close competitor and current exporter, China.

Figure 4: Country-wise Manufacturing Cost of Li-based Pouch Cell (NMC 622)



Source: BNEF, JMK Research.

4.D Falling Battery Prices

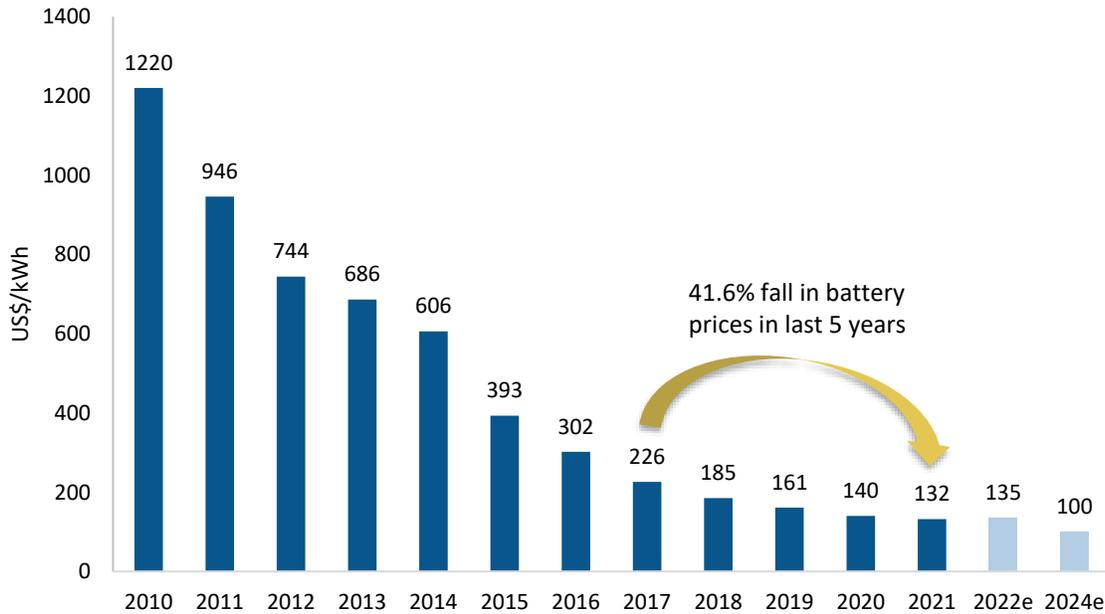
The Indian LiB market, by 2030, will primarily be driven by EVs as they will account for ~80 per cent of the entire demand. The drop in battery prices from US\$1,220/kWh in 2010 to US\$132/kWh in 2021 has been the key driver for adoption of EVs in India¹⁰ and further reduction in prices will increase demand for vehicles and batteries alike.

Despite the intense pressure from rising raw material and component costs, battery prices continued to fall in 2021. The drop in prices led automakers and stationary

¹⁰ BNEF. Battery Pack Prices Fall to an Average of \$132/kWh, But Rising Commodity Prices Start to Bite. November 2021.

storage developers to widely adopt LFP in 2021, helping offset the rising material costs.

Figure 5: Volume-Weighted Pack Prices of Batteries



Source: BNEF.

Going further, BNEF analysis shows that prices are expected to increase for the first time to US\$135/kWh in 2022 due to the impacts of higher raw material and component prices. Chinese LFP producers have already increased prices by 10-20%, which is in line with the projections.

BNEF analysis also suggests that higher prices in 2022 and 2023 could delay battery prices reaching US\$100/kWh by two years (2024). The US\$100/kWh is seen as the tipping point at which EVs are expected to become cost-competitive with ICE vehicles. This would reduce the margins that automakers could make on EVs but is unlikely to derail the EV industry.

5. LiB Manufacturing in India – Current Capabilities & Future Needs

Lithium-ion cells constitute ~65 per cent of the entire battery in terms of cost composition.¹¹ Conversion of lithium-ion cell to battery pack accounts for the remainder.

