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Assessment of the PLI scheme on

Electronic Vehicle Manufacturing in India

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Executive Summary

India's push toward electric mobility represents a monumental change in its transportation sector, aligning with global initiatives for sustainable development and carbon emission reduction. The government's ambitious targets aim for a substantial adoption of electric vehicles, with (EVs) 30% for private cars, 70% for commercial vehicles, and 80% for two and three-wheelers. These goals focus on environmental and economic benefits, including reduced reliance on fossil fuels, fostering domestic production of EV components, and fostering job growth in the Electric Vehicle industry.

Central to the electric vehicle (EV) revolution is lithium-ion batteries, the most critical and cost-intensive component. Proficiency in EV battery manufacturing has the potential to accelerate EV adoption by enhancing their cost-effectiveness and energy efficiency. However, India, like many developing nations, currently exhibits a significant reliance on imports, particularly from China, to fulfil its EV battery needs. China dominates the global battery manufacturing sector with a 900 gigawatt-hour production capacity, processing significant shares of lithium (67%) , cobalt (73%), graphite (70%), and manganese (95%). China controls 75% of the battery cell market, showcasing remarkable success in EVs due to proactive government and private sector collaboration and policies that focus on all tiers of the supply chain. Strategic measures, including targeted investments in R&D, have propelled China's innovation and has led to expansion in production capabilities across the EV supply chain. A continuous commitment to innovation complemented by consistent investment has driven the development of advanced and energy-efficient vehicles, further solidifying China's position as a global leader in the EV market.

This report examines India's EV Battery Value chain and investments and incentives by public and private stakeholders in India. When compared to China's progress within the EV battery value chain, Indian battery ecosystem lags behind. Currently, India possesses a presence in battery pack assembly and vehicle integration. However, significant deficiencies exist in upstream activities such as mineral procurement and refining, cell manufacturing, and downstream processes encompassing second-life utilisation (recycling and reuse). Additionally, research and development (R&D) efforts remain underdeveloped in India. This disparity is further amplified when compared to China's levels of private investment. India's current investment in the EV sector stands at a modest $3.5 billion, a stark contrast to China's staggering $222 billion in private investment. However, an examination of the incentives and policies implemented by the Indian government reveals a holistic strategy. Its policies address gaps in various stages of the EV value chain and align with best practices observed globally, demonstrating a commitment to fostering domestic EV development.

India's investment in the EV sector stands at a modest **$3.5 Billion** a stark contrast to China's staggering **$222 Billion** in private investment.

The Production Linked Incentive (PLI) for Advanced Chemistry Cells (ACC) is crucial supply-side initiative, with a particular focus on boosting domestic EV battery production. To analyse the potential impact of this scheme on the entire ecosystem and, by extension, the national economy, this report employs the Input-Output model. The results estimate a $19.39 billion increase in economic output. The mining and quarrying sector is estimated to have the most significant upswing, with a projected gain of $1.54 billion. Beyond just output, the analysis predicts a significant increase in employment, with over 1 million new employment opportunities. Battery production is projected to be the biggest job creator, adding an estimated 179,546 roles to the sector.

The report not only outlines projections from the input-output model but also underscores the imperative of a dual-pronged strategy: accelerating production and fostering innovation. This approach is pivotal not just for meeting domestic EV battery demand but also for seamless integration into the global value chain. Drawing insights from battery value chain analysis and policy assessments, the report underlines importance of capacity building in mining and refining, fostering localized production, along with vigorous and well-structured R&D initiatives.. Strengthening these foundational elements is paramount as major initiatives like FAME I & II and PLI rely heavily on their efficacy. Furthermore, the anticipated decline in oil imports resulting from the EV transition hinges significantly on lithium procurement and refining capabilities. Failing to develop these domestic capacities risks offsetting the intended import reduction, potentially leading to a shift from one import dependency (oil) to another (lithium). Additionally, the report stresses the necessity of substantial investments, akin to those witnessed in China by both governmental and private entities. These investments, spanning the entire battery ecosystem from upstream mining to downstream production, are instrumental in constructing a seamless value chain. Addressing the need for an enabling business environment, the report advocates for governmental support in alleviating financial and logistical barriers. Additionally, private entities are encouraged to proactively engage in innovation, localization, and production enhancement efforts. These combined efforts are fundamental to positioning India competitively in the global EV battery market.


01

Introduction

Governments globally are advocating for the establishment of indigenous battery value chains as a fundamental aspect of national industrial policy.

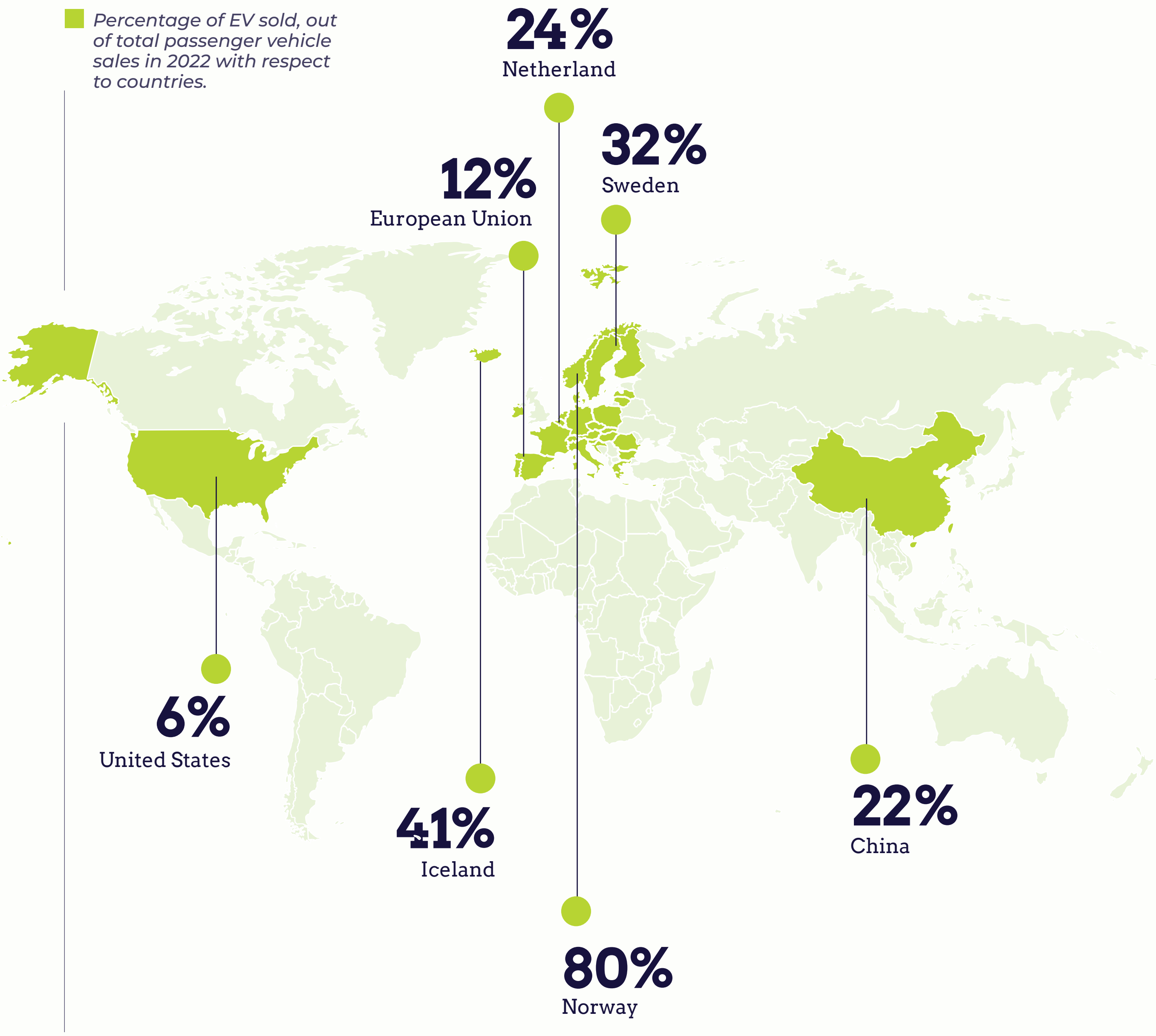
The global consensus among economies to establish resilient local supply chains is particularly evident in the electric vehicle (EV) battery manufacturing sector. This strategic shift is closely aligned with international climate objectives, demonstrating a collective commitment to sustainable practices and a concerted effort to mitigate the carbon footprint associated with the rapidly expanding electric vehicle industry.

The COVID-19 pandemic served as a catalyst, revealing vulnerabilities in global supply chains and emphasising the dangers of overreliance on foreign economies for essential components. This prompted a strategic realignment, focusing on reshaping supply networks, and prioritising localization. As a result, establishing resilient, sustainable, and secure supply chains has become a defining objective for economies across the globe.

Within the automotive sector, there is a strong need to shift towards a low carbon economy, which is a crucial step towards electric vehicles (EVs).

This endeavour is fuelled by the twin objectives of reducing supply chain dependencies and taking advantage of the economic prospects offered by the growing EV industry. Countries seek to reduce reliance on unpredictable global markets, strengthen their technological independence, and gain a competitive edge in the worldwide transition to electrification by developing their domestic battery production capacity. In consonance with this global shift, India has implemented supply-side measures and production-based strategies to bolster its EV Battery manufacturing capabilities. This report attempts to conduct a detailed analysis of India's one such initiative in this domain - the Production Linked Incentives for Advanced Chemistry Cells.

1.1 Overview of the Global EV Batteries Ecosystem

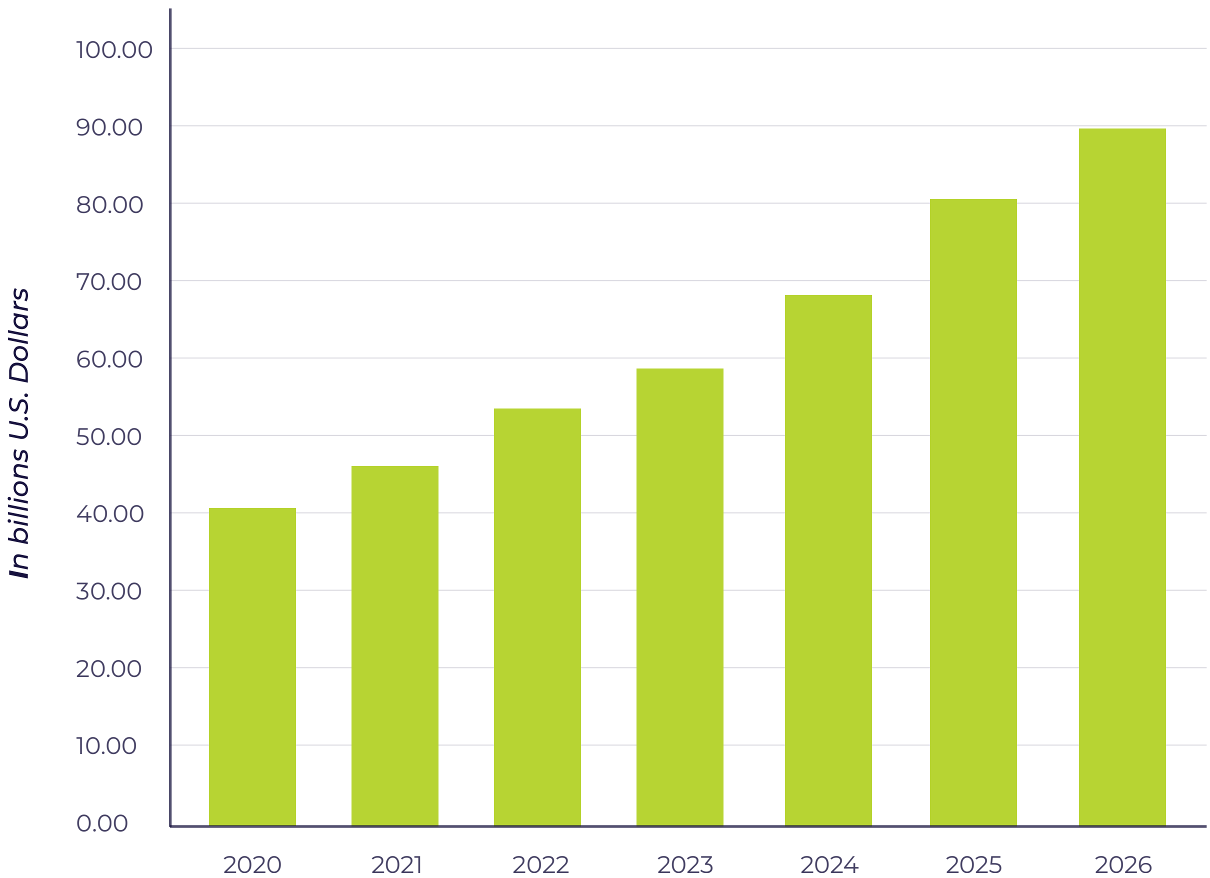


10%

of worldwide passenger vehicles sold, are EVs

The EV market has experienced a notable upswing, accounting for 10% of worldwide passenger vehicle sales, representing a tenfold expansion in comparison to previous years. Norway is at the forefront, with an impressive 80% of its passenger vehicle sales in 2022 being fully electric, outpacing Iceland (41%), Sweden (32%), the Netherlands (24%), China (22%), the entire European Union (12%), and the United States (6%) (IEA, 2023). Batteries, accounting for 30% to 40% of an EV's value, are crucial to this sector. The emphasis on achieving net-zero emissions highlights the critical significance of ensuring a dependable source of vital minerals and metals for battery manufacturing. This emphasis not only motivates the pursuit of securing resources but also stimulates competition to create economically efficient and technologically sophisticated batteries to achieve a substantial market value in the expanding electric vehicle battery business (IEA).

***Figure 1** - The projected size of the global litium-ion battery market from 2020 to 2026 (in billions U.S. Dollars)*



Source- Statista; Research and Markets

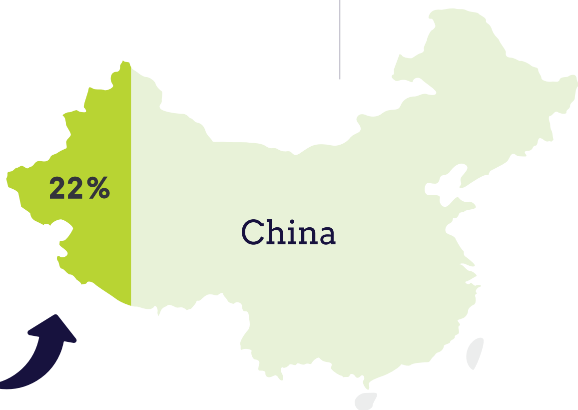
In this industry, China is one of the biggest manufacturers and dominates the entire downstream EV Battery Supply Chain. This can be attributed to the meticulous strategic planning and dedicated efforts carried out for over two decades. This includes a comprehensive range of battery policies that cover many aspects such as production incentives, procurement and processing of raw materials, research and development, the establishment of innovation hubs, and the enforcement of strict battery recycling laws.

In 2022, electric vehicles accounted for 22% (4.4 million units) of passenger car sales in China. Globally, Chinese companies manufacture 80% of the best-selling electric vehicle models (Jaeger, 2023).

China sold

4.4 Million units

of electric vehicles accounted for
22% of passenger car sales in China.



China commands a significant portion of the global battery manufacturing sector, with approximately 900 gigawatt-hours of capacity, constituting 77% of the world's total. This nation houses six out of the top ten largest battery producers globally. The key to China's ascendancy in the battery domain lies in its comprehensive control over the electric vehicle (EV) supply chain, right from the processing of raw materials.

China has

900 Gigawatt-hours

of production capcity, constituting
77% of the world's total.

To illustrate, China is responsible for processing[1] around 67% of the global supply of lithium, 73% of cobalt, 70% of graphite, and 95% of manganese (Mining Technolgy, 2023).

Along with this, China dominates the production capacity of battery cells, holding three-quarters of the global share. This dominance extends to the specialized production of cathode and anode materials, where China is responsible for 70% of the world's cathode material and 85% of anode material production capacity (IEA, 2022).

[1] Battery production required high purity of minerals which can be processed using heavy industrial processes. Unless processed in the specialized way, minerals cannot be used for battery production, increasing the importance China in the supply chain (Source: IEA).

