Industry Research Report
On

Lithium Ion Battery

June 2024

Disclaimer

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Global Macroeconomic Scenario

The global economy, estimated at 3.1% in 2023, is expected to show resilience at 3.1% in 2024 before rising modestly to 3.2% in 2025. Between 2021 – 2022, global banks were carrying a historically high debt burden after COVID-19. Central banks took tight monetary measures to control inflation and spike in commodity prices. Russia's war with Ukraine further affected the global supply chains and inflated the prices of energy and other food items. These factors coupled with war-related economic sanctions impacted the economic activities in Europe. Any further escalation in the war may further affect the rebound of the economy in Europe.

While China, the largest manufacturing hub of world, was facing a crisis in the real estate sector and prices of properties were declining between 2020 - 2023, with the reopening of the economy, consumer demand is picking up again. The Chinese authorities have taken a variety of measures, including additional monetary easing, tax relief for corporates, and new vaccination targets for the elderly. The Chinese Government took several steps to help the real estate sector including cracking down on debt-ridden developers, announcing stimulus for the sector and measures to encourage the completion and delivery of unfinished real estate projects. The sector is now witnessing investments from developers and demand from buyers.

Global headline inflation is set to fall from an estimated 6.8% in CY 2023 to 5.8% in CY 2024 and to 4.4% in CY 2025. This fall is swifter than anticipated across various areas, amid the resolution of supply-related problems and tight monetary policies. Reduced inflation mirrors the diminishing impact of price shocks, particularly in energy, and their subsequent influence on core inflation. This decrease also stems from a relaxation in labour market pressure, characterized by fewer job openings, a slight uptick in unemployment, and increased labour availability, occasionally due to a significant influx of immigrants.

Global GDP Growth Scenario

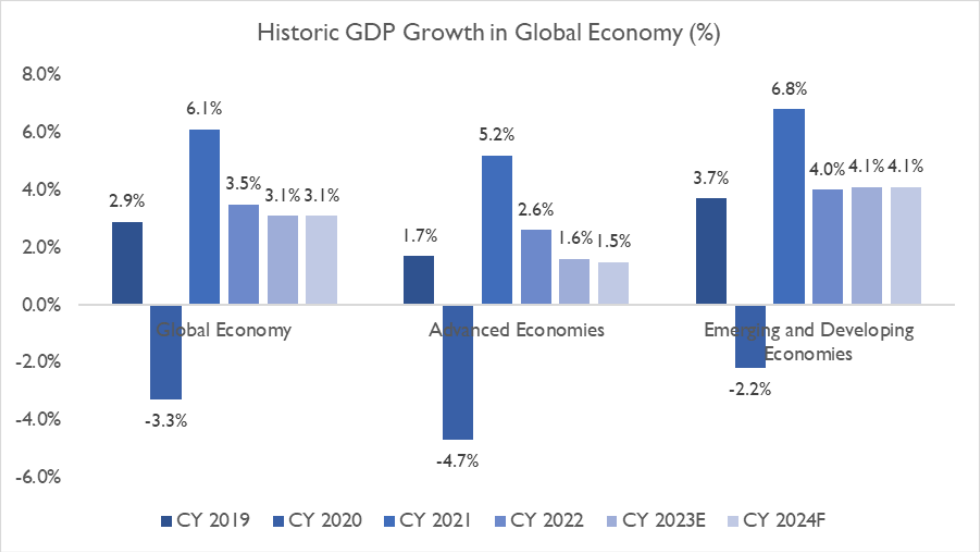
The global economy started to rise from its lowest levels after countries started to lift the lockdown in 2020 and 2021. The pandemic lockdown was a key factor as it affected economic activities resulting in a recession in the year CY 2020, as the GDP growth touched -3.3%.

In CY 2021 disruption in the supply chain affected most of the advanced economies as well as low-income developing economies. The rapid spread of Delta and the threat of new variants in mid of CY 2021 further increased uncertainty in the global economic environment.

Global economic activities experienced a sharper-than-expected slowdown in CY 2022. One of the highest inflations in decades, seen in 2022, forced most of the central banks to tighten their fiscal policies.

Russia's invasion of Ukraine affected the global food supply resulting in a further increment in the cost of living.

Further, despite initial resilience earlier in 2023, marked by a rebound in reopening and progress in curbing inflation from the previous year's highs, the situation remained precarious. Economic activity lagged behind its pre-pandemic trajectory, particularly in emerging markets and developing economies, leading to widening disparities among regions. Numerous factors are impeding the recovery, including the lasting impacts of the pandemic and geopolitical tensions, as well as cyclically-driven factors such as tightening monetary policies to combat inflation, the reduction of fiscal support amidst high debt levels, and the occurrence of extreme weather events. As a result, global growth declined from 3.5% in CY 2022 to 3.1% in CY 2023.



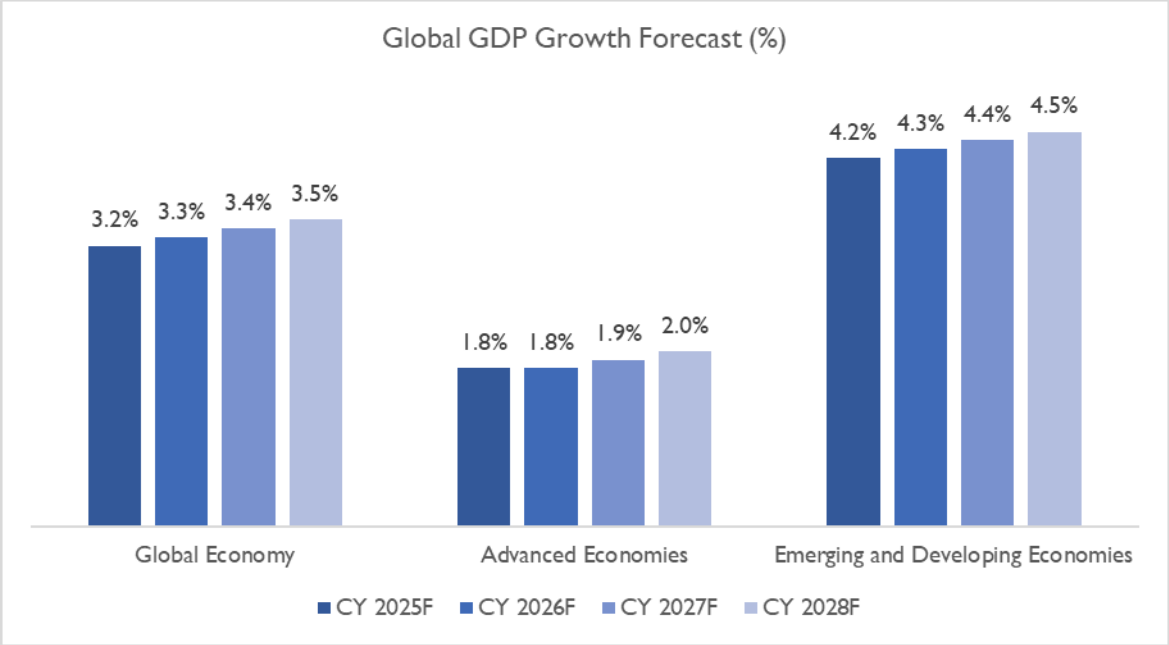
Source – IMF Global GDP Forecast Release 2024

Note: Advanced Economies and Emerging & Developing Economies are as per the classification of the World Economic Outlook (WEO). This classification is not based on strict criteria, economic or otherwise, and it has evolved over time. It comprises of 40 countries under the Advanced Economies including the G7 (the United States, Japan, Germany, France, Italy, the United Kingdom, and Canada) and selected countries from the Euro Zone (Germany, Italy, France etc.). The group of emerging market and developing economies (156) includes all those that are not classified as Advanced Economies (India, China, Brazil, Malaysia etc.)

In the current scenario, global GDP growth is estimated to have recorded a moderate growth of 3.1% in CY 2023 as compared to 3.5% growth in CY 2022. While high inflation and rising borrowing costs are affecting private consumption, on the other hand, fiscal consolidation is affecting government consumption.

Slowed growth in developed economies will affect the GDP growth in CY 2024 and global GDP is expected to record a flat growth of 3.1% in CY 2024. The crisis in the housing sector, bank lending, and industrial sectors are affecting the growth of global GDP. Inflation forced central banks to adopt tight

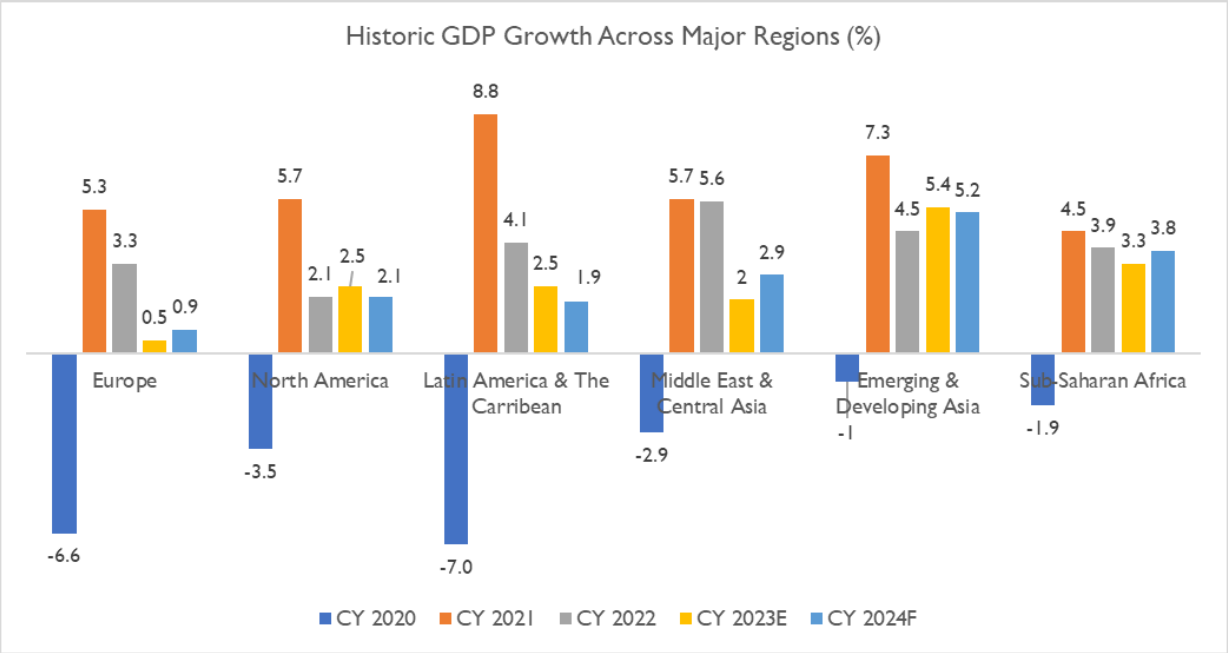
monetary policies. After touching the peak in 2022, inflationary pressures slowly eased out in 2023. This environment weighs in for interest rate cuts by many monetary authorities.



Source – IMF Global GDP Forecast Release 2024, D&B Estimates

GDP Growth Across Major Regions

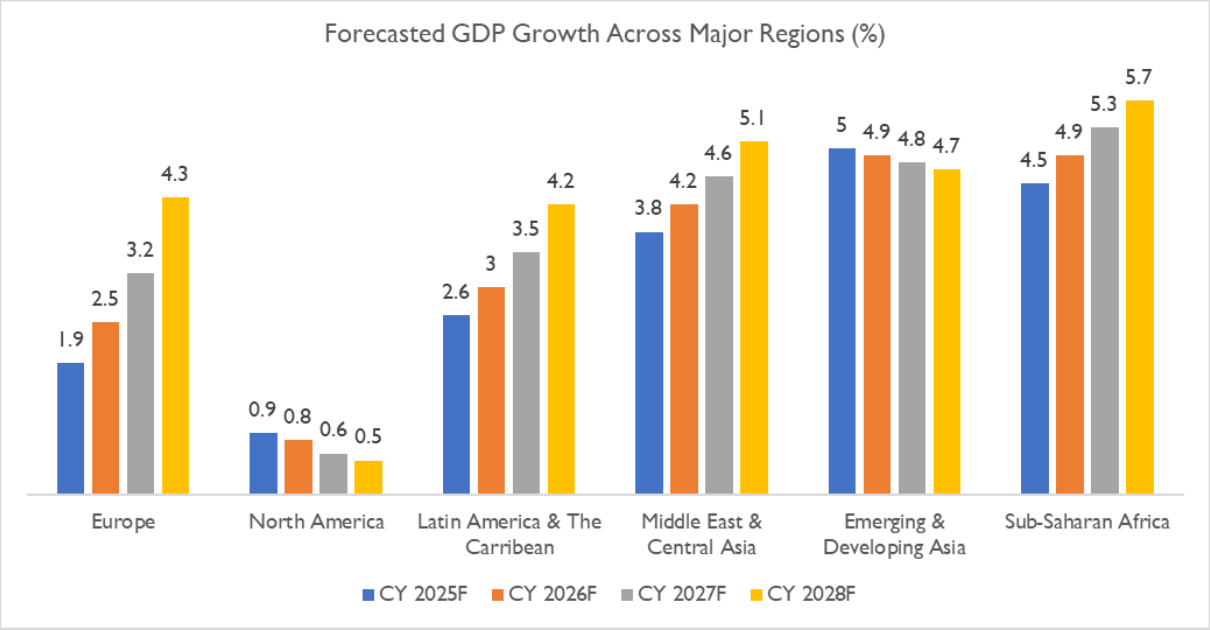
GDP growth of major regions including Europe, Latin America & The Caribbean, Middle East & Central Asia, and Sub-Saharan Africa, were showing signs of slow growth and recession between 2020 – 2023, but leaving Latin America & The Caribbean, 2024 is expected to show resilience and growth. Meanwhile, GDP growth in Emerging and Developing Asia (India, China, Indonesia, Malaysia etc.) is expected to decrease from 5.4% in CY 2023 to 5.2% in CY 2024, while in the United States, it is expected to decrease from 2.5% in CY 2023 to 2.1% in CY 2024.



Source-IMF World Economic Outlook January 2024 update

Except for Emerging and Developing Asia, Latin America & The Caribbean and the United States, all other regions are expected to record an increase in GDP growth rate in CY 2024 as compared to CY 2023. GDP growth in Latin America & The Caribbean is expected to decline due to negative growth in Argentina. Further, growth in the United States is expected to come down at 2.1% in CY 2024 due to lagged effects of monetary policy tightening, gradual fiscal tightening, and a softening in labour markets slowing aggregate demand.

Although Europe experienced a less robust performance in 2023, the recovery in 2024 is expected to be driven by increased household consumption as the impact of energy price shocks diminishes and inflation decreases, thereby bolstering real income growth. Meanwhile, India and China saw greater-than-anticipated growth in 2023 due to heightened government spending and robust domestic demand, respectively. Sub-Saharan Africa's expected growth in 2024 is attributed to the diminishing negative impacts of previous weather shocks and gradual improvements in supply issues.



Source-IMF, OECD, and World Bank, D&B Estimates

Global Economic Outlook

We are more optimistic about the global economy's prospects than we were at the onset of last year – and for good reason. The global economy avoided a widely anticipated recession in 2023 and will likely not see one in 2024. Looking at the current inflation trajectory, no one is guessing how much higher interest rates will go from here, which is a good outcome for both businesses and policymakers. Instead, financial markets are now betting on the timing and magnitude of rate cuts – and this is where we recommend caution for businesses. There are a few things to consider; first, rate cuts will likely follow an evident deterioration in economic conditions, i.e., after the economic damage is visible in data, which usually comes with a lag. By that logic, rate cuts by themselves may not be a positive outcome but only a means to offer relief from economic pain. Second, for most central banks that have been grappling with high inflation, higher expectations of rate cuts from financial markets will make them harder and riskier to deliver. Loosening too soon risks reversing the inflation trajectory and if key central banks get their inflation projections wrong for a second time, it will only spell more trouble.

The violence that began in the Middle East on October 7 continues to escalate. Apart from Israel and the Palestinian territories, Yemen, Syria, Iraq, Jordan, Iran, and Pakistan have all become embroiled in some form of violence over the past four months, including cross-border fire. This can be largely attributed to the heavy presence of militias and terrorist groups in these countries. Consequently, security threat levels are elevated across the region and business operations are difficult. The most obvious impact on commercial activity has been on shipments passing through the Red Sea, which have been forced to re-

route under attacks from Houthi rebel groups, elevating shipping costs and stretching delivery timelines. It has also added to volatility in the global energy markets. More importantly, the escalating conflict has reversed the gains made on global supply-side normalization and remains the biggest risk to hard-earned global disinflation – the two big economic accomplishments of 2023. Dun & Bradstreet's Global Supply Chain Continuity Index captured this dynamic as it fell 6.3% for Q1 2024, with suppliers' delivery time and delivery cost indices both deteriorating. In this context, for the global economy, a lot is riding on the ceasefire discussions that are currently underway between Israel and Hamas.

February marked the second anniversary of the start of the Russia-Ukraine conflict, which, at present, seems to be at a stalemate. From a business impact standpoint, events outside the zone of action, particularly in the EU, have gained more prominence than the conflict itself. These impacts range from immediate concerns about manufacturing performance, the cost of living, and energy security in the largest European economies, and go on to cover longer-term themes such as the bloc's first serious attempt at expansion in years, which includes Ukraine's bid for membership.

Geopolitical rumblings are also on the rise in the Asia-Pacific region, with North Korea issuing fresh threats, in words and in actions. Incessant saber-rattling may not necessarily lead to a conflict, but such posturing is unhelpful for the business and investment climates. In summary, geopolitics remains the biggest risk to the global economy today, dampening investments, disrupting supplies, and weakening the fight against inflation. There is one silver lining in all of this. High geopolitical temperatures around the world seem to have raised the stakes of stability for the U.S. and Mainland China. This was evidenced in their willingness to diffuse the Middle East, in keeping North Korea in check, and in Beijing's relatively muted reaction to a Democratic Progressive Party (DPP) victory in Taiwan Region's January 2024 polls. Mainland China may be keen to hold on to this new equilibrium until its economy fully stabilizes. As for the U.S., the outcome of the nomination races and the presidential election in November 2024 will be the key determinant of its foreign policy direction.

India Macroeconomic Analysis

GDP Growth Scenario

India's economy showed resilience with GDP growing at estimated 7.6% in FY 2024. The GDP growth in FY 2024 represents a return to pre pandemic era growth path. Even amidst geopolitical uncertainties, particularly those affecting global energy and commodity markets, India continues to remain one of the fastest growing economies in the world.

Country	Real GDP Growth (2023)	Projected GDP Growth 2024
India	7.8%	6.8%
China	5.2%	4.6%
Russia	3.6%	3.2%
Brazil	2.9%	2.2%
United States	2.5%	2.7%
Japan	1.9%	0.9%
Canada	1.1%	1.2%
Italy	0.9%	0.7%
France	0.7%[1]	0.7%
South Africa	0.6%	0.9%
United Kingdom	0.1%	0.5%
Germany	-0.3%	0.2%

Source: The International Monetary Fund

Countries considered include - Largest Developed Economies and BRICS (Brazil, Russia, India, China, and South)

Countries have been arranged in descending order of GDP growth in 2023).

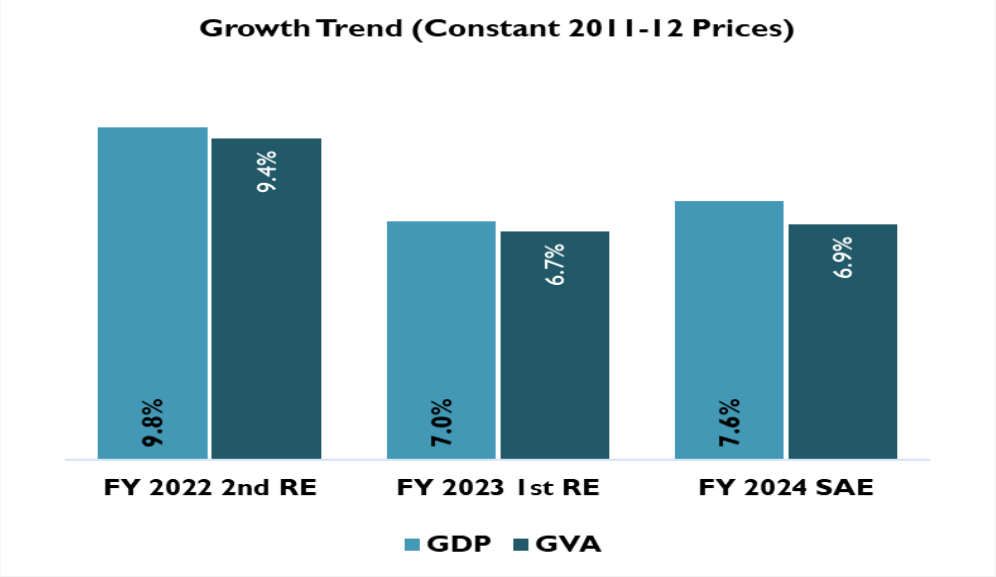
There are few factors aiding India's economic recovery – notably its resilience to external shocks and rebound in private consumption. This rebound in private consumption is bringing back the focus on improvements in domestic demand, which together with revival in export demand is a precursor to higher industrial activity. Already the capacity utilization rates in Indian manufacturing sector are recovering as industries have stepped up their production volumes. As this momentum sustains, the country may enter a new capex cycle. The universal vaccination program by the Government has played a big part in reinstating confidence among the population, in turn helped to revive private consumption.

[1] European Commission

Realizing the need to impart external stimuli, the Government stepped up its spending on infrastructure projects which in turn had a positive impact on economic growth. The capital expenditure of central government increased by 37.4% increase in capital expenditure (budget estimates), to the tune of Rs 10 trillion in the Union Budget 2023-2024. The announcement also included 30% increase in financial assistance to states at Rs 1.3 trillion for capex. The improvement was accentuated further as the Interim Budget 2024-2025 announced an 11.1% increase in the capital expenditure outlay at Rs 11.11trillion, constituting 3.4% of the GDP. This has provided the much-needed confidence to private sector, and in turn attracted private investment.

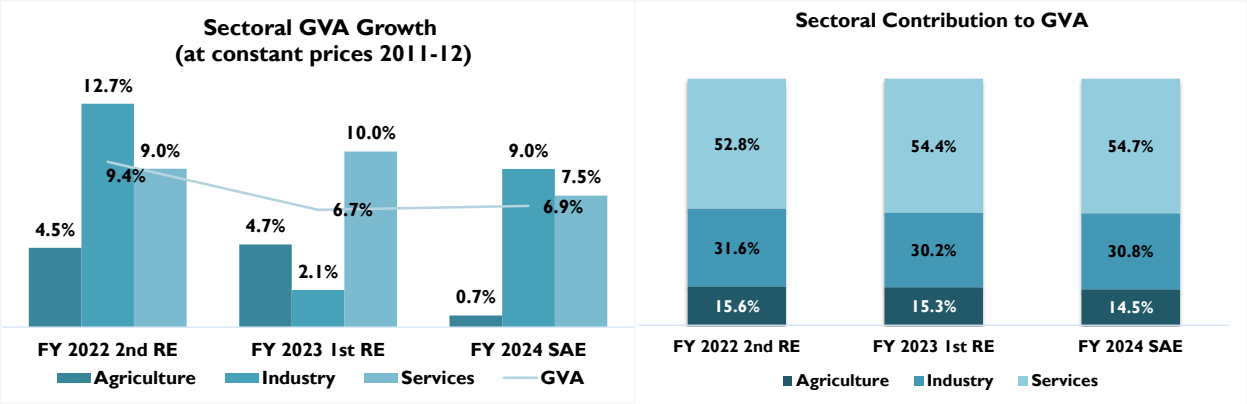
On the lending side, the financial health of major banks has witnessed an improvement which has helped in improving the credit supply. With capacity utilization improving, there would be demand for credit from corporate sector to fund the next round of expansion plans. Banking industry is well poised to address that demand. Underlining the improving credit scenario is the credit growth to micro, small and medium enterprise (MSME) sector as the credit outstanding to the MSME sector by scheduled commercial banks in the financial year FY 2023 grew by 12.3% to Rs 22.6 trillion compared to FY 2022. The extended Emergency Credit Linked Guarantee Scheme (ECLGS) by the Union Government has played a major role in improving this credit supply.

As per the second advance estimates 2023-24, India's GDP in FY 2024 grew by 7.6% compared to 7.0% in the previous fiscal on the back of solid performances in manufacturing, mining, and construction sectors. The year-on-year increase in growth rate is also partly due to by a strong growth in investment demand led by public capital expenditure.



Source: Ministry of Statistics & Programme Implementation (MOSPI), National Account Statistics, 2023-24
RE stands for Revised Estimates, SAE stands for Second Advance Estimates

Sectoral Contribution to GVA and annual growth trend



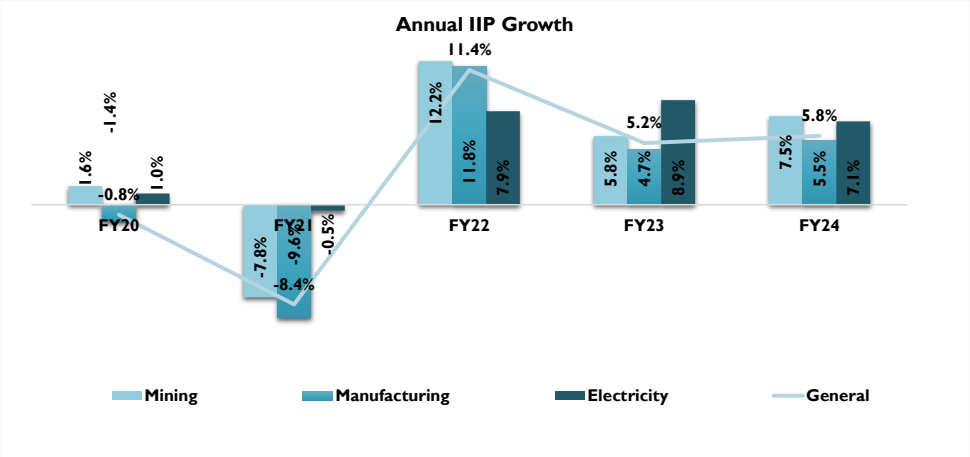
Source: Ministry of Statistics & Programme Implementation (MOSPI)

Sectoral analysis of GVA reveals industrial sector recovered sharply registering 9% y-o-y increase in FY 2024 against 2.1% in the previous fiscal. In the industrial sector, growth across major economic activity such as mining, manufacturing, construction sector rose significantly and it registered a growth of 8.1%, 8.5% and 10. 7% in FY 2024 against a growth of 1.9%, -2.20%, and 9.44% in FY 2023, respectively. Utilities sector observed a marginal moderation in y-o-y growth to 7.5% against a 10% in the previous years.