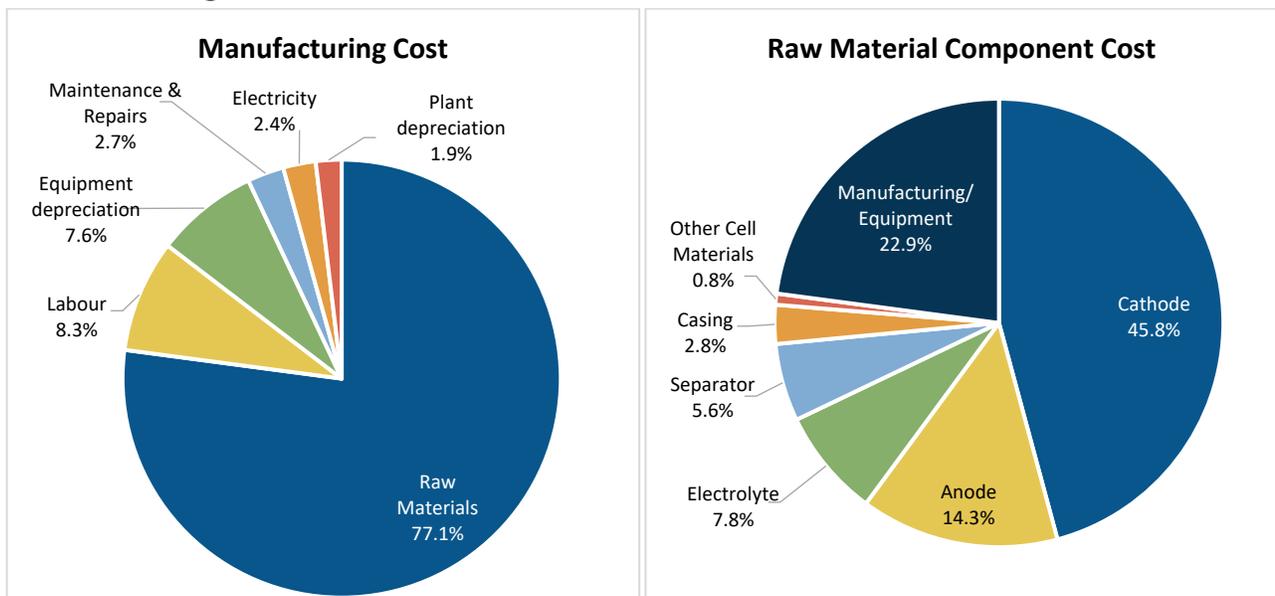
In terms of cell production, raw materials account for about 77per cent of the

¹¹ Stakeholder consultation.

overall costs (Figure 6, Raw Material Component Cost) and manufacturing for the remaining 23 per cent (Figure 6, Manufacturing Cost).¹²

At present, India has to import all the raw materials for cell manufacturing. It is also likely that in the next four to five years, ~55% of all this raw material needed for cell manufacturing will still be sourced from other countries (primarily China).¹³ However, India can leverage its huge cost opportunities in terms of cheap labour and power until it becomes self-sufficient in raw materials as well.

Figure 6: Manufacturing Cost and Component Cost Breakup for Cell Manufacturing



Source: Industry Interviews, JMK Research.

5.A Current Manufacturing Capabilities Along the Value Chain

The following table indicates the various steps involved in a typical cell to battery manufacturing value chain and India’s capabilities along this value chain.

¹² Stakeholder consultation.

¹³ Stakeholder consultation.

Table 3: Current Capabilities Along the LiB Manufacturing Value Chain in India

Stage of Value Chain	Description	India - Current Status	India - Issues	India - Scope	Current/Potential Players in India
Material Sourcing	Virgin raw material obtained directly after mining	Not yet started	Only a few reserves in the world; minuscule in India and no owned mines elsewhere	Look for alternate source for cobalt; abundant sources of nickel exist	None
Material Manufacture	Manufacture/chemical processing of anode, cathode, electrode, separator, casing, terminals	Synthetic graphite anode by Epsilon Carbon		India can manufacture copper-aluminium foils and do battery-grade graphite processing with graphite being available abundantly; aluminium is widely available which can be used as cathode collector	Epsilon Carbon
Cell Manufacture	Manufacture of cells from materials	TDSG started cell production from December 2020, cell chemistry: LTO (Lithium Titanium Oxide); GODI announced manufacture of first batch of cells in January 2022 with cell chemistry: NMC 21700; plant by Lucas-TVS/24M Technologies, Inc. partnership to start commercial production by H2 2023	Raw material availability: lack of industry knowledge and technology to design, engineer, manufacture, test, assemble, and service cells	PLI Scheme to mobilise incentives and evince interest from players	TDSG; GODI; Lucas-TVS/24M Technologies, Inc. Reliance, Adani, Greenko, ChargeXO, Amara Raja, Exide
Cell to Pack Conversion	Cell to pack assembly along with BMS	Started and mostly dominated by unorganized players and only a few OEMs	Complete Knocked-down (CKD), Semi Knocked-Down (SKD) issues and	Customised battery packs for Indian terrain and temperature; BMS to move from	Exide-Leclanché; Amara Raja; Okaya; Waaree;