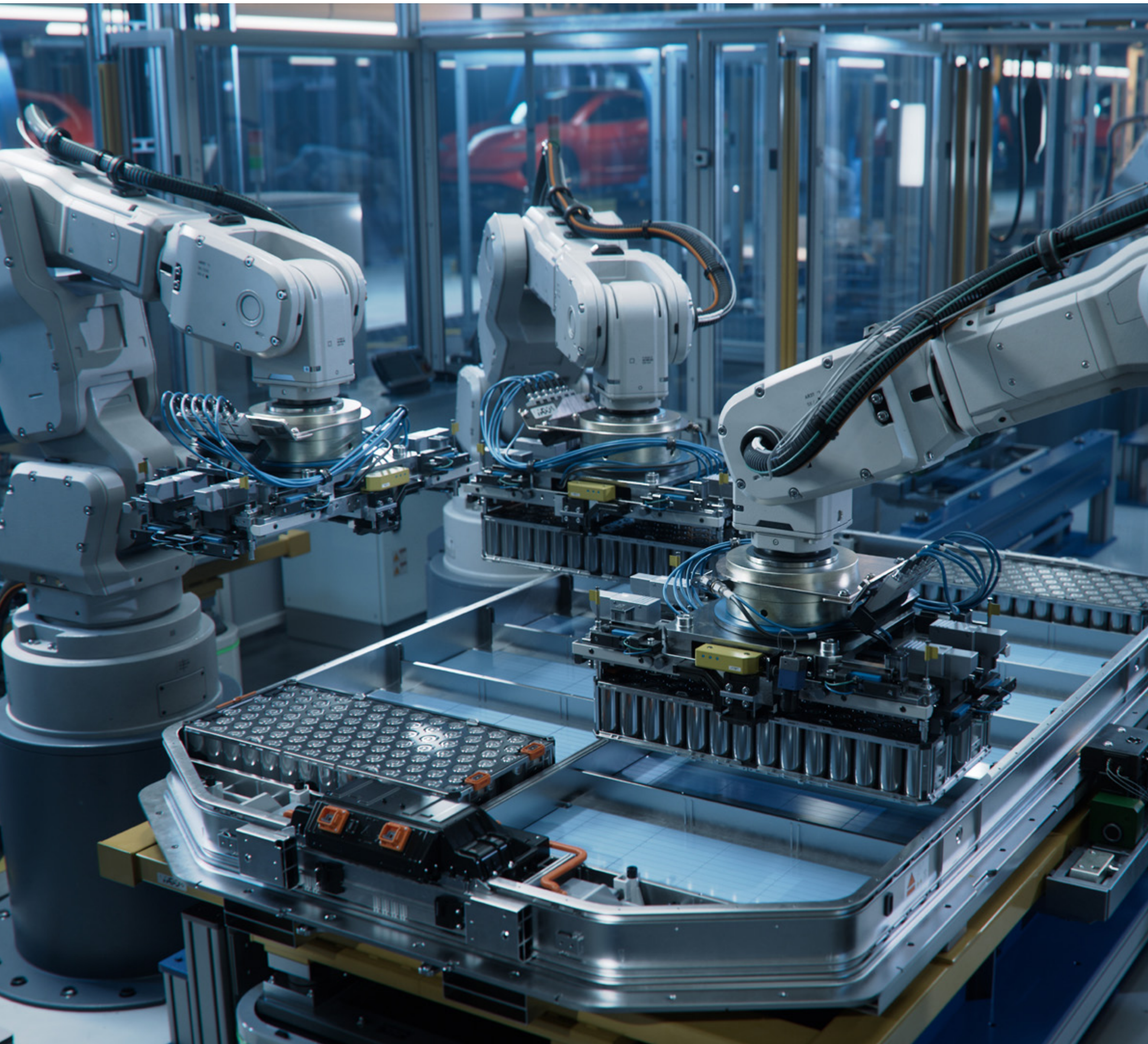
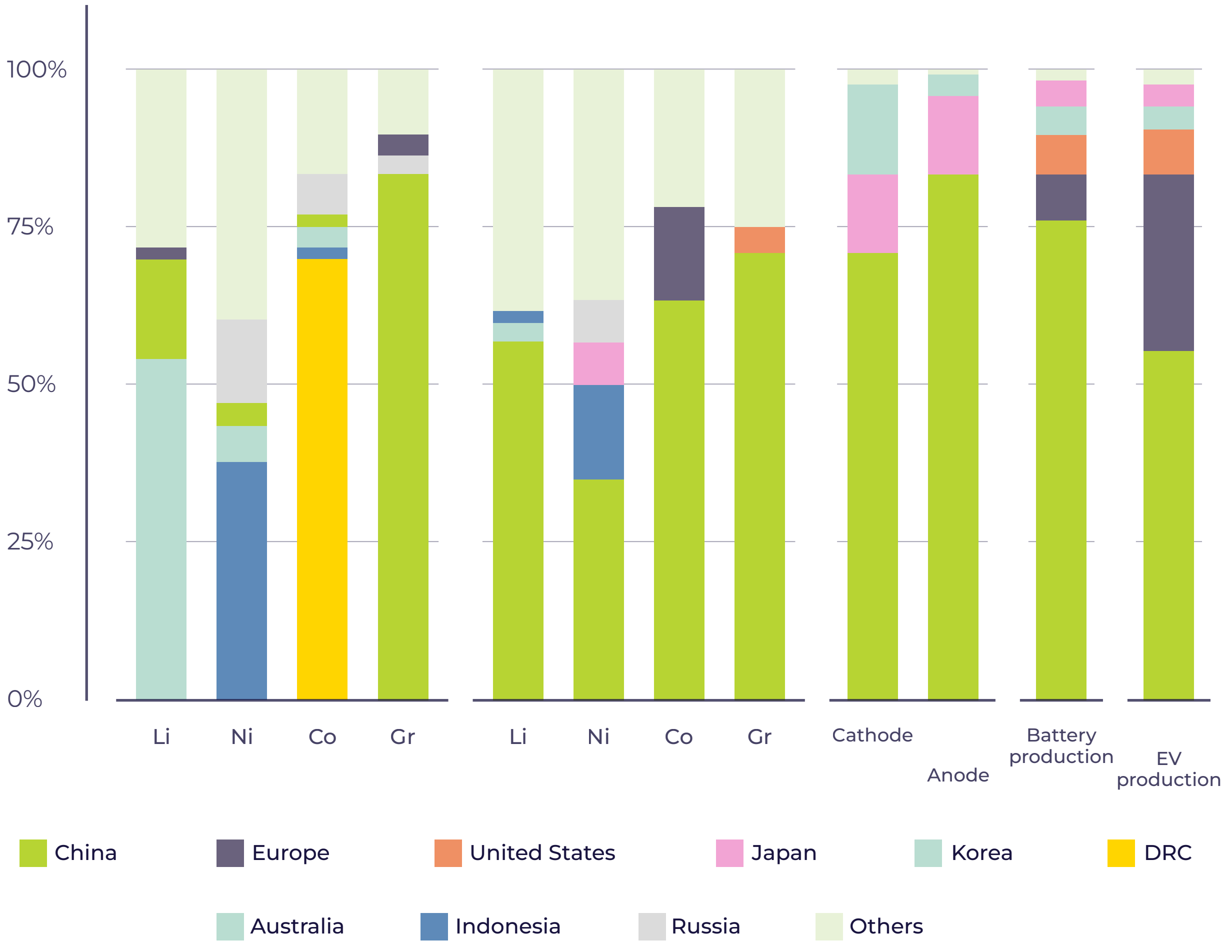


Figure 2 *- Geographical Distrubution of the global EV battery supply chain*



Notes: Lilithium; Ni = nickel; Co = cobalt; Gr = graphite; DRC = Democratic Republic of Congo. Geographical breakdown refers to the country where the production occurs. Mining is based on production data. Material processing is based on refining production capacity data. Cell component production is based on cathode and anode material production capacity data. Battery cell production is based on battery cell production capacity data. EV production is based on EV production data. Although Indonesia produces around 40% of total nickel, little of this is currently used in the EV battery supply chain. The largest Class 1 battery-grade nickel producers are Russia, Canada and Australia.

Source- IEA, 2022

Acknowledging the significant reliance on China and its dominant position in the electric vehicle (EV) industry, countries around the world are implementing various strategies to establish robust value chains with a focus on local production. The United States has launched targeted initiatives such as the Battery500 Consortium and the Inflation Reduction Act, alongside various tax incentives to stimulate the battery sector. The European Union has rallied its member states under the European Battery Alliance, supplemented by individual policy measures from its member economies. Japan has introduced the Next-Generation Vehicles strategy and is actively engaging in international partnerships to further its ambitions. In the United Kingdom, programs like the Faraday Battery Challenge are designed to enhance EV battery technology. Meanwhile, India's Production Linked Incentive scheme for the Automobile sector is instrumental in cultivating a robust EV ecosystem. These strategic, battery-centric initiatives are pivotal, augmenting consumer-focused demand incentives across these nations to bolster the adoption of electric vehicles. (Blackridge, 2023; Council on Foriegn Relations, 2019; South China Morning Post, 2023; IEA, 2023; UK Research and Innovation, 2023; IEA, 2023).

Table 1- *Summary of Major Incentives focused on EV Batteries.*

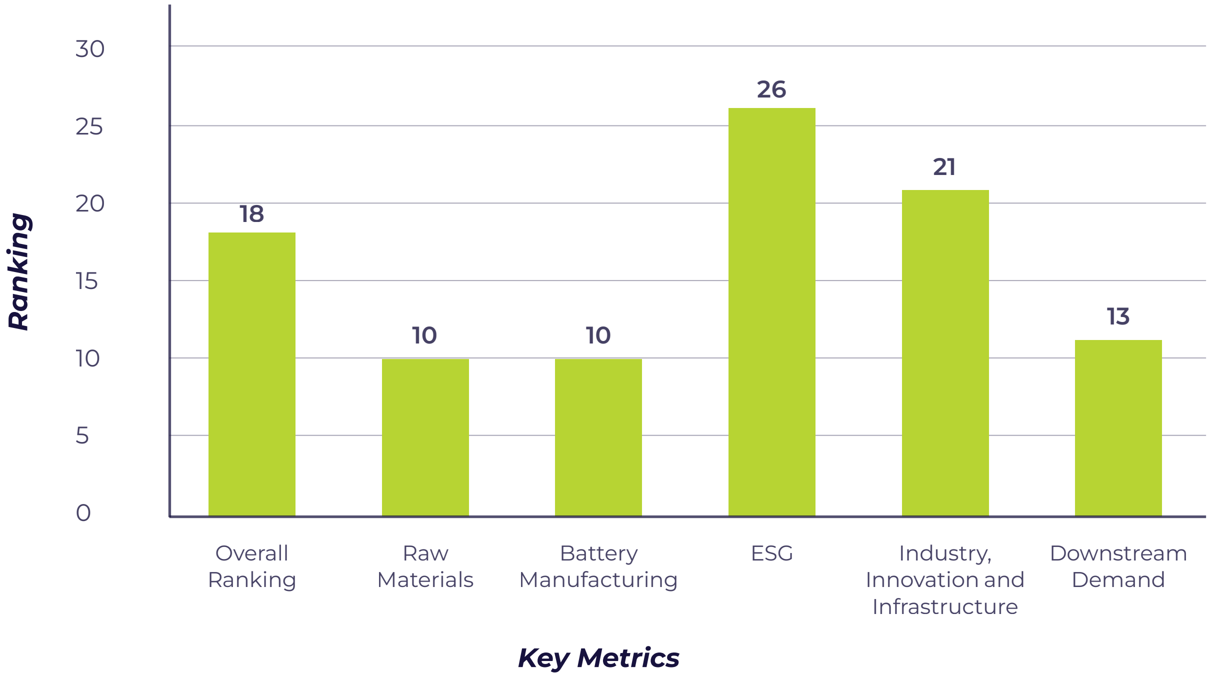
Country	Major Initiatives for EV Batteries
China	**China All-Solid-State Battery Collaborative Innovation Platform (CASIP)** is a consortium which brings together Industry Giants, academic institutions and government resources to accelerate research and development in solid state battery technology. **13th Five-Year Plan** has incentives focused in battery technology and research. **Made in China 2025** is a strategic plan for enhancing Chinese manufacturing sector with specific support towards EV batteries.
	China's National Mineral Resources Plan for 2016-20 aimed at securing supplies of raw materials including the ones required for EV batteries.
United States	Battery500 Consortium is a multi-institution program working to develop next-generation Li-metal anode cells. The U.S. Department of Energy supports projects to enhance battery recycling and manufacturing capacities. **Inflation Reduction Act, 2022** includes a combination of grants, loans, tax provisions and other incentives to accelerate the deployment of clean energy, clean vehicles, clean buildings and clean manufacturing.
United Kingdom	**Faraday Battery Challenge** is investing in research and innovation projects, and facilities, to drive the growth of a strong battery business in the UK.

Country	Major Initiatives for EV Batteries
Japan	Next-Generation Vehicle Strategy made to popularise the usage of ZEVs
	Subsidies for Manufacturers of EV batteries
European Union	**European Battery Alliance (EBA)**
	Regulation on batteries as a part of EU Green deal to reduce environmental and social impacts throughout all stages of the Battery cycle

Source - Black Ridge Research, IEA, UKRI, SCMP, CFR, Authors Analysis.

Bloomberg New Energy Finance (BNEF) conducted an analysis of the global lithium-ion battery supply chain, evaluating thirty leading nations based on 45 specific metrics across five main areas. These areas include the availability and supply of necessary raw materials, the manufacturing of battery cells and their components, domestic demand for electric vehicles and energy storage solutions, supportive infrastructure, innovation, and sectoral growth, as well as Environmental, Social, and Governance (ESG) factors. In 2022, India stands at the 18th position out of 30 economies in these global lithium-ion battery supply chain rankings. India ranks 10th in access to raw materials, 10th in battery manufacturing, 26th in ESG, 21st in Industry innovation and Infrastructure and 13th in downstream demand (BloombergNEF, 2022).

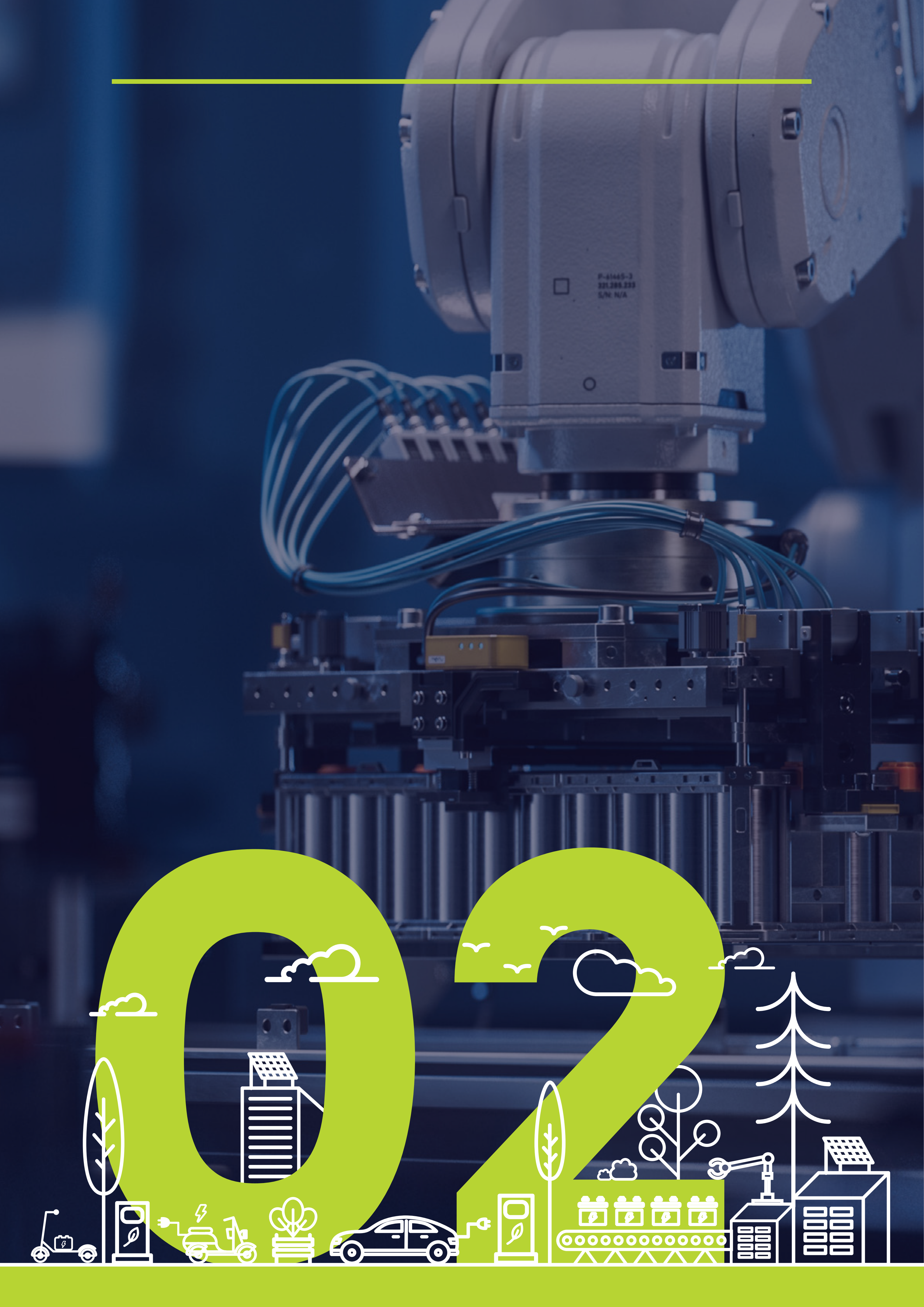
Figure 3 *- India's Global Litium-Ion Supply Chain Ranking*



Source- BloombergNEF, 2022

Nations worldwide are striving to improve electric vehicle (EV) battery technologies, which is a crucial step in their strategic efforts to achieve carbon neutrality and transition to electric transportation fleets. India is currently in the nascent phase of the electric vehicle (EV) battery business and progressing towards establishing its presence in the global ecosystem. The nation is making concerted efforts to improve its battery environment and international standing, resulting in a noticeable momentum towards progress. With the potential growth of India's electric vehicle (EV) battery sector, it is crucial to evaluate the policy tools that are driving this progress.

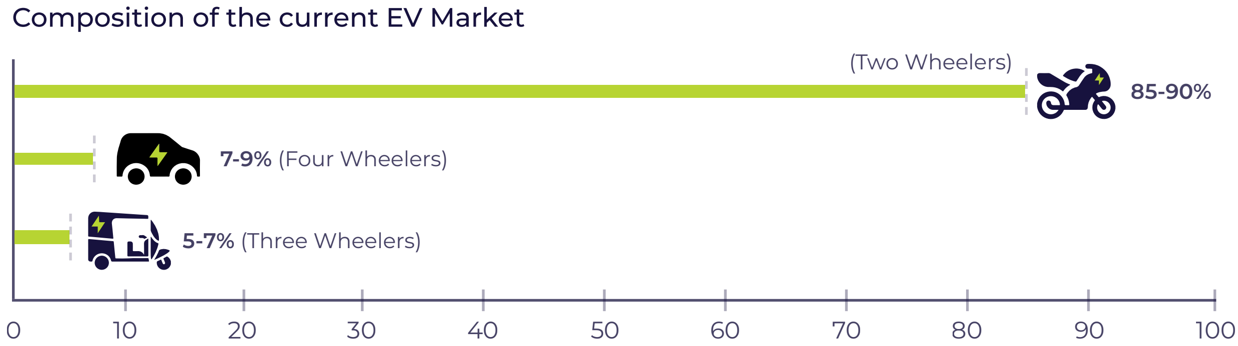
This report provides a critical analysis of the Production Linked Incentive (PLI) scheme in India, with a focus on the PLI for Advanced Chemistry Cells (ACC) within the automobile industry. This report examines the current policy framework and employs an input-output model to project the potential implications of the PLI ACC policy on the economy.

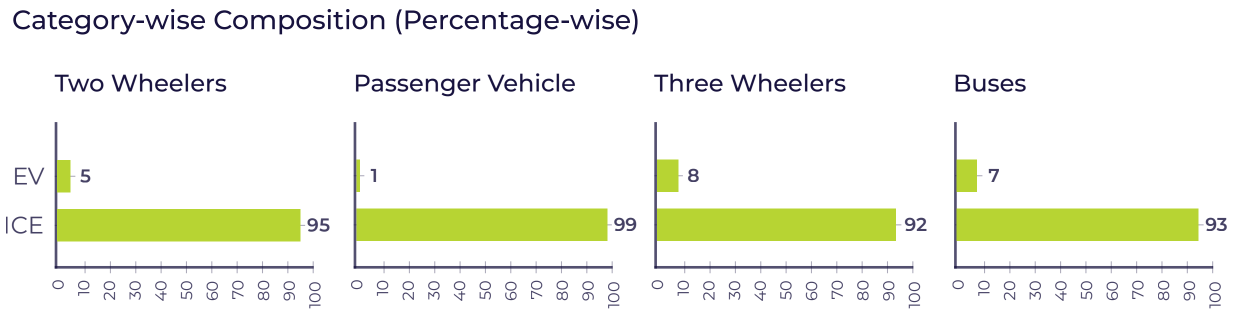

02

Indian EV Battery Ecosystem

India is actively pursuing its electrification objectives and is committed to various targets including the EV30@30 initiative and decarbonization strategies established at the COP26 summit. Presently, the electric vehicle (EV) market in India is predominantly comprised of two-wheelers (2W), which represent 85%–90% of all EVs sold, succeeded by four-wheelers (4W) at 7%–9%, and three-wheelers (3W) at 5%–7% (Seetharaman, et al., 2023). The market penetration is led by three-wheelers at 8%, followed by electric buses at 7%, electric two-wheelers at 5%, with passenger vehicles at approximately 1%. By 2023, e-rickshaws, which constitute 90% of the three-wheeler segment, reached a penetration rate of 53%, driven by increased accessibility, reduced maintenance costs, advances in technology, and an escalating demand for efficient passenger transit systems (Vahan Dashboard, 2023; Economic Times, 2023).

***Figure 3** - Composition of the Indian EV market.*





Source - Seetharaman, et, 2023, Vahan Dashboard, 2023.