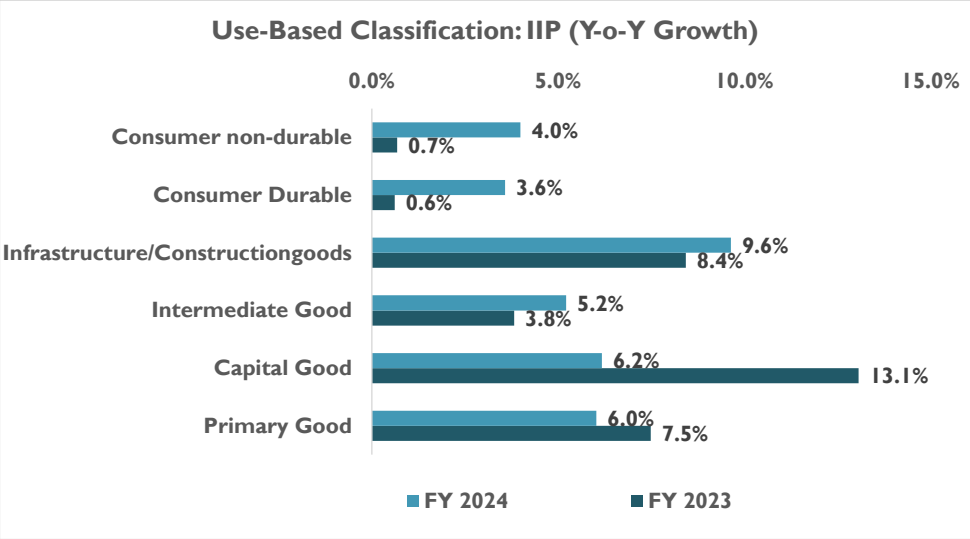
Talking about the services sectors performance, with major relaxation in covid restriction, progress on covid vaccination and living with virus attitude, business in service sector gradually returned to normalcy in FY 2023. Economic recovery was supported by the service sector as individual mobility returned to pre-pandemic level. The trade, hotel, transport, communication, and broadcasting segment continued to strengthen and grow by 10% in FY 2023 against 9% in the previous year. However, second advance estimates for FY 2024 reveal a decelerated growth in the largest component of the GDP, i.e., the service sector. In FY 2024, the sector registered a growth of 7.5%, as compared to the 10% growth recorded in FY 2023. This slowdown is primarily attributed to a pronounced deceleration in the Trade, Hotel, Transport, Communication, and Broadcasting services. The growth rate in this subsector nearly halved, decreasing from 12% in FY 2023 to 6.5% in FY 2024. This slowdown is influenced by the normalization of the base effect and potentially some dilution in discretionary demand. Financial services, real estate and professional services sector recorded 8.21% y-o-y growth against 9.05% y-o-y growth in the previous year, while public administration and defence services sector recorded 7.75% yearly increase against 8.92% increase in the previous year.

Index of Industrial Production

Industrial sector performance as measured by IIP index exhibited mild improvement in FY 2024 by growing at 5.8% (against 5.2% in FY 2023). Manufacturing index, with 77.6% weightage in overall index, grew by 5.5% in FY 2024 against 4.7% in FY 2023 while mining sector index too grew exhibited healthy improvement by growing at 7.5% against 5.8% in the previous years. Electricity sector Index witnessed improvement of 7.15% against 8.9% y-o-y growth in FY 2023.



Source: Ministry of Statistics & Programme Implementation (MOSPI)

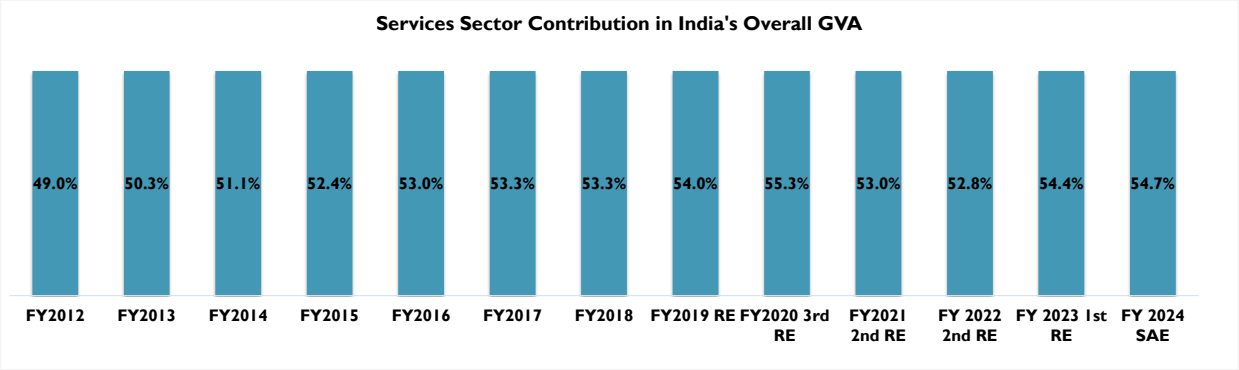


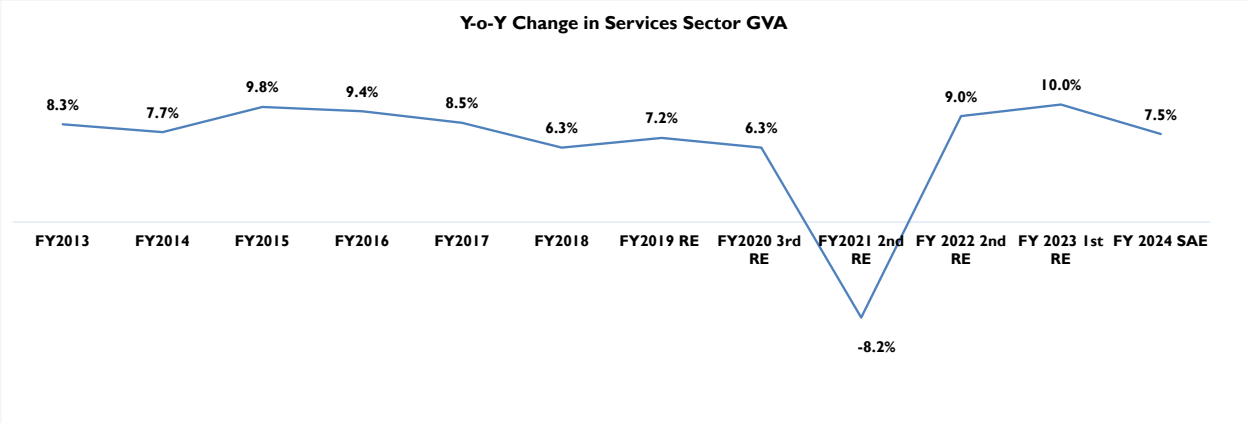
Sources: MOSPI

As per the use-based classification, excluding capital good and primary good, other segment observed healthy y-o-y growth against the previous year. Infrastructure / construction goods followed by intermediate goods were the bright spot while consumer non-durable and consumer durable both observed sharp growth over the previous year. However, the mild growth in IIP indicates towards challenging operating business climate as global headwinds, high inflation, and monetary tightening cumulatively impacted the broader industrial sector performance.

Expansion in Service Sector

Services sector is a major contributor to the country's overall economic growth. Since 2012, its contribution to India's GVA has increased from 49% to nearly 55% currently (in FY 2024) as per Second Advance estimates. While excluding 8.2% decline in FY 2021, the services sector GVA has observed average 8.2% growth between growth between FY 2013-24 and it has exhibited robust 8.8% average increase in the post pandemic period (FY 2022-24). The expansion of the service sector has spurred the development of multiple industries, including IT, healthcare, tourism, transport, and finance, among others.



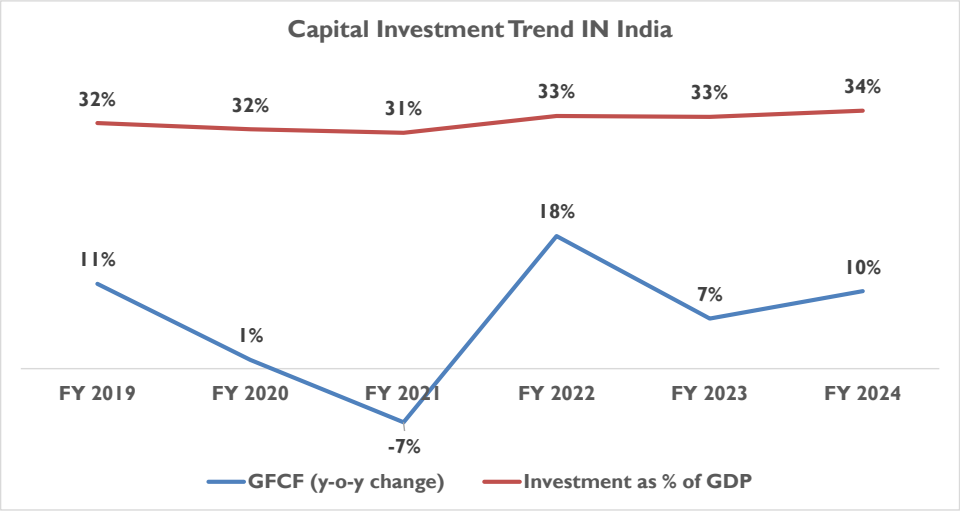


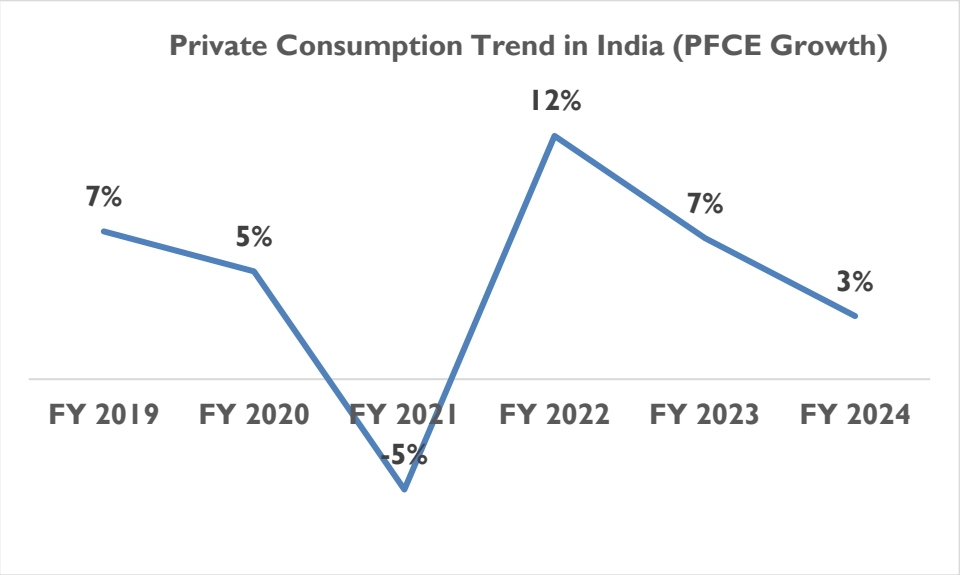
Source: Ministry of Statistics & Programme Implementation (MOSPI)

India's HSBC Services Purchasing Managers' Index**,** an important indicator to track service sector performance, increased to 61.4 in May 2024 from 60.8 in the previous month. Since August 2021, the services sector has consistently remained above the threshold of 50, which distinguishes growth from contraction.

Investment & Consumption Scenario

Other major indicators such as Gross fixed capital formation (GFCF), a measure of investments, gained strength during FY 2024 as it grew by 10% on y-o-y basis against 7% yearly growth in the previous fiscal, while GFCF to GDP ratio measured all time high settled higher at 34%.



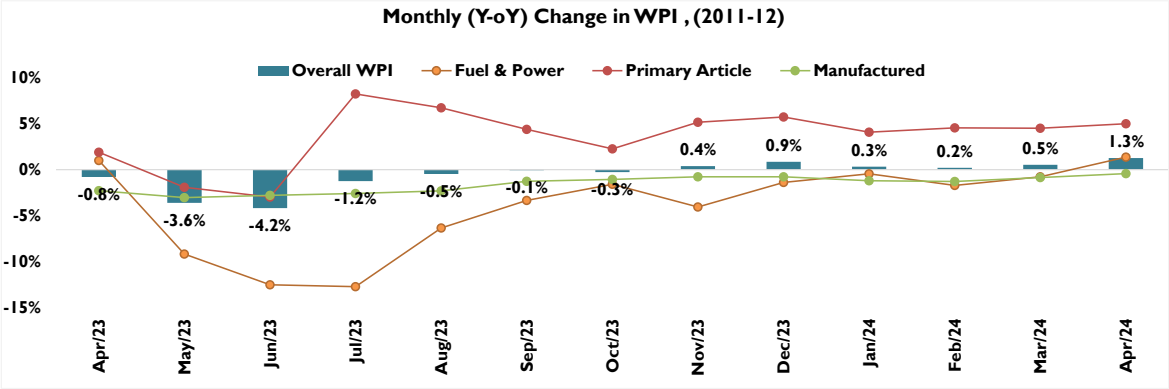


Sources: MOSPI

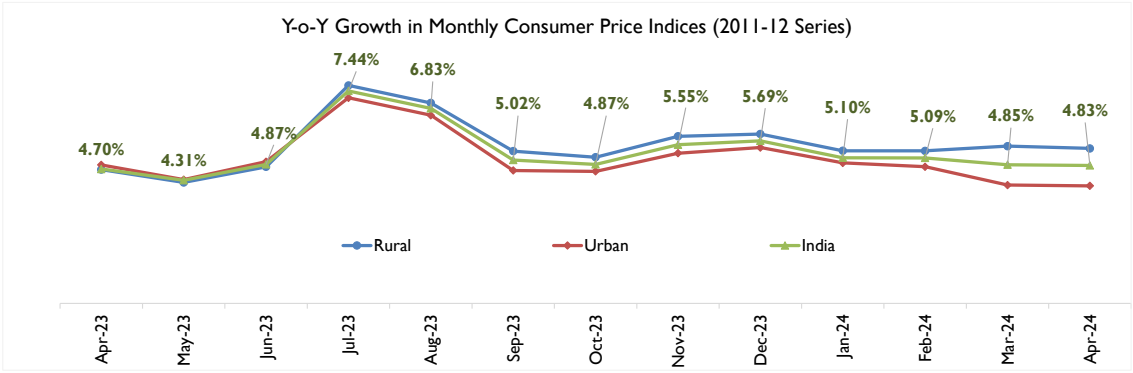
Private Final Expenditure (PFCE) a realistic proxy to gauge household spending, observed decelerated and registered 3.1% y-o-y growth in FY 2024 which is less than half of the previous year indicating sustained weakness in consumer spending.

Inflation Scenario

The inflation rate based on Wholesale Price Index (WPI) exhibited rose to1.3% in the month of April 2024 on the back of steady growth in the prices of primary article which grew by 5% in April 2024 on y-o-y bases. Increasing prices of food articles and energy prices contributed to increasing inflation.



Source: MOSPI, Office of Economic Advisor.

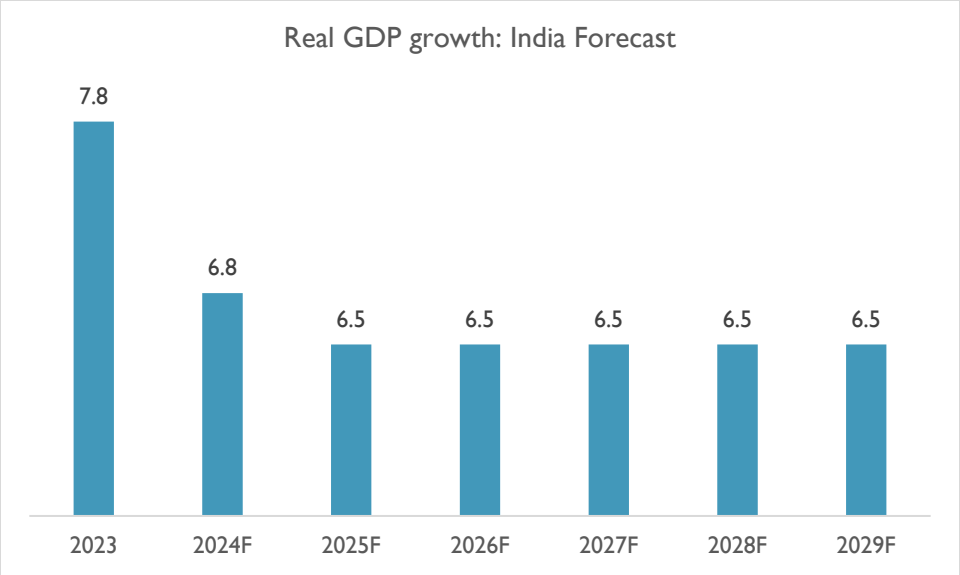


Source: CMIE Economic Outlook

Retail inflation rate (as measured by Consumer Price Index) eased to 4.83% in April 2024 as compared to 4.85% in March 2024. The CPI inflation for rural and urban for the month of April 2024 was 5.43% and 4.11% against 5.51% and 4.14% respectively in March 2024. Retail inflation moderated during FY 2024 after the peak of 7.4% in July 2023 and it fluctuated between 4.85%-6.83%. CPI measured below 6% tolerance limit of the central bank since September 2023. As a part of anti-inflationary measure, the RBI has hiked the repo rate by 250 bps since May 2022 to current 6.5% while it has been holding the rate at 6.5% since 8 Feb 2023.

India's Economic Growth Outlook

Looking ahead to 2024, India's projected GDP growth of 6.8% in 2024 stands out as the fastest among major emerging markets, significantly outpacing China's 4.6% and Brazil's 2.2%. This robust growth trajectory is expected to sustain at 6.5% annually from 2025 to 2029, reflecting strong economic fundamentals and continued momentum.



Source: IMF

This decent growth momentum in near term (2024) is accompanied by a slowdown in inflation, as well as various other factors in the medium to long term that will support the economy. These include enhancements in physical infrastructure, advancements in digital and payment technology, improvements in the ease of doing business and a higher quality of fiscal expenditure to foster sustained growth.

On the demand side, improving employment conditions and moderating inflation are expected to stimulate household consumption. Further, the investment cycle is gaining traction, propelled by sustained government capital expenditure, increased capacity utilisation and rising credit flow. Additionally, there are positive signs of improvement in net external demand, as reflected in the narrowing merchandise trade deficit. Despite the supply disruptions, exports clocked positive y-o-y growth in December 2023 and January 2024.

From uplifting the underprivileged to energizing the nation's infrastructure development, the Government has outlined its vision to propel India's advancement and achieve a 'Viksit Bharat' by 2047 in the interim budget announced on 1st Feb 2024. Noteworthy positives in the budget include achieving a lower-than-targeted fiscal deficit for FY24 and setting a lower-than expected fiscal deficit target for FY25, proposing dedicated commodity corridors and port connectivity corridors, providing long-term financing at low or nil interest rates to the private sector to step up R&D in the sunrise sectors.

Achieving a reduced fiscal deficit of 5.8% in FY24 and projecting a lower than-anticipated fiscal deficit of 5.1% are positive credit outcomes for India. This showcases the country's capability to pursue a high-growth trajectory while adhering to the fiscal glide path. There has been a significant boost to capital

expenditure for two consecutive years; capital expenditure – which is budgeted at 3.4% of GDP (INR 11.1 trillion/USD 134 bn) for 2024/25 – is at a 21-year high (3.3% of GDP in 2023/24). The enhancement of port connectivity, coupled with the establishment of dedicated commodity corridors (energy, mineral and cement), is poised to enhance manufacturing competitiveness. This strategic move aims to fulfil India's export targets and reduce logistics costs.

However, headwinds to external demand emanate from recession in key exporting partners - the UK and Germany (which collectively account for over 5% of India's export portfolio) - and the spiralling effect it will have on other European countries. Supply disruptions posed by the conflict in the Red Sea, leading to rerouting of shipments through Africa, are impacting sectors exposed to exports to Europe, running on thin margins, especially small businesses. Although headline inflation moderated to 5.1% in January 2024, a three-month low, volatility in crude prices and uncertainties about food inflation are likely to keep the central bank cautious in the near term.

India's optimistic economic outlook is underpinned by its demographic dividend, which brings a substantial workforce that boosts labor participation and productivity. The burgeoning middle class and urbanization contribute to increased domestic consumption, driven by rising incomes and purchasing power. Extensive investments in infrastructure, encompassing roads, railways, ports, and digital connectivity, are enhancing productivity and efficiency, with government initiatives like the Smart Cities Mission and PM Gati Shakti creating a conducive growth environment. This digital transformation, catalyzed by initiatives such as Digital India, is fostering a tech-driven economy marked by enhanced internet penetration, digital payments, and e-governance, thereby fueling growth in sectors like fintech, e-commerce, and digital services. The push to position India as a global manufacturing hub through Make in India and PLI schemes is further boosting industrial output, exports, and domestic production capabilities. Compared to other major emerging markets facing demographic and economic challenges, India's combination of demographic strengths, policy reforms, and strategic initiatives positions it as a standout performer and a significant driver of global economic growth in the foreseeable future.

Some of the key factors that would propel India’s economic growth.

Government focus on infrastructure development & Road Infrastructure Improvement

Infrastructure development has remained recurring theme in India’s economic development. The launch of flagship policies like National Infrastructure Pipeline (NIP), and PM Gati Shakti plan have provided the coordination & collaboration that was lacking earlier. Both NIP and PM Gati Shakti are ambitious billion-dollar plans that aim to transform India’s infrastructure, elevating it to the next level. These projects are expected to improve freight movement, debottleneck the logistics sector, and improve the industrial

production landscape, which would provide the incremental growth in GDP India's growing economic activities are propelling the development and expansion of road infrastructure across the nation. As the Indian economy continues its robust growth trajectory, it relies heavily on the presence of efficient transportation networks to facilitate the movement of goods and people. Roads play a vital role in opening areas and stimulating economic and social development and growth of several allied industries including lithium-ion batteries application in several sector.

Development of Domestic Manufacturing Capability

The Government launched Production Linked Incentive (PLI) scheme in early 2020, initially aimed at improving domestic manufacturing capability in large scale electronic manufacturing and gradually extended to other sectors. At present it covers 14 sectors, ranging from medical devices to solar PV modules. The PLI scheme provides incentives to companies on incremental sales of products manufactured in India. This incentive structure is aimed to attracting private investment into setting up manufacturing units and thereby beef up the domestic production capabilities. The overall incentives earmarked for PLI scheme is estimated to be INR 2 lakh crore. If fully realizing the PLI scheme would have the ability to add nearly 4% to annual GDP growth, by way of incremental revenue generated from the newly formed manufacturing units.

Strong Domestic Demand

Domestic demand has traditionally been one of the strong drivers of Indian economy. After a brief lull caused by Covid-19 pandemic, the domestic demand is recovering. Consumer confidence surveys by Reserve Bank / other institutions are points to an improvement in consumer confidence index, which is a precursor of improving demand. India has a strong middle-class segment which has been the major driver of domestic demand. Factors like fast paced urbanization and improving income scenario in rural markets are expected to accelerate domestic demand further. This revival is perfectly captured by the private final consumption expenditure (PFCE) metric. PFCE as a percentage of GDP increased to nearly 59.2% during the first half of FY 2023F[2], which is the highest level it has achieved during the past few years. Although pent-up demand has played a part in this surge, this is an indication of normalization of demand. There are two factors that are driving this domestic demand: One the large pool of consumers and second the improvement in purchasing power. As per National Statistics Office (NSO) India's per capita income (in current prices) stood at INR 1.72 lakhs in FY 2023 which is nearly double of what it was in FY 2015. This

[2] India Economic Survey FY 2023, Full year data is yet to be released.

increase in per capita income has impacted the purchasing pattern as well as disposable spending pattern in the country. Consumer driven domestic demand is majorly fueled by this growth in per capita income.

Digitization Reforms

Ongoing digitization reforms and the resultant efficiency gains accrued would be a key economic growth driver in India in the medium to long term. Development of digital platforms has helped in the seamless roll out of initiatives like UPI, Aadhaar based benefit transfer programs, and streamlining of GST collections. All of these have contributed to improving the economic output in the country. Some of the key factors that have supported the digitization reforms include – the growth in internet penetration in India together with drop in data tariffs, growth in smartphone penetration, favourable demographic pattern (with higher percentage of tech savvy youth population) and India's strong IT sector which was leveraged to put in place the digital ecosystem. All these factors are expected to remain supportive and continue to propel the digitization reforms in India.

