Ministry of Heavy Industries

GOVERNMENT OF INDIA

सत्यमेव जयते

Aggregation of Multi-Sectoral Long-Term Battery Storage Capacity Demand and Long-Term Action Plan

March 2026

Ministry of Heavy Industries
Government of India,
Udyog Bhawan, Rafi Marg, New Delhi- 110011

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Ministry of Heavy Industries (MHI)

REPORT ON

AGGREGATION OF MULTI-SECTORAL LONG-TERM BATTERY STORAGE CAPACITY DEMAND AND LONG-TERM ACTION PLAN

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FOREWORD

As India advances towards the goal of **Viksit Bharat @2047**, our strategy must seamlessly blend rapid economic growth with sustainable development. Guided by the visionary leadership of Hon'ble Prime Minister Shri Narendra Modi, who has championed the call for an **Atmanirbhar Bharat**, we are prioritizing self-reliance in critical technologies. The Prime Minister has emphasized, **"We have to move forward with the mantra of 'Make in India, Make for the World'."** Advanced Chemistry Cells (ACCs) are central to this mission, serving as the bedrock for our energy security, grid stability, and the electric mobility revolution.

Globally, the ACC value chain—from critical minerals to cell manufacturing—is concentrated in a few geographies, creating vulnerabilities and supply disruptions. As India accelerates its clean energy transition and industrial growth, establishing a robust, globally competitive domestic battery ecosystem is imperative. We must transition from importing energy storage solutions to innovate them, positioning India as a global hub for energy solutions. The Indian industry has shown commendable agility in recognizing this shift and has leveraged this trust to meet the rising multi-sectoral demand for advanced battery technologies.

The report, *"Aggregation of Multi-Sectoral Long-Term Battery Storage Capacity Demand and Preparation of a Long-Term Action Plan,"* outlines our strategic roadmap to achieve these goals. Developed through rigorous consultation, it aligns policy with long-term demand to accelerate the ACC ecosystem. Through the combined efforts of the government and private sector - embodying the spirit of *Sabka Prayas* - I am confident we will successfully implement this plan and cement India's leadership in the clean energy landscape. I commend all those who have contributed to shaping this important Report.

(H.D. Kumaraswamy)

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FOREWORD

As India accelerates its journey towards becoming a "Viksit Bharat," energy storage has emerged as a critical determinant of our industrial competitiveness and energy security. Under the visionary leadership of Hon'ble Prime Minister Shri Narendra Modi, our policies are firmly aligned with the conviction that **India's growth story will be written by green growth**. To support this transition, the Government has already catalyzed the ecosystem through the PLI Scheme for ACC Battery Storage, setting the stage for India to rise as a global hub for clean energy technologies.

To fully realize this vision, building a self-reliant battery ecosystem is non-negotiable. It is my privilege to introduce the report, **"Aggregation of Multi-Sectoral Long-Term Battery Storage Capacity Demand and Preparation of a Long Term Action Plan."** This report has combined demand across diverse sectors, including mobility, grid storage, etc., and provides the definitive market signal that global investors and manufacturers require. It reinforces the business case for establishing giga-scale capacities within India, ensuring that Advanced Chemistry Cells (ACCs) become the catalyst for our clean energy transition.

I congratulate the Ministry officials and industry partners for this insightful study, which will serve as a vital guide for policymakers and industry alike. Together, we are laying the groundwork for a future-ready, self-reliant, and greener India, truly embodying the spirit of Atmanirbhar Bharat.

(Bhupathiraju Srinivasa Varma)

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FOREWORD

India's transition toward a clean, resilient, and self-reliant energy future is intrinsically linked to the strategic development of advanced battery storage systems. Recognizing the pivotal role of Advanced Chemistry Cells (ACCs) in strengthening energy security, enhancing industrial competitiveness, and meeting climate commitments, the Ministry of Heavy Industries, in consultation with NITI Aayog, has undertaken a focused initiative to aggregate multi-sectoral battery storage demand and formulate a comprehensive long-term action plan. This initiative marks a decisive step toward building a future-ready and globally competitive battery ecosystem in India.

To ensure the action plan is robust and forward-looking, the Ministry engaged in extensive consultations with key Ministries, Departments and a broad spectrum of industry stakeholders—including ACC manufacturers, component suppliers, BESS manufacturers, recyclers, and other ecosystem participants. This collaborative process enabled a holistic assessment of cross-sectoral demand and helped identify the policy, technological and investment interventions required to establish a competitive and sustainable domestic battery manufacturing value chain.

The Report outlines strategic pillars such as manufacturing scale-up, component indigenization, raw material security, technology advancement, policy support, and institutional coordination—laying a strong foundation for long-term self-reliance. I am confident that this roadmap will catalyze innovation and investment at scale, enabling Indian industry to build a globally competitive ACC ecosystem and positioning India as a leader in advanced battery technologies. I would like to extend my sincere gratitude to all the Ministries, Departments and Industry stakeholders whose invaluable insights and collaborative spirit were instrumental in the preparation of this Report.

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PREFACE

The Government of India has recognised long-term battery storage as a strategic pillar for the nation's energy security, industrial competitiveness and the achievement of the "Viksit Bharat" vision. To translate this recognition into actionable policy, the Ministry of Heavy Industries (MHI) has prepared a report titled "**Aggregation of Multi-Sectoral Long-Term Battery Storage Capacity Demand and Long-Term Action Plan**".

This report is the outcome of a rigorous, "whole-of-government" approach. It synthesizes insights from an extensive stakeholder engagement programme involving NITI Aayog; key ministries like M/o Power, M/o New & Renewable Energy, M/o Electronics & Information Technology, M/o Railways, and M/o Telecommunications; along with representatives from industry across the ACC value chain.