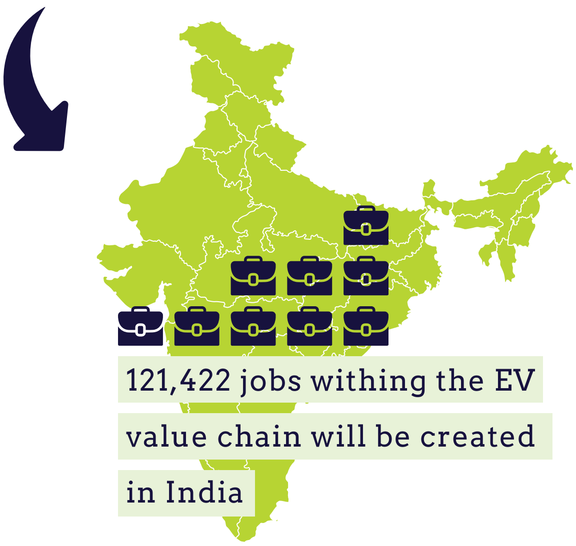
During the 2018 Global Mobility Summit in New Delhi, Prime Minister Narendra Modi presented the vision for India's transport future, highlighting seven essential principles: Common, Connected, Convenient, Congestion-free, Charged, Clean, and Cutting-edge (PIB, 2018).

Amitabh Kant, G20 Sherpa of India Highlighted that

100% 2-Wheelers & 3-Wheelers

65-70% Buses

to be transitioned to electric vehicles (EVs) by 2030 to meet the EV30@30 target.



Aligning with this vision, Amitabh Kant, G20 Sherpa of India, stressed the importance of transitioning 100% of 2-wheelers and 3-wheelers, and 65%-70% of buses to electric vehicles (EVs) by 2030 to meet the EV30@30 targets. A study by the Council on Energy, Environment and Water (CEEW) posits that reaching a 30% threshold in EV sales could lead to a significant 31% reduction in oil imports, the creation of approximately 121,422 jobs within the EV value chain, a market expansion exceeding INR 2 lakh crore (USD 24 billion) for EV powertrains and batteries, and an investment of about INR 13,372 crore (USD 1.6 billion) in public charging infrastructure by the year 2030 (Soman, Kaur, Jain, & Ganesan, 2020).

India's

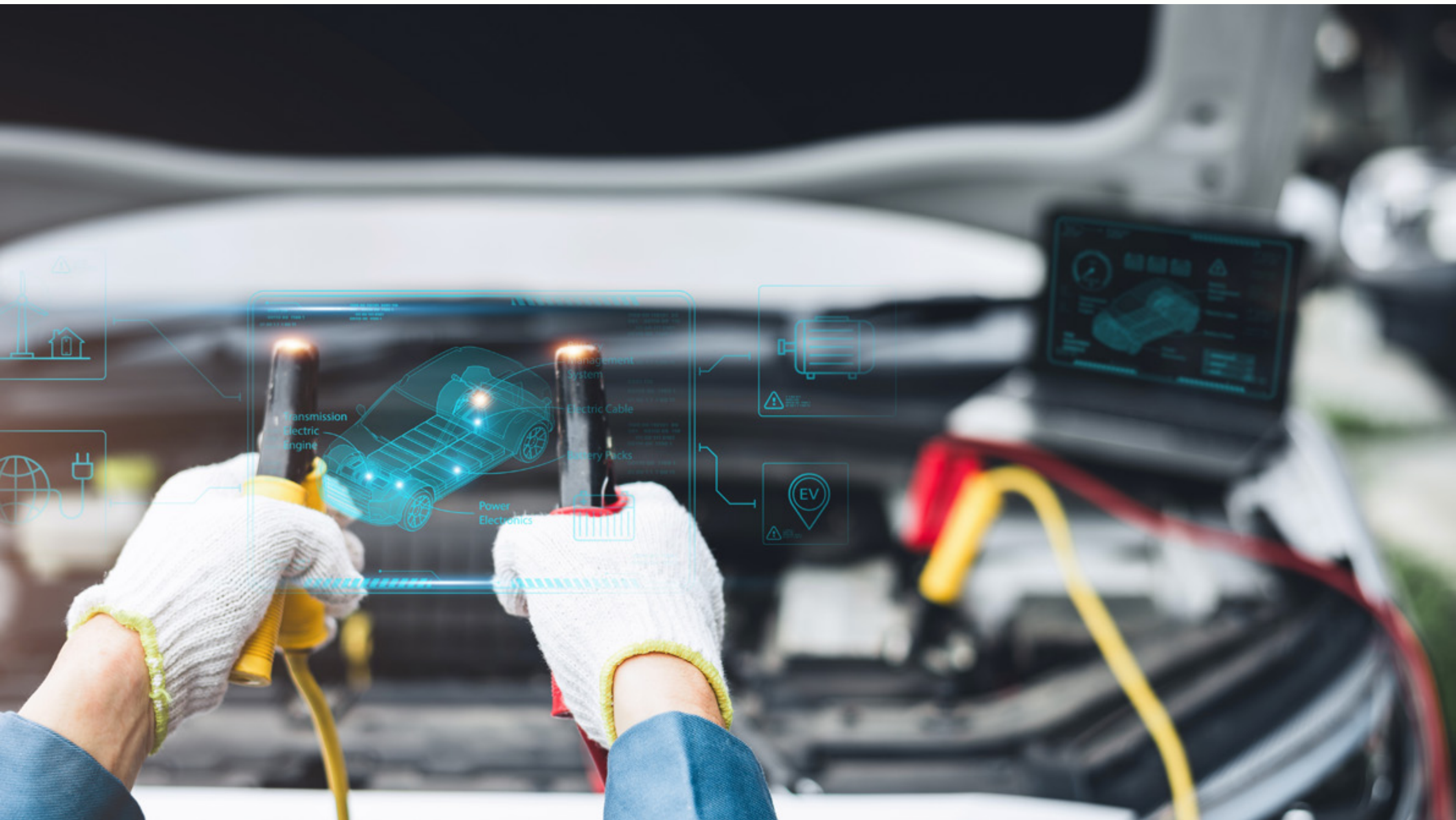
Advanced chemistry battery industry is expected to increase at a CAGR of **50%** from **20 GWh to 220 GWh** between the year 2022 to 2030.

India's advanced chemistry battery industry is expected to increase at a compound annual growth rate of almost 50%, from 20 GWh in 2022 to an estimated 220 GWh by 2030. Oil import costs could drop by an anticipated INR 2 lakh crore (USD 24 billion) to INR 2.5 crore (USD 30 billion) as a result of increased production of batteries and electric vehicles (CII, 2023). However, India's participation in the global EV battery value chain is still in its early stages, mainly involved in battery assembly and depending significantly on imports from China, Taiwan, and European countries.

2.1 India's Initiatives Towards Building the EV Battery Ecosystem

There have been concerted efforts in India that have aimed to provide stimulus to all stakeholders in the ecosystem, catalyzing comprehensive growth in the automotive sector. The National Auto Policy 2002's initial goals were to modernise the industry and boost value addition. It laid the groundwork for the National Auto Policy 2018 which aimed to implement Corporate Average Fuel Economy standards, upgrade emission standards beyond Bharat Stage VI by 2028, and introduce differential taxation based on vehicle size and CO_2 emissions. (Ministry of Heavy Industries and Public Enterprises, 2018; ACMA, Grant Thornton, 2023).

In order to maintain fuel security and environmental sustainability, the Government of India's National Electric Mobility Mission Plan (NEMMP) 2020, initiated in 2013, supports the transition to hybrid and electric vehicles to ensure fuel security and environmental sustainability. It sets ambitious sales targets and provides fiscal incentives under the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) schemes. FAME I and II aim to catalyse a disruptive shift in the automotive sector by focusing on lowering car costs, promoting technology development, funding pilot projects, and constructing charging infrastructure (Ministry of Heavy Industries and Public Enterprises, 2020). The Green Urban Transport Scheme (GUTS), which aims to reduce air pollution in urban areas by switching public transport vehicles to eco-friendly alternatives, was launched in 2017 in an effort to lessen the environmental impact of urban transport (GOI, n.d.).

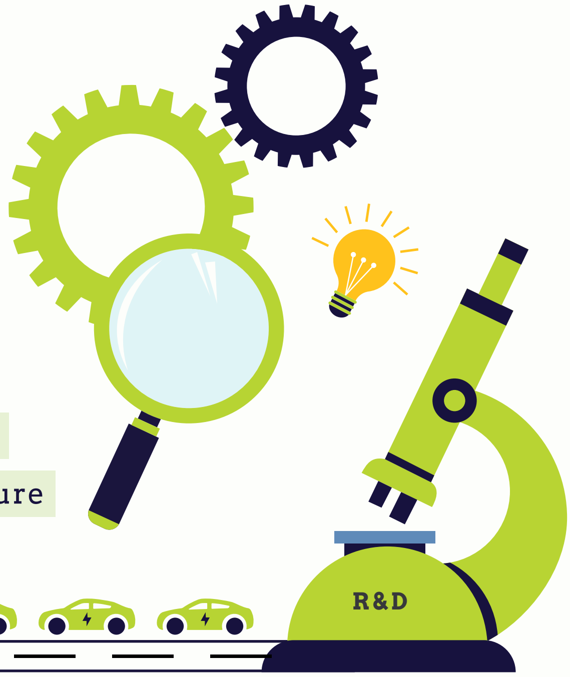


Indian Government

Committed a substantial sum of

₹ 3727.30 Crore

towards the development of world class automotive testing and R&D Infrastructure Project through the NATRiP Scheme



The Government of India has committed a substantial sum of money, INR 3,727.30 crore, towards the development of world-class automotive testing and R&D facilities through the National Automotive Testing and R&D Infrastructure Project (NATRiP). With the help of India's IT capabilities, the project aims to increase the competitive advantage of the country's automotive industry and bring it up to par with other global automotive sectors (National Automotive Testing and R&D Infrastructure Project, 2019).

To address environmental concerns associated with older vehicles, the Voluntary Vehicle-Fleet Modernization Program (VVMP) was announced. The objective of this programme is to ensure that the scrappage business is transparent and environmentally conscientious by organising and regulating it. The VVMP is expected to foster a sustainable ecosystem for the retirement of outdated and polluting vehicles. This, in turn, would aid in the process of extracting value from the scrappage process and bolstering conservation efforts (Ministry of Road Transport and Highways, 2023).

The mentioned policies have played a crucial role in fostering the electric vehicle (EV) industry in India. However, their emphasis has primarily been on consumer incentives and market growth, with inadequate focus on addressing supply-side challenges. Particularly, the critical issue of dependency on imported batteries, which are crucial to the functioning of electric vehicles, remains unaddressed. This research delves deeper into the Production Linked Incentive (PLI) Scheme which has been explicitly formulated to bridge the prevailing gap. An exploration of the Scheme's framework, the beneficiaries, and the projected implications will be presented. Furthermore, the report will identify existing shortcomings within the PLI scheme and propose policy recommendations to effectively address these deficiencies, thereby enhancing the Scheme's impact on India's EV ecosystem. However, despite initial momentum, the policy has encountered roadblocks after rounds of stakeholder consultations and is currently at a standstill.

Box 1 - The Potential of Battery as a Service (Baas) in India

India faces numerous obstacles that impede the extensive adoption of Electric Vehicles (EVs). The challenges encompass range anxiety, inadequate charging infrastructure, and the substantial upfront cost of ownership, primarily due to the expensive electric vehicle batteries. An effective approach to address these difficulties is the implementation of Battery as a Service (BaaS) model. BaaS models involve users purchasing an EV without the battery, instead opting to subscribe to a service that allows them to swap a depleted battery for a fully charged one at designated swapping stations. This approach aims to enhance the convenience of owning an EV while minimizing downtime for recharging. By segregating the battery component from the electric vehicle (EV), the initial expense of each car is considerably diminished. In addition, BaaS solves the problem of inner-city charging, where residential areas may not have access to plug-in charge outlets at home. This service offers benefits to both customers and service providers. BaaS enables the recycling and reutilization of batteries, including repurposing second-life swappable batteries for storage facilities located at these swap stations. (Shoosmiths and Cornwall Insight, 2022)

In the Budget for the fiscal year 2022-2023, the government announced its plans to implement a complete Battery Swapping Policy, along with the establishment of interoperability standards. A preliminary version of the battery swapping strategy was developed, focusing on a wide range of difficulties including technical complexities, legislative and institutional frameworks, and financial factors. These initiatives were designed to promote the growth of strong battery swapping ecosystems, which

are essential for enabling widespread use of battery swapping technology in India. (NITI Aayog, 2022). However, despite initial momentum, the policy has encountered roadblocks after rounds of stakeholder consultations and is currently at a standstill.
In India, Battery as a Service (BaaS) has grown notably in the 2 and 3-wheeler segments, particularly in last-mile and delivery services. Several key players operate within this segment of the EV value chain. Sun Mobility, for example, designs its smart batteries for quick swapping at quick interchange stations, providing interoperability across 2- and 3-wheelers from multiple EV manufacturers. In this scenario, after purchasing batteries from battery manufacturers, the EV maker acts as a network operator, offering switching services to clients. Bounce Infinity is another example of this concept in action, as it not only makes EVs but also operates battery changing stations. The network operator works with battery manufacturers to acquire or lease batteries, collaborates with EV manufacturers, and provides swapping services directly to end-user consumers or through Operations and Maintenance Partnerships. Furthermore, prominent participants in the BaaS sector, such as Reliance Industries and UK BP Plc, which operate under the brand name "Jio-bp," have adopted similar approaches. They are actively involved in battery sourcing, vehicle manufacture, and customer swapping services (Prakash, Shrivastava, & Srinivasan, 2022).
Gogoro plans to invest billions of dollars in developing a viable battery swapping infrastructure across India. The company received approval from the Maharashtra government in June to invest $1.5 billion over the next eight years. This investment includes $500 million for vehicle manufacture and a major $1 billion budget for constructing battery swapping infrastructure, reflecting their strategic plans to roll out such stations nationwide (Patel, 2023).

Battery as a Service (BaaS) is largely viewed as a realistic short-term method for increasing the use of electric vehicles. However, its effectiveness is limited. One key

component is battery interoperability, which necessitates standardised batteries that are compatible with multiple vehicle models. Without strong battery standardisation, the scalability of battery swap stations is limited, resulting in each station servicing only specific brands or models. This fragmentation may stifle progress in battery technology by discouraging businesses from investing in varied battery designs. Furthermore, the most significant hurdles in EV penetration and battery technology are in the 4-wheeler (4W) market, which the BaaS model cannot address. Additional logistical challenges regarding tracking battery ownership increases to the challenges of mainstream BaaS adoption. Furthermore, as battery technology advances, increasing cost and range effectiveness of batteries, importance of BaaS may shrink.

Acknowledging these challenges, it is evident that if applied to segments like fleet transportation, public transit, and smaller vehicle categories, the Battery as a Service (BaaS) model can be successful particularly with government support and business collaboration. Especially in India, where these vehicle segments play a crucial role, BaaS can prove highly beneficial, especially during the ongoing development of charging infrastructure.

2.2 Production Linked Incentives

Aiming to increase India's share of the global value chain, 'Make in India 2.0' has designated 27 areas as critical objectives. The need to cut imports, the potential for exports, the desire to create jobs, and the competitive advantages of Indian businesses were taken into consideration when choosing these industries. This project includes the development of Production Linked Incentive (PLI) schemes targeted at the manufacturing sector. Over the next five years, it is anticipated that these initiatives will generate capital expenditures of over ₹3 lakh crore. More than 60 lakh people in India are expected to gain employment as a result of them, and the manufacturing sector's share of the nation's overall capital formation, which has ranged from 17%–20% from FY12 to FY20, will rise. (Ministry of Finance, 2023)

Within the automotive industry, two PLI schemes were announced in 2021:

> The first, the PLI-Auto initiative, is focused on promoting the production of Advanced Automotive Technology products.
>
> The second scheme, is on setting up manufacturing facilities for Advanced Chemistry Cell (ACC). (Ministry of Heavy Industries, n.d.)

Box 2 - PLI for Automobile and Auto Components

> This PLI targets the advancement of Zero Emission Vehicles (ZEVs), encompassing both Battery Electric Vehicles (BEVs) and Hydrogen Fuel Cell Vehicles (HFCVs). It is supported by a budgetary allocation of INR 25,938 crore spanning five fiscal years, starting from 2022-23 and extending until 2026-27.

Fund disbursement under this scheme is slated to commence in the following financial year, stretching from 2023-24 to 2027-28. (Ministry of Heavy Industries, n.d.). This scheme is designed to incentivize the indigenous manufacturing of Advanced Automotive Technology (AAT) products, thereby drawing investment into the automotive manufacturing ecosystem. The Scheme's core goals are to address cost competitiveness, foster economies of scale, and establish a strong supply chain for AAT products. Moreover, it is anticipated to spur job creation and assist the automobile industry in ascending the value chain to produce goods with higher added value (PIB, 2022).

The scheme is divided into two key components: The Champion OEM Incentive, which offers a 'sales value linked' incentive for OEMs manufacturing advanced automotive technology vehicles, covering a diverse array of vehicles and addressing cost disadvantages. Meanwhile, the Component Champion Incentive aims to elevate auto component manufacturers to 'Automotive Champions' status, emphasizing global scaling and market leadership in advanced automotive technology components. (GOI, 2024)

The incentive scheme requires companies to meet all eligibility criteria, including non-automotive firms that can invest in manufacturing advanced automotive technology in India. Eligibility hinges on meeting annual cumulative domestic investment targets (50% Domestic Value Addition (DVA) and sustained growth from the first year. Investments must come from the applying entity to ensure accountability, with incentives contingent upon annual investment fulfilment. Failure to meet this condition results in a loss of incentives for that year but does not preclude eligibility for future incentives if subsequent investment criteria are met. (GOI, 2024)

To avail the benefits under the scheme, the Production Linked Incentive scheme outlines specific incentive slabs for Original Equipment Manufacturers (OEMs) and new non-automotive investor companies. For both players, the incentive rates are pegged as a percentage of the sales value, scaling with the sales volume. (GOI, 2024)

> This PLI Scheme for Automobile and Auto Component Industry in India has been successful in attracting proposed investment of INR 74,850 crore against the

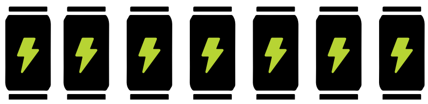
target estimate of investment INR 42,500 crore over a period of five years. The proposed investment of INR 45,016 crore is from approved applicants under Champion OEM Incentive Scheme and INR 29,834 crore from approved applicants under Component Champion Incentive Scheme (PIB, 2022).

In total, 95 of the applicants[2] have received approval to participate out of the 115 companies that submitted their application in this PLI scheme. Previously, the Ministry of Heavy Industries (MHI) had approved 20 applicants, including their 12 subsidiaries, under the Champion OEM Incentive scheme. Following this, MHI processed further applications for the Component Champion incentive scheme, resulting in 75 applicants and their 56 subsidiaries being accepted. Remarkably, two Auto OEM companies have successfully qualified for both segments of this incentive scheme (PIB, 2022).

2.2.1 PLI for Advanced Chemistry Cell (ACC)

The announcement of the plan was made to increase domestic value addition and decrease reliance on imports. According to estimates, the PLI ACC plan will enhance the share of renewable energy at the national grid level and decrease imports by INR 2,00,000 crore to INR 2,50,000 crore due to the oil import bill (PIB, 2022). With a budget of INR 18,100 crore, this project aims to strengthen the infrastructure for battery storage and electric mobility in India. It seeks to increase the country's output of Advanced Chemistry Cells (ACC) by setting up large-scale ACC and battery production facilities that give priority to significant domestic value addition.