		and big battery pack players	Chinese technology used which is not capable of withstanding high Indian temperatures	hardware to cloud with focus on State of safety, State of Function, Thermal protection, fault isolation, and fault sensors (AI-based BMS)	Coslight India; Trontek; Ather; Ola Electric
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Source: JMK Research.

As shown above, India is mainly active in cell to pack conversion. In cell manufacturing, some players have started building initial capacities (TDSG and GODI) and others (Lucas-TVS/24M Technologies, Inc.) have announced concrete plans to enter this space.

At present, in India most big EV OEMs, primarily passenger car players, have developed their battery pack assembly facilities in-house using imported lithium-ion cells while other players import complete battery packs. The E2W and E3W OEMs either deploy battery packs from local manufacturers or, in such big players as Ola Electric, Ather, Cosbike and now Pure EV have in-house assemblies.

E3W is an unorganised market so most E3W OEMs buy battery packs directly from local manufacturers, gaining warranty and service guarantees. Also, OEMs without huge procurement requirement and prior experience in batteries also prefer to procure locally. For this, OEMs have to pay a premium of 10-15 per cent, the price of avoiding pressure of procuring raw materials, building service infrastructure etc.

Securing supplies of critical raw materials and strong coordination between stakeholders (in both the manufacturing and cell assembly) continue as critical factors for the successful operation of cell and battery manufacturing in India.

Battery Recycling as a Manufacturing Option: Given the unavailability of raw materials and hence import dependence on China, India needs to look for alternative manufacturing/battery re-use options, among them battery recycling/urban mining. Since 90 per cent of lithium, cobalt, nickel, manganese, and graphite are recoverable, urban mining can help here. At present, India does not have any policy framework or mechanism for lithium-ion battery recycling and second-use market. The Indian Government, in October 2019, foreshadowed a recycling policy for LiB with tax concessions for recyclers. Various states have announced incentives for battery recycling in their respective EV policies. Concepts such as battery leasing -- the battery is returned at the end of the lease period, and the onus to re-purpose and recycle lies with the manufacturer -- are already popping up. Battery suppliers have started selling with a buy-back option.

5.B Need for LiB Manufacturing in India

India is set to witness huge demand for LiB specifically from the EV industry. However, India has not been producing lithium-ion cells until now and has been meeting all its domestic demand through imports. Given the ongoing border

tensions with China, India cannot solely rely on China for key minerals such as lithium. China's mining and battery companies acquired 6.4 million metric tons (Mt) of lithium-ion reserves and resources (as of October 2021) – almost as equal to the 6.8 Mt of lithium acquired by all other companies globally in 2020.¹⁴

In addition, the customised cell chemistry requirements in the Indian market makes it imperative to analyse why the country needs to indigenise the industry now. Some key reasons include:

Requirement of Indian Terrain-specific Cell

Though batteries have long been in demand in India, adoption of LiBs started when Reliance used them for its telecom towers with both the battery chemistries – LFP and NMC. The latter's chemistry couldn't withstand the high temperature requirements of ~45-50°C and hence caught fire -- LFP could, and this became the primary reason for the adoption of this chemistry type.

India is still importing ~60-65% of the total component requirement for battery packs from China.¹⁵ The cell chemistry imported from China however is not suitable for the Indian terrain and temperatures because they can, at most, withstand 45°C – 50°C. However, in India, for most of the year, this is the ambient temperature range. Using Chinese cell chemistries for Indian battery packs limits the overall charging to this temperature. For batteries to perform over a huge operating temperature range, from hot regions of Rajasthan to cold regions of Leh-Ladakh and in between, India needs to have its own cell chemistries.