An aggregation-based approach was adopted to project demand, ensuring that quantitative forecasts for sectors ranging from EVs and grid-scale BESS to data centers and railways are grounded in reality. These projections have been cross-validated against national targets to ensure alignment with our renewable energy and emission reduction commitments. The report shall serve as a practical blueprint for **Demand Outlook @ 2047**, **Ecosystem Assessment**, and **Action Plan @ 2047** to realize the **"India Battery Vision @ 2047."**

I extend my sincere gratitude to partner ministries, departments, and industry stakeholders for their constructive participation. I also acknowledge the contribution of M/s Deloitte Touche Tohmatsu India LLP (Deloitte) for their valuable support and analytical inputs in shaping this report. This report shall serve as a definitive reference for policymakers and investors to work together for building self-reliant and robust battery ecosystem.

9/3/2026
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Abbreviations

AAM	Anode Active Material
ACC	Advanced Chemistry Cell
AI/ML	Artificial Intelligence/Machine Learning
AIS	Automotive Industry Standard
ALMM	Approved List of Models and Manufacturers
BESS	Battery Energy Storage Systems
BFSI	Banking, Financial Services and Insurance
BMS	Battery Management System
BTS	Base Transceiver Station
BUs	Billion Units
C&I	Commercial and Industrial
CAFE	Corporate Average Fuel Economy
CAM	Cathode Active Material
CAPEX	Capital Expenditure
CPC	Calcined Petroleum Coke
Cu	Copper
DG set	Diesel Generator Set
DISCOM	Distribution Company
DVA	Domestic Value Addition
EMS	Energy Management System
EPR	Extended Producer Responsibility
ESG	Environmental, Social, and Governance
ESO	Energy Storage Obligation
FDI	Foreign Direct Investment
FDRE	Firm and Dispatchable Renewable Energy
FTAs	Free Trade Agreements
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSSS	Grid-Scale Stationary Storage
GWh	Gigawatt-hour
HSN	Harmonized System of Nomenclature
HVAC	Heating, Ventilation, and Air Conditioning
IESS	India Energy Security Scenarios
INR	Indian Rupee
IoT	Internet of Things
IT	Information Technology
JV	Joint Venture

Ktpa	Kilo Tonnes Per Annum
kWh	Kilowatt-hour
MGV	Medium Goods Vehicle
MoU	Memorandum of Understanding
MSMEs	Micro, Small and Medium Enterprises
MTPA	Million Tonnes Per Annum
MWh	Megawatt-hour
Na-ion	Sodium-ion
Na-S	Sodium-sulphur
NCA	Nickel Cobalt Aluminium
NCMM	National Critical Mineral Mission
NEP	National Electricity Plan
NMC	Nickel Manganese Cobalt
OEM	Original Equipment Manufacturer
PLI	Production-Linked Incentive
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
QCOs	Quality Control Orders
R&D	Research and Development
RTC	Round-the-Clock
SPR	Strategic Petroleum Reserves
SSBs	Solid State Batteries
TCO	Total Cost of Ownership
TOD	Time-of-Day
TRL	Technology Readiness Level
TWh	Terawatt-hour
UPS	Uninterruptible Power Supply
VAT	Value Added Tax
VGF	Viability Gap Funding
VRE	Variable Renewable Energy


1

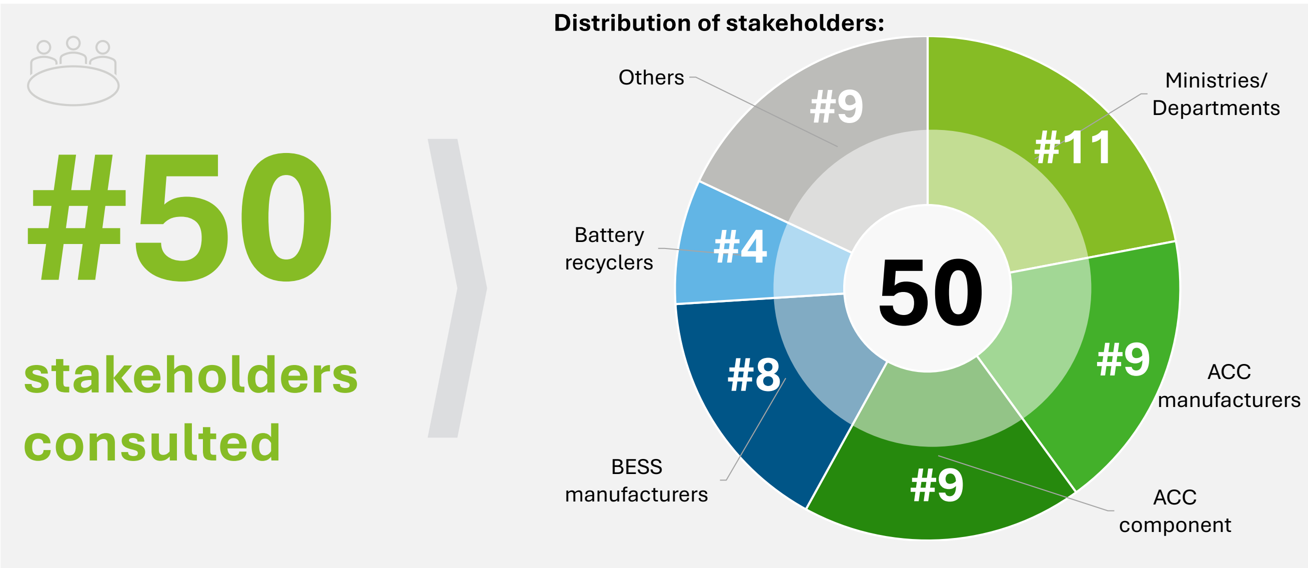
Chapter 1. Executive summary

India's vision of Viksit Bharat @2047 and its 2070 net-zero target require a major transformation of the energy system. Large-scale renewable energy adoption and electrification of mobility will play a central role in this transition, with batteries acting as a key enabler. Batteries help maintain grid stability while integrating renewable energy, power electric vehicles, and support reliable electricity supply for commercial and industrial facilities. They also provide backup for critical infrastructure such as data centres and telecom towers. In addition, batteries play an important role in India's rapidly growing electronics manufacturing sector, which has expanded significantly with strong policy support.