Currently a total of **30 GWh**



of capacity has been given to three firms for ACC and Battery production facilities.

The programme will go into effect on January 1, 2023, and run for two years. The next leg of the scheme will run for five years, until the end of 2029. A total of 30 GWh of capacity has currently been given to three firms, leaving 20 GWh available for future allocations (Ministry of Heavy Industries, n.d.).

[2] Refer to Appendix- Section 8.1 for list of Applicants.

Eligibility Criteria and Benefits for the PLI ACC Scheme:

The PLI ACC Scheme is designed to be technology-neutral, granting beneficiary enterprises the autonomy to choose the advanced technology that best aligns with their specific needs. This includes the selection of essential equipment, materials, and goods to establish cell manufacturing. While there are detailed criteria accessible for the PLI linked to automobiles and auto components, there appears to be a lack of precise criteria for the PLI ACC programme (PIB, 2022).

According to the available information, in the PLI ACC scheme, the beneficiary firms are required to achieve a minimum of 25% DVA by the end of 2nd year and 60% by the end of 5th year of the Scheme. Additionally, these firms are required to invest INR 225 crore per GWh of committed capacity within the initial two years (PIB, 2023; Ministry of Heavy Industries, n.d).

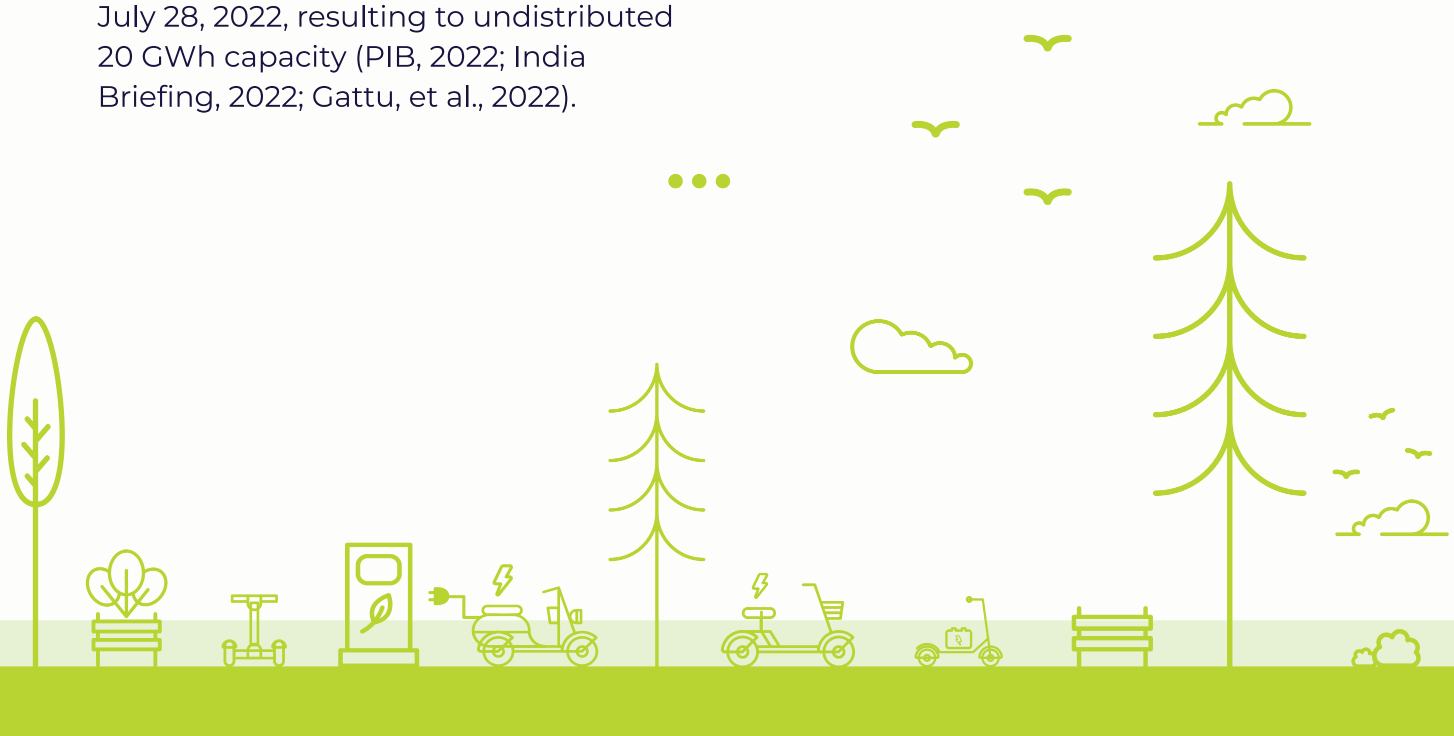
Though the details regarding the distribution of incentives are not exhaustively outlined, based on the available information, beneficiaries are required to establish their manufacturing operations within a two-year timeframe. Subsequently, the program will allocate incentives over the following five years, which will be contingent upon the revenue generated from the sales of domestically produced batteries (PIB, 2022). These payments will be determined by factors such as energy efficiency, sales volume, battery lifespan, and the degree of localization. Furthermore, the Scheme envisions a collaborative framework involving the state and central governments, alongside the manufacturers. In this tripartite agreement, the state government is expected to facilitate the private sector's efforts by offering land for the construction of the facility and aid in procurement processes. (India Briefing, 2023)

Current Status of the Scheme

For the Advanced Chemistry Cell (ACC) Battery Storage Programme in India, 10 companies placed bids in response to the Request for Proposal issued by the Ministry of Heavy Industries (MHI). The bidding process followed a 'two-envelope' system, comprising a qualification bid weighted at 80% and a commercial bid at 20%. For qualification, bidders must meet a net worth criterion of INR 225 crore per GWh, capped at INR 1,500 crore, and provide bid security at 1% of this net worth. The final selection was determined using a Quality & Cost Based Selection (QCBS) process, with bidders ranked according to their technical and financial scores. The ACC capacities have been allocated in order of their rank, till a cumulative capacity of 50 GWh per year. Initially, four companies were selected and five were shortlisted to share the designated 50 GWh capacity. Yet, ultimately, only three of the selected bidders; Reliance New Energy Solar Limited, and Ola Electric Mobility Private Limited, formalized their commitment by signing the Program Agreement under the Production Linked Incentive (PLI) Scheme for ACC Battery Storage on July 28, 2022, resulting to undistributed 20 GWh capacity (PIB, 2022; India Briefing, 2022; Gattu, et al., 2022).

The Scheme is designed to achieve significant long-term objectives, which means that it may take a considerable amount of time before tangible outcomes become apparent. Due to its recent establishment, it is too early to comprehensively evaluate the Scheme's trajectory and outcomes. However, it is crucial to regularly assess the performance of the plan and its impact on the automotive industry and to evaluate if the established goals are enough considering the ambitious economic and environmental objectives. Evaluating the wider ramifications of this strategy is crucial as it has the capacity to stimulate expansion not only within the automotive industry but throughout the entire economy.

The next part of this report is two-fold: initially, it will investigate the existing battery value chain in India, alongside the stakeholders' readiness to embrace a forward-looking PLI scheme. Subsequently, the investigation will expand to evaluate the direct, indirect, and ensuing impacts of the PLI schemes.




03

Battery Value Chain In India

India's goal to encourage the use of electric vehicles is centred around two main initiatives: the Faster Adoption and Manufacturing of Electric Vehicles (FAME) Scheme, which provides incentives to boost consumer demand and develop charging infrastructure, and the Production-Linked Incentive (PLI) Schemes, along with other supportive incentives mentioned earlier. Despite these efforts, the transition to electric vehicles (EVs) remains sluggish, uneven, and limited in scope. Currently, smaller vehicle categories like two and three-wheelers have higher rates of electrification, while the adoption of electric vehicles in the four-wheeler segment is substantially lower. The exclusive dependence on demand incentives has been found to be inadequate in stimulating investment on the necessary scale (Roychowdhury, Chattopadhyaya, & Tripathi, 2023). This gap in the policy framework along with high initial costs and inadequate charging infrastructure is, stymieing the progress of EVs in India.

These barriers could be mitigated by enhancing the technical efficiency of electric vehicles, which fundamentally relies on the effectiveness (in terms of both range and cost) of EV batteries. At this critical point, it is essential for policy measures to adapt and advance to facilitate the adoption of EVs and to amplify battery manufacturing capabilities. The transition from consumer-focused incentives, which are most effective in an emerging market, to a comprehensive approach that nurtures the supply chain and fosters an ecosystem conducive to growth is imperative (Ubaid ur Rehman & Aslam, 2022).

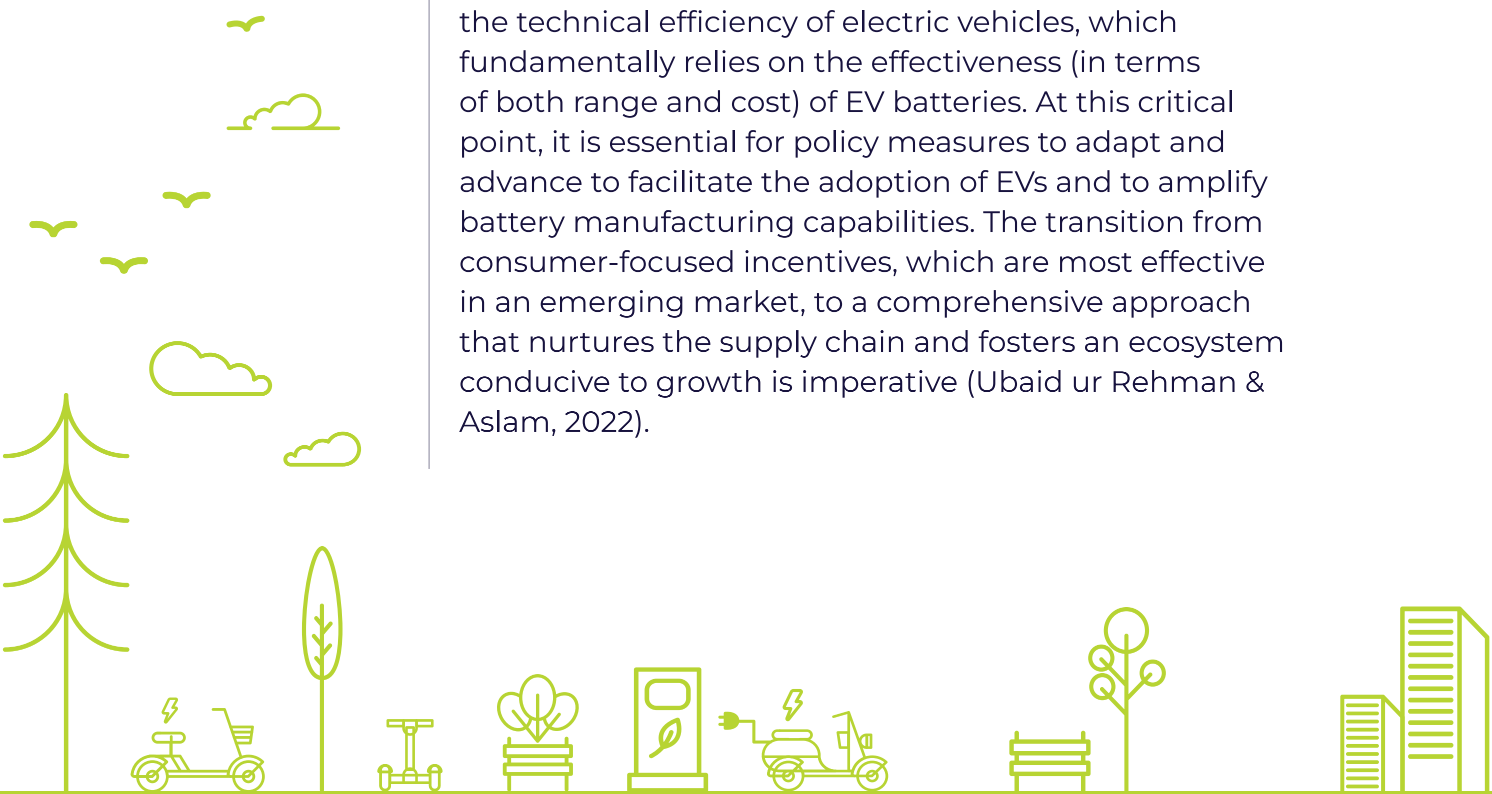


Figure 5 *- Evolution of Policies at varying stages of the Market.*

01 Nascent stage of Market

- Purchase Subsidies
- Purchase tax exemption
- Tax Rebates
- Reduction of custom duties and registration

02 Maturity Stage of Market

- Fuel regulations
- Carbon emission regulations.
- Tail- end Emission regulations

03 Acceration of Growth

- Focus on Infrastructure growth
- Charging Infrastructure
- Improvement in Battery technology
- Advancements in Research and Development.

Source - Ubaid ur Rehman & Aslam, 2022; Authors Analysis.

In order to meet the 2070 net-zero emissions objective, the International Energy Agency emphasises in its 2023 assessment of India's road transport sector transition that electric vehicles must account for at least 50% of the market within the next ten years.

It is vital to establish a competitive domestic battery business given China's existing dominance in the EV market, India's reliance on imports, and its geographic limitations in terms of raw material endowments. To maintain its growing electric vehicle business and to become a leader in the global EV ecosystem, India needs to build cost-effective, large-scale, and technologically advanced battery manufacturing. In the absence of unwavering commitment to this field, India's chances of obtaining a competitive advantage or becoming self-sufficient in a sector that is becoming more and more important will decline. Thus, creating a strong battery value chain is a crucial objective that needs to be pursued quickly and strategically.

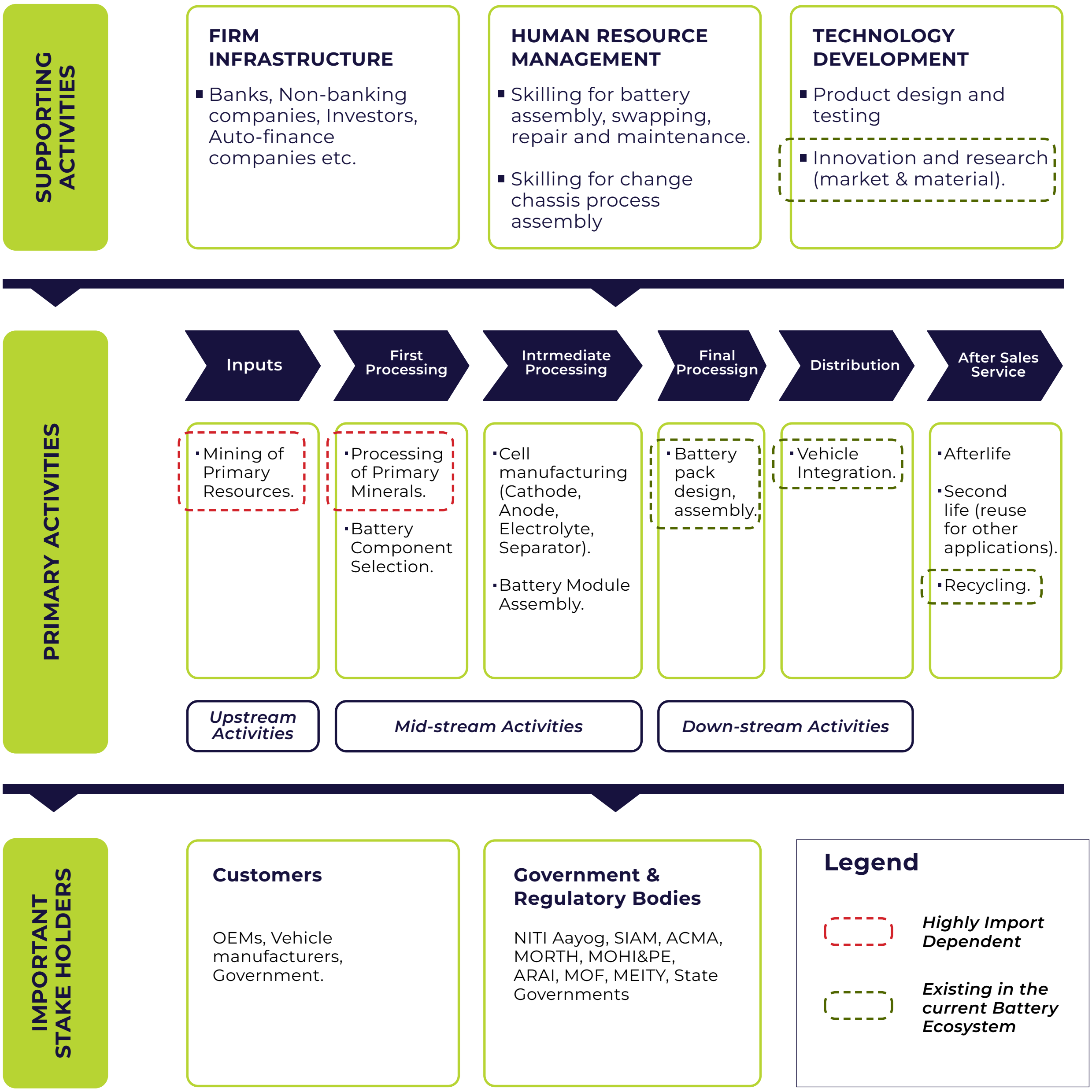
Production-Linked Incentive (PLI) schemes are strategically designed to fortify a competitive electric vehicle (EV) supply and value chain. The efficacy of such policies, however, hinges upon the stakeholders' level of preparedness. Failure to capitalise on the potential benefits and enhancements that this scheme proposes to give could be caused by a lack of structural integrity and preparedness among the value chain's components. To guarantee that the PLI plan achieves its intended effects, a thorough understanding of the value chain's components and their corresponding developmental stages is therefore essential.

3.1 Components of the Battery Value Chain and their presence in India.

India's recent initiation into developing its value chain for electric vehicle (EV) lithium-ion batteries (LIB) signifies a crucial step towards sustainability. Yet, due to the infancy of this development not all elements are yet integrated within the local ecosystem. A thorough examination of the existing value chain and the proactive engagement of relevant stakeholders are essential to develop a robust system. A careful analysis of the current value chain and the proactive involvement of pertinent players is necessary to create a strong system. Six essential manufacturing segments are involved in the creation of EV lithium-ion batteries: cell assembly, pack assembly, cell cathode, cell anode, cell electrolyte, and cell separator. A complex supply chain, comprising mining companies, refineries, cell component makers, battery cell manufacturers, and original equipment manufacturers (OEMs), is involved in the production of these components, with each of these parties playing a crucial role (IISD, 2023)

Figure 6 clearly illustrates the components present in the Indian ecosystem, the highly import-dependent components and the lack of crucial components in the ecosystem. Currently, India's involvement in this supply chain is mainly restricted to the assembly of batteries, with a significant dependence on imports principally from China, Taiwan, and other European nations. India imported almost 450 million units of lithium-ion batteries in the fiscal year 2020, with an investment of nearly USD 865 million (EY, 2022).