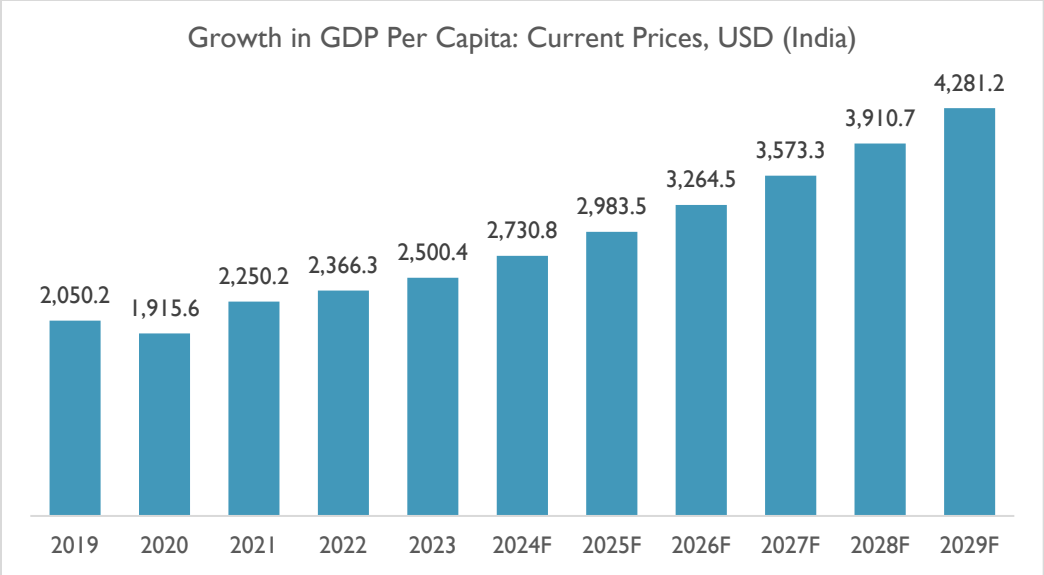
Increased adoption of digital technology and innovation, inclusive and sustainable practices, business-friendly and transparent regulations, and heightened corporate research and development (R&D) investments will further bolster the country's growth. These factors will collectively support employment growth across both private and public sectors, including micro, small, and medium enterprises (MSMEs).

Major Demographic Factor Contributing to India Growth

India's Per capita GDP trends

India is poised to become the world's third-largest economy with a projected GDP of USD 5 trillion within the next three years, driven by ongoing reforms. As one of the fastest-growing major economies, India currently holds the position of the fifth-largest economy globally, following the US, China, Japan, and Germany. By 2027-28, it is anticipated that India will surpass both Germany and Japan, reaching the third-largest spot. This growth is bolstered by a surge in foreign investments and a wave of new trade agreements with India's burgeoning market of 1.4 billion people. The aviation industry is witnessing unprecedented orders, global electronics manufacturers are expanding their production capabilities, and suppliers traditionally concentrated in southern China's manufacturing hubs are now shifting towards India.

To achieve its vision of becoming the world's third-largest economy by 2027-28, India will need to implement transformative industrial and governmental policies. These policies will be crucial for sustaining the consistent growth of the nation's per capita GDP over the long term.

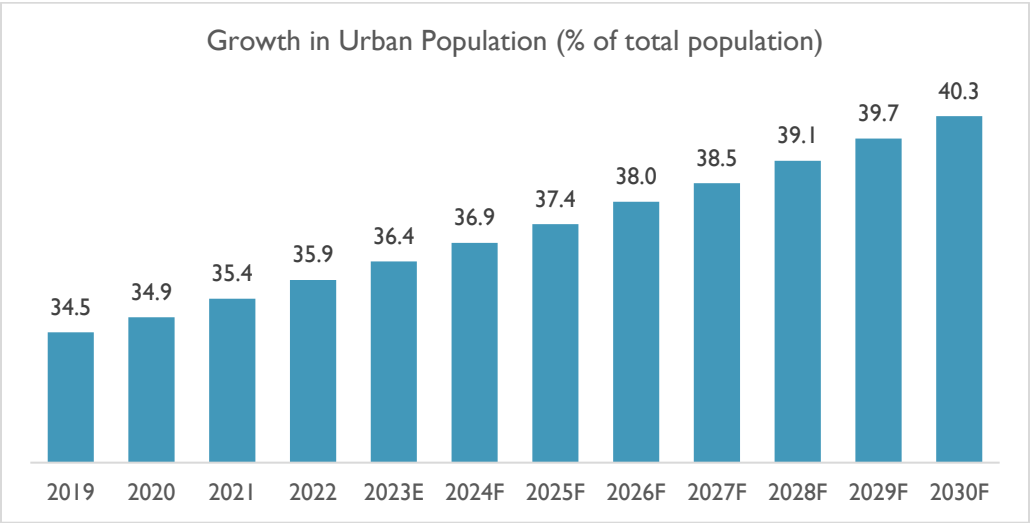


Source: IMF

From 2024 to 2029, India's per capita GDP is projected to grow at a compound annual growth rate of 9.4%. This growth will be driven by the service sector, which now accounts for over 50% of India's GDP, marking a significant shift from agriculture to services.

Increasing Urbanisation

As per the handbook of urban statistics 2022, India's urban population has been on a steady rise, with urban dwellers accounting for over 469 million in 2021, is projected to soar to over 558 million by 2031 and further exceed to 600 million by 2036.



Source: World Bank, D&B Research and Estimates

The share of urban population in total population has been quickly escalating. In 2019, 34.5% of the total population was urban. By 2023, this is estimated to have reached to 36.4%, showing an increment of 2.1%

in a span of four years. The share of urban population is further forecasted to cross 40% by 2030. This increase in urban population is set to demand drastic changes in infrastructure development. With cities expanding rapidly, there will be an increased need for improved housing, water supply, sewage systems, and electricity. Urban planning will need to account for higher population densities, necessitating the development of smart cities with integrated technology for efficient management of resources and services. This transformation will also require significant investment in public health, education, and recreational facilities to enhance the quality of urban living.

Overview: Lithium Ion Battery

Storage battery or rechargeable battery is a type of electrical battery comprising one or more electrochemical cells enabling electrochemical reactions which are electrically reversible. Some of the popular and commercial battery chemistry that are used world over include lead–acid, nickel metal hydride (NiMH), nickel cadmium (NiCad), lithium ion (Li-ion), and lithium-ion polymer (Li-ion polymer). These storage batteries have higher initial cost than disposable battery but can be recharged and used many times. These batteries find wide application in motor vehicles as well as back-up power supply units.

Amongst all, Lead acid batteries are one of the oldest rechargeable batteries with more than 150 years of existence. With a proven arrangement for reliable and low-cost energy storage, lead-acid batteries play an important role in our day-to-day life and still hold a substantial share in the overall battery market. Lead acid battery demand is broadly segment into two – automotive batteries and industrial batteries Automotive batteries (including batteries sold to OEMs and replacement batteries) form the largest component, accounting for close to 50% of total battery sale. Industrial batteries can be further divided into three: conventional flooded lead battery, valve regulated lead acid (VRLA) battery and nickel cadmium battery.

In industrial segment, it finds application in a wide range of industries such as Telecom, Railways, Power Control, Solar and UPS, amongst other. Also, the industry has been witnessing significant technological advancements to push its deployment in new and emerging application segments such as EV and energy storage application. Although, the lithium-ion batteries have built a remarkable presence in EVs and grid scale storage applications, but lead-acid batteries continue to stay ahead in terms of production costs, adoption.

In India, lead acid batteries hold a dominant position which can be attributed primarily to the cost advantage of lead acid batteries. The domestic capability to manufacture lead acid batteries, including sealed lead acid ones, is well established, with numerous players in the sector. This has resulted in low production costs due to easy access to raw materials, labor, and utilities, making these batteries available at a lower cost.

Lithium-ion battery

A lithium-ion battery or Li-ion battery (LIB) is a type of rechargeable battery. These are widely used in portable electronics, PDAs, iPods, cell phones, laptops, electronic toys etc. and are growing in popularity for its application electric vehicle and energy storage application in solar energy. In many applications, the industry is witnessing shift from conventional batteries to lithium-ion batteries because of their customizable property where in the number of cells in the battery can be adjusted based on the energy

requirement. Structurally, EV battery is different from the Li-ion battery used in portable electronic batteries used in tablets, phones, and laptops. ***The EV battery contains a series of small cells grouped in a module. Several modules are then tightly assembled to make a traction battery pack***.

Lithium is the also lightest solid element and possesses the highest oxidation potential. Li-On battery have higher energy density compared to the standard lead acid and NiMH batteries, which make it a preferred material for EV. Furthermore, longevity of Li-ion battery and its reducing cost are another major reason for this shift. *As per industry estimates, Lead acid batteries that cost around INR 7,000 lasts only but a lithium-ion battery that costs INR 30,000. Currently, batteries account for almost 40-50% of the cost of an electric vehicle*.

Li-On Batteries Structure

Lithium-Ion battery is made of one or more power generating compartments called cells where each cell essentially comprises of three components. -positive electrode, negative electrode, and electrolyte. A **positive electrode** connects to the battery's positive terminal, a **negative electrode** connects to the negative terminal and chemical called an electrolyte is in between them. Lithium-ion batteries comprise a family of battery chemistries that employ various combinations of anode and cathode materials.

Lithium-ion batteries are often clubbed together with group of batteries that contain lithium, but their chemical composition may differ widely and so do their performance. Li-ion battery uses an intercalated lithium compound as one electrode material, compared to the metallic lithium used in a non-rechargeable lithium battery. In the Li-ion batteries, lithium ions move from the negative electrode (anode) to the positive electrode (cathode) during discharge and vice-versa when charging.

In lithium batteries, cathode materials largely include minerals such as aluminium, cobalt, lithium, manganese, and nickel, with anode made up of graphite. The positive electrode is typically made from a chemical compound called Lithium-cobalt oxide (LiCoO2) or Lithium Iron phosphate (LiFePo4). The negative electrode is generally made from carbon(graphite). Following are major advantages and disadvantage of Li-ion Battery.

Advantages

- Amongst all the rechargeable batteries, li-ion battery has highest energy density which typically range 50-260 Wh/kg, compared to 60-120 Wh/kg for a nickel-metal hydride (NiMH) battery, 45-80 Wh/kg for Nickel-cadmium battery and only 30-50 Wh/kg for a lead-acid battery.
- Does not need prolonged priming when new. One regular charge is all that's needed. LIBs hold a charge well. They usually lose approximately 5% of their charge each month, against a 20% monthly loss for NiMH batteries.
- Low Maintenance - no periodic discharge is needed; there is no memory.

- LIBs do not require complete discharge prior to recharging.
- LIBs can handle more charge/discharge cycles.
- Lithium is 100% recyclable

Limitations

- Requires protection circuit to maintain voltage and current within safe limits.
- LIBs are highly sensitive to higher temperatures. Higher temperature leads to a much faster degradation rate than normal.
- LIBs start to degrade the moment they leave the factory. Subject to aging, even if not in use - storage in a cool place at 40% charge reduces the aging effect.
- If a LIB is fully discharged, it gets totally damaged.
- There exists a small possibility that if the LIB pack fails, it may burst open into flame.
- Transportation restrictions - shipment of larger quantities may be subject to regulatory control. This restriction does not apply to personal carry-on batteries.
- Expensive to manufacture - about 40% higher in cost than nickel-cadmium.

Manufacturers of Li-ion batteries have experimented with the materials used on the cathode & anode as well as varying composition of electrolyte which causes lithium-ion batteries to vary in their energy density levels. Li-ion battery have a high energy density[3] and low self-discharge. Following are few the most popular lithium-ion battery chemistries, along with their respective energy densities, use cases, benefits, and constraint.

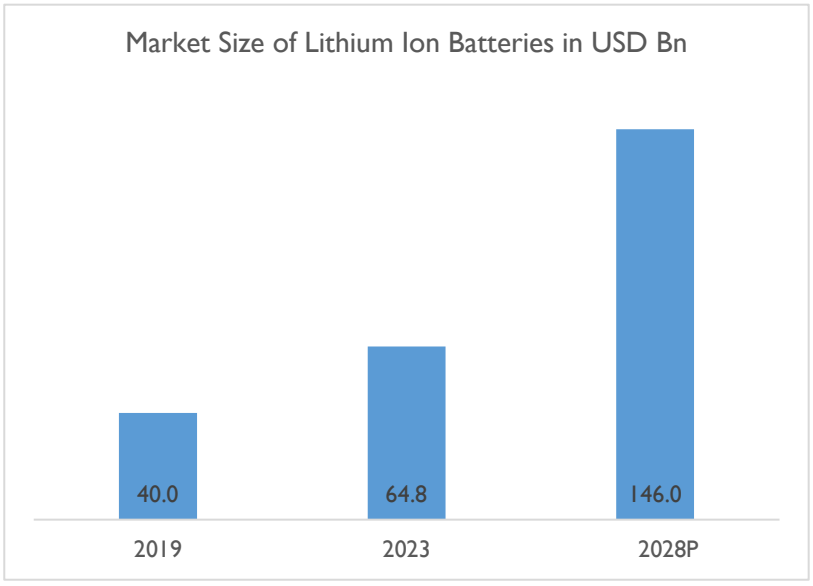
Global Lithium-Ion Battery Industry

Market Scenario

The lithium-ion battery industry is experiencing a remarkable surge, transforming the way humans power their lives. From electric vehicles (EVs) to consumer electronics, these versatile batteries are playing a pivotal role in the clean energy transition. The global lithium-ion battery market has witnessed a significant leap, reaching an estimated USD 64.8 billion in 2023, compared to USD 40 billion in 2019. This translates to a compound annual growth rate (CAGR) of 13%, indicating a steady and consistent expansion. Going forward, the market is projected to soar even further, reaching over USD 146 billion by 2028, with a

[3] Energy density is the measure of how much energy a battery contains in proportion to its weight and is typically presented in Watt-hours per kilogram (Wh/kg). A watt-hour is a measure of electrical energy that is equivalent to the consumption of one watt for one hour.

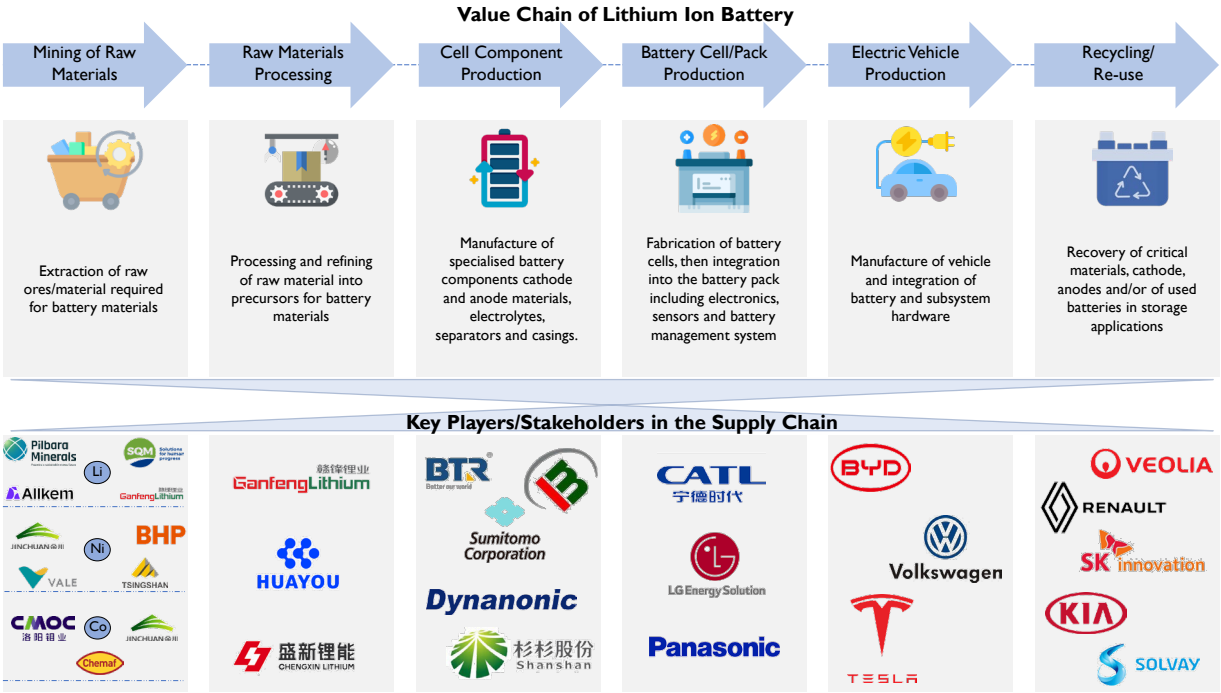
projected CAGR of 17.6%. This exponential growth trajectory underscores the immense potential of lithium-ion batteries in shaping the future of energy.



Sources: Dun & Bradstreet Desk Research

Global Li-ion battery value chain

Lithium-ion battery supply chains consist of multiple complex stages that are spread around the world. They involve extracting minerals, refining chemicals, synthesizing materials, fabricating cells, and assembling modules. Below graphics explains the Lithium -ion battery supply chain.

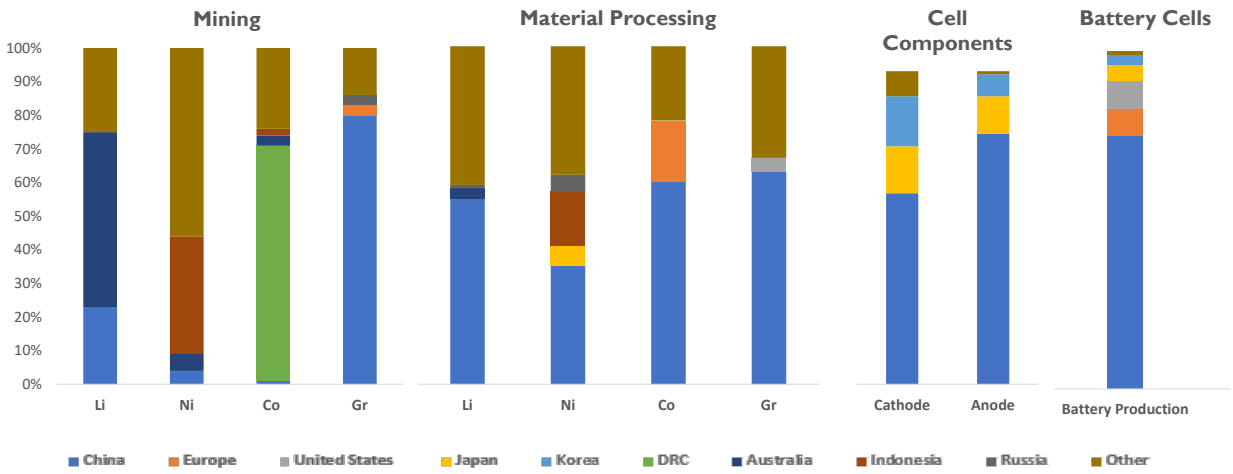


- **Mining:** The five key battery materials are *lithium, nickel, cobalt, graphite, and manganese*. Lithium is extracted from two very different sources brine or hard rock and are found in high elevation areas of Bolivia, Argentina and Chile in South America with China being the largest producer. Nickel is found primarily in two types of deposit -sulphide found in Russia, Canada, Australia and laterite found in Indonesia, Philippines and New Caledonia. Cobalt is predominantly mined as a by- product of copper or nickel mining. Over 70% of cobalt is produced in the Democratic Republic of Congo (DRC) and Glencore (Switzerland) is the largest global producer. Graphite is the dominant anode material and can be found naturally or produced synthetically. Natural graphite mining is dominated by China contributing 80%, though global production is becoming more diversified. Manganese resources are more widely distributed around the world than the other battery metals and remain available at relatively low cost.
- **Raw Material Processing:** Batteries require high priority materials and therefore high-grade sources, as well as significant refining, is required to reach sufficient quality battery chemical precursors. These refining processes typically involves heavy industrial processes based on heat or chemical treatment (typically *pyrometallurgy and/or hydrometallurgy*) to refine the raw ore into the usual required chemicals, lithium carbonate or hydroxide, or cobalt and nickel sulphate. Adding complexity, certain raw materials are more or only suitable to produce battery precursors.
- **Cell Component Production:** Batteries are comprised of several highly specialised components including cathode and anode materials, electrolytes, and separators. These components require advance materials chemistry an engineering for their production. The most complex processing is required to form battery active materials from the high priority chemicals produced from raw material processing such as lithium hydroxide and nickel sulphate. These materials are further processed using specialised synthesis to produce active materials for the cathode and anode.
- **Battery Cell and Pack Production:** Producing the battery cells is a multi-step process with 2 broad stages: *electrode manufacturing* and *cell fabrication*. Though cell manufacturers have different cell designs, The cell manufacturing processes are similar. Manufacture of the battery pack may be completed either by the cell manufacturer or by the automaker. Cells are first housed together in module frames, then the battery pack is assembled through the integration of modules, the battery management system, electronics, and sensors, all encased in a final housing structure.
- **Battery Cell and Pack Production:** The battery pack is integrated into the EV by the automakers, where it relates to the electric motor, on-board charge module, high voltage distribution box, electric transmission, and thermal systems, depending on the vehicle

architecture. Automakers focussing only on EVs must develop greenfield factories, while for incumbent automakers pre-existing vehicle assembly factories can be retooled and repurposed for EV production.

- **Recycling/Re-use:** Re-use or repurposing involves refurbishing EV batteries for less demanding second-life applications, typically in stationary storage. Spent EV batteries typically still have around 70-80% of their usable capacity, therefore, repurposing generates additional value from these batteries. Re-use requires disassembly of the pack, testing of the module/cells, and repackaging into new packs for new applications. The primary drivers of cost of refurbishing batteries are the logistics involved in their collection, testing of remaining useful life, and the physical disassembly and repacking of cells/packs. Reuse, however, faces economic and regulatory challenges including ensuring reliable grading of cells/packs, liability and ensuring the cost of repurposing is competitive with new batteries.

China Dominates the entire downstream Lithium-ion Battery Value Chain:

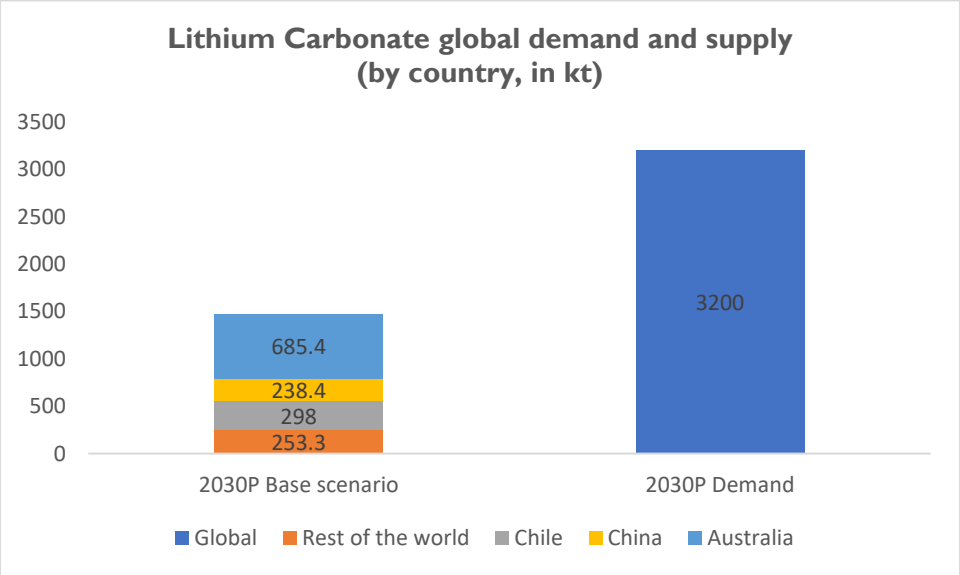


Industry Sources

Raw material Availability

In addition to the above, there is a growing concern over the scarcity of raw materials used in Li-ion batteries. The demand for lithium, driven primarily by battery-related applications, is expected to increase significantly in the coming years. Currently, around 60 percent of lithium production is dedicated to batteries, but this figure could rise to 95 percent by 2030. While lithium reserves exist worldwide, high-grade deposits are mainly concentrated in a few countries, including Argentina, Australia, Chile, and China.

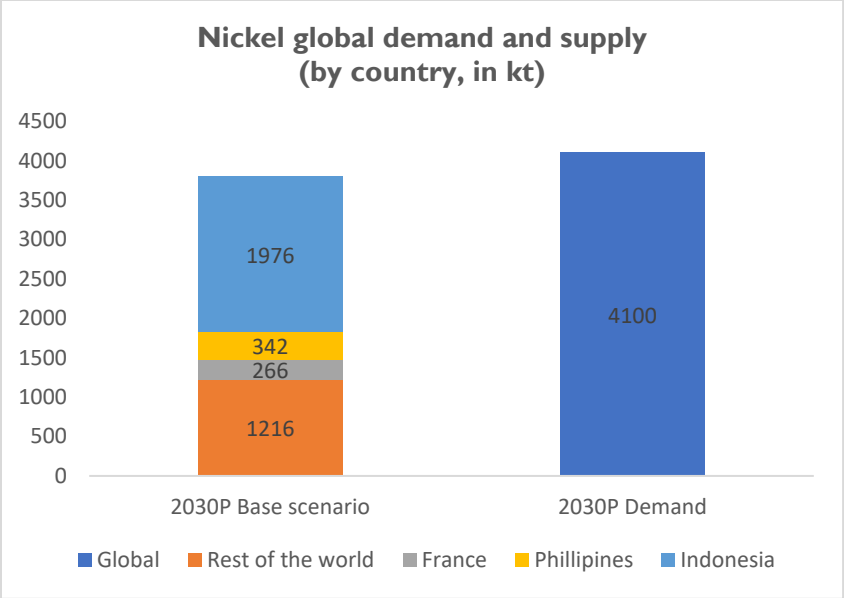
To meet the growing demand for lithium, there will need to be a substantial increase in mining activities. However, it is important to note that lithium mining projects require significant investments and face various challenges, including environmental concerns and local opposition. Additionally, as the technological advancements in battery technology continue to evolve, there may be a need for more lithium-heavy batteries, further increasing the demand for lithium.