The Government of India recognizes that advanced chemistry cell (ACC) battery storage is a strategic pillar for the nation's energy security, industrial competitiveness and the achievement of the "Viksit Bharat" vision. As part of the government's efforts to promote this sector, the Ministry of Heavy Industries (MHI) was tasked with aggregating multi-sectoral battery-storage demand and preparing a comprehensive long-term action plan.

To ensure that the action plan and roadmap are comprehensive, the Ministry of Heavy Industries conducted extensive stakeholder consultations over the past several months. Around fifty (50) stakeholders were consulted during the study. The report draws on the insights, feedback, and recommendations received during these consultations.

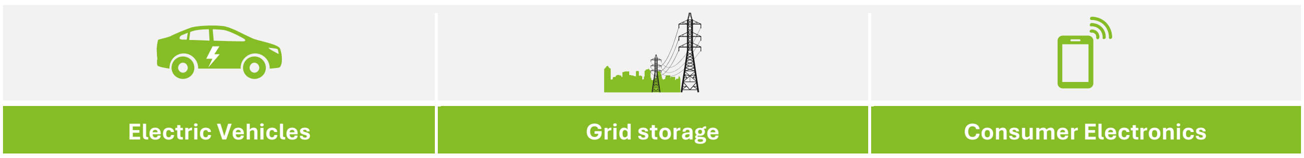
Figure 1: Summary of stakeholders consulted for the study

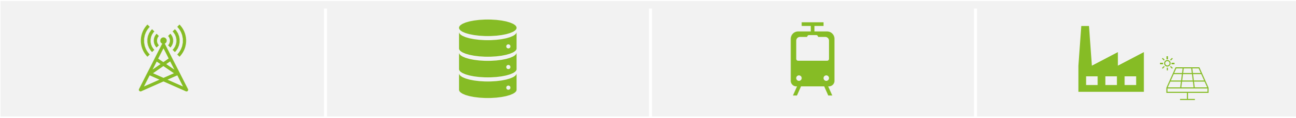


1.1. Aggregated multi-sectoral battery demand @2047

Batteries have emerged as a key technology across a multitude of sectors, underpinning India's economic growth and clean energy transition.

Figure 2: Key sectors with potential battery demand by 2047

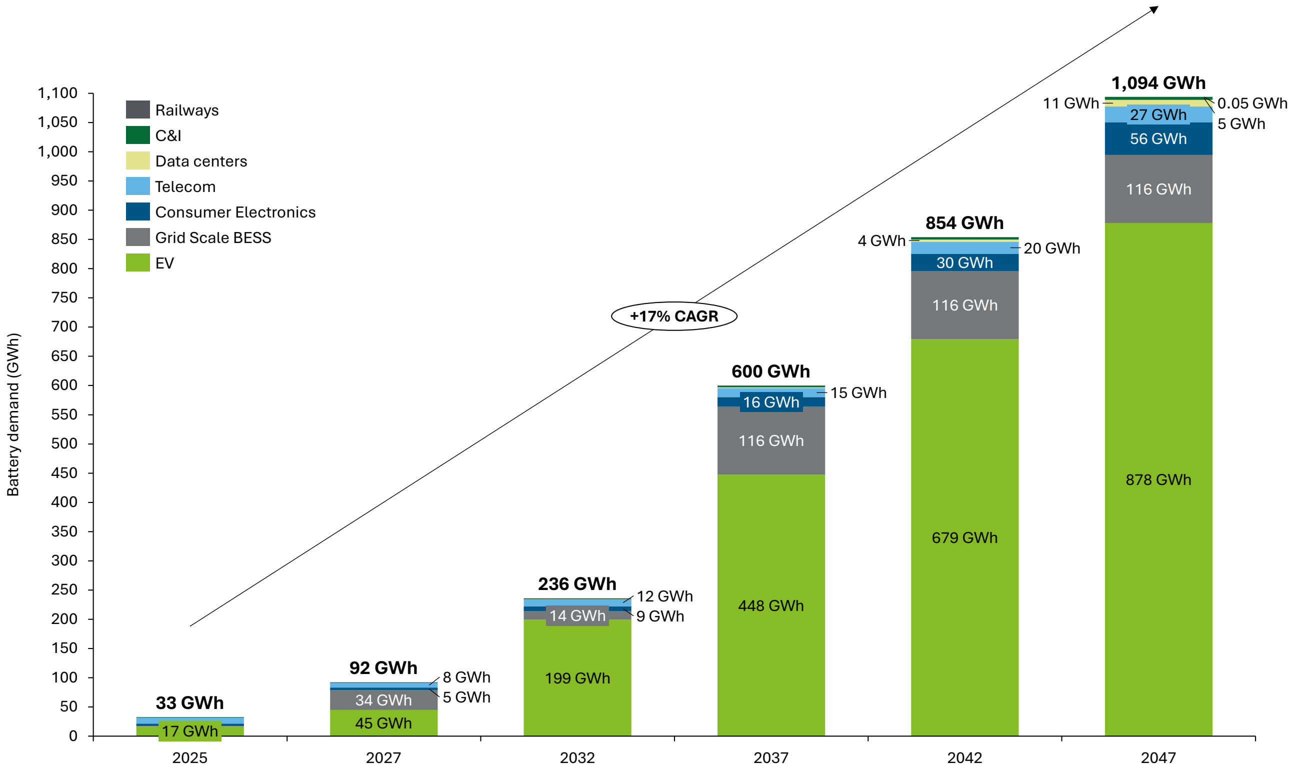




Telecom	Data Center	Railways	C&I power backup

By 2047, total battery demand across key sectors is estimated at 1,094 GWh. EVs account for majority with ~80% (878GWh) of total demand, which is driven by large-scale electrification of the passenger road transport sector. Grid-scale BESS demand will represent ~11% of the overall demand followed by consumer electronics representing ~5% share in 2047 demand. Finally, the remaining demand is driven by segments such as Telecom (~27 GWh, 2%), supported by continuous network expansion and backup needs, Data Centres (~11 GWh, 1%), Commercial & Industrial (C&I) power backup (~5 GWh, 0.5%) and Railways (~0.05 GWh).