***Figure 6** - Current EV Battery Value Chain in India*



[a] Assembly of Cell Packs are undertaken by some firms like Mahindra, Ather, Exide, SunMobility, AmaraRaja. Battery Pack manufacturing is done majorly by ForseePower, Coslight, Pure, Grinntech, Inverted, Trontek, Livgaurd, Okaya, Cyngni, among others. (CITATION Gul22 \l 1033 (Gulia, Gupta, Jadhav, & Garg, 2022) CITATION She19 \l 1033 (Shekhar, Sharma, Patel, & Sawant, 2019).

[b] Vehicle Integration is done within the plants by OEMs.

[c] Recycling is integrated with E waste management. Key Battery Recycling Companies in India like TATA Chemicals, Attero Recycling, Lohum Cleantech, Exigo Recycling, SungEel India Recycling, LICO Materials, Eco Tantra, Batx, Ziptrax; take up majority of battery recycling. (CITATION JMK23 \l 1033 (JMK Research and Analytics, 2023) CITATION DTE23 \l 1033 (DTE, 2023)

India's

Lithium-ion battery market is projected to grow from

2.9 GWh in 2018

to approximately

132 GWh by 2030

Representing a CAGR of

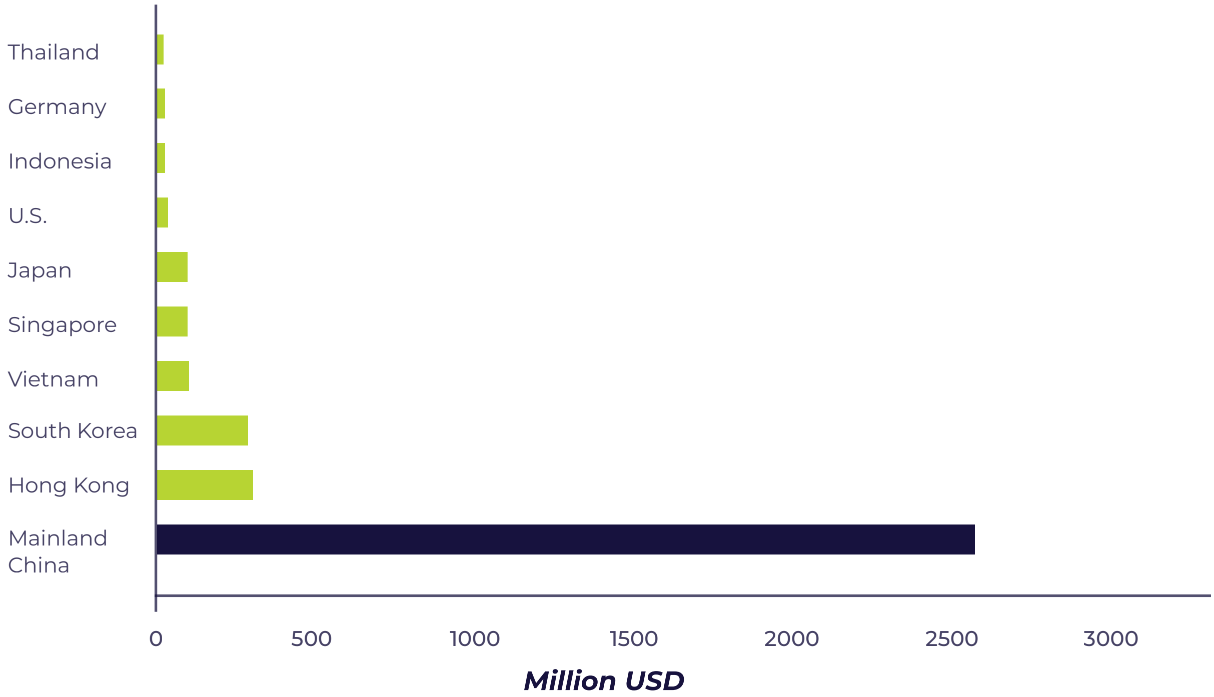
35.5 %

India's value chain highlights its deficiency in essential mineral reserves required for cell production. Consequently, there is a substantial dependence on imports to obtain the necessary minerals for battery manufacturing. India's insufficient deposits of crucial minerals for cell production need a substantial dependence on imports to get the necessary materials for battery production. India's lithium imports in the fiscal year 2023 amounted to INR 23,171 crore, a significant increase over the previous year's figure of INR 13,673.15 crore, underlining the overdependence on foreign resources (Business Today, 2023). Irrespective of the mineral origins, the predominance of processing capabilities in China results in India, along with numerous other global economies, being heavily reliant on China for mineral processing. Approximately 67% of the global lithium supply, along with 73% of cobalt, 70% of graphite and 95% of manganese is processed by China (Mining Technolgy, 2023). Developing domestic capabilities to process these minerals could propel India to the forefront of the electric vehicle (EV) battery industry.

Recognizing the strategic disadvantage of its mineral import dependence India is turning inward to capitalise on the untapped potential of battery recycling and mineral conservation to achieve energy self-sufficiency. As per industry research, the lithium-ion battery market in India is projected to grow from 2.9 GWh in 2018 to approximately 132 GWh by 2030, representing a compound annual growth rate (CAGR) of 35.5%. This surge in battery usage suggests an expanding pool of 'spent' batteries, which, if not managed, could pose significant environmental and health risks. The recycling sector has the potential to be worth around USD 1 billion by 2030. Multiple Indian corporations are entering this lucrative field by launching or announcing plans for recycling activities. Significant advancements in the field include Tata Chemicals' establishment of lithium-ion battery recycling in Mumbai, Raasi Solar's intentions to build a 300 MW facility specifically for lithium battery recycling, and Mahindra Electric's dedication to battery recycling (JMK Research and Analysis, 2019). In addition to the clear economic benefits, recycling batteries enhances the environmental sustainability of electric vehicles (EVs). In July 2023, the Government made adjustments to its mining regulations, which resulted in the permission for private miners to enter the mining industry. This decision was made after the Government discovered its initial lithium resources in Jammu and Kashmir, estimated to be around 5.9 million tonnes. The Atomic Minerals Directorate for Exploration and Research (AMD), a vital component of the Department of Atomic Energy (DAE), is now involved in the hunt for lithium in geologically favourable regions located in the Mandya and Yadgir districts of Karnataka. The AMD's preliminary surface surveys and limited subsurface exploring efforts have identified the presence of around 1,600 tonnes of lithium deposits in the Marlagalla region of Mandya district, Karnataka (PIB, 2022). These efforts are aimed at making India less reliant on importing materials and giving it an edge in the battery recycling and repurposing business. As these important minerals are scarce, there's a big opportunity for India to become a leader in the advanced battery service industry.

Along with the absence of abundant natural mineral resources, India's significant importation of battery storage equipment, which amounted to INR 20,000 crore as of 2021, highlights the need for indigenous battery processing and storage technologies (ETN, 2021). The fiscal year 2023 underscored this dependency with Mainland China emerging as the preeminent supplier of accumulators and batteries to India, totalling imports close to USD 2.6 billion (Ministry of Commerce and Industry, 2023). The reliance of India on China for minerals, cells and other components is increasing the import burden. To build a strong EV battery ecosystem capable of accomplishing its economic and environmental goals, India must reduce its dependency on China.

***Figure 7** - Import value of accumulator and battery to India FY 2023, by leading region (Million US Dollars).*



Source - Ministry of Commerce and Industry, 2023.

Currently, India is mostly engaged in the downstream processes of battery pack assembly and packaging, which are limited to a few industry players. There is an urgent need to promote the involvement of a broader spectrum of participants, such as major manufacturers and Original Equipment Manufacturers (OEMs), in this specific area of the industry. Both the government and the corporate sector should allocate substantial resources towards research and development in cell manufacture. India's establishment of a substantial global footprint in the battery industry relies heavily on the creation of affordable and highly advanced batteries.

In order for the anticipated economic advantages of decreased oil imports to be realised, it is imperative to decrease reliance on imports for minerals, cells, and batteries. This strategic change is necessary to ensure that efforts to address the current capacity shortage do not unintentionally strengthen dependence on Chinese imports. Moreover, the lack of a component that enhances value in the industry could restrict the development of a robust electric vehicle ecosystem that can produce high-performing batteries. India's electric vehicle (EV) market may face challenges in terms of its adoption and growth due to its dependence on imports, as well as the comparatively higher costs and limited battery range compared to other economies.

Box 3 - Battery Reuse and Recycling as Sustainable Solutions

Electric vehicles (EVs) have emerged as a solution to high emissions from transportation. However, the sustainability aspect of EVs, particularly concerning battery use, remains a topic of debate (B R, 2023). When evaluating emissions in the lifecycle of a vehicle, two main aspects are considered: the manufacturing process and the usage period. EVs incur significant environmental costs during the manufacturing of batteries and the energy sources used to power them.

Battery manufacturing, starting from mining, has a significant environmental toll due to the toxic fumes released and the water-intensive nature of the process. For instance, protests erupted in Tibet and China, over the environmental damage caused by lithium mining activities. Similarly, in China's Yichun City, production of lithium was halted following an investigation into toxic pollutants in the main source of residential water. The South American Lithium Triangle, encompassing Chile, Argentina, and Bolivia, has experienced heavy water depletion due to intensive lithium extraction practices fuelled by EVs in recent years. In Chile alone, 65% of the region's water was used for lithium extraction. Protests arose in Nevada over the "Lithium Americas Project" because of the anticipated heavy use of groundwater. Although manufacturing has the most significant environmental impact, powering batteries also plays a role in environmental degradation, particularly in developing nations such as India. As of 2021, India sourced a substantial portion of its power from thermal sources, primarily coal, contributing significantly to the country's emissions and environmental degradation. (B R, 2023).

The substantial environmental costs linked to battery manufacturing and the limited availability of lithium as a resource underscore the importance of prudent and efficient use of lithium and lithium-ion batteries. This urgency necessitates a focus on innovation and a heightened emphasis on battery reuse and recycling.

> Second-life battery energy storage solutions have emerged as a strategic approach to conserve resources, stimulate economic progress, and promote circularity in the industry. These batteries find applications beyond initial use, such as powering fast-charging stations to avoid straining the power supply, acting as grid-connected storage for commercial establishments, and serving small-scale needs like home storage and solar streetlights.

Second-life battery energy storage solutions have emerged as a strategic approach to conserve resources, stimulate economic progress, and promote circularity in the industry. These batteries find applications beyond initial use, such as powering fast-charging stations to avoid straining the power supply, acting as grid-connected storage for commercial establishments, and serving small-scale needs like home storage and solar streetlights. Depending on their application, second-life batteries can remain functional for anywhere between 5 to 20 years (Gattu, et al., 2022). Furthermore, the recovery of valuable materials like lithium, cobalt, nickel, and manganese through recycling reduces reliance on scarce minerals. Additionally, recycling plays a crucial role in preventing the release of hazardous substances such as lead, cadmium, and mercury, thus safeguarding both the environment and human health (Lohum, 2024). If not mitigated by sustainable behaviours, these emissions will cancel out the substantially lower emissions of electric vehicles (EVs) compared to internal combustion engine (ICE) vehicles.

India has implemented several waste management acts, including the E-Waste (Management and Handling) Rules of 2011, and 2016, and the E-Waste (Management) Amendment Rules of 2018, which encompass a broad range of recyclable materials. The most recent addition is the Battery Waste Management Rules of 2022, replacing the Batteries (Management and Handling) Rules of 2001. These new rules encompass all battery types, including Electric Vehicle

(EV) batteries, portable batteries, automotive batteries, and industrial batteries. The rules function based on the concept of Extended Producer Responsibility (EPR) where the onus is placed on battery producers (including importers) to collect, recycle/refurbish waste batteries, and incorporate recovered materials into new batteries (PIB, 2022; Gattu, et al., 2022).

India must take significant strides in the reuse and recycling sector. All aspects of the reuse and recycling sector are essential including streamlining battery disposal for proper recycling by established recyclers, setting up disposal agencies, incentivizing research and development (R&D) and start-ups in this domain, and establishing clear rules delineating corporate responsibilities (Gattu, et al., 2022). Advancements in this field offer both economic and environmental benefits. Developing expertise in battery recycling could also provide India with a competitive edge similar to China's prowess in mineral refining. Extending the lifespan of batteries is crucial to reducing the environmental impact of EVs, making them a viable alternative to internal combustion engine (ICE) vehicles, and mitigating the overexploitation of mineral-rich areas.


04

Investment Insights Into India and China's Approaches to EV Battery Ecosystem

4.1 China's Strategic Investment Approach

China has leveraged its early entry and manufacturing prowess in the development of the electric vehicle sector. The Chinese government's approach in the EV industry has been characterized by heavy investment in infrastructure, significant coordinated support through various incentives and subsidies and consistent revisions in policies at all tiers of the government. These efforts have facilitated China's dominance, making it a vital link in the global supply chain.

Focus on Lithium Extraction and Refining

China's strategic ascendancy in the global lithium battery market is attributed to the government's efforts for vertical integration within the supply chain. By capitalising over multiple production stages, Chinese firms have optimized operations, foregoing reliance on external suppliers. This strategic alignment is a response to China's internal resource scarcities and a proactive measure to secure the burgeoning demand for electric vehicles and lithium batteries. The Belt-and-Road Initiative (BRI) plays a pivotal role, as China acquires economic lithium assets in other nations, particularly in Latin America's "Lithium Triangle" (Argentina, Chile, and Bolivia) which are have been integrated into the BRI framework. These nations welcome Chinese investment as it promises to strengthen their infrastructure and enhance their economic indicators, while offering China access to essential minerals and an expansive market for its high-tech exports. (Zulfiqar, 2023)

Battery Capacity and Cost Efficiency

The landscape of battery gigafactory construction illustrates China's remarkable lead in the industry. With 125 active gigafactories, China's operational capacity is over tenfold that of Europe and North America combined, as reported by BMI. The economic efficiency of China in this sector is noteworthy; constructing a gigafactory in North America incurs a cost upwards of USD 100 million, representing a 46% higher investment per gigawatt-hour compared to those in China (Irwin-Hunt, 2022).

North America

incures a cost upwards of

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representing a

46 %

higher investment per gigawatt-hour compared to China

China's competitive advantage becomes clear when considering its average cost per gigawatt-hour for new battery manufacturing capacity, estimated at roughly USD 72 million. Moreover, certain Chinese plants demonstrate even greater cost-efficiency, with figures falling around USD 55 million per gigawatt-hour. This financial efficiency highlights China's formidable position in the global battery manufacturing sector. (Irwin-Hunt, 2022)

In China, persistent dedication to investment from government and private players has culminated in the notable manufacturing and financial prowess of China's battery industry.

China's Investment Strategies

Fiscal and taxation policies have been pivotal in fostering the growth of China's new energy vehicle (NEV) industry. Since the early 2000s, the Chinese government has deployed a series of schemes to catalyse this development. The initial major schemes like the Development and Application of Key Technologies of Clean Energy Vehicles, Energy Saving and New Energy Vehicles, Key Technology and System Integration of EVs in Modern Transportation Technology had a cumulative investment of USD 25.61 billion (Zhang, Rao, Xie, & Yanni, 2014). These schemes underscore the comprehensive approach China has adopted, channelling substantial funds at both national and local levels alongside enterprise input to solidify the foundation and accelerate the advancement of the NEV industry.

Since 2019

The lithium-ion battery gigafactory landscape has seen investments of

$300 Billion

with China's share amounting to a significant

74% ($ 222 Billion)

of the total investment[3] (Benchmark, 2023)

The cumulative scale of tax exemptions for the sector, including support and tax breaks for both manufacturers and consumers soared beyond

200 Billion Yuan

in 2022 ($ 29.16 Billion)[4]

China has committed to extending and enhancing vehicle purchase tax reduction and exemption policies, aiming to reach an ambitious total of

520 Billion Yuan

(USD 75.81 billion) in tax exemptions from 2024 to 2027 (People's Republic of China, 2023).

[3] This figure is.an approximation based on GwH capacity of China and the total Investments globally.
[4] The conversion of the figure from Chinese Yuan to US Dollars is calculated through the average reference rate of CNY to USD for the year 2021-22. For every such conversion hereafter, the same methodology is used for every year mentioned.

On a regional scale

local governments have aligned their objectives with the national vision for electric mobility. The municipal authorities in Chengdu, for instance, have set a goal of

800 Electric Vehicle on the road by 2025

with upto

50 Million Yuan ($ 9.29 Million)

being pledged to car manufacturers that develop and market new EV models, and incentives for

8000 Yuan

offered to individual consumers purchasing an EV.

Guangzhou City has similar measures like the allotment of 30 billion Yuan (USD 4.37 billion) for a development fund in February 2023, dedicated to supporting the new energy automobile industry, encompassing sectors from vehicle manufacturing to the research and development of automotive chips and power batteries (Baidu, 2023).

These concerted actions across governmental tiers showcase China's accelerated drive toward realizing its NEV ambitions and ensure that no province, with or without established potential, is left behind in the industry's rapid expansion.

Private Investment by Chinese Firms

In the competitive landscape of China's electric vehicle (EV) industry, BYD Auto in 2006 constructed an EV production base in Huizhou with an investment of up to 5 billion Yuan (USD 0.77 billion),

BYD Auto

in 2006 constructed and EV production base in

Huizhou

with an investment of up to **5 Billion Yuan** (**$ 0.77 Billion**)

which subsequently led to its selection as the primary supplier of public taxis in the city. In 2016, BYD Auto secured a government contract in April 2016 with a 1.81 billion Yuan (USD 0.27 billion) tender to supply Shenzhen Eastern Bus with plug-in electric buses (Li, Yang, & Sandu, 2018).

BYD Auto

secured a government contract in April 2016 with a

1.81 Billion Yuan (**$ 0.27 Billion**)

tender to supply Shenzhen Eastern Bus with plug-in electric buses (Li, Yang, & Sandu, 2018).

China's prowess in the lithium-battery market is further exemplified by Sunwoda Electronic's strategic move to invest at least Yuan 16.5 billion (USD 2.57 billion) in a lithium-carbonate project in Yichun City of Jiangxi province. This investment is geared towards enhancing, Sunwoda's control over upstream resources and diminishing production costs (S&P Global, 2022).

Sunwoda Electronic's

strategic move to invest at least

16.5 Billion Yuan (**$ 2.57 Billion**)

in a lithium-carbonate project in Yichun City of Jiangxi province.

A Chinese battery maker has invested USD 2 billion in an Illinois gigafactory as well. CATL, China's leading power battery manufacturer, reported a substantial increase in battery installations, with 20.5 GWh in January, an 88.1 per cent surge from the previous year. This achievement sustained CATL's global market dominance, securing a 39.7 per cent share, and maintaining its status as the only battery supplier globally with a market share of over 30 per cent (Kang, 2024). BYD, although experiencing growth with a 34.4 per cent increase at 7.4 GWh in January, saw its market share dip to 14.4 per cent, from 17.2 per cent the previous year, indicating competitive market dynamics (Kang, 2024). CATL's strategies extend beyond domestic investments to significant international collaborations, such as the takeover of Canada's Millennial Lithium Corp and the formation of a billion-dollar agreement with the Bolivian government for lithium mining. Such strategic moves not only amplify China's global reach in lithium investment but also enhance its position as a key player in the international battery industry (Zulfiqar, 2023; Bloomberg, 2023).

> This achievement sustained CATL's global market dominance, securing a
>
> **39.7 % Share**
>
> and maintaining its status as the only battery supplier globally with a market share of over
>
> **30 %**

In 2023, Chinese firms collectively had an outbound investment of USD 28.2 billion into EV-related industries.