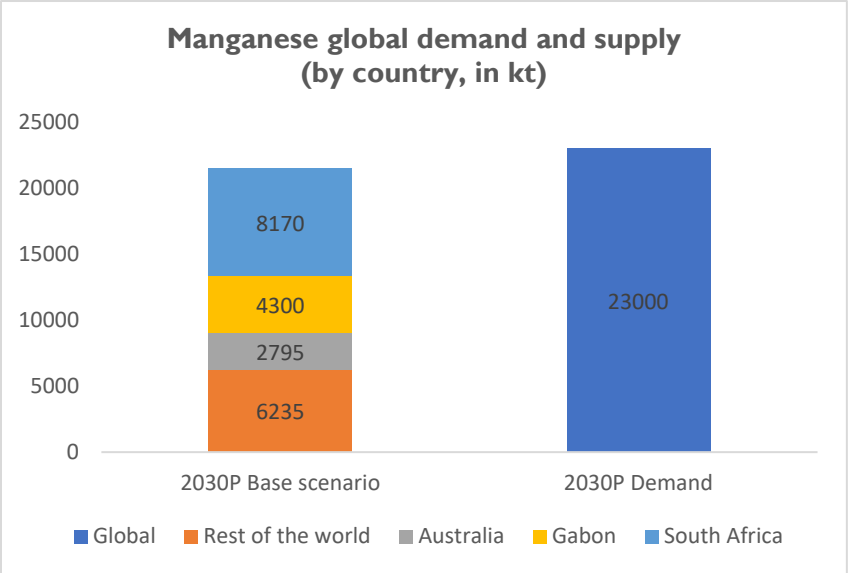


Source: D&B research estimates

To ensure sufficient lithium supply in the future, stakeholders need to strive for the full potential scenario. This scenario takes into account the impact of nearly every announced project in the pipeline and necessitates substantial additional investment in mining projects. Moreover, emphasizing smart product technology choices can also contribute to addressing the potential shortage of lithium. For instance, exploring alternatives such as silicon anodes instead of Li-metal can help reduce the reliance on lithium and ensure a more sustainable supply chain.

While lithium reserves theoretically have the capacity to meet the demand for batteries, it is crucial for industry stakeholders to proactively plan and invest in mining projects to avoid potential supply shortages. This includes exploring alternative technologies, optimizing resource extraction, and investing in sustainable practices to mitigate the environmental impact of increased lithium mining activities.

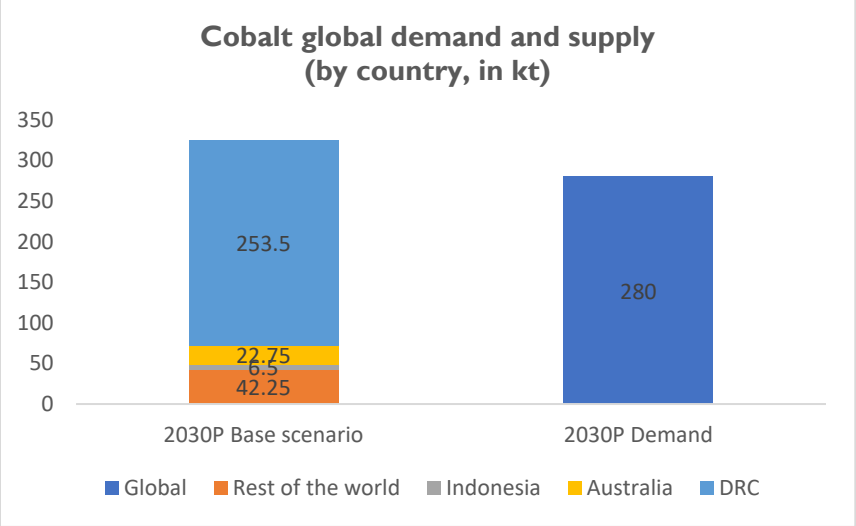




Source: D&B research estimates

For nickel, reserves are spread across multiple countries, including Australia, Canada, Indonesia, and Russia. In the base scenario, there is only a small shortage of nickel anticipated in 2030. This is primarily due to the recent shift towards more lithium iron phosphate (LFP) chemistries, which utilize less nickel, as well as plans to increase mining capacity. However, in the full potential scenario, there could be a significant oversupply of nickel if mining and refining potential is fully realized. Despite this potential oversupply, companies might still encounter challenges in acquiring sufficient quantities due to quality requirements, such as the need for class 1 nickel instead of class 2 nickel in the form of ferroalloys, and the limited geographic distribution of mines.

On the other hand, the supply of manganese is expected to remain stable through 2030 as no additional capacity announcements are anticipated. However, there is a slight projected supply shortage in the base scenario due to a slight increase in demand. It is important to note that there is some uncertainty surrounding manganese demand projections, particularly regarding the potential market share gain of lithium manganese iron phosphate (LMFP) cathode chemistries, especially in the commercial vehicle segment. This uncertainty suggests that the demand for manganese could vary depending on the adoption and market penetration of these chemistries.



Source: D&B research estimates

Cobalt, on the other hand, is projected to be present in access. Approximately 75 percent of mined cobalt comes from the Democratic Republic of Congo (DRC) as a by-product of copper production. The share of cobalt in batteries is expected to decrease, while supply is set to increase due to growing copper mining in the DRC and nickel mining in Southeast Asia. While shortages of cobalt are unlikely, price volatility may persist as it is primarily obtained as a by-product. Efforts to reduce cobalt reliance and develop alternative battery chemistries are underway to mitigate supply chain risks and enhance sustainability.

Li-ion battery Recycling:

Lithium-ion battery are high reactive properties and improper handling is dangerous for environment as these batteries are capable of poisoning water bodies, soil and air. Therefore, amidst growing lithium-ion battery demand, scarcity of critical input resources and to secure a steady supply of price sensitive commodities at low environmental cost, ***investing in battery recycling infrastructure* is critical**. Given the finite resource availability, it become essential to invest in into technologies aimed at extending the use life of components and recovering the embedded materials.

Industry sources suggest, a li-ion battery in EV is about has a shelf life of about 8 years and after 5 to 8 years of use its capacity drops to below 70-80% which is not sufficient enough for EV give the desired range. However, after use in vehicles for about 7-8 year, the used lithium-ion battery still preserves about 70-80% of its capacity that can be tested and used for stationary energy storage applications like in homes, offices, streetlights, data centres, amongst others for at least an additional three to five years which thereby can help in increasing the overall battery usage life cycle. It is a tested process and is being applied mainly in some international market such as Europe, China and US. This is one of the effective ways where Indian battery solution providers can apply to mitigate battery-disposal issues. However, this method does not address the of sourcing critical elements like lithium and cobalt, which are essential to produce new EV batteries. As per industry sources, the seven principal components (cobalt, lithium, copper, graphite, nickel, aluminum, and manganese) constitute more than 90% of the total economic value of a spent lithium-ion battery which can be extracted, recycled, and used for new EV application. Thermal treatment process for the electrolyte followed by a mechanical and chemical treatment process to extract lithium and other component is applied on discharged and dismantled batteries.

There are three primary methods for Li-ion battery recycling: *pyrometallurgy, hydrometallurgy* and direct recycling. Pyrometallurgy involves smelting the battery in a high temperature oven, recovering only a fraction of metals from the cathode. Hydrometallurgy involves a chemical leaching process to precipitate out individual metals. Currently, most battery recycling uses a combination of pyrometallurgy and hydrometallurgy as they are well suited to a poorly sorted feedstock of cells. These methods rely on reclaiming the expensive metals specifically nickel and cobalt, and often the copper and aluminium. Current global capacity for battery recycling is around 200 kt/year with China accounting for about half. This dominant position is expected to be retained due to announced additional capacity. Most battery recycling companies are independent recyclers, but OEMs, battery manufacturers, miners and processors are starting to enter the market.

Recycling Benefit

Each of the metals used in Lithium Ion Battery have either ESG issues or supply security issues, or both. For example, 70% of the world's cobalt is being mined in DR Congo region and it is projected that we will run out of cobalt by 2030 which make recycling an essential economic activity to support the lithium supply.

Prior research conducted reveals that 70% reduction in energy consumption when lithium-ion cell is produced from recycled cobalt vis-à-vis virgin raw material. For lithium, instead of resource depletion, the uninterrupted supply from suppliers remains crucial. The country may face undersupply of lithium soon which favor large scale recycling of batteries.

Besides being energy intensive, traditional lithium mining is a water-guzzling process which requires about 500,000 gallons of water to produce 1 tonne of Lithium which has associated social and ecological implication.

The rapid surge in electric vehicle (EV) demand has brought about a parallel growth in EV battery production, with projections indicating a global gigafactory capacity of over five terawatt hours (TWh) annually by 2030. This surge in production has also spotlighted the emerging opportunities within the battery recycling sector as these batteries near their end-of-life stage.

Factors Driving Demand for Battery Recycling:

1. **Raw Material Scarcity:**
   The core composition of electric vehicle batteries primarily relies on lithium-ion technology and incorporates rare elements like Lithium, Nickel, and Cobalt. As the electric vehicle industry expands, there is a foreseen increase in demand for these precious elements. However, this heightened demand raises concerns about their limited availability, which is further concentrated in just a handful of countries. This potential supply chain challenge looms over the industry.
2. **Supply Chain Resilience:**
   Several automotive OEMs and cell producers are taking proactive measures to ensure supply chain stability. They are seeking to secure local sources of recycled raw materials to maintain consistent supply at stable prices. To exemplify, VW's partnership with Redwood Materials in the US and GM's collaborations with Li-Cycle and Cirba Solutions are indicative of the efforts to ensure a dependable supply chain. By sourcing from domestic recyclers, these companies are also sidestepping the creation of demand for raw materials from conflict regions or those sourced via methods involving child labour.

3. **Decarbonization Initiatives:**

   To align with the ambitious targets set by automotive OEMs for decarbonization, there is a notable preference for utilizing recycled battery materials over newly mined ones. Recycled materials boast significantly lower carbon emissions – about four times lower – leading to a reduction of more than 25 percent in the carbon emissions footprint per kilowatt-hour (kWh) of battery cell capacity manufactured. This approach underscores the industry's commitment to sustainability and its endeavours to minimize environmental impact.

Battery recycling not only mitigates the negative environmental impact of battery disposal but also has the potential to reduce the overall cost of batteries and, consequently, electric vehicles. This approach aligns with the *circular economy model*, focusing on maximizing the utilization of existing resources.

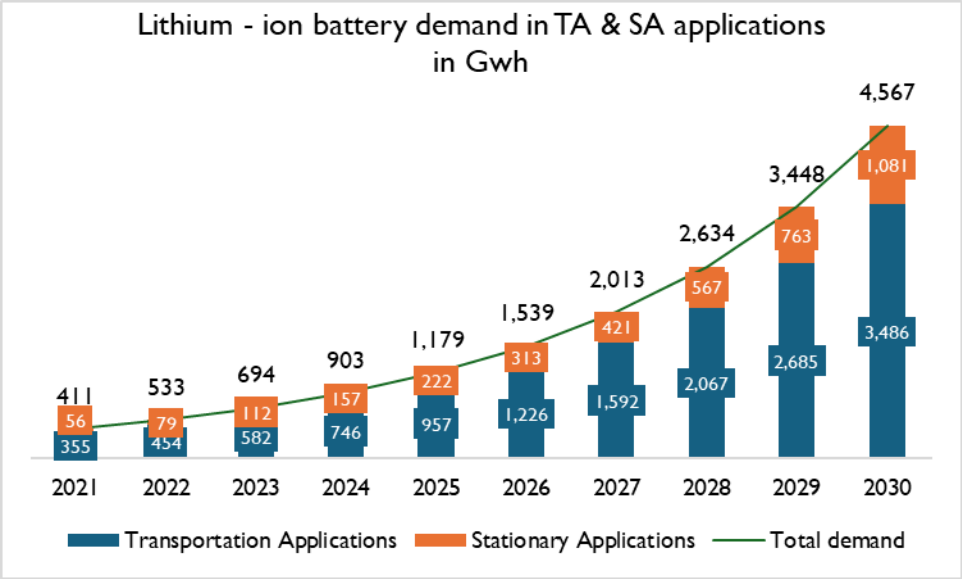
Major Factors Impacting the Creation of Lithium-Ion Battery supply chain.

Li-ion battery supply chain is complex and involves a wide range of players from miners and refiners of raw material to battery manufacturers or assembler. The following are some of the factors that have a material impact on developing a lithium battery supply chain:

- **Availability of input materials:** The production of Lithium-ion batteries requires a variety of raw materials including lithium, cobalt, nickel, manganese, and graphite. These materials are not evenly distributed around the world, and some countries such as China have a significant dominance in the production of these materials. This concentration of supply can make the Lithium-ion battery supply chain vulnerable to disruptions, such as political instability or natural disasters.
- **Price volatility of input materials:** The prices of raw material for li-ion batteries can be volatile, which can impact the cost of batteries and overall competitiveness of the end use application such as EVs.
- **Technology development:** The technology of producing li-ion batteries is constantly evolving, and new battery chemistries are being developed that offer improved performance and cost. However, the development of a new battery technologies can be long and expensive process and there is no guarantee that the new technology will be successful.
- **Manufacturing capacity:** The manufacturing capacity of li-ion batteries particularly the EV batteries is still relatively limited, and this can lead to bottlenecks in the supply chain. To meet the growing demand for EVs, it is necessary to increase the manufacturing capacity for EV batteries.

- **Government policies:** Government policies can have a significant impact on the EVs battery supply chain. For example, government subsidies for EV purchase can boost demand for EVs, while government regulation on battery recycling can impact the cost batteries.

Global Demand Scenario



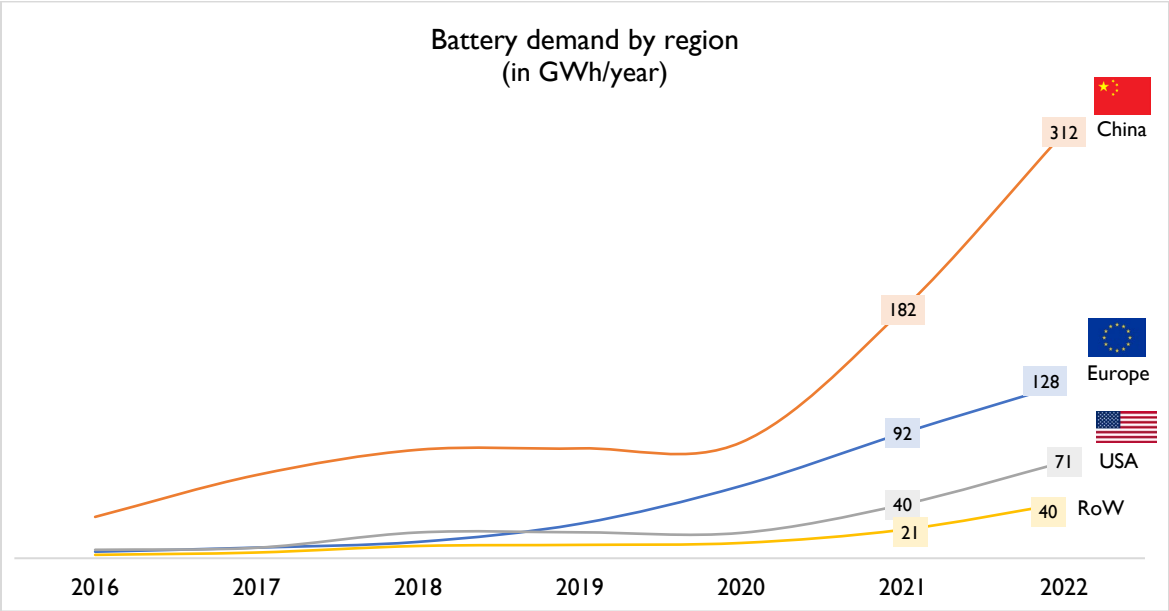
Source: (Niti Aayog, D&B analysis)
Note: As per Niti Aayog latest report, the historical projection is available from 2022 – 2030 and actual figure is for 2021.

The lithium-ion battery sector is witnessing remarkable growth across transportation and stationary applications, as evidenced by the latest projections. The demand is expected to rise significantly, with total demand increasing from 411 GWh in 2021 to 4,567 GWh in 2030. In the transportation segment, driven by the surging adoption of electric vehicles worldwide, the demand is forecasted to skyrocket from 355 gigawatt-hours (GWh) in 2021 to a staggering 3,486 GWh by 2030, nearly a tenfold increase. This exponential growth can be attributed to mounting environmental concerns, favorable government policies, technological advancements, and rising consumer demand for sustainable mobility solutions. Concurrently, the stationary applications segment, encompassing energy storage systems for renewable sources like solar and wind, is poised for substantial expansion. The demand is projected to surge from a modest 56 GWh in 2021 to a significant 1,081 GWh by the end of this decade, a remarkable twentyfold increase. This trajectory is driven by the global transition towards clean energy sources, the need for reliable energy storage solutions, and advancements in battery technologies that enhance cost-effectiveness and efficiency. Overall, the lithium-ion battery market is expected to witness an unprecedented surge in demand, catalyzed by the worldwide push for sustainable energy solutions, technological innovations, and supportive policy frameworks.

Regional scenario: Li-ion battery demand scenario in key regions

Global Outlook for Li-ion Batteries:

The global market for lithium-ion (Li-ion) batteries is experiencing rapid growth, driven by advancements in battery technology, supportive government policies, and increasing awareness of environmental sustainability. As the demand for energy storage solutions increases across various sectors, understanding regional dynamics in Li-ion battery demand and production becomes crucial for stakeholders in the value chain.



Sources: IEA report. Notes: ROW stands for Rest of the World

Europe

Battery demand in Europe has shown a significant increase from 2016 to 2022, rising from 4.8 GWh/year to 127.7 GWh/year. This growth indicates a rising need for energy storage solutions for applications such as renewable energy integration, grid stabilization, and industrial uses. Europe's ambitious targets for reducing carbon emissions and transitioning to cleaner energy sources drive the demand for Li-ion batteries to support renewable energy projects and energy storage solutions. Furthermore, Europe's focus on developing a circular economy for batteries, including recycling and second-life applications, contributes to this demand growth.

China

China is the world's largest manufacturer of Li-ion batteries, benefiting from economies of scale, vertical integration, and continuous technological improvements. The demand is fueled by the country's leadership in renewable energy, requiring substantial battery capacity for storage and grid stability, and by industrial applications like backup power and power tools.

China's lithium-ion (Li-ion) battery demand soared from 30.3 GWh/year in 2016 to 312 GWh/year in 2022. The rapid growth is driven by strong government support, including subsidies, incentives, and strict regulations aimed at promoting renewable energy and grid modernization. Significant investments in research and development have also advanced battery technology.

Strategic initiatives like the Belt and Road Initiative (BRI) and international partnerships enhance China's position in the global market. The country's commitment to achieving carbon neutrality by 2060 further drives Li-ion battery demand, alongside efforts to develop recycling technologies for sustainable lifecycle management.

Challenges remain, such as securing a stable supply of critical raw materials and addressing environmental impacts. However, China's proactive approach, strategic investments, and focus on innovation and sustainability ensure its continued leadership in the Li-ion battery market.

United States

The United States also experiences a considerable increase in Li-ion battery demand from 2016 to 2022, climbing from 6.2 GWh/year to 70.6 GWh/year. The US is witnessing a surge in renewable energy installations, driving the need for advanced energy storage solutions. Advancements in energy storage technologies and increasing awareness of energy resilience contribute to the growing demand for Li-ion batteries in the United States. The country's focus on grid modernization and the development of smart grid technologies further supports this growth.

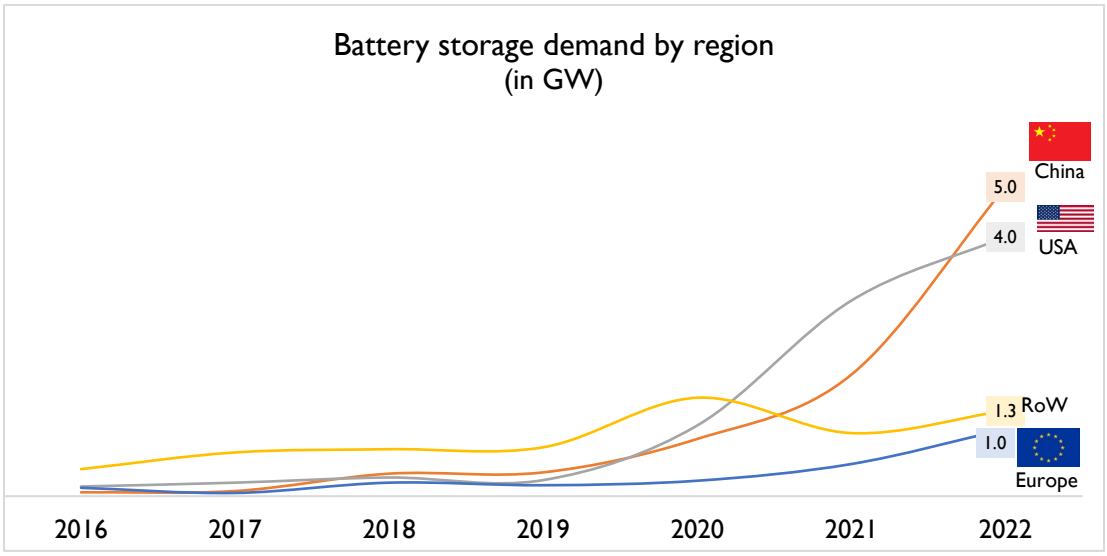
Rest of the World

Battery demand in other regions, including various countries around the world, shows growth over the years, although at a slower pace compared to Europe, China, and the United States. Factors influencing battery demand in these regions include economic development, infrastructure investments, policies supporting clean energy transitions, and advancements in technology. As Li-ion battery technology

becomes more affordable and versatile, these regions are likely to see increasing adoption of batteries for various applications, including renewable energy integration, grid stabilization, and industrial uses, driving overall demand growth.

From 2016 to 2022, there has been a significant increase in Li-ion battery demand across Europe, China, the United States, and other regions. This growth is driven by factors such as renewable energy integration, grid modernization efforts, and advancements in energy storage technologies. Understanding these regional dynamics is crucial for stakeholders aiming to capitalize on the growing Li-ion battery market.

Growth in Battery Storage Demand



Sources: IEA report
Notes: ROW stands for Rest of the World

The growth of lithium-ion battery storage capacity in various countries is driven by a combination of factors, reflecting global trends towards electrification, renewable energy adoption, and sustainable development.

China: In China, substantial government support and policies promoting electric vehicle (EV) adoption and renewable energy deployment have spurred investment in battery manufacturing capacity. Domestic market demand, fueled by a large and rapidly growing EV market, further amplifies the need for advanced battery technologies. China's strategic industrial policies prioritize the development of domestic battery manufacturers and incentivize research and development (R&D) investments to enhance battery

performance and reduce costs. From 2016 to 2022, China's battery storage capacity surged from 0.06 GW to 4.81 GW, demonstrating remarkable growth driven by these factors.

United States: In the United States, the rise in lithium-ion battery storage capacity is propelled by increasing EV adoption, supported by federal and state-level incentives, as well as regulatory measures aimed at reducing emissions and improving fuel efficiency. The deployment of energy storage systems for grid stabilization and renewable energy integration further drives demand for batteries. Technological innovation and government funding initiatives contribute to advancements in battery R&D and commercialization efforts. Over the same period, the United States witnessed significant growth, with battery storage capacity expanding from 0.15 GW in 2016 to 4.03 GW in 2022.

Europe: In Europe, ambitious climate targets and regulatory frameworks drive demand for renewable energy and electric transportation, stimulating investment in battery manufacturing capacity. Regulatory measures such as stringent emissions standards and carbon pricing mechanisms incentivize the electrification of transportation and the deployment of energy storage solutions. Investment in battery manufacturing facilities, research consortia, and cross-border collaborations accelerates technology development and scale-up efforts. From 2016 to 2022, Europe's battery storage capacity increased from 0.13 GW to 1.04 GW, reflecting the region's commitment to sustainable energy transition.

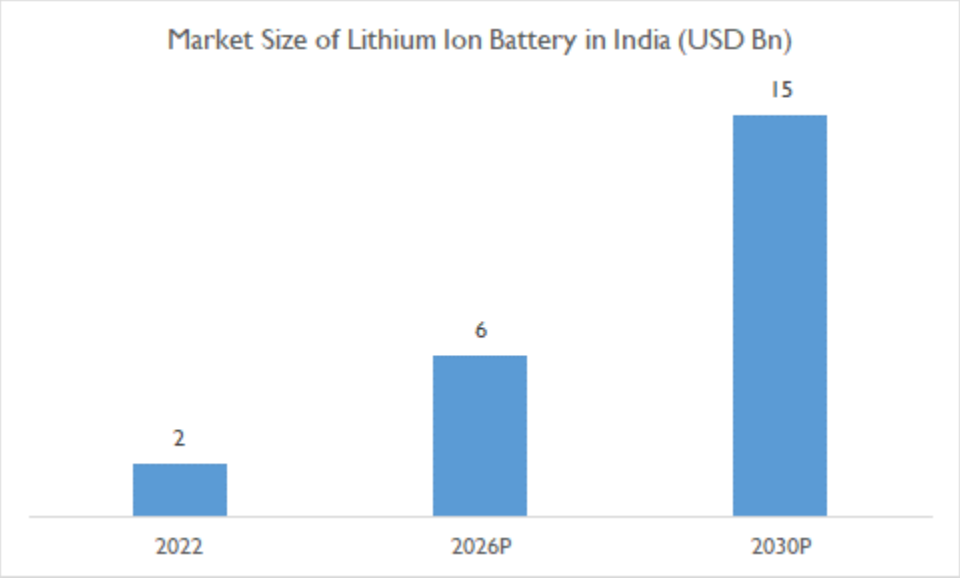
Rest of the World: Outside of the major regions, emerging markets offer significant growth opportunities for battery manufacturers. The global shift towards renewable energy sources necessitates energy storage solutions to address grid stability issues, driving demand for lithium-ion batteries. Government support and incentives, as well as international partnerships and technology transfer agreements, play a crucial role in facilitating the growth of battery manufacturing capacity in these regions. Rest of the World experienced a steady increase in battery storage capacity from 0.42 GW in 2016 to 1.33 GW in 2022, highlighting the growing importance of batteries in supporting energy transition efforts globally.