Figure 3: Projected all India annual multi-sectoral battery demand till 2047, GWh



1.2. National battery roadmap for Viksit Bharat @2047

Considering the central role batteries will play in the Viksit Bharat @2047 and the country's Net Zero @2070 ambitions, India should aim to become a global hub for competitive and sustainable battery manufacturing. Achieving this will require building a secure and innovative battery ecosystem that strengthens India's energy security and promotes circularity across the value chain.

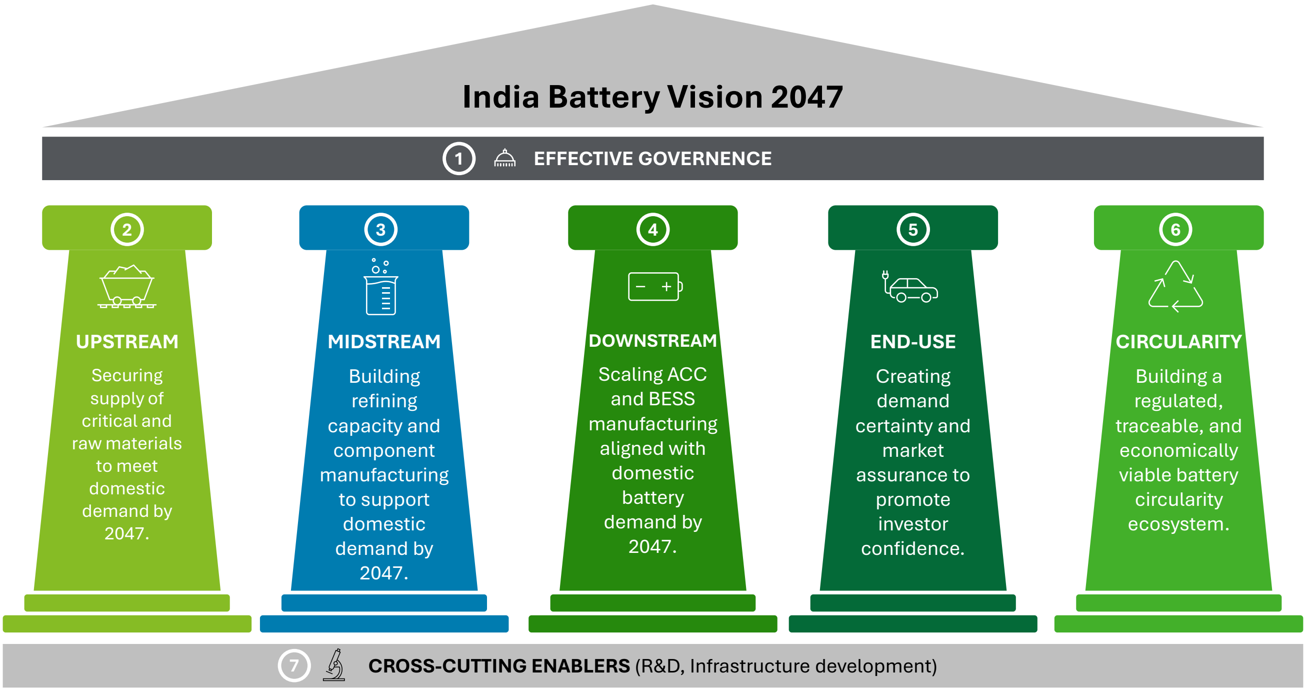
India's Battery Vision 2047:

> ## India Battery Vision 2047
>
> By 2047, India will be a **global hub** for **competitive**, **sustainable** battery manufacturing and **innovation**, with an end-to-end, secure, and **circular** battery value chain, creating **skilled jobs**, achieving strategic autonomy & **energy security**, and contributing to global **net zero ambitions**.

To address these vulnerabilities, India will need coordinated efforts across the entire battery value chain. A holistic, long-term action plan is essential to strengthen self-reliance and advance the vision of Atmanirbhar Bharat in this sector.

In view of this, seven (7) pillars of National Battery Roadmap have been identified:

Figure 4: Seven pillars of National Battery Roadmap

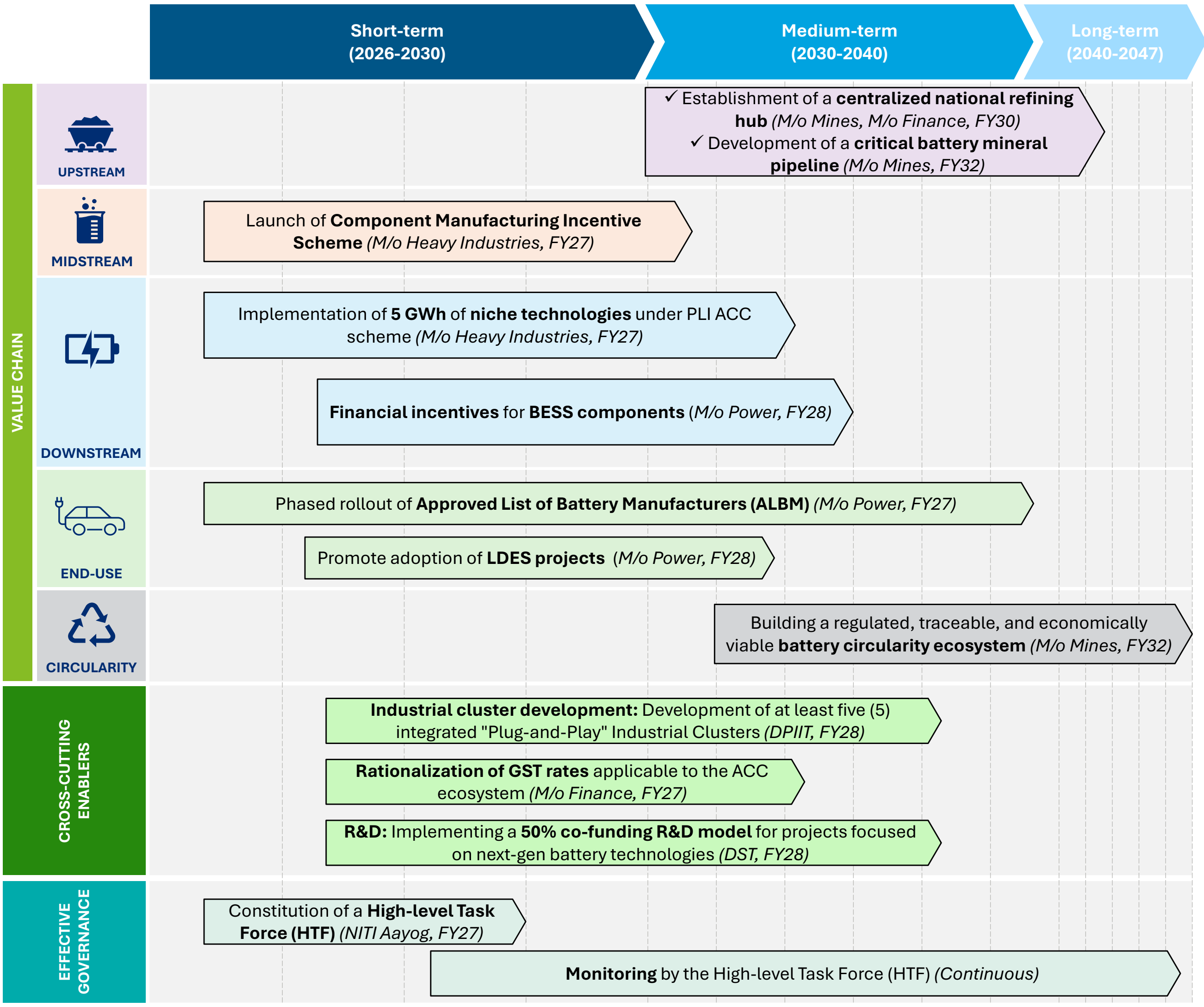


Based on the inputs received from the stakeholders, action items for National Battery Roadmap @2047 are developed for each of the seven (7) pillars. India will need a phased approach to achieve its Battery Vision 2047.

In the near term, the priority is to build a strong domestic manufacturing core focused on ACC cell manufacturing and key ACC component manufacturing. India's rapidly growing domestic demand for batteries provides a strong foundation to attract and anchor investments in these areas. At the same time, end-use interventions are proposed to be implemented to provide demand visibility and confidence for investors. Alongside these efforts, cross-cutting enablers such as policy support, infrastructure, and talent development also play a crucial role in building a globally competitive manufacturing ecosystem.

After, establishing this manufacturing core, India can gradually expand upstream and strengthen circularity across the battery value chain. In the long term, developing a critical mineral supply pipeline and establishing a centralized national refining hub will help create stable domestic demand from ACC and component manufacturing, thereby supporting upstream investments. In parallel, developing a strong battery recycling and circularity ecosystem will become increasingly important as larger volumes of batteries reach end-of-life. As shown in figure below, this phased pathway will help India build a resilient, self-reliant, and sustainable battery ecosystem over time.

Figure 5: India's National Battery Roadmap 2047



The proposed roadmap aims to enable India to achieve self-reliance across the battery ecosystem by the time the country reaches its Viksit Bharat @2047 milestone.

2

Chapter 2. Introduction

2.1. India's energy transition and net-zero ambitions

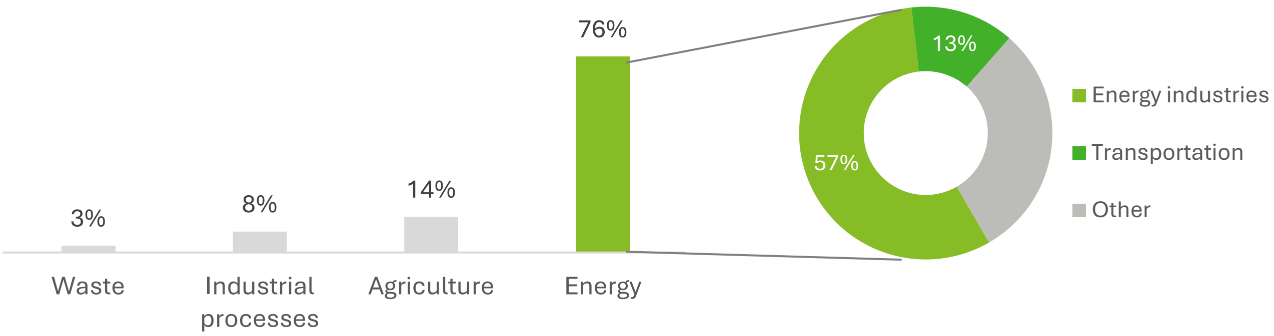
India stands at a pivotal point in its Viksit Bharat journey as it works to align rapid economic growth with clean and sustainable development. At COP26 in Glasgow, India's strategy towards Net Zero was articulated by the Hon'ble Prime Minister Shri Narendra Modi, underscoring India's resolve to pursue climate action in parallel with its development priorities and setting a clear direction for its future.

Despite having much lower per-capita greenhouse gas (GHG) emissions compared to the global average, India is the world's third-largest GHG emitter[1]. The country faces the complex challenge of balancing rapid economic development with the need to reduce carbon emissions. As India's population and economy grow, it must manage rising energy demand while transitioning to a sustainable, low-carbon future.

As per India's Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change (December 2024), three-fourths of the country's total emissions are represented by the energy sector; within this sector, energy industries (electricity generation, petroleum refining, and manufacturing of solid fuels) and the transport sector together account for ~70% of emissions.