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>
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>
> **$ 28.2 Billion**
>
> into EV-related industries.

This figure does not take into account several substantial projects for which the financial details are not publicly available. These investments are part of a strategic trend where Chinese battery manufacturers not only expand their domestic production capabilities but also extend their supply chains internationally. This expansion is likely a response to the increasing global market demand and the political impetus for re-shoring manufacturing capabilities (Cash, 2024)

The remarkable progress in China's EV battery manufacturing is largely attributable to the concerted efforts of private stakeholders, augmented by a massive push from the government, propelling the industry forward with significant momentum.

4.2 India's Investment Strategies in EV Batteries Ecosystem

Indian Government Investments

The Indian government has launched significant policy initiatives to foster the growth of electric mobility. To gauge the extent of the government's investment in this sector, the major policies that have been implemented can be taken into consideration, which collectively represent the country's financial investment towards electric vehicle adoption and infrastructure development.

India's push towards electric vehicles (EV) is marked by generous policy funding, led by the National Electric Mobility Mission Plan (NEMMP) 2020 with a substantial outlay of INR 14,000 crore (Ministry of Heavy Industries).

National Electric Mobility Mission Plan (NEMMP) 2020

who leds generous policy funding, marked India's push towards electric vehicles (EV) with a substantial outlay of

₹14000 Crore

Under NEMMP,

FAME I - Scheme saw INR 895 crore allocated until March 2019

FAME II - Received INR 10,000 crore, extended in February 2024 to INR 11,500 crore to bolster EV adoption for a five-year period starting April 2019 (PIB, 2023; Ministry of Heavy Industries, 2023)

The only scheme with a specific focus on battery technology is the PLI ACC Battery Storage scheme, receiving INR 18,100 crores, while the automobile sector benefits from the PLI AAT with INR 25,938 crore.

the FAME I scheme saw INR 895 crore allocated until March 2019, and FAME II received INR 10,000 crore, extended in February 2024 to INR 11,500 crore to bolster EV adoption for a five-year period starting April 2019 (PIB, 2023) (Ministry of Heavy Industries, 2023). The only scheme with a specific focus on battery technology is the PLI ACC Battery Storage scheme, receiving INR 18,100 crores, while the automobile sector benefits from the PLI AAT with INR 25,938 crore. The Heavy Industries Minister further allocated INR 500 crore to the Electric Mobility Promotion Scheme (EMPS) for 2024 (PIB, 2024), These investments reflect the Indian government's robust support for developing a sustainable EV ecosystem.

Cumulatively all the major polices amount to USD 8 Billion[5], while approximately 22% (USD 1.76 billion) of outlay has strictly been allocated to building gigafactories by the Government of India.

The Government is actively seeking lithium procurement from the reserves in Jharkhand, Rajasthan, and Jammu and Kashmir through domestic initiatives. It has engaged private sector participation by restructuring mining regulations and auctioning 20 mineral blocks (PIB, 2023). On an international level, India has formed an agreement with Australia to develop new supply chains based on Australia's processed critical minerals. This agreement aims to aid India in reducing emissions from its power sector, especially in the electric vehicle domain (PIB, 2023). Moreover, the Ministry of Mines under the Government of India has recently signed a contract with Khanij Bidesh India Limited (KABIL) and the public enterprise of Catamarca province in Argentina. This contract represents the first lithium exploration and mining venture by the Government of India. Under this agreement, KABIL has gained the exploration and exclusivity right for five blocks to conduct evaluations, prospecting, and exploration, and, following lithium discovery, the right to mine the mineral for commercial production (PIB, 2024).

[5] This figure is the sum of total allocation of NEMMP, PLI ACC, PLI AAT and investment in EMPS. The figures in Indian rupees are first converted into US$ dollars based upon the respective reference rate for the related years and summed to arrive at the total government expenditure on EVs.

Private Investment by Indian Firms

India is swiftly positioning itself as a significant player in the large-scale lithium-ion battery manufacturing arena. TDS (TOSHIBA Corporation, DENSO Corporation and Suzuki Motor Corporation) has the distinction of being the country's first extensive Li-ion battery plant with an investment of USD 186.36[6] million. Exide Industries has forged a partnership with China's SVOLT Energy Technology. This alliance is poised to advance India's battery production capabilities with a substantial investment of USD 805.37 million, aimed at establishing a greenfield manufacturing facility boasting a capacity of 12 GWh. Furthermore, reinforcing the indigenous innovation landscape, Amara Raja has inaugurated the nation's initial technology hub dedicated to Li-ion cell development within its Tirupati facility in Andhra Pradesh, with an investment of USD 33.55 million (Sempf, Chaudhari, Shah, Kumar, & Bansal, 2022; Ghosh & Bhaskar, 2021; Financial Express, 2022).

Original equipment manufacturers (OEMs) are also ramping up their battery production competencies. Lucas TVS, for example, has entered into a partnership with 24M Technologies, a US-based Li-ion battery tech firm, to establish a gigafactory in Chennai with an investment of USD 336.81 million. Ola Electric is intensifying its foray into the battery domain with a USD 1 billion investment for a 50 GWh battery manufacturing facility and has also strategically invested in StoreDot, an Israeli company at the forefront of extreme fast-charging battery technologies (Sempf, Chaudhari, Shah, Kumar, & Bansal, 2022; ETN, 2023; Economic Times, 2022).

Ola Electric

Electric is intensifying its foray into the battery domain with a

$1.0 Billion

investment for a

50 GWh

battery manufacturing facility

The leading EV manufacturer in India, Tata Group, is to establish a lithium-ion cell gigafactory in Gujarat. At the outset, an investment of USD 1,614.71 million will be channelled into the early phase of this pivotal project. Suzuki Motor Corp., in conjunction with Toshiba Corp., has already publicized their Li-ion battery ambitions in India.

Toshiba Corp.

Announced a

$138.7 Million

investment to set up a Li-ion battery facility in Gujarat . (TOI, 2023)

[6] The conversion from INR to USD is based on historical reference rate provided by the Reserve Bank of India obtained from https://www.rbi.org.in/scripts/referenceratearchive.aspx.

In addition to the publicized investments, there are numerous planned projects by OEMs like Adani, JSW, Mahindra, and Hero, whose financial contributions are yet to be determined, which will increase the potential growth in investment figures. Significant investments from both the public and commercial sectors are required to develop gigafactories and an efficient electric vehicle (EV) ecosystem capable of meeting target capacities. India must learn from China's accomplishments in this sector. On the government front, India has allocated roughly USD 8 billion to EV production and battery efforts, which is consistent with China's total expenditure of approximately USD 27.7 billion over the last two decades. The incentives available in India are at par with those in China. However, some forward-looking policies like mandates, credit trading, ease of acquisition of raw materials for battery production and so on can be imbibed into our policy framework by integrating insights from China's production incentives.

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However, a stark contrast emerges when examining private-sector investment. Over the past five years, Indian private entities have committed around USD 3.5 billion to this sector, a figure that pales in comparison to China's staggering USD 222 billion.

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While China's considerable investment in the electric vehicle sector can be ascribed to its competitive edge, manufacturing expertise, and global stature, it is noteworthy that China's financial commitment was substantial even at the early stages of its journey.

This stands in stark contrast to the initial investment levels observed in India. Given that India is at a nascent stage in its EV development, the current investment levels constitute less than 2 per cent of China's total expenditure. This analysis brings to light the imperative for India to not only set ambitious goals that align with the global EV landscape but also to foster rapid and proactive engagement from private sector participants to realize these objectives.

In this context, the Production-Linked Incentive (PLI) scheme, which is intended to remedy these shortfalls, gains significance. The report will attempt to study the potential multiplier of PLI on Advanced Chemistry Cells on the output, employment and overall economy.


CHARGING
Time remaining
6 hr 10 min
60 %
3 kW : +22 kWh : 16/16 A : 220 V
Stop
Unlock Port

05

Estimating the Impact of the PLI Scheme Using an Input-Output Framework

5.1 Rationale for Choosing Input-Output Model for PLI Analysis

In the examination of the economic multipliers that economic policies have, scholars and analysts have predominantly utilized three approaches: the input-output (I-O) model, the social accounting matrix (SAM) model, and the computable general equilibrium (CGE) model. The I-O model is notably the most prevalent among these due to its straightforwardness and cost-efficiency as the I-O model does not necessitate intricate or challenging-to-acquire data, making it a preferred and accessible approach (Pirmana, Alisjahbana, Yusuf, Hoekstra, & Tukker, 2023). The input-output (IO) model of an inter-sectoral economy was crafted by Leontief to analyse the structure of the American economy (Leontief, 1936). It was, then, extended to multiple regions by Isard (1951) in order to include the regional location of economic activities and inter-regional trade. I-O analysis has become a basic tool in national accountancy to depict the inter-sectoral linkages and the particular contribution of each activity sector to the economy of a nation or a region (Leurent & Windisch, 2015).

The I-O model has some inherent shortcomings, in the sense that it is static, and has restrictive assumptions of constant returns to scale and coefficients that are only valid within short-term analyses. Other more sophisticated and dynamic models, like SAM, CGE and econometric computing can overcome these challenges as they also consider price and substitution elasticities, distributions of income across different skill levels and so on. However, the extensive data requirements that are difficult to procure make it hard to apply in many situations (Masouman, 2013; Pirmana, Alisjahbana, Yusuf, Hoekstra, & Tukker, 2023). These limitations make the input-output model the most viable model to study the impacts of exogenous shocks on the economy, study interactions in sectors and direct and indirect repercussions of the same (Prakash & Balakrishnan; Masouman, 2013; Bezdek, Wendling , & Bezdec, 2005).

There have been several studies using the input-output model to analyse policy, technological, and socio-economic disruptions. In a 2002 paper (Roy, Das, & Chakraborty, 2002), the I-O model is employed to explore the burgeoning Indian IT industry, assessing the degree of informatization within the Indian economy from 1983 to 1990. In, 2010, Lurweg, Oelgemöller, and Westermeier analysed the sectoral employment repercussions of trade. The paper uses the I-O model to identify sectoral dynamics and their broader implications for economic development and specialization. A research focusing on France's transition (Leurent & Windisch, 2015) to electro-mobility and its widespread

implications, the I-O model is employed to quantify the economic impacts on public finances of adopting electric vehicles (EVs) as opposed to conventional vehicles (CVs). Their study underscores the model's capacity to incorporate fiscal and social transfers, revealing the multifaceted economic consequences of industrial and environmental shifts. In 2022, Chadha & Sivamani constructed a specialized adaptation of the I-O model of a 34-sector hybrid Energy Input-Output Table (EIOT) based on India's 131-sector Input-Output Table for 2015–16. This endeavour calculates the direct and indirect energy consumption and emissions from intermediate and final-use sectors, demonstrating the model's effectiveness in environmental-economic analysis. Moreover, Pirmana, Alisjahbana, Yusuf, Hoekstra, & Tukker (2023) capitalize on the I-O model's capabilities to assess the potential economic and environmental outcomes of establishing EV production in Indonesia. This study highlights the model's role in evaluating sectoral changes within the context of global economic trends and environmental concerns.

Several studies have integrated various analyses and built on the input-output model for a more refined analysis. Masouman (2013) extends the use of I-O modelling by integrating it with econometric techniques, creating an EC-IO model. This approach was employed for a precise assessment of structural shifts within the Illawarra region in New South Wales. This hybrid model seeks to enhance the precision of analyses and forecasts pertaining to structural shifts within the regional economy, illustrating the model's flexibility and potential for refinement when combined with other analytical frameworks. In 2021, a study by Adkins, Garbaccio, Ho, Moore, & Morgenstern (2021), investigates the effects of varied carbon pricing strategies across different industrial sectors and time horizons. This approach delineates the short-term utility of the I-O model and the long-term efficacy of the CGE model, emphasizing the temporal scalability of these analytical tools. Finally, the I-O model's relevance in socio-economic analysis is also evident in the study by Prakash & Balakrishnan, which examines the income and employment effects of technological advancements in India. This underscores the model's capacity to trace and quantify the impact of technological progress on the economy's structure and labour market dynamics.

Collectively, these applications of the I-O model, spanning from sector-specific studies to broad economic evaluations, illustrate its enduring value in economic analysis.

In this research, the analysis of the

> The model's ability to adapt to diverse analytical needs, be it assessing informatization, environmental impacts, or the nuances of fiscal policy, reinforces its status as an indispensable tool in the arsenal of economic researchers and policymakers.

direct and indirect impacts of the PLI ACC scheme necessitates the use of a comprehensive model. Considering data availability, the nascency of the EV market and the interaction in the sectors due to the disruption caused by EV batteries, the use of the Input-Output model, as opposed to other dynamic complex models is employed. A comprehensive IO model is constructed to analyse the effect of this new policy on output, imports and employment due to the PLI ACC scheme.

5.2 Input-output model structure and results

The Input-Output Model relies on Input-Output tables constructed using precise data collection and accounting methods. The automobile industry has undergone substantial changes in the last ten years, making previous I-O data less applicable. As a result, an updated Input-Output Model should be taken into consideration. Therefore, the input-output (I-O) table used in this report was obtained from the data repository of the Asian Development Bank (ADB).

A complete set of National Input-Output tables for India covering the years 2000–2022 are provided by this collection. The most recent data from 2022, which divides the Indian economy into 35 distinct sectors and describes economic transactions in millions of US dollars, is used in our analysis.[7]

To estimate the impact of PLI ACC, the battery industry is essential. Given that the current Indian I-O table does not explicitly list a distinct EV or Battery sector among its 35 sectors, we introduce an additional sector to assess the PLI scheme's economy-wide repercussions. The input column has been inculcated from the Japanese Input-output model. The input vectors for this sector are derived from the Japanese I-O model, which has a granular breakdown of 509 industries. Due to the systematized structure of automobile production and the input structure of the automobile industry in these tables, each part is generally considered to be common throughout the world (Suehiro & Purwanto, 2020). The total output and final demand for the sector have been based on the BNEF and CII study estimates.

For the estimation of employment implications, we base our analysis on the sector-specific data from the Periodic Labour Force Survey (PLFS) administered by the National Statistical Office (NSO).

[7] The data for the sector "Private households with Employed Persons" and "Public Administration and Defense; Compulsory security" is absent from the provided table, and thus, it is omitted from our analysis.

PLFS captures both formal and informal aspects of economic activities and offers insights into labour market dynamics. This level of detail enables a more localised understanding of economic activity and labour force dynamics. Furthermore, the PLFS captures data using 5-digit NIC codes, allowing for a higher level of industry-specific analysis for our Input-Output tables (Kapoor, Ketels, Debroy, & Negi, 2023).

In the absence of the Indian battery sector and its attendant data, we adopt the labour coefficient for “Miscellaneous Electrical Equipment” from the Japanese employment statistics as the closest substitute to the required data. Regarding the battery sector’s total output for 2023, the model takes the total output for the battery sector to be 20 GWh, with a value calculated at USD 139 per kWh, culminating in a total output of USD 2,780 million (BNEF, 2023; CII, 2023).

This aggregate output is then divided into intermediate and final demand, reflecting the dual nature of battery demand—utilization by other sectors and direct end-user consumption. Based on the Japanese I-O table, 35.64% of the demand originates from intermediate sectors, with the remaining 64.36% constituting the final demand. When these proportions are transposed to the Indian context, the final demand translates to USD 1,790.408 million.

The use of NIC codes of Indian sectors, PLFS data, and the Japanese I-O model in congruence, however, introduces a lack of strict demarcations in sectors due to the varying accounting methodologies used in these datasets. The sectors have been meticulously categorized according to the descriptions available within these sources. A detailed theoretical structure of this model is elucidated in Section 2 of the Appendix.

5.3 Results of the model

i) Effects on Output

This section analyses the result of the input-output model created in this report to look at the total impact of PLI on battery manufacturing. The analysis of the increase in output in different economic sectors due to the growth in electric battery manufacture offers valuable insights into the interdependence of the economy and the prospects it holds.

The report estimates a USD 19,389.97 million increase in economic output, with the mining and quarrying sector showing the highest increase of USD 1,536.17 million.

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This is indicative of the expected demand for raw materials that are essential for the manufacturing of batteries. This surge brings to light the fact that the battery industry is highly dependent on key inputs such as lithium, cobalt, and nickel, all of which are considered to be essential components of contemporary battery technologies. As a consequence of this, the growth of this sector highlights the significance of securing a reliable supply chain for these materials to support the further expansion of the battery manufacturing sector.

I-O analysis indicates substantial growth expected in manufacturing-related industries. Specifically, chemicals and chemical products are forecasted to increase by USD 1,039.56 million, while basic metals and fabricated metals are anticipated to grow by USD 13,344.6 million. These numbers are indicative of the crucial role these industries play in advancing battery-related activities, providing essential components like electrolytes, cathode materials, casings, and connectors.

As per the results of the model, significant increases are estimated for industries that are associated with transportation and logistics, such as wholesale trade (USD 674.55 million) and inland transport (USD 376.46 million), which is a reflection of the ripple effects that increased battery production has had on supply chains that are related to these industries. As the demand for energy storage solutions and electric vehicles continues to rise, there is a corresponding need for efficient transportation networks and

distribution channels to facilitate the movement of raw materials, components, and finished products throughout the economy.
Modest growth is expected in industries such as education (USD 81.10 million) and health and social work (USD 21.19 million), which indicates potential indirect socio-economic benefits from increased economic activity and investment. The expansion of battery production could lead to job creation, income growth, and subsequently higher discretionary income and spending in the education and healthcare sectors.

Table 2 *- Direct and Indirect Effects on Prominent Sectors*

Sectors	Increase in Output (in million $)
Direct Effect	
Battery	1,0157.06
Mining and quarrying	1,536.12
Basic metals and fabricated metal	1,334.46
Chemicals and chemical products	1039.56
Rubber and plastics	964.91
Indirect Effect	
Construction	326.76
Financial intermediation	273.67
Retail trade, except of motor vehicles and motorcycles; repair of household goods	201.41
Education	81.11
Health and social work	21.19

Source- Authors Calculations

ii) Effects on Employment

The analysis estimated a significant increase in employment in various key sectors of the economy due to the growth of battery production. The analysis shows a major boost in overall employment, adding an estimated 1.03 million jobs, with the largest increase in battery production, which is expected to create 179,546 new jobs in that sector.

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The analysis predicts the mining and quarrying sector experiencing the largest job growth, with an estimated increase of 34,728 jobs, representing a percentage rise of 1.22%. This increase highlights the sector's importance in supporting the growing battery production industry, as it is heavily involved in obtaining necessary raw materials. Government initiatives focusing on mining exploration and advancements in material processing technologies are expected to further boost employment opportunities in this sector.

The rubber and plastics sector is estimated to experience significant growth, adding 76,627 jobs, which represents a substantial 1.09% increase in employment. This growth reflects the potential of the sector's capacity to meet the escalating demand for components and materials that are critical in battery production. Additionally, the chemicals and basic metals sectors have expected employment growth rates of 0.41% and 0.31%, respectively, reinforcing their pivotal role in supplying necessary materials and components for battery manufacturing.

The sector of other community, social, and personal services is expected to experience growth with an increase of 398,198 jobs (0.49%). This sector consists of the majority of the service sector components (e.g., professional services, environmental services, business and tech support services, and so on), which have a significant forward linkage with the manufacturing of EV batteries and the automobile industry. This sector's role in offering crucial support services to the growing battery production industry leads to increases in employment.