For optimal operation, batteries must suit the Indian weather conditions and applications so the chemistry is governed by the following unique requirements.

- **Temperature Operating Range:** Continuous operating performance at 50°C, much higher than, for example, European requirements.
- **Lowest \$/kWh Price:** Engineering efficiency and manufacturing scale such that \$/kWh costs be reduced as much as possible for the price-sensitive market
- **E2W/E3W BMS Compatibility:** Advanced BMS fitted in less space and cooling mechanisms efficient enough as E2W, E3W cannot accommodate thermal management such as liquid cooling
- **Phase change interstitial fill:** For battery weight reduction and safety, e.g., a 40 kg battery is difficult for one operator to swap
- **Cycle Life:** ~2.5 times that of other markets

¹⁴ S&P Global. [China mining, battery companies sweep up lithium supplies in acquisition blitz.](#) November 2021.

¹⁵ Stakeholder consultation.

- Modularity: To allow for battery swapping, replaceability, and recyclability

LFP and NMC battery chemistries are most suitable for India. LFP is preferred where space is greater and life expectancy requirement is higher as in E3W and traction applications. NMC is preferred where space availability is less, but energy density required is high as in E2W and E-Cars. In conditions of more than 50°C, it is the LFP chemistry that succeeds.

Stationary storage applications use LFP primarily for this reason. Similarly, for fleet operations in which an EV needs to ply in varying temperature ranges, LFP is best suited and the sole constraint is space. In India, NMC batteries typically last two to three years and LFP batteries, five to seven years so, given the option, Indians will go for more cost-effective LFP.

Table 4: Comparison of LFP with NMC in the Indian Context

Parameter	LFP	NMC
Temperature Performance (>50 degree C)	High	Low
Space Required	High	Low
Life Expectancy	High	Low
Stability (Safety)	High	Low
Energy Density	Low	High
Overall Costs (including Raw Material)	Low	High

Source: JMK Research.

Note: Refer Annexure for more details on battery chemistries and end-use applications.