Figure 6: India's GHG emission by sector (2020)

Figure 7: Energy sector GHG emission break-up



Source 1 MoEFCC (2024), India: Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change. Ministry of Environment, Forest and Climate Change, Government of India

2.2. Advanced chemistry cell battery storage

Advanced chemistry cell (ACC) battery storage will play a pivotal role in resolving India's high emission issues. Advanced chemistry cell batteries distinguish themselves from conventional batteries such as lead-acid and nickel-cadmium because of the following advantages:

Conventional batteries	Advanced chemistry cell batteries
• Lower storage capacity at the same weight and volume. • Shorter lifetimes, requiring frequent replacement. • Slower charging and lower peak power output. • Lower energy efficiency, delivering less energy compared to what was put in.	• Much higher storage capacity at the same weight and volume. • Long lifetimes, with the potential to last thousands of charge cycles. • Can charge quickly, with much higher peak power output. • Highly energy efficient, able to deliver similar levels of energy as what was put in.

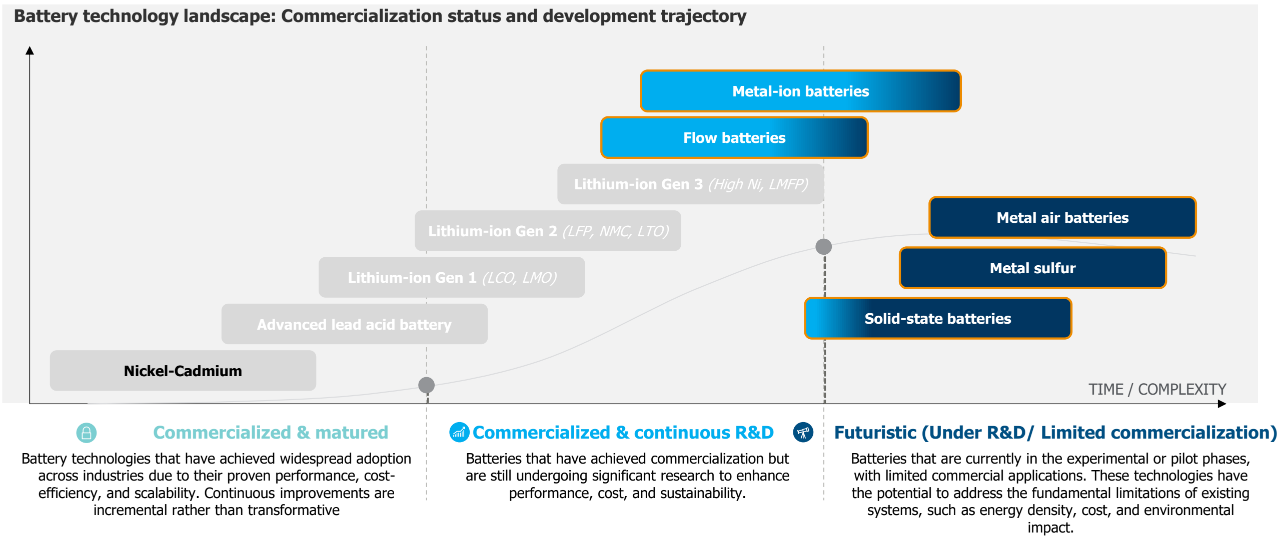
[1] United Nations Environment Programme (2025). Emissions Gap Report 2025: Off target

Lithium-ion ACC batteries have become the preferred battery technology across applications ranging from consumer electronics to electric vehicles and grid-scale energy storage, driven by the aforementioned advantages. Lithium-ion batteries were first commercialized in 1991 and have since achieved a nearly five-fold increase in energy density and a sharp decline in prices due to dedicated R&D efforts and gigawatt-hour-scale production.

2.2.1. Emerging ACC technologies

Based on current market developments and emerging industry trends, five key technology groups are emerging as next-gen ACCs:

Figure 8: Emerging next-generation acc technology groups based on market trends



Source 2 Industry reports

A brief overview of each technology group, along with the key battery technologies under them, is provided below:

1. **Metal-ion (Me-ion):** Metal-ion batteries store energy by shuttling metal ions between a cathode and anode, each coated on metal foils, through a porous separator filled with a liquid electrolyte. *E.g. Sodium-ion (SIBs), Magnesium-ion (MIBs), Zinc-ion (ZIBs), and Aluminum-ion (AIBs)*
2. **Metal-sulphur (Me-S):** Metal-sulphur batteries have sulphur as their cathode and pure metal (Li, Na, Mg, etc.) as their anode. During use, the metal converts into ions that travel through the electrolyte and bind with sulphur to form metal–sulphides. *E.g. Lithium-sulphur (Li-S), Sodium-sulphur (Na-S)*
3. **Metal-air (Me-air):** Metal–air batteries use a metal anode (such as lithium or zinc), an electrolyte, and a gas-diffusion electrode that draws in oxygen from air or a storage tank. When the metal and oxygen chemically react, they release electrical energy. *E.g. Lithium-air (Li-air), Zinc-air (Zn-air)*
4. **Redox flow batteries (RFBs):** Redox flow batteries (RFBs) consist of two electrolyte tanks, in which the electrical energy is stored in the form of redox couples, typically in aqueous solution. A battery cell, through which the electrolytes are pumped, converts the electrical energy into chemical energy and vice versa.
5. **Solid state batteries (SSBs):** A solid-state battery uses a solid electrolyte and separator in place of liquid components, enabling ions to move between the anode and cathode through a non-flammable medium.

The emerging next-gen ACC technologies have the potential to offer unique advantages in terms of longevity, resistance to extreme climates, and simpler supply chains for raw materials. However, these technologies still require significant time and investment to reach the same level of reliability and commercial availability as lithium-ion, making it the current technology of choice for most end-use applications.