Wholesale trade and commission trade, excluding motor vehicles and motorcycles, will experience a significant increase of 29,331 jobs. This sector plays a crucial role in managing the distribution and supply chain of battery-related products, leading to substantial employment growth. It is important to highlight that although some industries show modest growth in employment, their percentage growth rates are still significant. These industries benefit indirectly from the growing demand created by the expanding battery production sector, leading to a positive impact on job creation throughout the economy.

Table 3 - Effect on Employment of Prominent Sectors

Sectors	Increase in Output (Number)	Percentage Increase in Employment
Direct Effect		
Mining and quarrying	34728.17	1.22
Basic metals and fabricated metal	31022.24	0.31
Chemicals and chemical products	14663.80	0.41
Rubber and plastics	76626.66	1.09
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	6072.42	0.08
Electrical and optical equipment	8047.18	0.15
Indirect Effect		
Manufacturing, nec; recycling	3296.52	0.08
Wholesale trade and commission trade, except of motor vehicles and motorcycles	29330.14	0.44
Other community, social, and personal services	398197.34	0.49

Source- Authors Calculations

The growth of India's battery industry could lead to significant job creation, provided there is a focus on enhancing the skill levels in manufacturing production. Advancing to advanced lithium battery cell production requires substantial investment in workforce training. Moreover, with the automotive sector pivoting toward electric vehicles, retraining workers from traditional combustion engine manufacturing becomes imperative to mitigate unemployment and ensure a seamless workforce transition. Collaboration among stakeholders, including OEMs, government bodies, and educational institutions, is crucial in developing comprehensive training programs to bridge this skill gap and sustain India's ambition in sophisticated battery manufacturing.

The impact of the Production Linked Incentive for Advanced Chemistry Cell (PLI ACC) extends beyond the battery and automotive sectors due to its extensive forward and backward linkages. Mapping the value chain reveals connections from primary activities like mining to after-sales services such as technical and business support. If the PLI ACC achieves its objectives, particularly in establishing 50 GWh manufacturing units for EV batteries, the ripple effects will significantly impact the economy, both directly and indirectly. Expanding this analysis to include the effects of the Production Linked Incentive for Advanced Automotive Technologies (PLI AAT) would broaden the implications even further. Ultimately, the PLI ACC holds the potential to boost output by USD 19,389.97 million and create up to 1.03 million jobs, making it a critical driver of economic growth in India.


06

Policy Recommendations and Key Learnings

A) Policy Recommendations

1) Need for Integrated Efforts within the EV Ecosystem

A cohesive policy framework is required to encompass both upstream and downstream activities within the value chain, addressing gaps currently present in India's policy landscape.

The electric vehicle (EV) battery value chain in India is presently in its nascent stage, with a limited number of stakeholders and operational processes. The primary emphasis through the PLI scheme in the value chain is on the assembly of packs and cells, vehicle integration, and, to some extent, recycling. While national policies do acknowledge significant issues in this field, they are currently inadequate to effectively stimulate the intended impact due to a lack of cohesive implementation. The efficacy of these programmes relies on the improvement of supplementary activities within the value chain, such as mining, refining, localising production, and research and development. Investing in these tasks is essential for attaining cost-efficiency in battery manufacturing. Moreover, to guarantee the long-term viability of the electric vehicle (EV) transition, it is imperative to make significant advancements in after-sales services and the improvement of skill sets. Given the current scenario, a rapid acceleration in both production and innovation is required to meet domestic demand and to integrate into the global value chain effectively. This requires extensive expenditures and incentives throughout the entire electric vehicle (EV) ecosystem, with a substantial involvement of the private sector in addition to government initiatives. Establishing a stable and growing trajectory for the EV ecosystem is only possible by adopting a cohesive strategy.

2) Targeted Policy for Lithium Refining

Minerals have become crucial commodities in the electric vehicle (EV) industry, with lithium at the forefront. Currently, India is completely dependent on imports to fulfil its lithium requirements, procuring from countries like China and Hong Kong. This high reliance on imports raises the possibility that the reduction in oil imports enabled by the EV transition will be countered if lithium imports remain at current levels. In light of this risk, in 2024 there were efforts made to engage in negotiations with Argentina and Australia on the acquisition and extraction of lithium reserves. Along with this, changes in policies encouraging lithium exploring by altering mining laws is a crucial first step. There are ongoing domestic exploration initiatives are taking place in locations such as Jammu & Kashmir and Jharkhand. While these efforts are crucial, focusing solely on lithium procurement is insufficient. The development of refining capacities domestically is equally essential to facilitate its utilization in battery production. Currently, there has been limited progress in enhancing lithium processing capabilities, potentially resulting in sustained reliance on foreign processing, particularly from China. Establishing refining capabilities is essential not just for new batteries but also for sustainable lithium use through recycling. This will enable effective recycling processes for aged lithium batteries and utilizing it to its full potential. The

establishment of domestic refining capabilities emerges as imperative to meet local demand and bolster the cost-efficiency of electric vehicle (EV) battery production.

It is imperative to implement a policy framework that not only incentivizes the establishment of infrastructure for lithium refining but also prioritizes skill development and capacity building in this domain. Such policies are essential to foster a sustainable and robust ecosystem for lithium processing and utilization.

B) Key Learnings

1) Key Learnings from the I-O model

The findings derived from the input-output (I-O) analysis conducted in this report unveil crucial insights into the impact of the Production-Linked Incentive (PLI) scheme on India's battery production sector.

The analysis underscores a substantial surge in economic output, estimated at USD 19,390 million. The mining and quarrying sector is projected to experience the most pronounced growth, contributing an additional USD 1,537 million to the economy.

Additionally, the report forecasts a significant upswing in employment, potentially generating 1.03 million jobs across diverse sectors. The substantial expansion of employment anticipated in the battery production sector is expected to create 179,546 jobs, highlighting its considerable capacity for job creation. These findings collectively underscore the PLI scheme's potential to stimulate economic growth and facilitate job creation within the battery industry, reflecting its significance as a policy instrument in fostering industrial development and employment generation.

2) Key Learnings for Industry Players

The growth of successful EV battery ecosystems, especially in China, can be attributed to deliberate efforts across various fronts, providing two main takeaways from its success.

Collaboration Between Private Entities and Public Players for Accelerating Growth

The Chinese government, in collaboration with private sector partners, has methodically modified and improved the sector, resulting in a unified and forward-thinking industry. Private entities in China have taken a proactive approach to their investment strategies, going beyond establishing gigafactories. Their primary goal has been to establish streamlined supply chains that encompass all upstream as well as downstream activities. This encompasses the manufacturing and assembly of batteries and vehicles, with a focus on both personal and public transportation. Along with this, intensive and focused innovation and research and development (R&D) efforts have resulted in the development of more efficient and advanced technologies. These entities have also established facilities abroad and participated in international collaborations. China now has a competitive edge strongly driven by private players along with comprehensive government incentives.

Necessity of Investment and innovation by Private Players for Driving Growth

The proactive investment and innovation by private players in China have been enabled by the implementation of comprehensive policies that cover not just technological progress but also the creation of a conducive business environment. These programmes encompass tax incentives, assistance for mineral extraction and processing, and simplified land acquisition procedures. These initiatives have allowed private enterprises to focus on creating cost-effective, cutting-edge batteries and vehicles. Against this background, the PLI ACC programme seems insufficient. Its focus on revenue-based incentives (sales) overlooks the significant upfront costs associated with establishing gigafactories.

China's model that encompasses all the aspects of the EV battery value chain has demonstrated its effectiveness in serving domestic demands and leading worldwide exports. India can develop a strong supply chain and bridge the USD 3.5 Billion and USD 222 billion investment gap with China by using a similar approach and strategy. This would help expand and improve the resilience of India's electric battery and vehicle sector.

Presently, India is making impressive progress in the EV sector development. To gain a competitive advantage, meet demand, and strengthen sector resilience, a more integrated strategy is required, that aligns private sector investments and innovation with government policies and incentives.


07

Way forward

The structural evolution, pace, and financial requisites of economic transformations vary significantly depending on the stage of development and innovative capacities of nations. Countries such as China, which transitioned early on to EV development, have attained a certain level of market maturation through the implementation of diverse strategies that have contributed to their present standing. While contemplating their trajectory, it is imperative to consider their advantageous positions in terms of expenditure capacity, manufacturing prowess, and geographic advantage. From this standpoint, it is additionally imperative to acknowledge the significant differences that exist among these characteristics in economies such as India. Amidst this context, it is imperative to examine the trajectory of India, the analysis of its advancements, spending, and strategic objectives, while also incorporating a well-informed viewpoint derived from the experiences of other nations.

This report is a first step in research analysing the impact of PLI ACC on output, imports, and employment within the Indian economy by employing an input-output model. While this analysis is thorough, it is not exhaustive. This research is one of the initial quantitative assessments of the Production-Linked Incentive (PLI) scheme in the Indian economy. It aspires to showcase the preliminary effects of the PLI and to catalyse an informed discourse aimed at refining policy measures in tandem with the dynamic nature of the industry.

Achieving a comprehensive understanding requires an examination of the second PLI scheme focused on Advanced Automotive Technology (AAT) to present a holistic view of the impact of production-linked supply-side policies and their efficacy in fortifying the electric vehicle (EV) battery value chain.

However, the scarcity of electric vehicle (EV)-specific sectors within the input-output (IO) models of most economies poses a significant issue in conducting I-O analysis for the same. This gap is particularly huge in the Indian context, where the absence of sector-specific data impedes the ability to conduct a thorough analysis of such schemes. Furthermore, alongside the analysis of PLI schemes, considering the material endowments, processing capabilities, and manufacturing strengths of specific economies, an investigation into the trade balance shifts resulting from domestic battery production would enhance the depth of insights. Such an analysis would provide valuable information regarding the economic implications of domestic battery production on trade dynamics, contributing to a more nuanced understanding of the PLI scheme's broader impact.

Future investigations can include the aforementioned assessments, with the intention of finding policy shortcomings and ecosystem components that have been overlooked or undervalued and have the potential to improve India's electric vehicle battery production capacities. In order to decrease India's dependency on imports, future studies should investigate the potential of the country's battery recycling and repair business, as well as the country's ongoing attempts to create methods for retaining and reusing minerals.

In the battery value chain, India is currently at a vital juncture when it is still in a good position to manufacture components that are inclined towards the future. For this reason, it is vital to conduct an analysis of the existing policies in order to improve them while bringing them into alignment with the economic and environmental goals. A rigorous study of the policies that are currently in place and the modification of those policies to ensure that they correspond with national objectives must be undertaken. India has the capacity to accelerate the adoption of electric vehicles (EVs) by implementing these best practices, which will allow it to better align itself with international trends while also catering to the specific obstacles and opportunities that are present in its own economic environment. A strategic approach of this nature will not only help India achieve its goals, but it will also make a significant contribution to the movement towards environmentally responsible transportation on a worldwide scale.

08

Appendix

8.1 Section 1

Applicants Approved under the Scheme

Approved Applicants: Ashok Leyland Limited, Eicher Motors Limited, Ford India Private Limited, Hyundai Motor India Limited, Kia India Private Limited, Mahindra & Mahindra Ltd., PCA Automobiles India Private Limited, Pinnacle Mobility Solutions Private Limited, Suzuki Motor Gujarat Private Limited, Tata Motors Limited.

Champion OEM 2W & 3W: Bajaj Auto Limited, Hero MotoCorp Ltd., Piaggio Vehicles Private Limited, TVS Motor Company Limited.

New Non-Automotive Investor (OEM): Axis Clean Mobility Private Limited, Booma Innovative Transport Solutions Private Limited, Elest Private Limited, Hop Electric Manufacturing Private Limited, Ola Electric Technologies Private Limited, Powerhaul Vehicle Private Limited. Existing Automobile and Auto Component Manufacturing Companies Approved under Component Champion Incentive Scheme: Maruti Suzuki India Limited, Pinnacle Mobility Solutions Private Limited, Bharat Forge Limited, Hero MotoCorp Ltd., Advik Hi-Tech Private Limited, Aisin Automotive Haryana Private Ltd., Alicon Castalloy Limited, Aptiv Components India Private Limited, Aptiv Connection Systems India Private Limited, Asahi India Glass Ltd., Asia Investments

Private Limited, Automotive Axles Limited, Axletech India Private Limited, BASF Catalysts India Private Limited, Bosch Automotive Electronics India Private Limited, Bosch Chassis Systems India Private Limited, Bosch Limited, Cummins Technologies India Private Limited, Daicel Safety Systems India Private Limited, Dana Anand India Private Limited, Dana TM4 India Private Limited, Danblock Brakes India Private Limited, Delphi-TVS Technologies Limited, Denso Ten Minda India Private Limited, Garrett Motion Technologies India Private Limited, Hella India Automotive Private Limited, Hero Cycles Limited, Imperial Auto Industries Limited, International Tractors Limited, J.K. Fenner (India) Limited, Jay Ace Technologies Limited, Jay Fe Cylinders Limited, KalyaniTechnoforge Limited, Krishna Landi Renzo India Private Limited, Krishna Maruti Ltd., Kyungshin Industrial MothersonPvt Ltd, Linchpin Technologies Private Limited, Lucas-TVS Limited, Lumax Auto Technologies Limited, MahleAnand Thermal Systems Private Limited, Mando Automotive India Private Limited, Minda Corporation Limited, Minda Industries Limited, Mitsubishi Electric Automotive India Private Limited, Motherson Sumi Systems Limited, Motherson Sumi Wiring India Limited, Musashi Auto Parts India Private Limited, Napino Auto and Electronics Limited, Neel Metal Products Limited, Neolite ZKW Lightings Private Limited, Nidec India Private Limited, Padmini VNA Mechatronics Limited, Pricol Limited, Rockman Industries Limited, Sandhar Technologies Limited, Sansera Engineering Limited, Schaeffler India Limited, Sharda Motor Industries Limited, Sona BLW Precision Forgings Limited, Steel Strips Wheels Limited, Sundram Fasteners Limited, Tata Autocomp Systems Limited, Tata Cummins Private Limited, Tata Ficosa Automotive Systems Private Limited, The Hi-Tech Gears Limited, Toyota Industries Engine India Private Limited, Toyota Kirloskar Auto Parts Private Limited, Tube Investments Of India Limited, Valeo India Private Limited, Varroc Engineering Limited, Vitesco Technologies India Private Limited, Wabco India Limited, Yazaki India Private Limited.

New Non-Automotive Investor (Component) Companies:
Bharat Heavy Electricals Limited, Ceat Limited.

8.2 Section 2

Structure of Input-Output Model

Theoretical understanding of the model employed in the report is explained as follows:

Industry	Industry 1	Industry 2	Industry 3	Industry 4	Final Demand	Total Output
Industry 1	D11	D12	D13	D14	Y1	X1
Industry 2	D21	D22	D23	D24	Y2	X2
Industry 3	D31	D32	D33	D34	Y3	X3
Industry 4	D41	D42	D43	D44	Y4	X4
Value Added	Z1	Z2	Z3	Z4		
Total Output	X1	X2	X3	X4		

Here,

- X_i represents the total output for the industry 'i'
- D_{ij} represents the quantity of output from industry 'i' utilized in the production process of industry j
- Y_i refers to the final demand of industry 'i' in the economy net of the output used in other sectors
- Z_i refers to the value added to the intermediate inputs by the industry

Hence, the total output of an industry in the above model is given by:

$$X_1 = D_{11} + D_{12} + D_{13} + D_{14} + Y_1$$

For a generalized model with n industries, the output for industry 'i' is given by:

$$X_i = Sum(D_{ij}) + Y_i$$

For the input-output analysis, we assume that there is a fixed coefficient production function in the economy, i.e. for one unit of production of industry 'j' a fixed input from industry 'i' is required.

The following formula to transform the entries into input coefficients was employed:

$$A_{ij} = \frac{\text{(Contribution of industry 'i' to the output of industry 'j')}}{\text{(Total output of industry 'j')}}$$

This assumption leads us to simplify the output equations for all the industries to the following:

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + Y1$$
$$X_2 = a_{21}X_1 + a_{22}X2 + a_{23}X_3 + a_{24}X_4 + Y_2$$
$$X_2 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + a_{34}X_4 + Y_3$$
$$X_4 = a_{41}X_1 + a_{42}X_2 + a_{43}X_3 + a_{44}X_4 + Y4$$

Which can be expressed as

$$X_i = Sum(a_{ij} * X_i) + y_i$$

Here, aij refers to the input-output coefficient for industry 'i' and industry 'j', which refers to the amount of output of industry 'i' used for the production of 1 unit of output of industry 'j'.

The value of the input-output coefficient of industry 'I,i' is calculated as:

$$a_{ij} = D_{ij}/Xj$$

The system of equations describing the economy can be expressed in terms of matrices and vectors.

$$As\ X = A * X + Y$$

Further simplifying,

$$X – A*X = Y$$
$$X (I- A) = Y$$
$$X = (I-A)-1 * Y$$

As the relationship between the variables is linear, the change in the total output of an industry by a change in the final demand for the industry can be calculated by a slight modification to the above equation.

The change in output of industry 'i', given by del Xi can written as:

$$\Delta X_i = (I-A)-1 * \Delta Y_i$$

Hence, the input-output model can be used to calculate the change in the total output of an industry induced due to a change in final demand for the same industry.

For our analysis, we assume that the increase in final demand for the battery sector amounts to 9536.64 million USD. The increase in final demand is based upon the fact that it has been predicted that the battery sector will need to grow to 220 GWh in the year 2030. In the year, 2030 it has been predicted that the value of the cost of batteries will come down to USD 80 per kWh. As per these prices, the value of the total output in the year 2030 would be USD 17,600 million. The final demand in the battery sector would be USD 11,327.60 million. Hence, the difference between the final demands gives us the increase in final demand that is needed to achieve the target

The effect of an increase in final demand on employment in various sectors can also be calculated using the input-output approach. The increase in total employment in the economy can be calculated by the following equation:

$$\Delta L_i = L * (I-A)^{-1} * \Delta Y_i$$

Here, L refers to the diagonal matrix of the labour input coefficients of each sector. Labour coefficients for each sector are given by Total Employment in the sector/ Total output of the sector in the economy. As the output defined in the model is in million dollars, we calculate the labour coefficients in terms of total employment / total output in million dollars. This gives us the population employed in the economy per million us dollars of output.