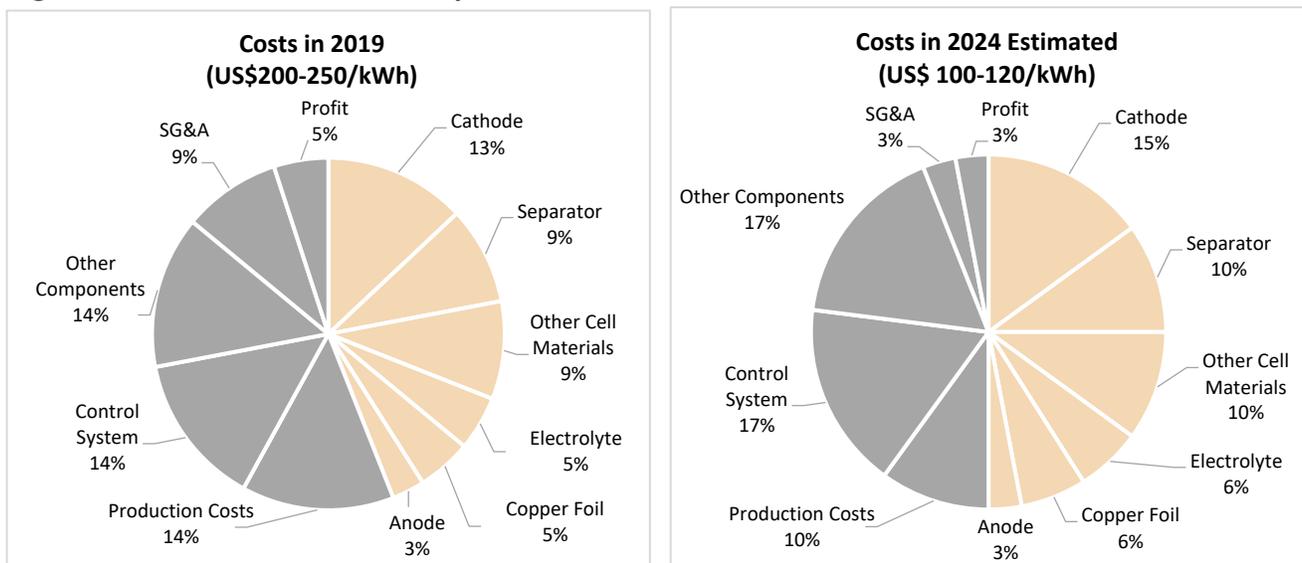
Rising International Cell Prices

Battery pack prices reached US\$200-250/kWh in 2019 but are expected to come down to US\$100-150/kWh by 2024.¹⁶ A closer look at the price breakdown indicates that while other component costs will balance out each other and reduce slightly, cell costs are expected to go up.

For India, an improvement in the quality of BMS and cell assembly alone will not bring down the total cost of the battery, given their minor share of the equation. Indigenous development of battery cells and components will stabilise and eventually bring down battery prices. It is believed that large-volume LiB production can reduce costs dramatically. With the requirement for 50GWh manufacturing capacity as per PLI ACC by 2030, the task seems achievable.

¹⁶ BNEF, stakeholder consultation.

Figure 7: Price Breakdown Comparison for LiB Packs



Source: BNEF, Industry Interviews, JMK Research.

Constraints in Cell Supply from China

There has been a surge in global demand for lithium-ion cells especially in the United States and Western Europe for use in EVs. This has made it difficult for countries like India with significantly low volume demand to enter into long-term contracts with cell manufacturers, as such players prefer supplying to markets that guarantee higher volumes and are relatively richer. Further, congestion in shipping routes, shortage of containers, and production curbs in China, the biggest exporter of lithium-ion cells to India, have constricted supplies to India.

Supply constraints in turn have raised costs significantly. Prices of battery-grade lithium carbonate and hydroxide, for instance, doubled in 2021 from 2020¹⁷ sometimes increasing 25 per cent month-on-month. In addition, shipping costs from China quadrupled in a year. All this has added to EV makers' costs. In the next two to three years, additional global cell production capacity will come online so for India, local sourcing of raw materials and cell manufacturing have roles to play to overcome these supply constraints.

6. Risks and Challenges

Among the challenges in the battery manufacturing space, short-term issues can be addressed once India has adequate infrastructure and government support. It may take some years to find solutions to long-term challenges such as the absence of requisite raw materials. Key stakeholder challenges include:

¹⁷ Automotive News. [Lithium prices jump again as miners can't keep up with EV battery boom.](#) October 2021.

6.A For Battery Pack Manufacturers

Big, reputable battery pack manufacturers with long market experience via LA batteries or having switched from LA to LiB face challenges primarily from the lack of regulations on the standards for manufacture as well as uncertain demand.

1. **Safety Concerns for end consumers from unorganized market:** The biggest challenge to the existing big players is the safety risk faced by end customers from small assemblers, who procure the raw materials from local traders and assemble the batteries without following safety standards, potentially leading to fire incidents. Increased safety risks give a bad name to the entire battery pack assembly market.
2. **Lack of LiB demand and fear of cannibalization of existing LA products:** India for now does not need high volumes of battery packs in end-use applications. This discourages some LA battery pack players as this will amount to cannibalisation of their existing business. Additionally, they will not turn to LiB manufacturing until they can assess whether demand will justify the switch. Furthermore, the abysmally low single-digit EBITDA¹⁸ margins discourage the entry of new big players in the market.

6.B For Cell Manufacturers

Manufacturing presents lucrative opportunities but is rife with challenges. Beyond scarcity of key raw materials and requirement of huge investments, there are:

1. **For Start-ups:** Huge capital expenditure (CAPEX) requirements and investments to the tune of Rs10,000m (US\$131m) for setting up a manufacturing facility of a minimum 5GWh capacity.
2. **For International Players:** Global players with deep pockets have yet to show much interest in starting from scratch in India, on commercial reasoning that it makes sense to expand existing facilities elsewhere. Samsung and LG Energy Solutions, for example, have facilities in Europe and United States, as well as China, and plan to expand or build new facilities. LG with a 4GWh plant already in Europe will expand it to 70GWh¹⁹ and also will boost cell production in United States to 110GWh by 2025.²⁰ Samsung is building a 7.5GWh factory in Europe (in addition to its 2.5GWh plant in the same location).²¹ Business sense is to operate in the regions that account for majority of EV demand at a global scale -- China, Europe (particularly Eastern Europe), and United States currently.
3. **For local players interested in setting up facilities:** The PLI ACC scheme