2.3. Role of battery storage in enabling Viksit Bharat @2047

India's aspiration for Viksit Bharat @2047 is closely tied to a fundamental transformation of its energy system, which must evolve to meet the 2070 net-zero goal. Large scale adoption of renewable energy sources and widespread electrification of the mobility sector are vital for the overall growth of India's energy landscape – and batteries are the cornerstone enabling the transition in these two sectors.

Batteries provide grid stability, flexibility, and reliability required to integrate large-scale renewables into the power system. Likewise, in case of the electric vehicles (EVs), batteries enable high-efficiency electric drivetrains, deliver superior performance and extend driving range. With ongoing improvements in battery technologies and costs, a larger share of the transport sector is being unlocked for electrification.

Beyond mobility, batteries are used by commercial and industrial (C&I) enterprises to firm up power supply for their facilities. Battery backup for data centres, telecom towers, and other critical infrastructure is also supporting the rollout of 5G and AI/ML technologies.

Batteries are also crucial for one of the fastest growing manufacturing sectors in India – Electronics. Promoted through comprehensive policy support, electronics manufacturing has grown nearly six-fold in the past 11 years, going from INR 1.9 lakh crore in FY2014-15 to INR 11.32 lakh crore in FY2024-25 and now forms India's third largest export category.[2]

2.4. HLC-VB & mandate of Ministry of Heavy Industries (MHI)

The Government of India has constituted a High-Level Committee on Implementation of Viksit Bharat Goals (HLC-VB) with the objective to fast-track the nation's development goals, monitor the implementation of flagship schemes and strategize key policy reforms.

Recognizing the strategic importance of battery storage to India's energy security and industrial competitiveness, the HLC-VB has entrusted the Ministry of Heavy Industries (MHI) to aggregate multi-sectoral long-term battery storage capacity demand and prepare a long-term action plan.

2.5. Stakeholder consultations

To ensure that the action plan and roadmap are comprehensive and effective, the Ministry of Heavy Industries has undertaken extensive stakeholder consultations with around 50 stakeholders over the past several months, including the Ministry of Power (MoP), Ministry of New & Renewable Energy (MNRE), Ministry of Electronics and Information Technology (MeitY), Ministry of Railways (MoR), Department of Telecommunications (DoT), Central Electricity Authority (CEA), and key private sector players including industry bodies. This report is developed on the insights, feedback, and actionable recommendations emerging from these discussions.

[2] PIB: Electronics manufacturing grows sixfold, exports grow eightfold in the last 11 years (Link)

Table 1: Coverage of the stakeholder consultations

11	9	9	8	4	9
Ministries/ Departments	ACC manufacturers	ACC component manufacturers	BESS manufacturers	Recyclers	Other ecosystem players

3

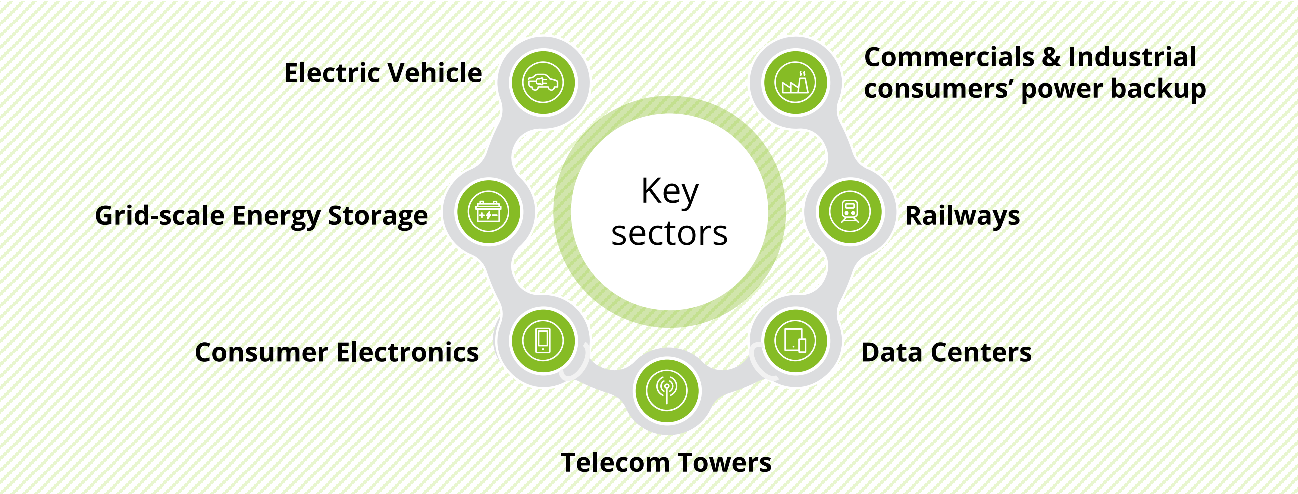
Chapter 3. India's battery storage demand outlook 2047

3.1. Use of batteries in various end-use applications

Batteries have emerged as a key technology across a multitude of sectors, underpinning India's economic growth and clean energy transition. Over the past decade, India's battery demand has evolved from being largely anchored in consumer electronics and lead-acid-based backup applications to a more diversified, lithium-ion-led market. Early growth was driven by consumer electronics, two-wheelers, and inverter-based power backup.

Since the late 2010s, demand has accelerated sharply with the onset of electric mobility, rising renewable energy capacity, and the need for more resilient power systems. Policy support for EV adoption, declining lithium-ion costs, and growing concerns around fuel security and emissions have collectively shifted the demand trajectory upwards. More recently, grid-scale storage, data centres, and high-reliability commercial applications have emerged as meaningful contributors, signalling a structural transition from episodic, backup-oriented use to continuous, performance-critical deployment of batteries.

Figure 9: Key sectors with potential battery demand by 2047



Batteries are now embedded across multiple sectors that underpin India's energy, mobility, and digital transformation.