Overall, the growth of lithium-ion battery storage capacity across different countries is underpinned by a convergence of factors, including government policies, market demand, technological innovation, and international collaboration. These factors collectively contribute to the global transition towards a more sustainable and electrified future, with batteries playing a central role in enabling the integration of renewable energy and the electrification of transportation.

Indian Lithium-ion battery Outlook

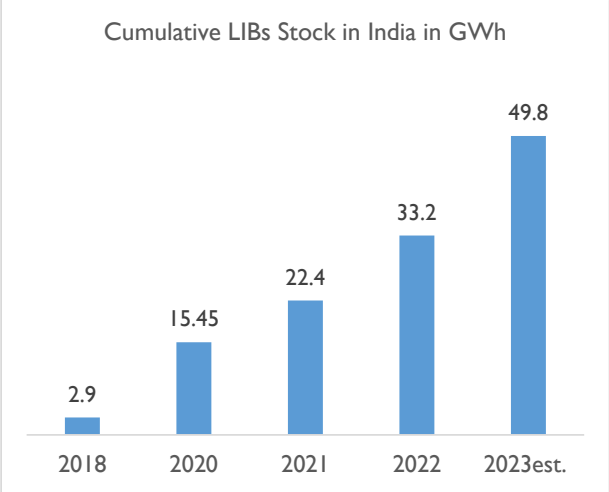
Market Scenario

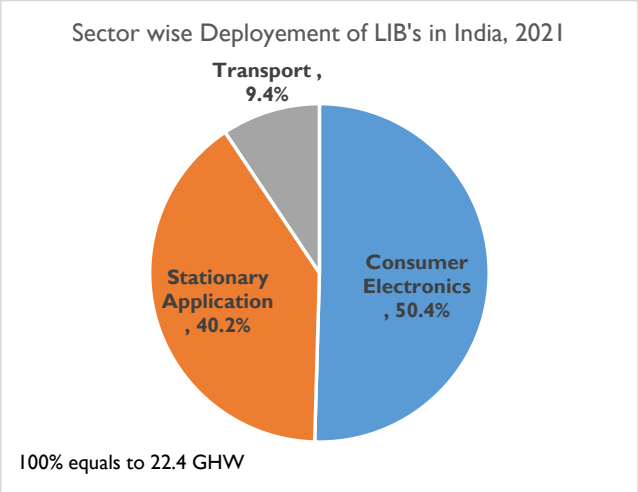
In value term, the size of the lithium-ion battery in India was estimated at around 2 billion which under (the accelerated scenario) is expected to grow to USD 6 Bn by 2026 and further to USD 15 Bn in 2030, driving by the increasing demand across the major end using vertical.



Sources: Niti Aayog

The lithium-ion industry demand is witnessing healthy demand growth in India backed by rising usage in diversified end user industry. The country's cumulative lithium-ion battery market in India have grown from 2.9 GWh in 2018 to 22.4 GWh in 2021 and is estimated to have grown further to 49.8 GWh in 2023. Between 2020-23, the market demand is estimated to have grown by 47%CAGR. This expansion is driven by advancements in battery technology, heightened investment in renewable energy infrastructure, and supportive government policies promoting green energy and sustainable transportation. Leading companies in the market are concentrating on increasing production capacity, improving battery efficiency, and ensuring sustainable supply chains to meet the growing demand while addressing environmental and resource-related challenges.





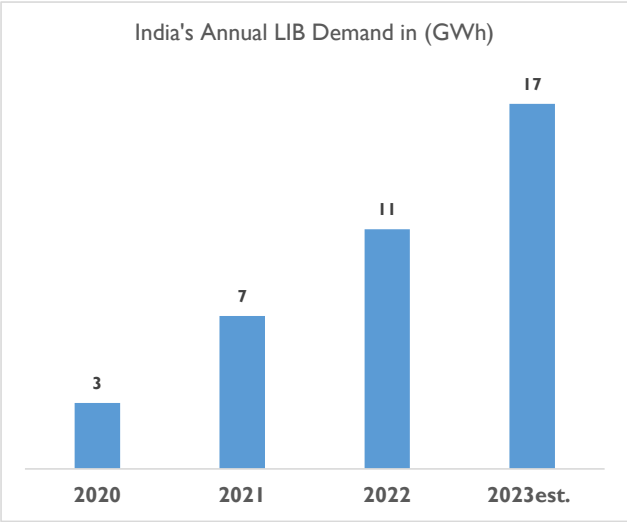
Sources: Dun & Bradstreet Desk Research and NITI Ayog Publication

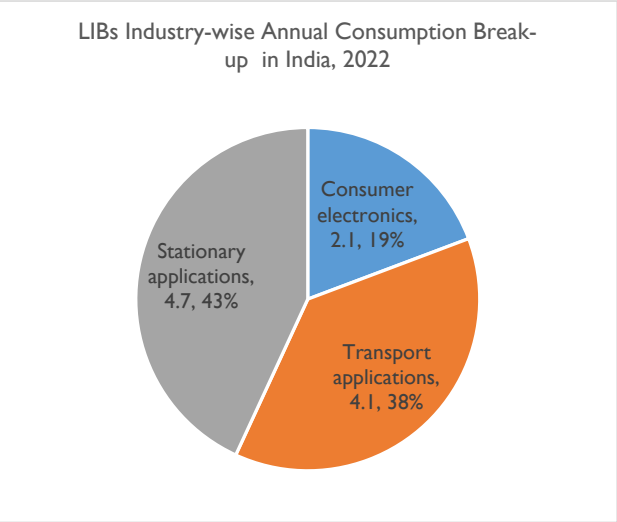
The current deployment of Li-ion batteries (LIBs) in India is predominantly driven by consumer electronics, including smartphones, laptops, notebooks, and tablets. Amongst several consuming sector, consumer electronic account for maximum deployment of 11.3 GWh followed by LIBs deployment in Stationary Application at 9GWh and transport application at 2.1 GWh translating into respective market share of 50.4%, 40.2% and 9.4%. Increasing consumer electronics adoption and continued development of smart devices backed by growing income has supported the consumption of lithium-ion batteries. This sector is expected to grow further with increased digitalization and technological integration in daily life.

Though consumer electronics have dominated LIBs consumption in India in the past, but the sector has been losing its share to the other two segments. In 2020, consumer electronic accounted for 61% of LIBs deployment while stationary application and EV sector account for 36% share and 3% share, respectively. Since 2016, the market for advanced cells, particularly LIBs, has grown exponentially, primarily due to their increasing usage in grid scale battery-based storage system in RE sector and accelerated EV adoption in India. This trend is expected to continue, transforming the LIBs consumption landscape in India.

Annual LIBs Demand

India annual Lithium-ion battery demand is estimated to have grown from 3GWh in 2020 to ~11 GWh in 2022 while 2023 it is estimated to have accelerate further to nearly 17 GWh in 2023. Annually, stationary application and transport application were estimated to have accounted for 43% and 38% share with annual demand of 4.7 GWh and 4.1 GWh, respectively while Consumer Electronics segment was estimated to account for a19% share, with 2.1 GWh lithium-ion battery consumption.

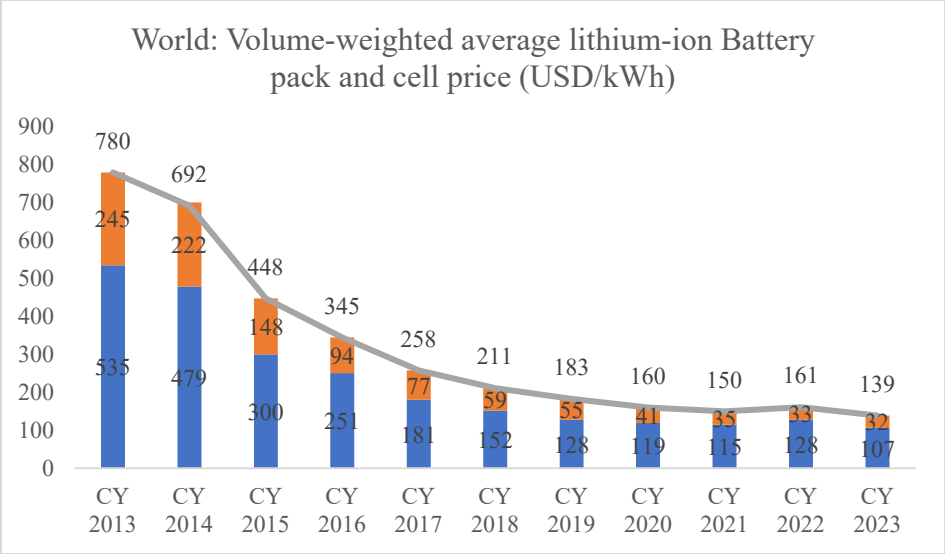




Sources: Dun & Bradstreet Desk Research and Advanced Chemistry Cell Battery Reuse and Recycling Market in India publication BY NITI Ayog and the UK government

Lithium-ion battery price trends

Previously, the biggest disadvantage of lithium-ion adoption was its higher price. However, the price of Li-ion cell & battery pack has been plummeting since 2010, on the back of incremental innovation in battery chemistry as well as economies of scale due to pick up in electric vehicle sale. The average price for Li-ion battery pack across all sectors, which was at USD 780 per kWh in 2013 have dropped to USD 139 per kWh in 2023. With lithium-ion battery pack accounting for anywhere between 30 to 50% of electric vehicle cost, this drop in battery cost have helped in bringing the cost of electric vehicle. However, after experiencing its first increase to USD 161 per kWh (a 7% year-over-year rise) in 2022, reversing the downward trend since 2010, the cost declined to USD 139 per kWh (a 14% year-over-year decrease) in 2023. This fluctuation highlights the dynamic nature of the market and the impact of various factors influencing battery technology costs. Although at the current price level too Li-Ion electric vehicle have high-cost differential with conventional vehicle, it is expected to come down as the price hits USD 100 per kWh. As per experts and players in battery technology industry, lithium battery prices are expected to fall again in 2024 as supply side of lithium extraction and refining strengthen while prices are expected to USD 100 per kWh by 2026 and to USD 73 per kWh by 2030.



Source: Bloomberg NEF Annual Battery Survey

Lithium-ion battery price in India 2024

Capacity (Watt per hour)	Total price (INR)
6 Ah / 75 Wh	2,250
12 Ah / 150 Wh	4,500
20 Ah / 250 Wh	7,500
30 Ah / 385 Wh	11,550
40 Ah / 500 Wh	15,000
20 Ah / 1000 Watt hour	30,000
40 Ah / 2000 Watt hour:	60,000
100 Ah / 5000-Watt hour:	150,000

Sources: Dun & Bradstreet Desk Research

Although India is dependent on imports for Li-Ion battery, this dropping cost will work out to India's advantage too. The lukewarm response to EV sector earlier was due to the higher cost of the battery which increases the overall ownership cost of EV. As the battery price drops this challenge will be solved, making the FAME II eligible E2Ws affordable to common masses.

New Product Launches and its use cases

Product	Use Case
High-Capacity Lithium-ion Inverter Batteries	Traditional lead-acid inverter batteries are being challenged by new high-capacity lithium-ion offerings. Companies like Luminous, Exide, and Tata Power are launching models boasting longer backup times, deeper discharge cycles, and faster recharge capabilities. These features are perfect for homes and businesses experiencing frequent power cuts.

Long-Life Smartphone Batteries	Smartphone manufacturers are integrating advanced lithium-ion batteries with extended lifespans. Brands like Samsung and Motorola are focusing on innovations like graphene-based electrodes and improved thermal management systems, leading to phones that stay charged longer.
Specialized Lithium-ion Batteries for EVs	Catering to the burgeoning EV market, companies like Reliance and Mahindra are developing lithium-ion batteries specifically designed for electric two-wheelers and three-wheelers. These batteries offer higher energy density, improved range, and faster charging times, making EVs a more attractive option for consumers.
Home Energy Storage Solutions:	Companies like Log9 Materials and Nsure are introducing lithium-ion battery packs for home energy storage. These systems allow homeowners to store solar power generated during the day and utilize it during peak hours, reducing dependence on the grid and electricity bills

India Demand Scenario in End user Industry consuming Lithium-Ion Batteries

Lithium-ion batteries are suitable power source for consumer electronics, power sectors, stationary application, industrial sector, and e-mobility. As Li-Ion have very extremely high energy densities compared to other established technologies (nickel-cadmium (Ni-Cd), nickel-metal hydride (NiMH) and lead-acid (Pb-Acid) batteries), it is ideal power source for EV or mobile phone, where excess weight is a liability.

Based on the application, LIB battery can be classified into three broad categories:

Consumer electronics applications (CEAs)	**Stationary applications (SAs)**	**Transportation applications (TAs)**
LIBs are used in electronics like mobile phones, tablets, laptops, cameras, etc. These rechargeable batteries are of a smaller size.	SAs include the batteries used for commercial and industrial applications like • Grid-connected battery energy storage for renewable integration	TAs include batteries for SLI application and onboard batteries for e-mobility applications. **e-mobility – battery storage:** ➢ Battery EV (light-duty, medium-duty and heavy-duty

	• Behind the meters application: ➢ Energy storage for telecom and data centres, ➢ Industrial logistics like forklifts, medical devices, and power tools ➢ Commercial and industrial energy storage for solar rooftops ➢ Rural electrification	➢ Hybrid EV **SLI – starting, lighting and ignition:** ➢ Plug-in hybrid EV ➢ Batteries in cars, trucks, bikes, and other internal combustion motorised vehicles

Consumer electronics

The consumer electronics sector remains a dominant force, constituting approximately 51% of India's cumulative lithium-ion battery (LIB) deployment in 2021. This segment encompasses a range of major appliances including laptops, mobile phones, power banks, notebooks, and tablets. India is one of the largest consumer electronics markets in Asia Pacific Region. Economic growth, rising income, increasing consumer aspiration, innovation, have led to surge in demand for various electronic products. Technology transitions such as the rollout of 5G networks and IoT are expected to drive the accelerated adoption of electronics products in India.

India boasts a staggering 1.2 billion telecom users and over 0.7 billion smartphone users, solidifying its position as one of the foremost markets for mobile devices. The smartphone market in India has seen a ten-fold increase from approximately 14.5 million shipments in 2011 to around 146 million in 2023, making it one of the world's 2nd most lucrative markets. For smartphones, the average battery capacity considered in estimating battery demand is 3000 mAh until 2024, and it's projected to rise to 4000 mAh thereafter. Similarly, the annual market for laptops and notebooks stands at approximately 13.5 million units, with an expected cumulative sales volume of around 150 million by 2030. Here, the average battery capacity factored into the computation of battery demand is 4400 mAh until 2024, increasing to 4500 mAh thereafter. The current market size of consumer electronics batteries in India is estimated to be approximately 11.3 gigawatt-hours (GWh), with LIBs constituting the majority share. Market expansion is evident, driven by increased sales in both urban and rural areas. This upward trend in demand is anticipated to persist until 2030. The explosive growth in consumer electronics/ appliances has benefitted li-ion batteries, which is an integral component of consumer electronic products. Cumulative LIB demand from Consumer electronic segment between 2022-2030 is estimated to be 36.4 GWh

On supply side, India was lagging in electronic hardware manufacturing, but recent years have seen a pickup in this domain backed by Government initiatives. The Government has identified growth of electronics manufacturing sector as a thrust area. These include Make in India programme, Electronic System Design & Manufacturing (ESDM), Modified Special Incentive Package Scheme (M-SIPS), rationalization of duty structure, phase manufacturing programme and preferential market access, amongst several others. In addition to above, the government has launched "Atmanirbhar Bharat Abhiyan" and Production Linked Incentives (PLI) scheme that is facilitating domestic manufacturing and driving the demand of battery demand.

Transport Applications: Electrical Vehicle

EV Sale in '000	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	Grand Total
E-2 Wheelers	2.0	28.0	26.8	44.8	252.6	728.1	944.1	2,026.5
E-3 Wheelers	92.0	116.0	143.1	90.9	172.5	401.9	632.5	1,648.9
E-4 Wheelers	1.2	1.9	2.4	5.2	18.6	47.5	90.4	167.2
E-Buses	0.0	0.1	0.4	0.4	1.2	2.0	3.7	7.8
Grand Total	95.2	146.0	172.7	141.2	445.0	1,179.4	1,670.7	3,850.3

Society of Manufacturers of Electric Vehicles (SMEV),

India's transportation sector is swiftly transitioning towards sustainability, led by the surge in electric vehicles (EVs). Electric two-wheelers, three-wheelers, and four-wheelers are reshaping urban mobility, driven by government incentives and environmental awareness. Increasing fuel price and concerns about emission related pollution have increased the interest for electric vehicles among consumers. Total EV sales in FY 2024 observed, 42% y-o-y increase. While the consolidated sales of EVs were 1,035 thousand unit in FY 2024, surging by 33.4% against 185.9% increase over the previous year. India's electric mobility program is driven by Government backed demand initiative model, which is at the core of the flagship Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME). The Union Government has set a target of converting 30% of vehicle fleet to electric by 2030, which is amongst the most aggressive plans that are being implemented across the globe. This aggressive policy framework has created a small but fast-growing EV industry in India, which is currently dominated by electric two wheelers. The rate of increase was sharp in FY 2023 due to lower volume level. The share of EVs in total registered vehicle continued to grow strong to 6.3% in 2023 from below 1% (0.7%) in 2020. The increasing

surge in EV sale is largely attributed to the pent-up demand from the second wave slowdown which got triggered due to revised FAME subsidies, high fuel prices and launch of new electric vehicles along with improved charging infrastructure.

E-4W: With an annual e-4W sale of over 90.4 thousand units in FY 2024, the **passenger car industry** in India is transforming. The pace of growth it has achieved in the 5 years is tremendous, pointing towards huge opportunity. From nearly 2,000 units per annum in FY 2020, electric car sales jumped to 90,431 units in FY 2024, a compounded annual growth rate of 148%. Electric four-wheelers (E4Ws) currently make the smallest contribution to overall EV sales in India, primarily due to high acquisition costs and a limited range of available models. Nonetheless, sales of commercial E4Ws are beginning to recover following the pandemic. Efforts by the government and various OEMs to introduce a wider range of EV models are expected to boost adoption rates. By 2030, LIB penetration in both commercial and passenger E4Ws is anticipated to reach 100%.EV sales in India are aggressively pushed by government support. Policies such as Automobile Mission Plan 2016-26 Phase-II, Faster Adoption & Manufacturing of Electric Hybrid Vehicles (FAME) Scheme (I & II) and most recently introduced the PLI scheme for automobile and auto components are likely to have a favorable impact on overall industry performance with deeper penetration of EV in the overall fleet volume.

Electric Two-Wheelers: In FY2024, sales of E2Ws reached approximately 944,126 units, 1.3x increase from the previous year. The demand for electric two-wheelers (E2Ws) in India has been growing steadily, primarily due to government incentives and subsidies. However, the growth potential has been somewhat hindered by stringent subsidy eligibility criteria, including minimum localization requirements and the exclusion of lead-acid E2Ws under the FAME II scheme.

Electric Three-Wheelers: The electric three-wheeler (E3W) market in India faced major setbacks during the COVID-19 pandemic, experiencing negative growth in FY21 and FY22. Challenges such as limited financing options, low awareness, and uncertainties around vehicle components like batteries have impeded growth. Despite these issues, future adoption is expected to increase, driven by rising demand for last-mile connectivity and goods delivery services. LIB penetration in E3Ws is projected to reach 40% by 2030.

The EV-Ready India dashboard has projected an impressive 45.5% CAGR in total EV sale between 2022-2030, indicating EV sales to reach 16 Mn units by 2030. The increasing demand for EVs is fueling the adoption of lithium-ion batteries (LIBs), paving the way for a greener automotive future in India. Growing public and private investment in electric vehicles have accelerated the R&D investment in overall EV eco

system including Lithium-ion battery. The total cumulative demand of batteries for electric mobility is estimated to grow to ~381 GWh by 2030, accounting 64% share in the cumulative LIB battery demand between 2022-30.

Stationary Application

The Indian government's commitment to transitioning to a low-carbon economy through clean energy adoption presents suitable opportunities for energy storage. Advances in battery technology and cost reductions across the supply chain have made battery storage more viable. The introduction of advanced chemistry cells (ACCs) has enabled the development of application-specific storage solutions more efficiently. Lithium-ion batteries play a crucial role in storing intermittent energy, ensuring a stable power supply. Amplus Solar and Tata Power have both deployed lithium-ion battery systems for uninterrupted power delivery and grid stabilization.

India is currently at the forefront of an energy transformation, swiftly transitioning towards cleaner, more reliable, and sustainable forms of renewable energy (RE). The Government of India (GoI) has set an ambitious target of achieving 500 gigawatts (GW) of installed RE capacity by 2030, comprising 170 GW of wind power and 280 GW of solar power, a significant increase from the current capacities of approximately 42 GW and 48 GW, respectively.

Due to the intermittent nature of RE sources, integrating them into the grid on such a massive scale poses various challenges, including the unpredictability of output timing and value. So, the government is developing **Solar Round-The-Clock (RTC)** hybrid systems combine solar energy with other renewable sources such as wind, along with energy storage solutions, to provide a continuous and reliable power supply. Lithium-ion batteries play a crucial role in these systems by storing excess energy generated during peak production times and releasing it during periods of low or no production, such as at night or during cloudy weather. This ensures a stable and uninterrupted power supply, making renewable energy more viable and reliable. Below development announced in this space in India are expected to drive the lithium-ion battery demand for grid scale energy storage solution.

Projects Developments in India:

- **ReNew Power's RTC Renewable Energy Project:**
  ReNew Power, a prominent player in India's renewable energy sector, is pioneering an RTC renewable energy project that integrates solar, wind, and battery storage technologies to deliver a reliable power

supply. The project incorporates cutting-edge lithium-ion battery storage systems to store surplus energy, ensuring uninterrupted power availability during periods of low solar and wind generation. With a goal to provide round-the-clock renewable energy to the grid, this initiative showcases the viability and dependability of RTC hybrid systems.

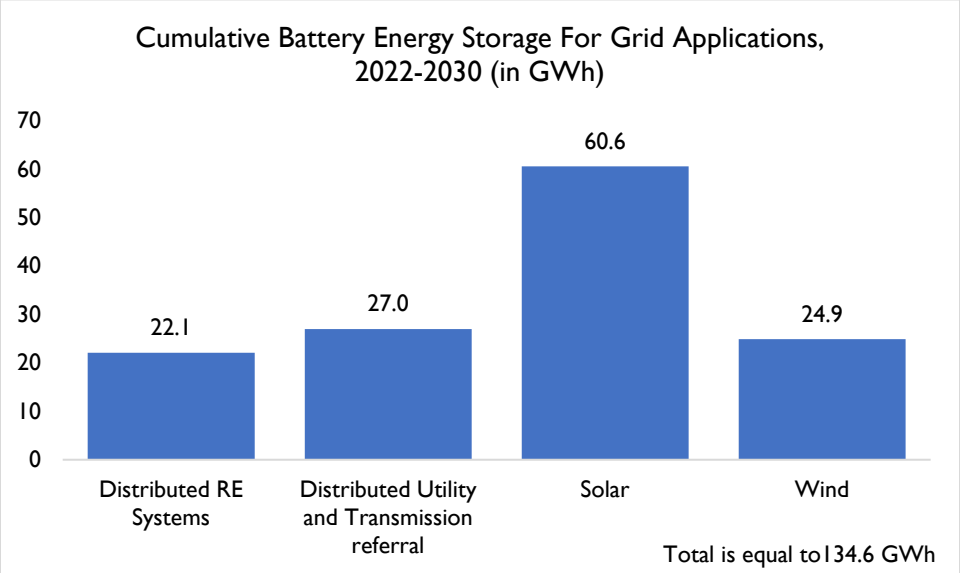
- **SECI's RTC Power Procurement:**
  SECI, through its recent tenders for RTC power procurement, has mandated the incorporation of energy storage solutions to ensure a stable power supply. Typically, these projects necessitate the integration of lithium-ion batteries to mitigate the intermittent nature of solar and wind energy, facilitating consistent electricity provision. SECI's initiatives are driving the advancement of RTC projects, advocating for the adoption of lithium-ion batteries and hybrid renewable energy systems nationwide.
- **Tata Power Delhi Distribution Limited (TPDDL) RTC Initiatives:**
  TPDDL is actively engaged in the integration of RTC hybrid systems within its distribution network to bolster grid stability and reliability. By leveraging lithium-ion batteries for energy storage, TPDDL endeavours to optimize peak load management and diminish reliance on fossil fuels. This initiative underscores TPDDL's commitment to fortify Delhi's energy infrastructure, fostering a more sustainable and resilient power supply for the region.

- **Adani Green Energy Limited (AGEL) RTC Projects:**
  AGEL is in the process of constructing large-scale RTC renewable energy projects, integrating solar, wind, and lithium-ion battery storage technologies to ensure uninterrupted power supply. These projects incorporate state-of-the-art lithium-ion battery systems to efficiently store and manage energy. AGEL's initiatives play a pivotal role in bolstering India's renewable energy capacity and underscore the viability of RTC hybrid systems in the energy landscape.