¹⁸ EBITDA - Earnings before interest, taxes, depreciation, and amortization

¹⁹ FTI Consulting analysis. [Energy Transition | European Battery Manufacturing: Charging Ahead](#). March 2021

²⁰ Electrive.com. [LG aims for 110 GWh cell production in the USA by 2025](#). March 2021.

²¹ FTI Consulting analysis. [Energy Transition | European Battery Manufacturing: Charging Ahead](#). March 2021

proposes incentives over a period of five years based on sales, energy efficiency, battery life cycle, and localization levels – that is, incentives on the finished product rather than during manufacturing – so the initial investment will all be done by the cell manufacturer only. China offers incentives at the time of setting up of factories.

- a. Economies of scale seem difficult to achieve in India in the coming three to four years given the high-cost economics involved and the lacklustre demand for EVs other than the E2W segment.
- b. India doesn't have any reserves of the key raw materials, cobalt and manganese. Lithium has also just been discovered in India in small quantities (~14,100 tonnes). So, even in the coming five to seven years, India will have to import majority of its raw materials (at least for cathode, electrolyte, and separator).²² Given that China controls the majority of the lithium and other raw material processing capabilities and given the border tensions with China, it is imperative to seek other sources.

6.C For OEMs

E-Car OEMs use primarily imported battery packs and BMS. E2W and E3W OEMs use battery packs manufactured in India, with associated design issues.

- **Faulty BMS:** Owing to E2W and E3W being price sensitive markets, the BMS has become a commoditised item and its manufacturing is not licensed, leading to safety compromises that are evident in recent cases of fires in E2Ws in India. Further, the programs of BMS manufactured in India do not usually go through the entire cycle life tests (often 50-100 cycle tests),²³ leading to incompatibility with cells supplied by some big players.

7. Conclusion

India holds huge scope for manufacturing LiB and cells. In the next few years, LiB manufacturing in India is expected to grow tremendously driven by huge demand from automotive and non-automotive segments. Government and industry efforts to address this demand are commendable. The FAME-II scheme, which aims to increase adoption of EVs, specifically E2Ws and E3Ws, is driving battery localization requirements and setting up of battery assembly plants in India. The PLI ACC scheme is a step towards local cell manufacturing. For adoption of LiB in stationary applications, further positive steps include the government's revised target of installing 450GW RE capacity by 2030 (for which 136GWh storage is required) and industry's efforts to have only LiB-based data centres and majority of telecom towers to be LiB-based.

²² ET Auto. [Lithium reserve found in Mandya near Bengaluru](#). February 2020.

²³ Stakeholder consultation.

In the absence of standardization in Indian battery manufacturing, government and the industry players need to take pertinent steps: on the government's part, standardization in terms of voltage levels, form factors, functionality of BMS and battery types; for industry, minimising the skill gap between battery manufacturing and R&D.

Battery life and performance will be key differentiators in the next three to five years. This will hold true regardless of the end use, whether EV, mobile phone or laptop. Such improvements will come from an effective BMS design and further focus on suitable battery chemistries.

Investments will be required for research to allow greater use of locally available raw materials and for increasing design expertise for BMS.

Urban mining will help the country in repurposing the spent batteries for re-use in secondary applications, so reducing imports and to an extent economic costs.

Overall, thanks to a strong push from government and enthusiasm from industry, the future looks bright for cell manufacturing and improvements in battery pack assembly and allied industries. The cell industry will be a consolidated market, dominated by players such as Exide, Amara Raja, Reliance, and Adani. They are expected to have vertically integrated gigawatt-scale LiB factories sourcing key raw materials through long-term contracts/investments in material-rich nations. EV OEMs are expected to have in-house battery pack manufacturing on automated assembly lines.

Battery life and performance will be key differentiators in the next three to five years, regardless of end use.