Bibliography

- ACMA, Grant Thornton. (2023). Auto-Electronics Manufacturing: Conquering the Next Frontier. Retrieved from https://www.acma.in/uploads/publication/research-studies/4_ACMA_Grant_Thornton_Bharat_Auto_Electronics_Manufacturing_Report.pdf
- GOI. (n.d.). Green Urban Transport Scheme (GUTS). Retrieved from PM Jan Dhan Yojana: https://pmjandhanyojana.co.in/green-urban-transport-scheme-guts/
- National Automotive Testing and R&D Infrastructure Project. (2019). Annual Report 2018-2019. Retrieved from https://heavyindustries.gov.in/sites/default/files/2023-09/natrip_ar_2018-19.pdf
- Ministry of Road Transport and Highways. (2023). Voluntary Vehicle- Fleet Modernization Program.
- Ministry of Heavy Industries. (n.d.). PLI Scheme for Automobile and Auto Component Industry. Retrieved from https://heavyindustries.gov.in/pli-scheme-automobile-and-auto-component-industry
- Sajeev, S. (2023). ANALYSIS OF THE PRODUCTION-LINKED INCENTIVE SCHEME OF THE GOVERNMENT OF INDIA: THE HITS AND THE MISSES.
- Ministry of Heavy Industries. (n.d.). PLI Scheme for National Programme on Advanced Chemistry Cell (ACC) Battery Storage. Retrieved from https://heavyindustries.gov.in/pli-scheme-national-programme-advanced-chemistry-cell-acc-battery-storage
- PIB. (2022, March 15). The Production Linked Incentive (PLI) Scheme for Automobile and Auto Component successful in attracting proposed investment of₹ 74,850 crore against the target estimate of investment ₹ 42,500 crore over a period of five year. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1806077
- PIB. (2023, February 10). Ministry of Heavy Industries launched PLI Schemes for Automobile and Auto Component Industry and National Programme on Advanced Chemistry Cell (ACC) Battery Storage with a vision to make India self-relian. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1897948#:~:text=In%20PLI%20Auto%2C%20minimum%2050,5th%20Year%20of%20the%20scheme.
- PIB. (2022, March 24). Allotment made for 50 GWh of battery capacity to 4 successful bidders for incentive under (PLI) Scheme for Advanced Chemistry Cell (ACC) Battery Storage. Retrieved from https://pib.gov.in/PressReleasePage.aspx?PRID=1809037
- India Briefing. (2022, July 29). ACC Battery Storage Manufacturing in India: Successful PLI Bids. Retrieved from https://www.india-briefing.com/news/india-incentives-for-acc-battery-storage-manufacturing-pli-scheme-3-companies-get-approval-22349.html/
- India Briefing. (2023, July 29). ACC Battery Storage Manufacturing in India: Successful PLI Bids. Retrieved from https://www.india-briefing.com/news/india-incentives-for-acc-battery-storage-manufacturing-pli-scheme-3-companies-get-approval-22349.html/
- Ministry of Finance. (2023). Economic Survey 2022-23. New Delhi.
- Roychowdhury, A., Chattopadhyaya, V., & Tripathi, M. (2023). ZERO EMISSION VEHICLE (ZEV) MANDATE POLICY. Centre for Science and Environment.
- Ubaid ur Rehman, Z., & Aslam, H. (2022). MARKET PREPAREDNESS AND SOCIO-

ECONOMIC PROSPECTS OF ELECTRIC VEHICLES IN PAKISTAN. Sustainable Development Policy Institute.
- IISD. (2023). India's Potential in the Midstream of Battery Production. Invest India, IISD.
- Mining Technolgy. (2023, October 6). "It is foolish to think we could ever remove our dependence on China": Livent CSO.
- ETN. (2021, May 12). ACC battery storage manufacturing set to take off in India. Retrieved from https://etn.news/energy-storage/cabinet-gives-nod-to-pli-scheme-on-acc-battery-manufacturing
- EY. (2022, August 12). Global EV market trends continue to influence Indian consumers.. Retrieved from https://www.ey.com/en_in/automotive-transportation/electrifying-indian-mobility-accelerating-the-pace-of-electric-mobility
- JMK Research and Analysis. (2019, September 2019). Recycling of lithium-ion batteries in India- $1,000 million opportunity. Retrieved from https://jmkresearch.com/recycling-of-lithium-ion-batteries-in-india-1000-million-opportunity/
- Business Today. (2023, November 14). India to invite bids for 20 critical minerals, lithium, graphite in 2 weeks, says report. Retrieved from https://www.businesstoday.in/technology/news/story/india-to-invite-bids-for-20-critical-minerals-lithium-in-2-weeks-says-report-405687-2023-11-14
- McKinsey & Company. (2021, March 3). The Indian automotive industry: From resilience to resurgence? Retrieved from https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-indian-automotive-industry-from-resilience-to-resurgence
- IEA. (2023, April 26). Global EV Data Explorer. Retrieved from IEA: https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer
- Climate Action Tracker. (2020). Elaborating the decarbonisation roadmap.
- IEA. (n.d.). Global Supply Chains of EV Batteries. Retrieved from https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf
- Blackridge. (2023, February 13). CATL, BYD, and Leading EV manufacturers form an Alliance in China for Solid- State Battery Commercialization. Retrieved from https://www.blackridgeresearch.com/news-releases/catl-byd-and-leading-ev-manufacturers-alliance-for-solid-state-battery-commercialization-china#:~:text=In%20January%20of%20this%20year,in%20solid%2Dstate%20battery%20technology.
- Council on Foriegn Relations. (2019, May 13). Is 'Made in China 2025' a Threat to Global Trade? Retrieved from https://www.cfr.org/backgrounder/made-china-2025-threat-global-trade
- South China Morning Post. (2023, November 10). China's strategic mineral supply push 'a very urgent mission', says resources minister, amid self-reliance push. Retrieved from https://www.scmp.com/economy/china-economy/article/3240941/chinas-strategic-mineral-supply-push-very-urgent-mission-says-resources-minister-amid-self-reliance
- IEA. (2023, December 11). Inflation Reduction Act of 2022. Retrieved from https://www.iea.org/policies/16156-inflation-reduction-act-of-2022
- UK Research and Innovation. (2023, February 23). Faraday battery challenge. Retrieved from https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/faraday-battery-challenge/
- IEA. (2023, November 21). https://www.iea.org/policies/16763-eu-sustainable-batteries-regulation.
- Seetharaman, M., Sampat, M., Kashyap, P., Sagi, P., Agarwal, A., & Modi, V. (2023). India Electric Vehicle Report 2023. Bain and Company.

- Vahan Dashboard. (2023). Retrieved from https://vahan.parivahan.gov.in/vahan4dashboard/
- Economic Times. (2023, March 27). E-rickshaws drive EV penetration of 3Ws to over 50% in FY23 Read more at: https://auto.economictimes.indiatimes.com/news/commercial-vehicle/e-rickshaws-drive-ev-penetration-of-3ws-to-over-50-in-fy23/99026538. Retrieved from ET Auto: E-rickshaws drive EV penetration of 3Ws to over 50% in FY23 Read more at: https://auto.economictimes.indiatimes.com/news/commercial-vehicle/e-rickshaws-drive-ev-penetration-of-3ws-to-over-50-in-fy23/99026538
- PIB. (2018, December 27). Year End Review 2018- Ministry of Heavy Industries & Public Enterprises. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1557431
- Soman, A., Kaur, H., Jain, H., & Ganesan, K. (2020). India's Electric Vehicle Transition: Can Electric Mobility Support India's Sustainable Economic Recovery Post COVID-19?
- CII. (2023, August 12). ACC battery market demand in India to grow at a CAGR of 50% : CII Report. Retrieved from https://www.cii.in/PressreleasesDetail.aspx?enc=k4FL5lDBb2Qjk/Mp44zoJW3FQnef7A/yi6dEDXiy0HyTIqanhwC02aP7T7MqgH33/VOxcxDfzdk/e/7x82Ocic zi9jU0ZKAnrq7ZuZCplxb5lyztxiBFOzKhGISFuPX36JGl+KlP9wf+Fn423T6XBDBuRSVoYhH KvVR54NGaUgU=
- The Economist. (2010, September 30). Dirty business. Retrieved from https://www.economist.com/international/2010/09/30/dirty-business
- Ministry of Commerce and Industry. (2023). Dashboard. Retrieved from https://dashboard.commerce.gov.in/commercedashboard.aspx
- BloombergNEF. (2022, November 12). China's Battery Supply Chain Tops BNEF Ranking for Third Consecutive Time, with Canada a Close Second. Retrieved from https://about.bnef.com/blog/chinas-battery-supply-chain-tops-bnef-ranking-for-third-consecutive-time-with-canada-a-close-second/
- Gulia, J., Gupta, N., Jadhav, A., & Garg, V. (2022). Lithium-Ion Battery (LiB) Manufacturing Landscape in India Market Trends and Outlook. JMK Research and Analytics.
- Shekhar, H., Sharma, S., Patel, U., & Sawant, V. (2019). Exploring cost-reduction strategies for Electric Vehicle (EV) Batteries. ICRIER, Shakti Sustainable Energy Foundation.
- JMK Research and Analytics. (2023, June). LITHIUM-ION BATTERY RECYCLING IN INDIA. Retrieved from https://jmkresearch.com/lithium-ion-battery-recycling-in-india/
- DTE. (2023, November 20). EV battery recycling can give wings to India's decarbonisation dreams but faces stiff challenges. Retrieved from https://www.downtoearth.org.in/news/energy/ev-battery-recycling-can-give-wings-to-india-s-decarbonisation-dreams-but-faces-stiff-challenges-92899
- Jaeger, J. (2023, September 14). These Countries Are Adopting Electric Vehicles the Fastest. Retrieved from WRI: https://www.wri.org/insights/countries-adopting-electric-vehicles-fastest
- Pirmana, V., Alisjahbana, S. A., Yusuf, A. A., Hoekstra, R., & Tukker, A. (2023). Economic and environmental impact of electric vehicles production in Indonesia. Clean Technologies and Environmental Policy.
- Roy, S., Das, T., & Chakraborty, D. (2002). A Study on the Indian Information Sector: an Experiment with Input-Output Techniques. Economic Systems Research.
- Chadha, R., & Sivamani, G. (2022). A Hybrid Energy Input-Output Table for India. CSEP.
- Adkins, L., Garbaccio, R., Ho, M., Moore, E., & Morgenstern, R. (2021). Carbon Pricing with Output-Based Subsidies. Resources for the Future.

- Prakash, S., & Balakrishnan, B. (n.d.). INPUT OUTPUT MODELLING OF EMPLOYMENT AND PRODUCTIVITY AS BASE OF GROWTH.
- Masouman, A. (2013). Application of an Input-Output Econometric Model to Investigate the Illawarra Economy. SBS HDR Student Conference, University of Wollongong.
- Lima, J. E., & Banacloche, S. (2021). Economic analysis based on input-output tables- Definitions, indicators and applications for Latin America. UN ECLAC, Development in transition, European Union regional facility for Latin America and the Caribbean, FEALAC.
- Leurent, F., & Windisch, E. (2015). Benefits and costs of electric vehicles for the public finances: An integrated valuation model based on inputeoutput analysis, with application to France. Research in Transportation Economics.
- Bezdek, R., Wendling, R., & Bezdec, R. (2005). Fuel Efficiency and the Economy: Input-output analysis shows how proposed changes to automotive fuel-efficiency standards would propagate through the economy. American Scientist.
- IEA. (2022). Global EV Outlook 2022- Securing supplies for an electric future.
- PIB. (2022, March 21). Lithium Import And Production. Retrieved from https://pib.gov.in/Pressreleaseshare.aspx?PRID=1807681
- GOI. (2024). Production Linked Incentive Scheme For Automobile And Auto Component Industry. Retrieved from myScheme: https://www.myscheme.gov.in/schemes/plisaaci
- Suehiro, S., & Purwanto, A. J. (2020). The Influence on Energy and the Economy of Electrified Vehicles Penetration in ASEAN. Economic Research Institute for ASEAN and East Asia (ERIA).
- BNEF. (2023, November 26). BloombergNEF's annual battery price survey finds a 14% drop from 2022 to 2023. Retrieved from https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/
- CII. (2023, August 12). ACC battery market demand in India to grow at a CAGR of 50% : CII Report. Retrieved from https://www.cii.in/PressreleasesDetail.aspx?enc=k4FL5lDBb2Qjk/Mp44zoJW3FQnef7A/yi6dEDXiy0HyTIqanhwC02aP7T7MqgH33/VOxcxDfzdk/e/7x82Ociczi9jU0ZKAnrq7ZuZCplxb5lyztxiBFOzKhGISFuPX36JGl+KlP9wf+Fn423T6XBDBuRSVoYhHKvVR54NGaUgU=
- Kapoor, A., Ketels, C., Debroy, B., & Negi, S. (2023). The 2023 India Cluster Panorama. Economic Advisory Council to the Prime Minister. Retrieved from https://eacpm.gov.in/wp-content/uploads/2023/08/Report_India_Cluster_Panorama_2023.pdf
- Zulfiqar, S. A. (2023, November 23). The New York Times | By Agnes Chang and Keith Bradsher Can the World Make an Electric Car Battery Without China? From mines to refineries and factories, China began investing decades ago. Today, most of your electric car batteries are made in China and th. Retrieved from RSIL: https://rsilpak.org/2023/china-takes-charge-the-politics-of-the-lithium-battery-economy/
- Irwin-Hunt, A. (2022, March 8). How China is charging ahead in the EV race. Retrieved from FDI Inteligence: https://www.fdiintelligence.com/content/feature/how-china-is-charging-ahead-in-the-ev-race-80771
- Zhang, X., Rao, R., Xie, J., & Yanni, L. (2014). The Current Dilemma and Future Path of China's Electric Vehicles. Sustainability, 1567-1593.
- Benchmark. (2023, January 4). Investment in battery gigafactories nears $300 billion since 2019 as China extends battery dominance. Retrieved from https://source.

benchmarkminerals.com/article/investment-in-battery-gigafactories-nears-300-billion-since-2019-as-china-extends-battery-dominance?mc_cid=9b16fab821&mc_eid=66d4993fb4

- People's Republic of China. (2023, 06 25). The preferential car purchase tax policy is extended and the total reduction and exemption is expected to reach 520 billion Yuan - precise policies will help expand the volume and improve the quality of new energy vehicles. Retrieved from https://www.gov.cn/zhengce/202306/content_6888094.htm
- Baidu. (2023, 04 06). "There are policies from above and countermeasures from below." State subsidies for new energy are on the decline and local subsidies are released. Retrieved from https://baijiahao.baidu.com/s?id=1762425752977714334&wfr=spider&for=pc
- Li, W., Yang, M., & Sandu, S. (2018). Electric vehicles in China. Energy & Environment, 1512- 1524.
- S&P Global. (2022, 12 08). China's leading battery maker Sunwoda invests $2.4 bil in upstream lithium projects. Retrieved from https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/120822-chinas-leading-battery-maker-sunwoda-invests-24-bil-in-upstream-lithium-projects
- Kang, L. (2024, March 6). Global EV battery market share in Jan 2024: CATL 39.7%, BYD 14.4%. Retrieved from CNEVPOST: https://cnevpost.com/2024/03/06/global-ev-battery-market-share-jan-2024/
- Bloomberg. (2023, September 10). Chinese battery maker to invest $2 billion in Illinois. Retrieved from http://timesofindia.indiatimes.com/articleshow/103541422.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
- Cash, J. (2024, February 29). Chinese outbound investment in EVs likely set new record in 2023. Retrieved from Reuters: https://www.reuters.com/business/chinese-outbound-investment-evs-likely-set-new-record-2023-2024-02-29/#:~:text=Chinese%20firms%20put%20%2428.2%20billion,in%20a%20Slovakian%20battery%20producer.
- Ministry of Heavy Industries. (n.d.). Retrieved from https://heavyindustries.gov.in/node/2953
- PIB. (2023, July 25). Fame India Scheme. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1942506
- Ministry of Heavy Industries. (2023, December 19). LOK SABHA UNSTARRED QUESTION NO. 2717.
- PIB. (2024, March 13). Ministry of Heavy Industries announces Electric Mobility Promotion Scheme 2024. Retrieved from https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2014366
- Sempf, F., Chaudhari, P., Shah, R., Kumar, A., & Bansal, P. (2022, September). E-MOBILITY: CELL MANUFACTURING IN INDIA. Retrieved from Arthur D Little: https://www.adlittle.com/en/insights/viewpoints/e-mobility-cell-manufacturing-india
- Ghosh, M., & Bhaskar, U. (2021, September 05). Suzuki, Toshiba to make Gujarat Li-ion unit an export hub. Retrieved from mint: https://www.livemint.com/companies/news/suzuki-toshiba-to-make-gujarat-li-ion-unit-an-export-hub-11612464060165.html
- Financial Express. (2022, December 12). Amara Raja's subsidiary to invest Rs 250 crore for a new plant in Andhra Pradesh. Retrieved from https://www.financialexpress.com/business/express-mobility-amara-rajas-subsidiary-to-invest-rs-250-crore-for-a-new-plant-in-andhra-pradesh-2910374/

- ETN. (2023, August 28). Auto-electrical components manufacturer, Lucas TVS eyes li-ion battery manufacturing. Retrieved from https://etn.news/e-mobility-blogs/auto-electrical-components-manufacturer-eyes-li-ion-battery-manufacturing#:~:text=In%20September%202021%2C%20Lucas%20TVS,on%20semi-solid%20platform%20technology.
- Economic Times. (2022, June 7). Ola in talks with multiple global suppliers for $1 bn cell manufacturing Read more at: https://economictimes.indiatimes.com/industry/renewables/ola-in-talks-with-multiple-global-suppliers-for-1-bn-cell-manufacturing/articleshow/92058583.cms?utm_source=co. Retrieved from https://economictimes.indiatimes.com/industry/renewables/ola-in-talks-with-multiple-global-suppliers-for-1-bn-cell-manufacturing/articleshow/92058583.cms?from=mdr
- TOI. (2023, June 3). Tata signs Rs 13000 crore lithium-ion battery plant deal with Gujarat Government. Retrieved from TOI: https://timesofindia.indiatimes.com/city/ahmedabad/tata-signs-rs-13000-crore-lithium-ion-battery-plant-deal-with-guj-govt/articleshow/100715644.cms
- Isard, W. (1951). Interregional and regional input-output analysis: A model of a space-economy. The Review of Economics and Statistics, 33(4), 318-328. https://www.jstor.org/stable/1926459
- Leontief, W. W. (1936). Quantitative input and output relations in the economic systems of the United States. The Review of Economics and Statistics, 18(3), 105-125. https://www.jstor.org/stable/1927837
- Chadha, R., Sivamani G (2022). Centre for Sustainable Employment. (n.d.). A hybrid energy input-output table for India. Azim Premji University. Retrieved February 19, 2024, from https://csep.org/working-paper/a-hybrid-energy-input-output-table-for-india/
- Prakash, S., & Balakrishnan, B. (n.d.). Input output modelling of employment and productivity as base of growth. Retrieved February 19, 2024, from https://www.iioa.org/conferences/15th/pdf/prakash.pdf
- Masouman Ashkan (2013). Application of an Input-Output Econometric
- Model to Investigate the Illawarra Economy. University of Wollongong. Retrieved February 19, 2024, from https://ro.uow.edu.au/cgi/viewcontent.cgi?article=1048&context=sbshdr. Note: Adjust the citation when the authors or the title of the document are identified.
- Adkins, L., Garbaccio, R., Ho, M., Moore, E., & Morgenstern, R. (2012). Carbon pricing with output-based subsidies: Impacts on U.S. industries over multiple time frames. Resources for the Future. https://media.rff.org/documents/RFF-DP-12-27.pdf
- Leurent, F., & Windisch, E. (2015). Benefits and costs of electric vehicles for the public finances: An integrated valuation model based on input-output analysis, with application to France. Research in Transportation Economics. Note: Insert the publication year once identified.
- Lurweg, M., Oelgemöller, J., & Westermeier, A. (2010, March 5). Sectoral job effects of trade: An input-output analysis for Germany (CAWM Discussion Paper No. 19). Econstor. https://www.econstor.eu/obitstream/10419/51271/1/671612018.pdf
- Ministry of Statistics and Programme Implementation (MoSPI). (2022). Periodic Labour Force Survey July 2021 - June 2022. Government of India. Retrieved from https://mospi.gov.in/PLFS-July-2021-June-2022

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