The integration of lithium-ion batteries in Solar RTC hybrid systems is transforming India’s renewable energy landscape by addressing the intermittency issues associated with solar and wind power. These systems ensure a reliable, 24/7 power supply, making renewable energy a more dependable and scalable solution for the country's growing energy needs. With significant projects such as those by ReNew Power, SECI, TPDDL, and AGEL, India is at the forefront of adopting and advancing RTC hybrid systems, showcasing the critical role of lithium-ion batteries in achieving a sustainable energy future.

Another crucial aspect in grid applications is the adoption of distributed RE systems such as microgrids, street lighting, and lanterns, which play a vital role in ensuring universal access to electricity across India. The integration of RE into the grid presents challenges such as fluctuations in plant outputs, variability in

generation, and mismatches between generation and demand peaks, all of which strain the grid and necessitate the flexibility of generation sources and the overall system. However, the current infrastructure may not possess adequate flexibility to accommodate the targeted RE capacity. Hence, battery energy storage has emerged as a key solution for providing uninterrupted power and balancing transmission and distribution loads.



Source: (Niti Aayog, D&B analysis)

On the distribution side, the increased penetration of rooftop solar photovoltaic (PV) systems, integration of electric vehicle (EV) chargers, and rising commercial loads pose challenges for distribution grid operators in maintaining network stability and reliability. Battery energy storage offers flexibility to address these challenges.

Several distribution companies in India, including BSES Rajdhani, BSES Yamuna, and TPDDL, are at various stages of installing battery energy storage systems in their distribution grids. While the market for battery energy storage is expected to witness moderate growth in the short term, the long-term outlook indicates an inevitable dependence on storage as the impact of various factors intensifies, making it a notable market driver.

Behind the Meter (BTM):

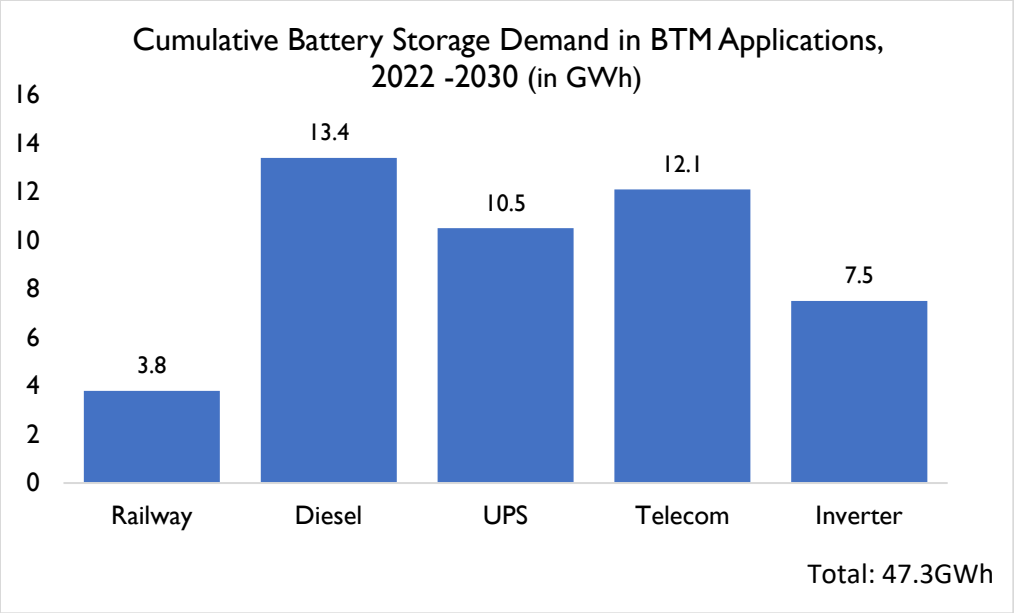
Behind the meter (BTM) refers to energy resources or technologies that are located on the consumer's side of the utility meter. In simpler terms, it means energy generation, storage, or

management systems that are installed on-site, typically at homes, businesses, or other facilities. Behind the Meter (BTM) applications sector, which includes inverter and UPS backup, telecoms, and diesel gensets, is also significant.

Recent examples of BTM technologies and initiatives include:

- Residential Solar Panels: Increasing numbers of homeowners are installing solar panels on their rooftops to generate electricity for their own use.
- Battery Storage Systems: Energy storage systems, such as lithium-ion batteries, are becoming more affordable and are being paired with solar installations to store excess energy for later use or backup power during outages.
- Demand Response Programs: Utilities are implementing programs that incentivize consumers to reduce their electricity usage during peak demand periods, often through BTM technologies like smart thermostats or appliances.
- Microgrids: Some communities or facilities are implementing microgrid systems that incorporate BTM resources to operate independently of the main grid during emergencies or to optimize energy usage and costs.
- Energy Management Systems: Smart home and building automation technologies are enabling more sophisticated management of energy usage, including optimizing when and how BTM resources are deployed.

By 2021, approximately 2.6 GWh of LIBs were deployed in the telecom sector, and the UPS and inverter backup market saw cumulative installations of around 1.7 GWh of lithium-ion-based battery backup.



Source: (Niti Aayog, D&B analysis),

India is the second-largest telecommunications market globally, with a subscriber base of 1.091 Bn as of March 2024. demand for robust backup power solutions has escalated with the expansion of 4G and the introduction of 5G networks to maintain seamless service delivery. This growth signals increasing demand, particularly for battery energy storage, given the remote locations of many telecom towers. The Telecom towers and data centres are turning to lithium-ion batteries for dependable energy storage. Indus Towers, a major player in the Indian telecom industry, relies on lithium-ion batteries at their tower sites to ensure network reliability. Similarly, Bharti Infratel employs lithium-ion batteries to sustain uninterrupted power supply for its telecom infrastructure.

The UPS backup market is driven by sectors like IT services, data centres, healthcare, and manufacturing. Despite slower long-term growth due to energy efficiency practices and grid reliability, data centers are projected to grow significantly, with load increasing from 0.5 GW to 3.1 GW by 2030. Lithium-ion battery penetration is expected to rise in data centres, healthcare, and IT services.

Diesel gensets, widely used by commercial and industrial users to supplement unreliable grids, currently total over 80 GW and are expected to grow to 128 GW by 2030. Battery energy storage models account for gensets operating 1,000 hours annually. India's inverter battery market is around 13 GWh, predominantly lead-acid batteries (97%). While urban demand is declining, rural demand is increasing and is expected to continue growing until 2030. Driven by several end use application, the total cumulative demand of Lithium-ion battery for BTM application in India is expected to reach 47.5 GWH by 2030.

Emerging Areas of Application

Beside above, lithium-ion battery demand is also expected to emerge from following segments.

Robotics and Automation:

The surge in robotics and automation adoption across industries such as manufacturing, logistics, and healthcare is driving the need for efficient, high-capacity batteries, with lithium-ion technology emerging as the favoured solution. GreyOrange, an Indian firm specializing in AI-driven robotics systems for warehouses and supply chains, integrates lithium-ion batteries into their autonomous robots to optimize operations. Additionally, this company pioneers service robots and automation solutions powered by lithium-ion batteries, enhancing mobility, and extending operational hours.

Drones:

The commercial and recreational use of drones is rapidly growing in India, with applications ranging from agriculture to surveillance. Drones require lightweight, high-energy-density batteries, making lithium-ion batteries ideal. Aarav Unmanned Systems and ideaForge design drones for various purposes, powered by lithium-ion batteries for extended flight times and efficiency.

Medical Devices:

The medical industry's need for portable and dependable power sources, particularly for ventilators, diagnostic equipment, and other portable medical devices, is growing, notably amid the COVID-19 pandemic. Medtronic, a frontrunner in medical technology, relies on lithium-ion batteries to power its portable medical devices like insulin pumps and ventilators, ensuring reliable and uninterrupted operation. Similarly, BPL Medical Technologies provides a suite of portable medical devices such as patient monitors and defibrillators, all powered by lithium-ion batteries to maintain consistent performance.

Internet of Things (IoT):

The rapid growth of IoT devices, reliant on durable and enduring power sources, is an emerging trend. Lithium-ion batteries are ideal for these applications, offering high energy density and longevity. Companies like SenseGiz specialize in IoT solutions, employing lithium-ion batteries in their smart sensors and tracking devices for security, healthcare, and asset tracking applications. Similarly, Tagbox delivers IoT-based cold chain monitoring solutions, leveraging lithium-ion batteries to power sensors and ensure real-time data accuracy.

These segments collectively contribute to the growing demand for lithium-ion batteries in India, driven by advancements in technology, supportive government policies, and the global shift towards sustainable energy solutions.

Demand Drivers

Underlying Growth drivers

Economic Growth	• Excluding the Pandemic years (FY2020-21), India's GDP is growing at 7-7.5% rate annually since FY 2014 favouring growth in consumption and investment demand.
Income Growth	• The country's Per capita income has increased from INR 68,572 in FY 2014 to INR 86,668 in FY 2023, registering a CAGR of 4.1% in the last 10 years.
Access To Large Market	• With over 1.42 Bn population, India emerged as the world most populous country in April' 23. India's population is projected to reach 1.54 Bn by 2032.
Demographics Advantage	• More than two-thirds of its population or 68% comprises people between the ages of 15 and 64 while with a median age of 31 by 2030, India will remain one of the youngest nations in the world.
Urbanisation	• The share of Urban population to total population in India grew from 27.8% to 31% between 2001-2011 and is further estimated to grow to 41.7% by 2030.
Per Capita Consumption	• Rural per capita consumption to grow 4.3 times by 2030, compared to 3.5 times in urban India
Rising Consumerisim	• India's consumption expenditure to grow from USD 1.5 trillion in 2021 to USD 6 Trillion by 2030 backed by the 370 Mn aspirational consumer age between 0-25 who will have grown up in India which have relatively better digital reach than before.
Increasing Millennial Population	• By 2030, India will have nearly 90 Mn new households headed by millennials
Affluent and Elite to drive spending	• India's affluent population and elite population is expected to grow by 2.1 X and 2.3X between 2019-2030
Digital Economy Growth	• India's digital economy is expected to reach USD 1 Tn by 2030 from USD 90 Bn
Internet User Growth	• India has second largest Internet users base which reached 881.25 Mn as on 31st Dec 2023, growing at CAGR of 8% between 2018-23.
Increase in Digital Payment	• Digital payments gross transaction value is expected to grow from USD 0.6 Tn in 2022 to USD 3.1 Tn (2030)
Government Inititiatives	• PLI Scheme, BIS standard For EV battery, FAME -I and Fame -II, driving the EV demand and EV batteries.

Major trends in Lithium-ion battery segment

***Transition from Lead Acid to Lithium Ion*:**

India, like many other countries, is witnessing a transformative shift in its automotive sector as it embraces sustainable mobility solutions. Central to the EV revolution is the transition from traditional lead-acid batteries to advanced lithium-ion batteries, which has been a game-changer in the Indian EV space.

The historical usage of lead-acid batteries in electric vehicles (EVs) in India dates back to the late 1990s and early 2000s, when India witnessed the emergence of a few pioneering electric vehicle manufacturers. These early adopters recognized the potential of EVs and identified lead-acid batteries as the go-to power source for most EVs due to their relative affordability and availability.

The widespread use of lead-acid batteries in early EVs was evident in the first generation of electric two-wheelers and three-wheelers. Electric rickshaws, commonly known as e-rickshaws or auto-rickshaws, started to gain popularity as a clean and economical mode of transportation in congested urban areas. However, as EV adoption gradually increased, the limitations of lead-acid batteries became more apparent, prompting the need for a significant transition to more advanced battery technology. This shift led to the emergence of lithium-ion batteries as the preferred power source for EVs in the country.

Two factors have played key roles in the transition that has happened in Indian EV battery space, in favour of lithium ion – these are technological advancement and favourable Government regulations. While the changes brought about by technological advancement was not specific to India, the transition triggered by Government regulations was purely an India specific phenomenon.

Technological Advancements

The rapid development and advancements in lithium-ion battery technology have been a major catalyst for the transition from lead-acid to lithium-ion batteries in the Indian EV market. Lithium-ion batteries offer superior energy density, longer cycle life, and faster charging capabilities compared to lead-acid batteries

Increased Energy Efficiency and Range

- Lithium-ion batteries boast of a significantly higher energy storage capacity compared to lead-acid batteries. The ability to store more electrical energy in the same 1 kg battery pack became a game-changer for electric vehicles. A lead-acid battery could store approximately 25 watt-hours of electricity in a 1 kg battery, whereas a lithium-ion battery could store up to 150 watt-hours, providing a remarkable six times more storage capacity.
- This increased energy storage capacity allowed EVs equipped with lithium-ion batteries to cover longer distances on a single charge, effectively addressing one of the main concerns of early EV adopters – range anxiety. Subsequently, EV owners could confidently use their vehicles for daily commuting and longer journeys without the worry of running out of charge.
- Furthermore, the higher energy storage capacity of lithium-ion batteries also contributed to more powerful performance. They could discharge faster and supply more power, making them well-suited for various driving conditions and providing a smoother driving experience.

Better Acceleration

- Lithium-ion batteries-based cars provide better mileage due to their lightweight nature. As a vehicle accelerates from a standstill, it needs to overcome its inertia, and the weight of the battery can significantly impact this process. Lithium-ion batteries are notably lighter than lead-acid batteries, making them more efficient in propelling the vehicle forward from a standstill. This characteristic is particularly advantageous for Hybrid Electric Vehicles (HEVs), where efficient energy utilization during acceleration is essential for optimizing fuel efficiency and reducing emissions.
- The lightweight property of lithium-ion batteries resulted in smoother and more responsive acceleration, offering a better driving experience for EV owners. In contrast, lead-acid batteries' heavier weight made acceleration less efficient and might have led to slower pick-up speeds and reduced overall driving range.

Extended Cycle Life

- Lead-acid batteries have a relatively low depth of discharge, which directly impact their cycle life. The depth of discharge refers to the percentage of the battery's total capacity that is utilized during each charge and discharge cycle. In the case of lead-acid batteries, they were typically not discharged more than 30-40% of their total capacity. This limited depth of discharge resulted in a shorter cycle life for lead-acid batteries.
- On the other hand, lithium-ion batteries were designed to be discharged up to 90% of their total capacity. This deeper discharge capability allows for more efficient use of the battery's energy

storage, translating to longer and more robust cycle life. The ability to discharge the battery to a greater extent without damaging its performance significantly contributed to the longer lifespan of lithium-ion batteries.

Reduced Frequency of Replacements

- Due to their extended cycle life, lithium-ion batteries outperformed lead-acid batteries in terms of longevity. Lead-acid batteries often needed to be replaced within 4 to 15 years, depending on their type and usage. This relatively short lifespan led to higher maintenance costs for EV owners, making lead-acid batteries less economical in the long run.
- In contrast, lithium-ion batteries were designed to last longer, with a higher number of charge and discharge cycles before showing signs of degradation. The reduced frequency of replacements for lithium-ion batteries not only lowered maintenance costs but also contributed to a more sustainable and eco-friendly approach to EV ownership.

Enhanced Cost Efficiency for Owners

- The longer life span of lithium-ion batteries directly translated to enhanced cost efficiency for EV owners. Despite the initial higher upfront cost of lithium-ion batteries compared to lead-acid batteries, the extended lifespan made them a more cost-effective investment in the long term.
- EV owners benefited from reduced maintenance and replacement expenses over the lifespan of the lithium-ion battery, offsetting the initial higher cost of purchase. Additionally, the improved energy storage capacity and longer driving range of lithium-ion batteries further contributed to cost savings, as EV owners could travel longer distances on each charge.

Recent investments Lithium-Ion Battery space

India has been seeing significant investments in the lithium-ion battery sector, driven by the growth in the electric vehicle (EV) market and supportive government policies. Here are some notable recent investments and developments:

- **Log9 Materials:** This startup inaugurated India's first commercial lithium-ion cell manufacturing facility in Bengaluru in April 2023. The plant has an initial capacity of 50 MWh, with plans to expand to 1 GWh by late 2024 or early 2025.

- **Nsure Reliable Power Solutions:** Based in Bengaluru, Nsure has invested over INR 1000 crore to establish a lithium-ion cell manufacturing facility in Karnataka. The initial production capacity is set at 1 GWh, with plans to expand up to 5 GWh in the next phase.
- **Reliance New Energy:** Reliance is setting up a giga factory at the Dhirubhai Ambani Green Energy Giga Complex in Jamnagar, Gujarat. The facility will initially produce lithium iron phosphate (LFP) batteries and is expected to be operational by 2026**.**
- **Tata Group:** Through Agartas Energy Storage Solutions, Tata is developing a 20 GWh lithium-ion storage battery factory in Sanand City, Gujarat, with an initial investment of INR 13,000 crore. Construction is expected to begin soon**.**
- **Lucas TVS and 24M Technologies:** They are setting up a ₹25 billion (~$342.33 million) gigafactory near Chennai to produce innovative lithium-ion battery cells. The plant will initially have a capacity of 10 GWh and is expected to start production in the second half of 2023.
- **Altmin Private Ltd:** In January 2024, Altmin a prominent Indian manufacturer specializing in cathode active material for lithium-ion batteries, unveiled its strategic initiative to invest IJS$ 100 million over the next five years.
- **Nexcharge-Leclanché Partnership:** Nexcharge, in collaboration with Swiss energy storage giant Leclanché, is pioneering lithium-ion battery pack and module manufacturing. Their Prantij plant in Gujarat, boasting six fully automated assembly lines across 610,098 square feet, targets a production capacity of 1.5 GWh.
- **Exide's Gigawatt-Scale Ambitions:** Exide Industries is gearing up to establish a multi-gigawatt lithium-ion cell manufacturing facility to align with India's Production-Linked Incentive (PLI) scheme. With an eye on capturing 12 GWh of lithium-ion cell production capacity by 2027, they aim to have an operational 6 GWh facility by December 2024.
- **Amara Raja Batteries Ltd.** In May 2023, the company announced its plan to set up manufacturing unit at at Mahbubnagar district in Telangana which will house a 16 GWh lithium-ion cell manufacturing plant alongside a 5 GWh battery pack assembly unit. This ambitious endeavour represents a substantial investment of over ₹9,500 crores (approximately USD 1.2 billion) over the next decade. Amara Raja's groundbreaking initiative signifies a bold step towards bolstering India's capabilities in lithium-ion battery production. The company recently announced its plan to start the commercial operations at its giga factory before the end of 2025.
- The Indian state of Karnataka and US battery firm IBC signed a MoU to setup a INR 8000 crore recyclable lithium-ion battery unit, in August 2023.

- A California-based player **Biliti Electric** has begun construction of its new e-3W and advanced Li-Ion battery packs manufacturing facility at Hyderabad at an investment of over INR4 billion. The plant aims to have a production capacity of 2,000 electric three-wheelers a month.
- In June 2023, the government approved the import of pet coke as a feedstock to produce graphite anode material for lithium-ion batteries. The import of pet coke for the purpose of fuel is absolutely prohibited.
- Exide Industries' EESL, established in 2022, is building a 12 GWh lithium-ion cell giga plant in Bengaluru, envisaging an investment worth INR 10 Bn. The first phase of 6Gwh is expected to be completed in FY 2025.
- Altmin Pvt Ltd has announced the development of a 3 GWh lithium-ion battery plant envisaging investment worth USD 100 Mn in India which is expected to commence operation in 2025.
- In January 2024, Panasonic has entered a Joint Venture with IOCL to develop cylindrical lithium-ion batteries.
- Himadri Speciality Chemicals has announced to invest INR 48 BN towards the manufacturing facility for lithium-ion battery components (2 lakh tonnes per annum) which is expected to be completed by 2030,
- Gujarat Fluorochemicals announced to spend USD 1 Bn to set up manufacturing batteries for EVs using fluorine chemistry.
- JSW energy announced to spend INR 400 Bn to set up an Integrated EV and battery manufacturing plant. It will install a 50GWh EV battery and is expected to start in 2025
- GODI India Private Ltd announced spend INR 80 BN to set up of R&D and Giga cell manufacturing facility that aims to have 2.5 Gwh cell assembly in first phase and planned to expand by 10 Gwh in second phase.

These investments are part of India's broader strategy to become a global hub for lithium-ion battery manufacturing, driven by initiatives like the Production Linked Incentive (PLI) scheme for advanced chemistry cell (ACC) battery storage. The government's "Atmanirbhar Bharat" and "Make in India" initiatives are also providing substantial support through financial assistance, grants, and export incentives to boost the domestic battery manufacturing and recycling ecosystem. These developments underscore India's commitment to advancing its capabilities in battery technology and supporting the rapid growth of the EV market, contributing to both economic growth and environmental sustainability.

Key Challenges in Indian Market

Low mineral reserves: - a major challenge in the Primary Production of Lithium Battery in India

In Li-ion batteries, cathode materials vary, but common formulations include minerals such as lithium, aluminium, cobalt, manganese, and nickel, while the anode is made of graphite. India lacks in reserves of some of the most important Li-ion components including lithium, cobalt, nickel and even in the copper used in conductors, cables, and busbars.

Lithium presence is largely confined to countries like Chile, Australia, Argentina, China, and United state while Cobalt, another critical material that goes into the manufacturing batteries for electric vehicles, is largely mined in Democratic republic of Congo (DRC), Australia, Cuba and Philippines, and has a very fragile supply chain. Few studies indicate sufficient lithium resources available globally to meet growing requirement, however, reliable supply, availability at affordable prices of raw material and processed functional materials used in the anode and cathode, poses a challenge.

Lithium	Country-wise Reserves	% share in total Reserve	Cobalt	Country-wise Reserves in Metric Tons	% share in total Reserve
Chile	9,300,000	**35.8%**	Congo (Kinshasa)	4,000,000	47.9%
Australia*	6,200,000	**23.8%**	Australia	1,500,000	18.0%
Argentina	2,700,000	**10.4%**	Indonesia	600,000	7.2%
China	2,000,000	**7.7%**	Cuba	500,000	6.0%
United States	1,000,000	**3.8%**	Philippines	260,000	3.1%
Canada	930,000	**3.6%**	Russia	250,000	3.0%
Zimbabwe	310,000	**1.2%**	Canada	220,000	2.6%
Brazil	250,000	**1.0%**	China	140,000	1.7%
Portugal	60,000	**0.2%**	Madagascar	100,000	1.2%
Other countries*	3,300,000	**12.7%**	United States	69,000	0.8%
			Papua New Guinea	47,000	0.6%
			Turkey	36,000	0.4%
			Morocco	13,000	0.2%
			Others	610,000	7.3%
Total	26,000,000		**Total**	**8,345,000**	**100.0%**

Sources: USGS, MINERAL COMMODITY SUMMARIES 2023

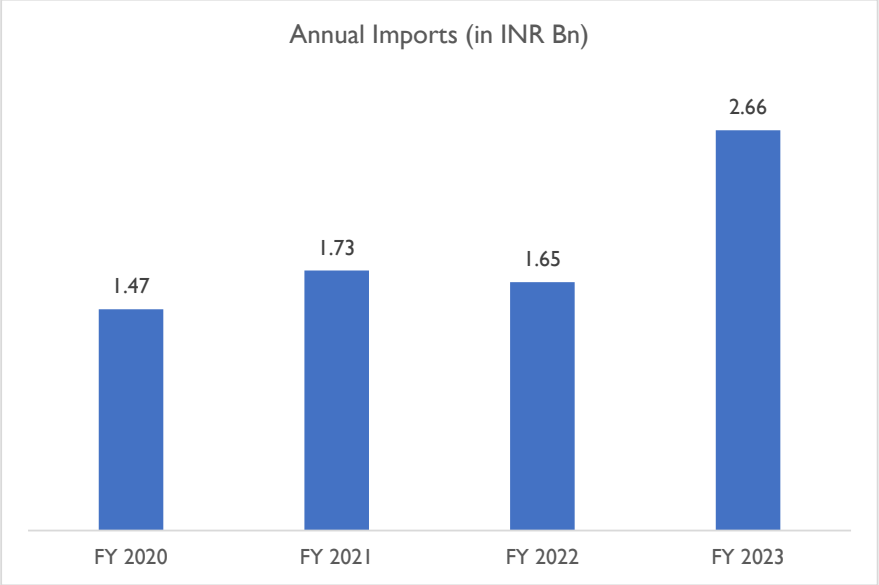
Due to lack of domestic resource availability, India also imports cobalt salts and materials like cobalt oxides and hydroxides, commercial cobalt oxides, and other articles.

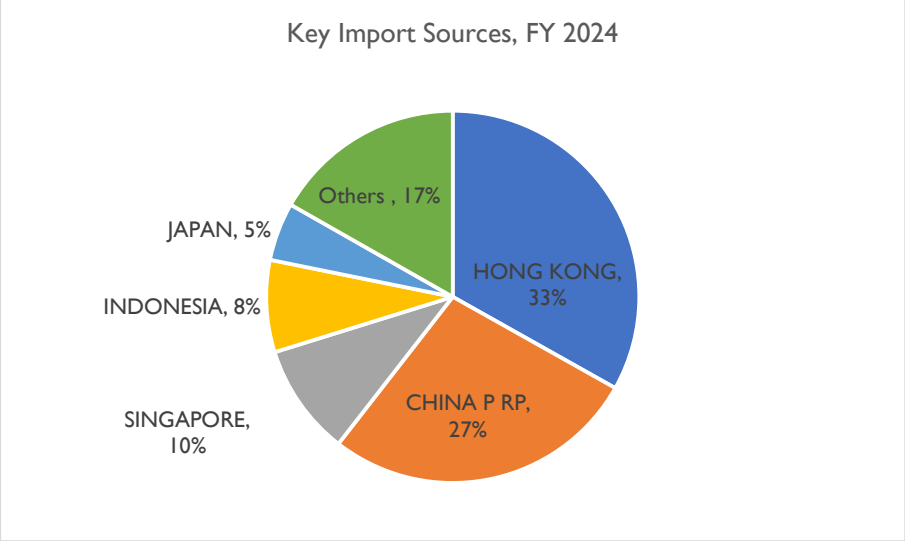
To build indigenous capabilities for supporting electric vehicle demand, three state run companies namely Hindustan Copper Ltd., Mineral Exploration Corporation Ltd. and National Aluminium Corporation Ltd. have agreed to set up a joint venture named Khanij Bidesh India Ltd., or KABIL in September 2017 to hunt for minerals like lithium and cobalt in overseas market.