8. Annexure

Table 5: LiB Chemistries and their Properties and Applications

Chemistry	Major Metals	Cycle Life [cycles]	Properties	Applications
LCO (LiCoO ₂) <i>[Lithium Cobalt Oxide]</i>	Cobalt	500-1,000	High risk re safety, good lifetime	Mobile phones, laptops, video cameras, other electronic devices
LMO (LiMn ₂ O ₄) <i>[Lithium Manganese Oxide]</i>	Cobalt- 2.5% Manganese- 21% Nickel- 7% Lithium Carbonate- 3.5% Others- 66%	1,000	Cheaper, safer than LiCoO ₂ and LiNiO ₂	EV Batteries (Nissan Leaf EV), power tools, medical devices
NCA (LiNiCoAlO ₂) <i>[Lithium Nickel Aluminium Cobalt Oxide]</i>	Cobalt- 6% Nickel- 35% Lithium Carbonate- 3.5% Others- 55.5%	2,000-3,000	High energy, high density	EV batteries (Tesla Model S EV), ISRO Satellites
NMC (LiNiMnCoO ₂) <i>[Lithium Nickel Manganese Cobalt Oxide]</i>	Cobalt- 19% Manganese- 17% Nickel- 19% Lithium Carbonate- 3.5% Others- 41.5%	2,000-3,000	High energy density, poorer temperature tolerance, high risk re safety	EV batteries, power tools
LFP (LiFePO ₄) <i>[Lithium Iron Phosphate]</i>	Iron, Phosphate	>3,000	Long lifetime, high stability, basic low cost	Starter batteries, light storage and 2W, 3W EV applications
LTO (Li ₄ Ti ₅ O ₁₂) <i>[Lithium Titanate Oxide]</i>	Titanium	>5,000	High temperature tolerance, much higher cycle-life, much lower energy density and hence more expensive than other cell chemistries	EV batteries, military/aerospace applications

Source: *Six Lithium-ion Battery Chemistries: Not all Batteries are Created Equal*; JMK Research.

Table 6: State-Level Incentives & Announcements for Manufacturing Under EV Policies

State	Incentives/Announcements for Manufacturing
Tamil Nadu	<ul style="list-style-type: none"> The Government will provide higher capital subsidy of 20% of the eligible investment over 20 years to manufacturing units engaged in EV battery manufacturing. Such units shall also be provided land at 20% subsidy in Tamil Nadu and at 50% subsidy in Southern districts. The special package will be applicable for investments made till December 2025.
Punjab	<ul style="list-style-type: none"> The State will actively encourage and engage with EV battery manufacturers to enable setting up of at least one giga-battery manufacturing unit in the state.
Uttar Pradesh	<ul style="list-style-type: none"> Mega Anchor Project (an integrated project which will have EV powertrain assembly, press shop, body shop, EV battery/Fuel cell assembly, assembly line, paint shop etc.), investing at least Rs10,000m (US\$131m) which will bring ancillary units of a minimum of Rs2,000m (US\$26m) investment within 3 years of establishment and Ultra-mega battery plant (for manufacturing batteries with an annual output of 1GWh or above, integrated with recycling facilities with a minimum investment of Rs10,000m, US\$131m) as defined in the policy will be reimbursed up to 25% of the cost of land at prevalent circle rate or purchase price, whichever is less. In addition, Micro, Small & Medium Manufacturing Enterprises (MSMEs) and large anchor EV Battery Manufacturing or Assembly Units (EBUs) (Indian OEM which designs, manufactures, or assembles EV battery with recycling set up, investing at least Rs3,000m (US\$39m) and brings along at least 10 vendor units as defined in this policy in the same cluster) will be provided incentives at par to those provided to industrial units under UP IIEPP 2017 including capital interest subsidy, infrastructure interest subsidy, industrial quality subsidy, stamp duty and electricity duty exemption, State Goods and Service Tax (SGST) reimbursement, etc.
Andhra Pradesh	<ul style="list-style-type: none"> The State aims to bring in manufacturing units of high-density energy storage of at least 10GWh capacity by 2023 to cater for domestic and export market. In case of Mega integrated (Mega Anchor) projects, government will offer land to dependent ancillary units at the same rates as offered to respective OEM (wherever Government allocates land to OEM) up to a maximum of 50% of the land allocated to OEM.
Maharashtra	<p>The state has a target of establishment of at least one gigafactory for the manufacture of ACC batteries.</p> <ul style="list-style-type: none"> Further, the State will provide all the benefits under 'D+' category of mega projects (with minimum fixed capital investment of Rs5,000m: US\$66m)/other categories to the Companies setting up manufacturing/R&D facilities related to battery assembly, cell manufacturing, recycling of EVs and EV batteries amongst others, irrespective of location of manufacturing unit in the state. D+ category benefits are meant for industries in the least developed parts of the State. The incentives include maximum incentive of 60% as a percentage of fixed capital investment (FCI) for MSMEs for a period of 10 years and 70% as a percentage of FCI for large scale industries for a period of 7 years, and exemption from stamp duty and electricity duty.