To secure sufficient supply of metal that are used in lithium-ion battery manufacturing for electric vehicles, India also started reaching out to the 'Lithium Triangle' players, comprising of Chile, Argentina, and Bolivia in 2018.

Import dependency: key challenges & initiatives done to lower the dependency.

The country has limited domestic production capacity, relying heavily on imports of lithium -ion cell[4] from countries like Hong Kong and China and Singapore.





This reliance exposes India to supply chain disruptions and price volatility. Additionally, the scarcity of raw materials such as lithium, cobalt, and nickel, which are essential for manufacturing lithium-ion cells, further

[4] 850650 Lithium

exacerbates the dependency on imports. Establishing a self-sufficient supply chain is complex due to these material shortages. Moreover, the high capital investment required to set up lithium-ion cell manufacturing plants is a significant barrier. The costs associated with technology, infrastructure, and skilled labour deter many potential investors. Technological gaps also pose a challenge; advanced manufacturing technologies and expertise are concentrated in countries with established industries, making it difficult for India to compete and innovate.

On demand side where the Indian Government has set an ambitious target to achieve 30% of new vehicle registrations to be electric and 450GW of renewables (for which nearly134GWh will be required) by 2030, it becomes critical to have a secure supply to support this vision. Consequently, the government to ensure secure supply has the target of reaching a cell manufacturing capacity of 50GWh by 2030. Thus, it has been taking announcing several measure that will the strengthen the domestic capabilities and reduce the import dependency in the coming years**.**

- One of the significant steps is the establishment of Khanij Bidesh India Ltd (KABIL), a joint venture involving three Central Public Sector Enterprises. KABIL is tasked with identifying, acquiring, developing, and processing critical minerals and metals, such as such as lithium, cobalt, copper, and nickel, both in India and abroad. This initiative aims to ensure a stable supply of essential raw materials, aligning with the vision of Atmanirbhar Bharat (self-reliant India).
- The government has also launched the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, which provides incentives for the adoption of electric vehicles. The requirement for EV manufacturers to assemble the traction battery packs locally to gain FAME-II incentives have led to the proliferation of battery pack assemblers in India.
- In the interim Budget 2024-25, INR 2,671.33 crores is allocated towards the FAME-II scheme to subsidize and promote clean energy vehicles.
- Furthermore, the government has allowed 100% FDI in electric mobility and has encouraged domestic manufacturing of battery packs, leading to the widespread adoption of lithium-ion battery technology over lead-acid batteries in mobile and stationary applications.
- The government trebled import duty on assembled battery packs to 15% from April 2021 while for lithium-ion cell used in manufacturing of lithium-ion accumulators for EV it was doubled to 10% to boost the domestic manufacturing.
- In the union Budget 2023-24, the government removed the import duty on capital goods and machinery (which ranged between 5-20% import duty) required to manufacture lithium-ion cells to nil per cent that applicable till March 2024.

- Another crucial initiative is the National Mission on Transformative Mobility and Battery Storage, which aims to facilitate research and development in the field of battery technology. To further boost domestic manufacturing, the government approved the PLI scheme for Advanced Chemistry Cell (ACC) manufacturing on May 12, 2021. With a total outlay of Rs. 18,100 crore over five years, the PLI scheme aims to establish a competitive ACC battery manufacturing setup in the country with a target capacity of 50 Giga Watt hours (GWh), and an additional 5 GWh for niche ACC technologies.
- The PLI scheme provides production-linked subsidies based on the applicable subsidy per KWh and the percentage of value addition achieved on actual sales by the manufacturers who set up production units. This initiative is expected to significantly reduce the import dependence of ACC batteries. The first round of the ACC PLI bidding concluded in March 2022, resulting in the allocation of a total capacity of 30 GWh to three beneficiary firms. The program agreements with the selected firms were signed in July 2022. Furthermore, the Ministry of Heavy Industries released a Request for Proposal (RfP) on January 24, 2024, for shortlisting and selecting bidders under the PLI scheme. This initiative aims to set up ACC manufacturing units with a total capacity of 10 GWh, supported by a budgetary outlay of Rs. 3,620 crore.

Through these comprehensive measures, India aims to build a robust domestic manufacturing ecosystem for lithium-ion cells, reduce its dependency on imports, and position itself as a significant player in the global battery market.

Regulatory Landscape

The Indian government has been actively promoting domestic manufacturing of Lithium-ion batteries as part of its efforts to boost the adoption of electric mobility and reduce the country's dependence on imports. Several policies and initiatives have been introduced to incentivize and support the growth of the EV battery manufacturing ecosystem in India. Some of the key government policies are:

National Electric Mobility Mission Plan (NEMMP):

The National Electric Mobility Mission Plan (NEMMP), launched in 2013, is a comprehensive and ambitious initiative aimed at achieving substantial electrification of the Indian automotive sector. The plan focuses on promoting hybrid and electric vehicles (EVs) to enhance national fuel security and reduce the country's dependence on traditional fossil fuels.

A key goal of NEMMP 2020 is to achieve a significant increase in the sales of hybrid and electric vehicles. The government has set an ambitious target of 6-7 million annual sales of such vehicles starting from 2020.

To achieve this target, the government plans to provide fiscal and monetary incentives to accelerate the adoption of these nascent technologies. Buyers of hybrid and electric vehicles will receive monetary support to incentivize their purchases.

Additionally, NEMMP policy aims to encourage domestic manufacturing of electric vehicle components, with a specific focus on batteries. To attract investments in the EV battery manufacturing sector, the government has introduced various incentives, subsidies, and tax benefits. These measures are designed to create a favorable environment for battery manufacturers to establish and expand their production capacities within the country.

Several steps have been implemented under the NEMMP framework to promote the adoption of electric vehicles and support the growth of the EV battery manufacturing sector. These include:

- **Tax Saving on EV Loans:** Section 80EEB of Income Tax Act allows tax saving of upto 1.5 lacs on the loan amount taken for the purchase of electric vehicles in India. This move aims to make electric vehicles more affordable and attractive to consumers, thereby encouraging higher adoption rates.
- **Reduced GST Rates**: The Goods and Services Tax (GST) rates on electric vehicles have been reduced from the earlier 28% with cess to 12% with no cess. This reduction in GST rates reduces the overall cost burden on electric vehicle buyers, making them more cost-competitive compared to conventional vehicles.
- **Incentives for Charging Infrastructure:** The sale of electricity for charging electric vehicles has been categorized as a 'Service.' This policy change provides significant incentives for investment in charging infrastructure, as service providers can avail tax benefits and other support, further encouraging the development of a robust charging network across the country.
- **Exemption of Permit:** The Ministry of Road Transport and Highways issued a notification regarding the exemption of permits in the case of battery-operated vehicles. This exemption removes a significant regulatory barrier for electric vehicle operators, making it easier for them to operate without the need for additional permits.

Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) India Scheme:

The Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) scheme is a significant initiative launched by the Indian government to promote the adoption and manufacturing of electric and hybrid vehicle technology. The scheme was initially introduced in 2015 and subsequently

updated as FAME India Phase II in 2019, with an allocated budget of Rs. 10,000 Crore for a period of three years starting from 1st April 2019.

FAME India Phase II was initially designed as a three-year subsidy program with the primary goal of supporting the electrification of public and shared transportation in the country. With an extension until March 2024, the scheme aims to facilitate the adoption of electric and hybrid vehicles across various segments, including electric buses, three-wheelers, four-wheeler passenger cars, and two-wheelers. The ambitious targets set by the government include the deployment of approximately 7,000 electric and hybrid buses, 500,000 electric three-wheelers, 55,000 electric four-wheeler passenger cars, and 1 million electric two-wheelers.

Additionally, FAME II also aimed to encourage the domestic manufacturing of electric vehicle components, with a specific focus on EV batteries. To support this vision, the scheme offers direct financial incentives to EV battery manufacturers, encouraging them to establish manufacturing facilities in India and produce batteries locally.

Production-Linked Incentive (PLI) Scheme

The Production Linked Incentive (PLI) scheme, known as the **'National Programme on Advanced Chemistry Cell (ACC) Battery Storage**,' was introduced in 2020 with the primary objective of promoting domestic manufacturing of advanced chemistry cell batteries, particularly lithium-ion batteries. The scheme aims to enhance India's manufacturing capabilities in the battery sector and reduce the country's reliance on imported batteries. In addition, the PLI scheme is not only aimed at supporting the growth of the electric vehicle sector but also facilitating the demand for battery storage solutions in stationary applications.

Under the PLI scheme, the government has set an ambitious target of achieving a manufacturing capacity of Fifty (50) Giga Watt Hour (GWh) of advanced chemistry cell batteries by 2024. Additionally, the scheme aims to encourage the development of niche battery technologies, with a target of 5 GWh of such manufacturing capacity. By promoting domestic value addition and ensuring globally competitive cost structures, the government seeks to foster the growth of a robust indigenous battery ecosystem in India.

To support the implementation of the PLI scheme, *the government has allocated a budgetary outlay of ₹18,100 crore*. The manufacturers who will be eligible for receiving the incentive will be selected through a competitive bidding program, post which they will have to commission the manufacturing facility within a period of two years.

Companies selected to receive the investment should commit upfront to set up ACC manufacturing facility of minimum of 5GWh capacity and ensure minimum of 60% domestic value addition at project level within a span of 5 years.

This substantial funding is intended to incentivize companies to establish large-scale battery manufacturing facilities within the country. The scheme provides production-linked incentives to the selected manufacturers, thereby encouraging them to invest in setting up Giga-factories to produce advanced chemistry cell batteries and building a strong domestic supply chain.

The National Mission on Transformative Mobility and Battery Storage (NMTMBS)

NMTMBS established in 2019, is a strategic initiative by the Indian government to drive mobility initiatives and promote the development of sustainable transportation solutions. One of the key objectives of the mission is to set up large-scale manufacturing plants for electric vehicle (EV) batteries and components, fostering the growth of a robust EV ecosystem in the country.

To achieve this goal, the NMTMBS recommends and drives strategies for transformative mobility, focusing on the adoption of cleaner and greener transportation options. Additionally, it emphasizes the implementation of a Phased Manufacturing Program (PMP) that extends until 2024. This PMP is designed to localize production across the entire EV value chain, encouraging the establishment of large-scale, export-competitive integrated batteries and cell-manufacturing Giga plants in India.

The PMP offers support and incentives to attract investments and advanced technologies in the EV sector. By facilitating the development of world-class manufacturing facilities for EV batteries and components, the NMTMBS aims to strengthen India's position as a global leader in electric mobility.

Phased Manufacturing Program (PMP)

The Phased Manufacturing Program (PMP) is a strategic initiative by the Indian government aimed at promoting the localization of Electric Vehicle (EV) components, including batteries, in a systematic manner. The primary objective of the program is to increase the domestic value addition in the production of these components, ultimately reducing the overall cost of EVs and enhancing their affordability for consumers.

The PMP focuses on encouraging indigenous manufacturing of electric vehicles, their assemblies, sub-assemblies, and various parts. It envisions a graded duty structure that promotes progressive indigenization over a period. By gradually reducing import duties on EV components, the government aims to incentivize and support the growth of domestic manufacturing in the EV sector.

Furthermore, the PMP also covers a specific aspect known as the PMP for Electric/Hybrid (xEV) Parts. This program defines the effective date of indigenization of xEV parts to avail incentives under the Faster Adoption and Manufacturing of Electric Vehicles (FAME) Phase-II scheme. It aims to accelerate the localization of EV components, ensuring that they meet the specified domestic content requirements to qualify for incentives and benefits under the FAME program.

By implementing the Phased Manufacturing Program, the Indian government is fostering a self-reliant and vibrant ecosystem for electric vehicle manufacturing. The program not only supports the growth of the EV industry but also strengthens the overall manufacturing capacity and capabilities in the country.

Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS):

The Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS) is a transformative policy initiative that addresses the challenges faced by the domestic manufacturing of electronic components and semiconductors in India. It is designed to bolster the electronics manufacturing ecosystem in the country.

The scheme provides financial incentives of 25% on capital expenditure for a specific list of electronic goods. These goods represent the downstream value chain of electronic products, including electronic components, semiconductor/display fabrication units, ATMP (Assembly, Testing, Marking, and Packaging) units, specialized sub-assemblies, and capital goods required for manufacturing the aforementioned goods. The focus on high-value-added manufacturing enhances the overall competitiveness of the electronics industry in India.

SPECS is applicable to both new units and existing units looking to expand capacity, modernize, or diversify. Any entity registered in India is eligible to apply under the scheme, making it inclusive and accessible to various players in the electronics manufacturing sector.

This scheme may offset the disability faced by domestic manufacturers in the electronic components and semiconductor space. By providing financial incentives and support, the scheme aims to attract investments, stimulate growth, and strengthen the indigenous manufacturing capabilities in the electronics sector. This will contribute to India's journey towards becoming a global hub for electronics manufacturing and technology innovation.

India-Bolivia MoU:

In a significant development, India and Bolivia signed a Memorandum of Understanding (MoU) focused on the development and industrial use of lithium to produce lithium-ion batteries. Under this MoU, Bolivia has agreed to support the supply of lithium and lithium carbonate to India, facilitating the joint ventures between the two countries to establish lithium battery production plants in India. The agreement opens opportunities for Indian companies to set up production capabilities in Bolivia, as well as for the import of lithium to India to meet the growing demand for battery manufacturing.

This collaboration with Bolivia is expected to have a transformative impact on India's EV battery ecosystem. By gaining access to a stable supply of lithium, India's domestic production capabilities are likely to receive a significant boost. The increased availability of lithium will drive the manufacturing of lithium-ion batteries within the country, supporting the growth of the electric vehicle industry.

The MoU holds the promise of enhancing India's position as a key player in the global EV battery market. By securing a steady supply of critical raw materials and fostering joint ventures for battery production, India aims to become self-reliant in meeting its lithium-ion battery requirements and reduce reliance on imports.

Regulations pertaining to LIB Recycling

India until February 2020 did not have a formal lithium-ion battery scrapping and waste handling policy. To streamline the collection and recycling of used batteries in an environmentally sound manner, the government introduced Batteries (Management & Handling) Rule. The act notified in 2001 continues and amended in to be the major policy measure regulating the sector. On February 20, 2020, the Ministry of Environment, Forest and Climate Change (MoEFCC) published the draft **Battery Waste Management Rules, 2020,** which is set to supersede **Batteries (Management and Handling) Rules, 2001**. The amended rule is applicable all types of batteries (including Lithium-ion battery, lithium cobalt oxide battery (ICR), Lithium-ion manganese oxide battery (IMR), Lithium-ion polymer battery, Lithium iron phosphate battery, Lithium–sulfur battery, Lithium– titanate battery, thin film lithium-ion battery)) regardless of their shape, volume, weight, material composition or use. It is also applicable to all appliances into which a battery is or may be incorporated but not apply to batteries used in equipment used for providing essential security, as arms, ammunitions, and war material, and intended specifically for military purposes; space exploration; emergency alarm and lighting and medical equipment.

In India, the recycler used to face severe challenge pertaining to the recycling channel where collection, storage, and transportation of the waste batteries to recycling plant was a task even in B2B and the idea of tapping B2C segment was logistically inconceivable. Therefore, the amended policy imposes liability on battery producers to collect used batteries under the Extended Producers Responsibility (EPR). Many

Battery suppliers in India have already started selling with a buy-back option. The revised policy makes it incumbent on producers to collect and channelize used batteries at end of life of batteries or end of life of equipment containing battery.

Recovery target (minimum percentage) mandated for the recycler in India:

Type of Battery	2024-25	2025-26	2026-27 and onwards
Portable	70	80	90
Automotive	55	60	60
Industrial	55	60	60
Electric Vehicle	70	80	90

Note: Maximum recovery target is subject to the percentage of non-recoverable hazardous material content in the Battery. It would mean the reduction of recovery target by the same percentage of the hazardous material present in the Waste Battery.

BIS Quality Standards

In India, the Bureau of Indian Standards (BIS) has established the Compulsory Registration Scheme (CRS) to Lithium-ion batteries to protect consumers from buying counterfeit or unsafe products. The BIS Standard IS 17855:2022 is applicable for Electric Vehicle Batteries which is set in accordance with the ISO 12405-4:2018. Moreover, the Lithium-ion-batteries must also be tested by an accredited testing laboratory to ensure that they certain standards specified under ISO 12405-4:2018. This standard test the lithium-ion battery packs and system for basic characteristic such as performance, reliability and electrical functionality in high power or high energy application. The Ministry of Electronics and Information Technology (MeitY) has made it mandatory for all the importers of Lithium-ion-batteries to obtain BIS (CRS) registration to ensure that they meet essential quality and safety standards.

Union Budget 2023-24:

In the 2023-24 Union Budget, Finance Minister Nirmala Sitharaman unveiled a progressive approach towards energy transition and sustainability. With a budget allocation of INR 35,000 crore, the government is committed to making crucial capital investments that will pave the way for achieving net-zero targets by 2070.

To promote the adoption of clean energy technologies, the government has introduced several initiatives. Notably, it will provide viability gap funding to support Battery Energy Storage Systems with a capacity of 4,000 MWH, facilitating the growth of energy storage solutions in the country.

In the electric vehicle (EV) sector, the government continues to prioritize incentives and support for manufacturers. The Faster Adoption of Manufacturing of Electric Vehicles Scheme – II (FAME – II) and the

Production Linked Incentive Scheme (PLI) are already in place to boost domestic EV manufacturing. An increased budget allocation of INR 51.72 billion towards the FAME-II scheme, representing an 80 percent increase from previous years, aims to subsidize and promote the adoption of clean energy vehicles in India.

Moreover, the government is actively encouraging domestic production of lithium-ion cells for batteries by waiving customs duty on machinery required for manufacturing. This step will strengthen the local battery manufacturing ecosystem, reducing reliance on imports and enhancing India's self-sufficiency in battery technology.

Duty Structure

India has one of the highest import tariffs on vehicles in the world. In line with efforts to localize the EV supply chain, the government has rationalized customs duty on most of the imported EV components including Lithium-ion batteries while increase the custom duty on EV. In Union Budget 2023-24, removal of custom duty on specified capital goods/machinery for manufacture of lithium-ion cell for use in battery of EVs was announced. Simultaneously, custom duty on vehicles, including EV in Semi-Knocked Down (SKD) was increase to 35% from existing rate of 30%. Also, increase in custom duty from 60% to 70% on electrically operated vehicle in Completely Built Unit (CBU) form, other than with CIF value more than USD 40,000 was announced.

S.No.	Item Description		Current BCD w.e.f. 30/01/2019	Phased Manufacturine proposal	
				Proposed BCD	**Proposed Date of PMP**
1	CBU	Bus (HS 8702) & Trucks (HS 8704)	25%	50%	April 2020 onwards
2	SKD	PV(HS 8703) & 3W (HS 8703/8704)	15%	30%	
		2W(HS 8711)		25%	
		Bus(HS 8702)		25%	
		Truck(HS 8702)		25%	
3	CKD	Bus(HS 8704)	10%	15%	
		PV (HS 8703) 2W (HS 8711) 3W(HS 8703/8704)& Truck (HS 8704)			
4	Lithlum Ion cells (HS 85076000) for use in the		5%	15%	April 2021 onwards
5	Battery packs (HS 8507) for use in the		5%	15%	
6	Parts for use in the manufacture of electric AC or DC Charger AC or DC Motor AC or DC Motor Controller Power Control Unit (Inverter, AC/DC Energy Monitor Contactor Brake System for recovering Electric Compressor		0%	15%	April 2021 onwards

Tax Benefits and Custom Duties

- The Indian government has taken proactive steps to promote the adoption of lithium-ion batteries in the electric vehicle (EV) industry by offering significant tax benefits and customs duty reductions.
- To encourage domestic manufacturing of lithium-ion cells for EV batteries, the government has removed customs duty on the import of capital goods and machinery required for their production. This measure reduces the financial burden on manufacturers looking to establish or expand their lithium-ion battery manufacturing facilities in India. By exempting customs duty on these essential components, the government aims to foster a robust domestic lithium-ion battery manufacturing ecosystem, reduce import dependence, and promote "Make in India" initiatives.
- The customs duty exemption on the import of capital goods and machinery for lithium-ion cell production will remain in effect until March 31, 2024. This extended period provides manufacturers with a favourable window to invest in and ramp up their production capabilities, enabling them to meet the growing demand for lithium-ion batteries in the EV market.
- In addition to encouraging domestic manufacturing, the government has also extended concessions on lithium-ion batteries to further incentivize their adoption in EVs. By reducing the

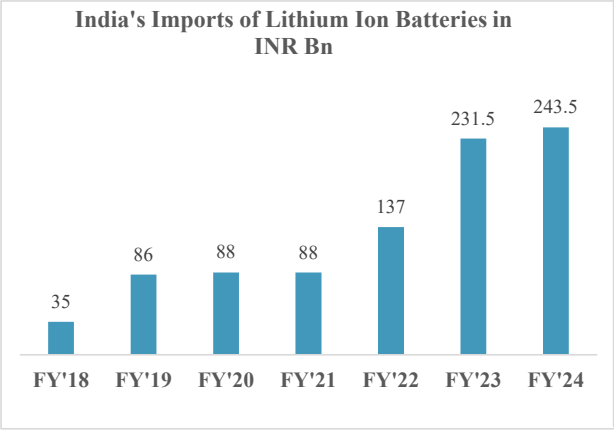
customs duty from 21% to 13% on lithium cells, the government has effectively lowered the import costs of these critical battery components. This reduction in customs duty not only benefits EV manufacturers but also makes EVs more affordable for consumers.

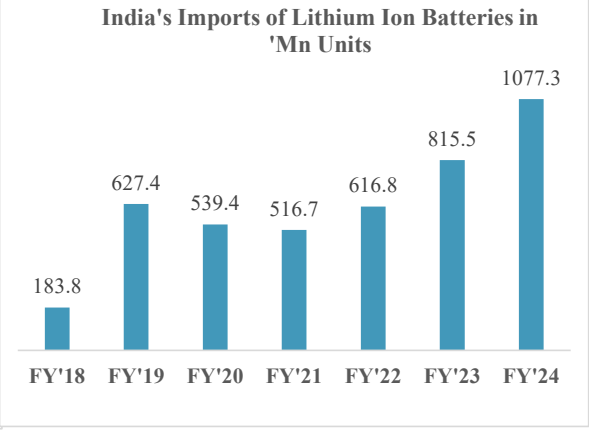
The lowered customs duty on lithium cells directly translates to cost savings for manufacturers, enabling them to offer competitive pricing for EVs equipped with lithium-ion batteries. As a result, consumers can access advanced and high-performance EVs at more affordable price points, accelerating the transition to cleaner and greener transportation options.

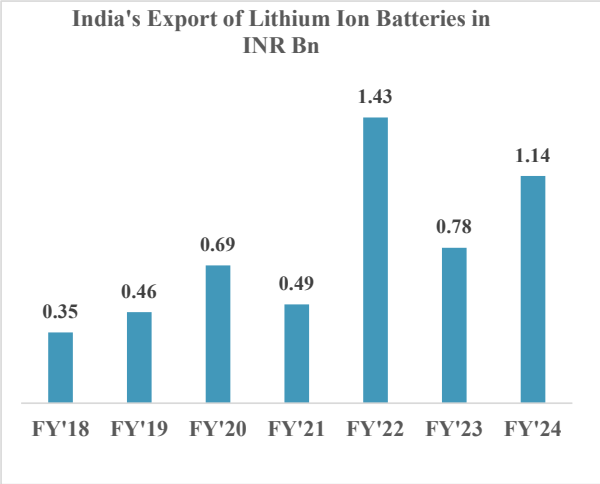
Foreign Trade Analysis

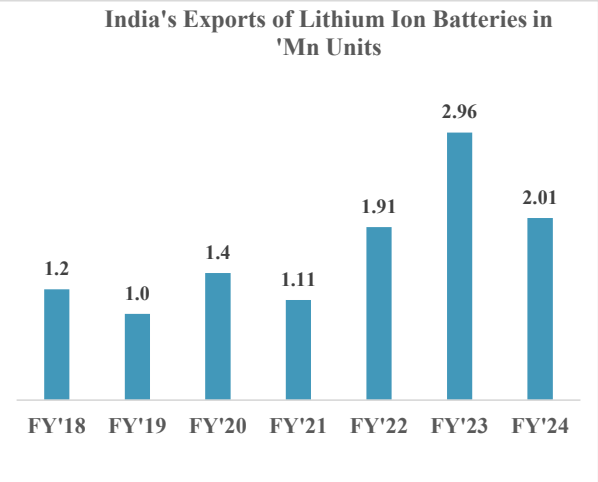
India primarily imports Li-ion cells and utilizes it further to manufacture battery packs of different capacity for various applications. India remained a net importer of lithium-ion cells and battery during FY 2019-FY 2024. India imported lithium-ion cell and battery worth INR 243.5Bn during FY 2024. indicating just a 5% growth over the previous year. Between FY 2019-24, the imports registered a robust CAGR of 28% while in FY 2024, it recorded 69.3% yearly growth in the previous year. Muted imports in FY 2024 can be attributed to government initiatives to attract investments from domestic and multinational companies to set up manufacturing facilities in India, and the exploration of domestic lithium reserves in Jharkhand, Rajasthan, and Jammu & Kashmir.