Odisha	<p>The Government of Odisha will explore possibilities of entering into MoU with Lithium Cell Manufacturers to start battery assembly plant in Odisha.</p> <ul style="list-style-type: none"> • The Small and Micro EV Battery manufacturing Units will be facilitated incentives as per the MSME Policy, 2016 and includes 25%-35% of capital investment basis the category of enterprise. • Capital subsidy, tax, and tariff incentives and other policy support will also be provided to attract private investment in dedicated areas/ zones for the manufacture of Lithium-ion Batteries in the long run.
Karnataka	<p>The State has set itself a target of inviting investments in setting up to 5GWh of EV battery manufacturing capacity.</p> <ul style="list-style-type: none"> • Investment Promotion Subsidy: 25% of the value of fixed assets (VFA) with a maximum of Rs0.15m (US\$ 1,971) for micro enterprises; 20% of VFA with a maximum of Rs0.40m for small enterprises; and Rs5m (US\$65,715) for medium manufacturing enterprises; investment subsidy of 20% of VFA with a maximum of Rs200m (US\$2.6m) per project for first two units in the State for large/mega/ultra/super mega EV cell manufacturing, EV battery pack/module manufacturing enterprises. • 100% exemption from stamp duty for EV cell manufacturing, EV battery pack/module manufacturing, and assembly enterprises. • Concessional registration charges of Rs1 (US\$0.013) per Rs1,000 (~US\$13). • 100% reimbursement of land conversion (converting the land from agriculture use to industrial use) fee and 100% exemption from electricity duty • One-time capital subsidy up to 50% of the cost of effluent treatment plants (ETPs), subject to a ceiling of Rs5m (US\$65,715) for MSMEs and Rs20m (US\$0.26m) for large/mega/ultra/super mega enterprises. • Interest free loan on Net SGST to large/mega/ultra/super mega EV cell manufacturing, EV battery pack/module manufacturing, and assembly enterprises.
Telangana	<p>The highlights of the Electronics policy, which will govern manufacture and assembly of EV batteries and cells, are as below:</p> <ul style="list-style-type: none"> • Capital Investment Subsidy: 20% of investment capped at Rs300 m (US\$3.9m) for Mega Enterprises. SGST Reimbursement: 100% net SGST reimbursement capped at Rs50 m (US\$0.7m) per year with a cumulative cap of Rs250m (US\$3m) over a period of 7 years for Mega Enterprises. <p>Power Tariff Discount: 25% for 5 years capped at Rs50m(US\$0.7m) for Mega Enterprises. Electricity Duty Exemption: 100% for 5 years capped at Rs5m (US\$65,715). Interest Subvention: 5.25% for 5 years capped at Rs50m (US\$0.7m). Transportation Subsidy: 60% with 10% reduction year-on-year (YoY) for 5 years; capped at Rs50 m (US\$0.7m). Stamp Duty/ Transfer Duty/ Registration Fees Reimbursements: 100% on first, 50% on second transaction</p>
Kerala	<p>Manufacture of Energy Systems and Storage (BMS, cell technologies and battery pack assembly, and second life applications for retired batteries) will be eligible for incentives under the Electronics System Design & Manufacturing (ESDM) and IT Policy. This includes 20% capital subsidy and concessions in electricity tariffs, property taxes, and tax breaks.</p>

Source: State EV Policies, JMK Research.

About JMK Research & Analytics

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