By volume, imports measured 1,077.3 Mn units in FY 2024, which grew by 32% y-o-y. Increasing import reflects reviving demand scenario for Li-ion cell that goes into manufacturing of battery packs of different capacity for its application several sector especially EV sector. Between FY 2019-24, India's lithium-ion batteries import have grown at a solid pace of 28.9% CAGR.





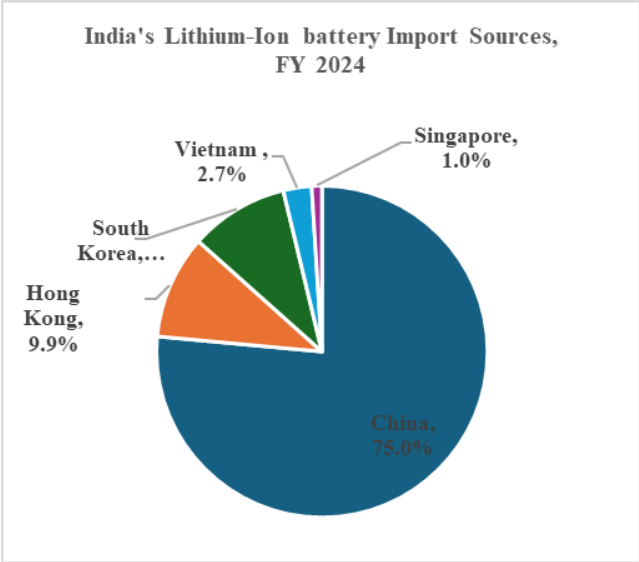


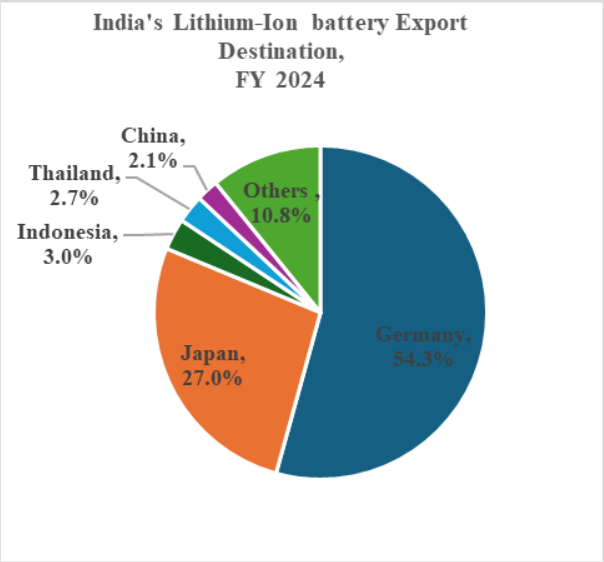


Sources: Department of Commerce

India's export of lithium-ion has too witnessed growing trend indicating India's improving manufacturing strength. India's annual export value of lithium-ion battery grew at a robust pace of 46.3% to reach INR 1.14 Bn in FY 2024 compared to a fall of 45.6% in FY 2023. The increase in export is largely attributed to strengthening global demand. In volume terms, export fell by 32% in FY 2024 to reach 2.01 Mn units, compared to a 55% y-o-y surge in FY 2023. India's Li-ion battery export have grown at CAGR of 41.8% in value terms and by 11.8% by volume terms. The trend of higher export revenues with substantially lower corresponding volumes, is probably indicative of improved price realization.

Trading Partners





Sources: Department of Commerce

China with 75% share, remained India's largest import source for lithium-ion cell and batteries followed by Hong Kong, South Korea, Vietnam, and Singapore. These top five countries contributed 98.1% share in India's overall import value during FY 2024.

For export, Germany emerged as India's largest export partner for lithium-ion cell during FY 2024. Other export destination for lithium-ion cell export from India included Japan, Indonesia, Thailand, and China.

Lithium-Ion Battery Supply Scenario in India: Domestic Manufacturing

India has well established Lead Acid battery manufacturing industry while the country still progressively working towards augmenting the Li-ion battery cell manufacturing to meet current and future demands of energy storage. The domestic lithium-ion battery manufacturing landscape in India is experiencing a seismic shift as the country gears up to embrace the electric mobility revolution. The domestic manufacturing capabilities is evolving rapidly as a multitude of companies have announced hefty investments to kick-start the manufacturing of lithium-ion batteries within the nation's borders. This strategic move comes in response to the surging demand for electric vehicles (EVs) and the pressing need for robust renewable energy storage solutions. Recognizing the potential of the EV market and realizing the importance of securing a local supply chain for batteries, several domestic and international companies have ventured into India's battery manufacturing space.

The Indian lithium-ion battery market is witnessing a surge in activity, with established players like Grinntech Motors and Services Pvt. Ltd (400 MWh capacity) and JLNPhoenix Energy (CLN Energy) (550 MWh capacity) vying for dominance. These companies cater to the growing demand for lithium-ion batteries in various sectors, including electric vehicles (EVs) and energy storage systems. A new entrant, Log9, is making waves with its focus on Li-ion cell manufacturing (50 MWh capacity). This indicates a potential shift towards domestic cell production, which could reduce reliance on imports and improve supply chain security.

The investment in domestic lithium-ion battery manufacturing is a significant step towards achieving greater energy independence and reducing reliance on imports. Companies such as Amara Raja Batteries, Log9 Materials, Exide, TVS Lucas, Ola Electric, TDS Lithium-Ion Battery Gujarat Private Limited and Munoth Industries Limited (MIL) have planned to make investments that together exceed INR 23,000 crores. By establishing local manufacturing capabilities, India aims to strengthen its position in the global EV market and create new employment opportunities within the rapidly expanding green technology sector.

Moreover, the Indian government's support through various policies and incentives, such as the Production Linked Incentive (PLI) scheme and the National Mission on Transformative Mobility and Battery Storage, has further catalysed the growth of domestic battery manufacturing. These initiatives provide financial incentives and support to companies setting up large-scale battery manufacturing facilities in India, fostering a conducive environment for the establishment of a robust lithium-ion battery ecosystem.

Additionally, the discovery of lithium reserves in Jammu and Rajasthan has bolstered the confidence of companies to invest in domestic battery manufacturing. The availability of indigenous raw materials, growing end-user industries demand particularly EV and grid scale energy storage market along with favorable policy environment, is drawing considerable interest from both established battery manufacturers and new entrants.

With the presence of several large players with significant financial capabilities and technological expertise, the lithium-ion battery manufacturing industry in India is poised to become intensely competitive. As the demand for EVs and its usage in renewable energy continues to soar, established global battery manufacturers and leading Indian conglomerates are vying for a prominent position in this rapidly evolving sector. The high intensity of competition is further intensified by the presence of substantial barriers to entry. Setting up a lithium-ion battery manufacturing facility requires substantial capital investment, advanced technology, access to raw materials, and a robust research and development infrastructure. This poses significant challenges for new entrants and smaller players, making it challenging for them to gain a foothold in the market.

Thus, the industry is likely to witness consolidation, with a handful of dominant players holding a significant market share. The competition is expected to revolve around innovation, cost-effectiveness, and quality, as companies strive to deliver cutting-edge battery solutions that meet the evolving demands of the electric mobility and renewable energy sectors in India.

Competitive Landscape

The storage battery market in India is consolidated Exide Industries and Amar Raja Batteries Ltd are considered the leaders in Indian storage battery segment. Together, these two players account for major in the storage battery market. Both the players cater to the OEMs as well as replacement in automotive and serve to wide range of industries in industrial segment including Telecom, Grid scale energy storage, Railways, Power Control, Solar and UPS. H B L Power Systems Ltd., High Energy Batteries (India) Ltd., Luminous Power Technologies Pvt. Ltd., and Okaya Power Pvt. Ltd., amongst other players operating in the storage battery segment.

In Lithium-ion segment, India has seen good is witnessing a good progress in battery pack manufacturing segment and there exists intense competition amongst manufacturer for importing cells from China and assembling them into packs to fulfill domestic demand. As per JMK research stakeholder consultation, of the total cost of LiBs, cells account for 65%, the battery pack 15%, BMS 15%, and the balance being the outer box. Currently, battery pack and associated BMS manufacturing is entirely dominated by domestic players. Indian manufacturer can 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 are imported by India and BMS and outer box are also primarily supplied by the Indian battery pack assemblers only.

Currently, while few firms are engaged in trading in battery packs and cells imported from abroad, many battery manufacturers prefer to manufacture batteries locally which have superior quality though costlier when compared to Chinese counterparts. The LiB pack manufacturing market in India is fragmented and comprised of numerous active players including Coslight India, Okaya, Exicom, Trontek, Amptek, Lohum Cleantech, Cygni, Grinntech, Pure EV etc. Most players have been serving both the EV and stationary markets with companies in this segment compete based on configuration of battery packs, quality, durability, recharge cycle, and application. Witnessing progress in the battery pack manufacturing, the industry stakeholders are relishing development in next stage of value chain that is cell manufacturing. Existing battery manufacturers like Amara Raja and Exide which are also leading players in LAB manufacturers in India, have already announced their plans to start lithium-ion cell manufacturing. Beside existing battery manufacturer, the lucrative cell manufacturing business is also attracting 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 and Tata group. In addition to above and after the revised PLI ACC scheme, the country's big business conglomerates the likes of Adani Group, Larsen and Toubro Ltd (L&T), Bharat Heavy Electricals Ltd. (BHEL), and Reliance Industries Ltd., which have no previous experience in battery manufacturing, have also shown interest in investing in cell manufacturing in India.

Major factors shaping competition in the lithium-ion battery segment in India:

Domestic Manufacturing Capacity: The establishment of gigafactories and other large-scale battery manufacturing plants in India is a critical factor. Investments by companies like Tata Chemicals, Exide Industries, and Amara Raja Batteries to enhance production capacity play a significant role in shaping market dynamics by ensuring a steady supply of batteries and reducing costs through economies of scale.

Technological Advancements & Investment in Research and Development (R&D): Continuous improvements in battery technology, including advancements in energy density, charging speed, and lifecycle, remain crucial for companies seeking a competitive edge in the market. Collaboration with research institutions and technology partners for the development of next-generation batteries is essential. Furthermore, continuous investment in research and development is imperative for suppliers to remain ahead of technological trends and meet evolving market demands. By prioritizing innovation in battery chemistry, energy efficiency, and safety features, companies can develop cutting-edge products that offer significant competitive advantages.

Robust Supply Chain Infrastructure: India is investing in enhancing its supply chain infrastructure, including logistics and transportation networks, to ensure the smooth and cost-effective movement of raw materials and finished products. Improved infrastructure can reduce lead times and logistics costs, offsetting some of the disadvantages of relying on imported raw materials.

Cost Competitiveness: Reducing the cost of battery production through technological innovations, scaling up manufacturing, and improving operational efficiencies is crucial. Suppliers who can offer high-quality batteries at competitive prices will dominate the market.

Strategic Partnerships and Joint Ventures: Forming strategic alliances and joint ventures with international players can provide access to advanced technologies and new markets. For example, Exide's partnership with Leclanché and BHEL's collaboration with Convergence Energy Services Limited are strategic moves to enhance their competitive positioning.

Quality and Reliability: Ensuring high standards of quality and reliability in battery products is a key competitive factor. Suppliers who can consistently deliver high-performance, safe, and reliable batteries will build stronger customer trust and loyalty, crucial for long-term success.

Sustainability Initiatives: Emphasizing sustainable practices, such as the development of eco-friendly batteries and investing in recycling technologies, can differentiate suppliers in a market increasingly focused on environmental impact. Companies that align their operations with global sustainability standards will attract environmentally conscious customers and partners.

Market Diversification: Suppliers that diversify their market presence across various segments, such as automotive, industrial, consumer electronics, and energy storage, can mitigate risks associated with

dependence on a single market. This diversification allows for more stable revenue streams and greater market resilience.

These factors collectively influence the competitive landscape of the lithium-ion battery segment in India, with suppliers needing to strategically address each to maintain and enhance their market position.

Key Domestic Players in Li-ion battery segment:

Key Players	Brief Description
Amara Raja Batteries Limited (ARBL)	Established in 1985, Amara Raja Batteries Limited (ARBL) is a prominent player among India's leading business conglomerates. As the flagship company of the Amara Raja group, ARBL holds a prominent position as one of the largest manufacturers of Automotive and Industrial batteries in India. Their products are renowned for their quality and reliability, leading to exports to 50 countries worldwide. With a vision towards the future of electric mobility, Amara Raja has taken decisive steps, planning to invest Rs 9500 crore over a decade in the phased manufacturing of Li-ion batteries. The first phase, expected to span 2-3 years, will see an investment of Rs 1,500 crore to Rs 2,000 crore and create employment opportunities for approximately 4500 people. The company's new Li-ion battery plant boasts an impressive capacity of 16 GWh, signifying their commitment to contributing significantly to the growth of electric vehicles in India.
Log9 Materials	Incubated in 2015, Log9 Materials has emerged as a pioneering company in the research and development of battery technologies. Their RapidX series of batteries is touted as the safest EV batteries in the country, designed to efficiently power electric vehicles under diverse Indian and tropical conditions. In a significant stride towards domestic battery manufacturing, Log9 Materials has established its first Li-ion battery manufacturing plant in Jakkur, Bengaluru. With an initial production capacity of 50 MWh yearly, the plant will produce Lithium Ferro Phosphate (LFP) and Lithium Titanate Oxide (LTO) cells. Notably, Log9 Materials secured an investment of $40 million (Rs 325 Crore) from prominent investors, including Amara Raja, Incred Financial Services, Unity Small Finance Bank, Oxyzo Financial Services, and Western Capital

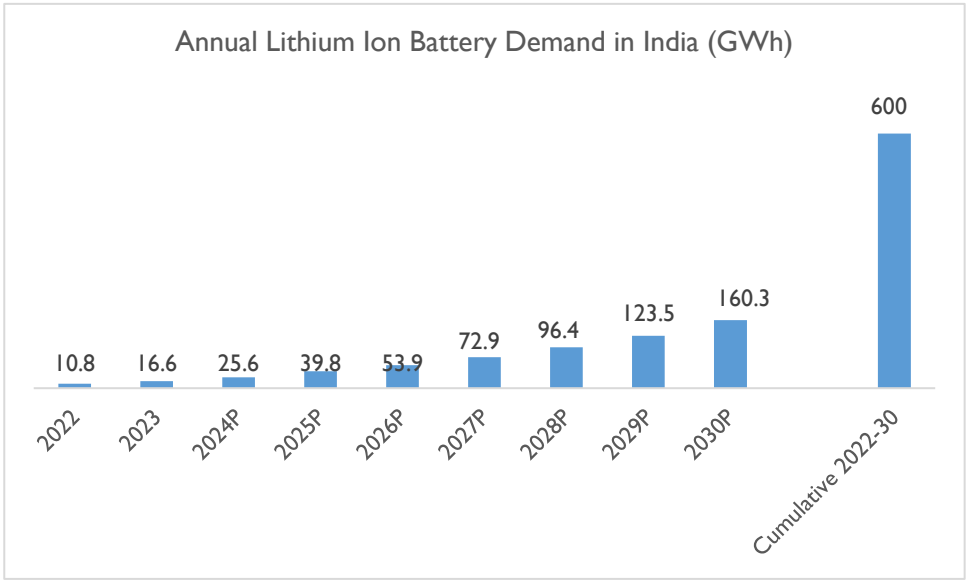
	Advisors. This investment will enable the company to ramp up its manufacturing capabilities to a substantial 2 GWh capacity by the end of 2024.
Battrixx	Founded in 2019 and based in Mumbai, Maharashtra, Battrixx is a prominent player in the EV battery space. As a wholly owned subsidiary of Kabra Extrusiontechnik Ltd. (KET), belonging to the Kolsite Group, Battrixx specializes in manufacturing advanced lithium-ion battery packs and modules for electric vehicles, solar power systems, and other applications. Their customized lithium-ion battery modules, packs, and Battery Management System (BMS) are designed to enhance the range and battery life of electric vehicles, ensuring safe and reliable energy storage systems.
Grinntech Motors And Services Private Limited	Founded in 2013, Grinntech has made a name for itself in the electric mobility space. The company specializes in lithium-ion battery technology and focuses on developing advanced batteries for electric vehicles and energy storage systems. Grinntech's emphasis on research and design, combined with its commitment to domestic manufacturing and assembly, ensures a reliable supply chain for EV batteries in India.
Exide Industries Limited	With a remarkable legacy spanning over seven decades, Exide Industries Limited has been a reliable and trusted name in battery manufacturing. Their portfolio includes a diverse range of batteries for automotive, home UPS, industrial applications, and solar energy storage systems. Manufacturing a staggering 8 million units of automobile batteries annually, including those for motorcycle applications, Exide has been a driving force in the Indian battery industry. In line with the EV revolution, Exide joined forces with Leclanche S.A., a Swiss-based company, in 2018 to venture into Li-ion battery production. Their state-of-the-art manufacturing facility, based on NMC, LTO, and LFP battery chemistry, has a capacity of 1.5 GWh. Expanding their commitment to domestic Li-ion battery manufacturing, Exide has initiated an investment of Rs 6,000 crore for a manufacturing plant in Bengaluru. Partnering with SVOLT, a global battery technology company, this sprawling 80-acre plant is expected to have a remarkable production capacity of 12 GWh of Li-ion cells.
TVS Lucas	With over 50 years of experience in manufacturing and designing electrical components for vehicles, TVS Lucas has established itself as a prominent

	player in the automotive sector. Their proven track record and global presence, with products sold in over 50 countries, exemplify their commitment to quality and innovation. TVS Lucas is now set to enter the Li-ion battery space, teaming up with U.S.-based 24M Technologies Inc. to establish a state-of-the-art factory near Chennai. This ambitious venture aims to manufacture semi-solid Li-ion battery cells in pouch and prismatic forms with an impressive capacity of 10 GWh.
Ola Electric Technologies	As a leading electric automobile manufacturing company, Ola Electric Technologies has been at the forefront of the electric scooter market in India and plans to venture into electric car manufacturing by 2024. Ola is not only revolutionizing the EV market with its scooters but also providing charging facilities known as Hyperchargers across more than 170 cities in India. In a strategic move towards self-reliance, Ola Electric Technologies is investing a whopping Rs 5,114 crore for NMC-based Li-ion cylindrical cell manufacturing. Their upcoming Gigafactory is set to mass-produce Li-ion cells with a capacity of 20 GWh, further complemented by a Rs 2,500 crore investment in an electric car plant.
TDS Lithium-Ion Battery Gujarat Private Limited	Established jointly by TOSHIBA Corporation (40% share), DENSO Corporation (10% share), and Suzuki Motor Corporation (50% share), TDSG's Li-ion battery manufacturing plant in Gujarat holds the distinction of being the first company to produce Li-ion Battery Packs for Hybrid Vehicles. With a significant investment of $180 million, this plant is set to manufacture and supply LTO-based Li-ion batteries for Maruti Suzuki and Suzuki Gujarat.
Tata Group	Established in 1868, Tata Group is an Indian multinational conglomerate. With operations spanning diverse sectors like steel, automotive, technology, and more, it's a prominent player in global business. Recently, Tata has taken a significant step towards the manufacturing of Li-ion EV batteries. In collaboration with the Gujarat government, the group has inked a preliminary agreement to establish a lithium-ion cell factory, investing around Rs 13,000 crore ($1.6 billion). This strategic move reflects Tata's dedication to the EV sector. The initial phase of the plant's operation is set to boast a manufacturing capacity of 20 Gigawatt hours, with the potential for doubling this capacity in a subsequent expansion phase.

Munoth Industries Limited (MIL)	Based in Chennai, Munoth Industries Limited has set up an advanced Li-ion battery manufacturing plant in Tirupati, Andhra Pradesh. This ambitious project, established in three phases with a total investment of Rs 799 crores, boasts an impressive production capacity of approximately 1.9 GWh per annum. The batteries produced will be used for energy storage and the EV segment, with a special focus on 2W and 3W vehicles.

India Battery Demand Forecast

Tracing the global growth trend, the lithium-ion battery is witnessing healthy demand growth in domestic market too. In 2022, LIB demand in India was estimated at 11GWH. The projected annual demand for Li-ion batteries (LIBs) in India expected grow to 160.3 GWh by 2030, taking the total cumulative demand to 600 GWh by 2030.



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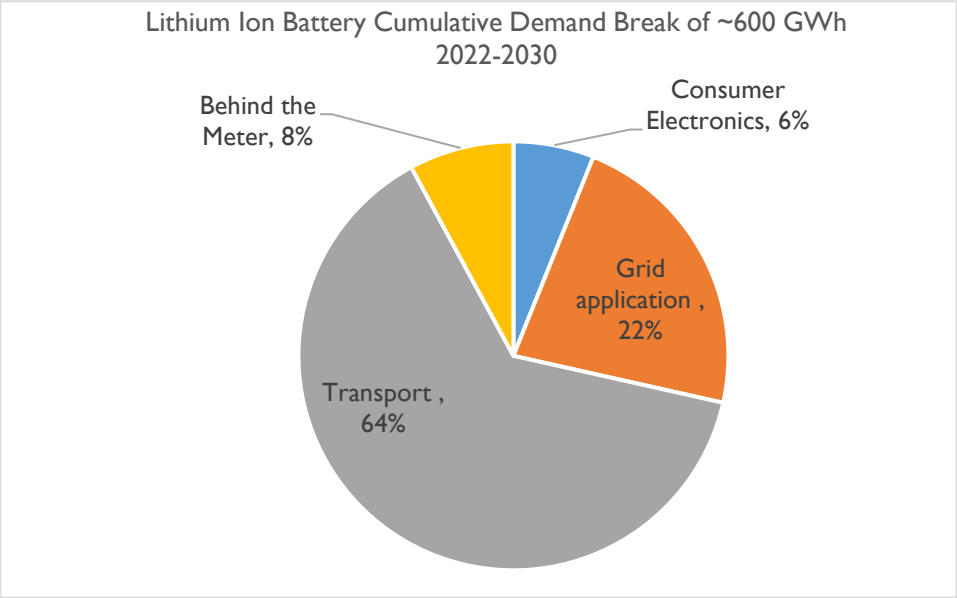

Source: (Niti Aayog, D&B analysis

The largest demand between 2022-30 is projected to come from EV at 381.4 GWh (64%), followed by stationary storage (grid scale) at 134.2GWh (22%), BTM at 47.3GWh (8%) and consumer electronic at 36.4 GWh (6%).

The increasing demand scenario underscores the critical need for the Indian battery manufacturing industry to secure its supply chain and enhance domestic value addition to meet the projected demand. The anticipated growth in LIB demand presents substantial economic opportunities, including job creation and technological advancements, while aligning with India's goals for a low-carbon economy. Strategic developments in the battery manufacturing sector are essential to capitalize on these opportunities and mitigate potential trade imbalances resulting from import dependencies. Overall, the substantial increase in LIB demand across various sectors, particularly in grid storage and electric mobility, highlights the transformative impact of battery technology on India's energy future.

KPI of major players

CLN Energy (INR Lakhs)			
	FY 2021	**FY 2022**	**FY 2023**
Total Revenue	1,460.18	12,168.96	12,881.94
EBIT	-314.88	504.55	767.03

PBT	-318.24	501.16	129.38
EBITDA	-240.61	639.00	713.72
PAT	-187.41	364.13	111.88
Equity Share Capital	100.00	113.50	113.50
ICR	-93.71	148.83	108.80
Current Ratio	0.56	0.85	0.82
Net Profit Margin	-12.83	2.99	0.87

TDS Lithium (INR Lakhs)			
	FY 2021	**FY 2022**	**FY 2023**
Total Revenue	82.90	5,060.80	1,28,281.20
EBIT	-5,396.60	-20,825.90	4,993.00
PBT	-8,896.80	-37,704.30	-11,827.00
EBITDA	-4,144.80	-7,786.30	23,104.80
PAT	-8,905.60	-37,704.30	-11,827.00
Equity Share Capital	11,630.00	11,630.00	11,630.00
ICR	-1.54	-1.23	0.30
Current Ratio	17.78	19.17	1.01
Net Profit Margin	-10742.6	-745.03	-9.22

Log9 Materials (INR Lakhs)			
	FY 2021	**FY 2022**	**FY 2023**
Total Revenue	74.01	248.45	675.38
EBIT	-64.59	-142.30	-711.22
PBT	-64.68	-144.83	-768.33
EBITDA	-53.40	-123.60	-629.21
PAT	-64.68	-145.08	-768.33

Equity Share Capital	0.43	0.44	0.44
ICR	-717.67	-56.25	-12.45
Current Ratio	19.48	1.87	2.66
Net Profit Margin	-87.39	-58.39	-113.76

PPAP Technology (INR Lakhs)			
	FY 2021	**FY 2022**	**FY 2023**
Total Revenue	72.42	1,001.18	1,394.37
EBIT	-97.21	-220.12	-432.87
PBT	-115.38	-328.59	-758.35
EBITDA	-83.02	-182.61	-300.99
PAT	-85.48	-256.14	-586.95
Equity Share Capital	630.00	1,379.93	1,379.93
ICR	-5.35	-2.03	-1.33
Current Ratio	5.85	1.10	0.84
Net Profit Margin	-118.03	-25.58	-42.09

Grinntech Motors (INR Lakhs)			
Key Metrics	**FY 2021**	**FY 2022**	**FY 2023**
Total Revenue	36.28	294.67	524.56
EBIT	-376.13	-681.84	-673.52
PBT	-376.74	-712.26	-743.77
EBITDA	-356.16	-605.18	-435.95
PAT	-353.40	-641.31	-674.23
Equity Share Capital	1.96	1.96	1.96

ICR	-616.61	-22.41	-9.59
Current Ratio	1.96	1.32	0.64
Net Profit Margin	-974.09	-217.64	-128.53