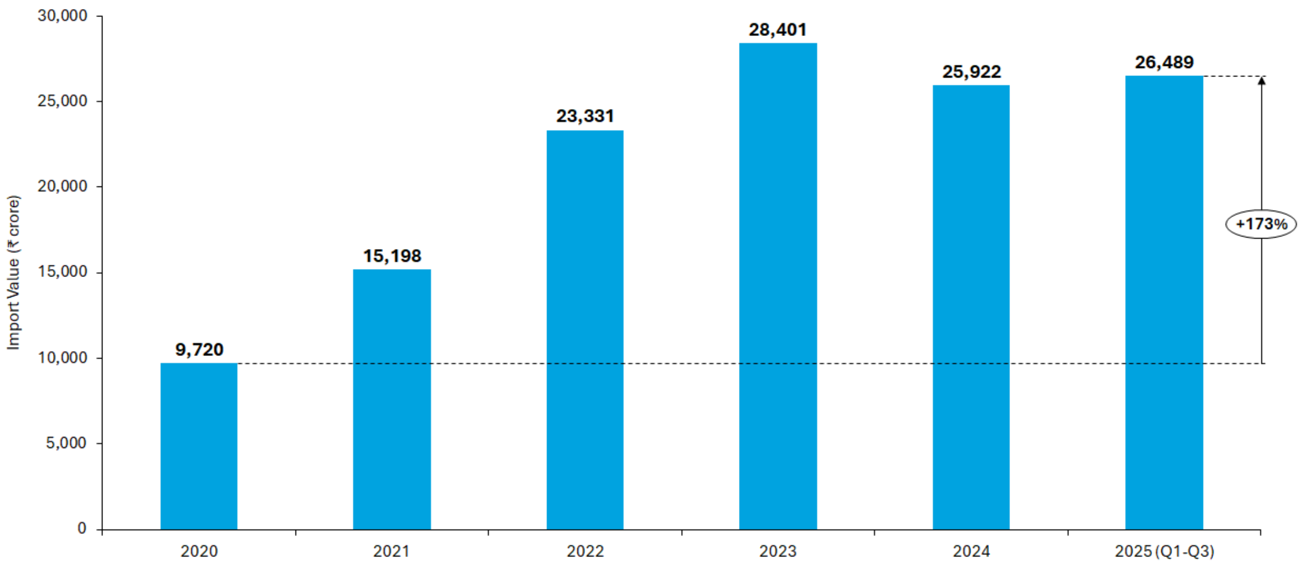
- **Electric vehicles** represent the largest and fastest-growing application, spanning personal mobility, public transport, and emerging freight segments.
- **Stationary storage** is expanding rapidly to support renewable integration, grid balancing, and peak management.
- **Consumer electronics** continue to provide a stable base of demand, while telecom towers are progressively migrating to lithium-ion systems for reliable backup.
- **Data centres** are creating a new segment which requires large quantities of power, high-availability, and power quality.
- **Commercial and Industrial** users are deploying batteries for tariff optimization, outage management, and diesel displacement.
- **Railways** add a steady layer of demand through the addition of new rolling stock using ACC battery backups.

Together, these applications create a diversified and durable demand profile that underpins India's long-term ACC manufacturing opportunity.

3.2. Historical growth of domestic battery demand

India's dependence on imported batteries has increased steadily over the last five years, reflecting a clear rise in domestic battery demand. Lithium-ion battery imports, tracked under the HSN codes 850650 and 850760, increased from ₹9,720 crore in 2020 to ₹25,922 crore in 2024.

This growth in import value indicates that India's battery demand is expanding faster than domestic manufacturing capacity. Rising use of batteries across electric mobility, telecom infrastructure, consumer electronics, and energy storage applications has led to greater reliance on imports to meet short-term needs. The import trend highlights a growing supply gap and underlines the strategic importance of strengthening domestic battery manufacturing to reduce import dependence and improve supply security.

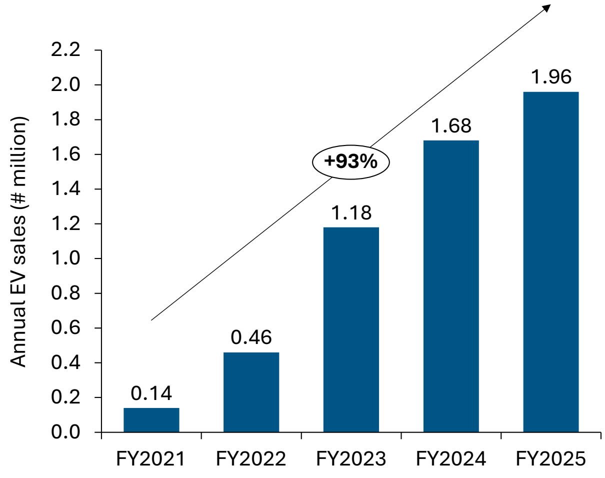


3.3. Sector-wise 2047 battery demand projections

3.3.1. Electric vehicles

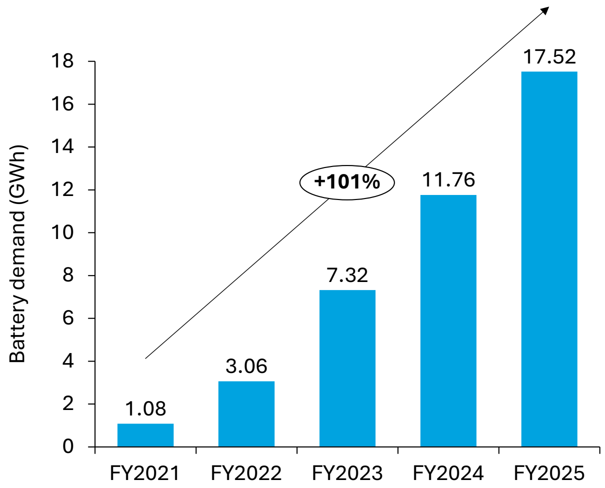
Indian EV industry has achieved remarkable growth over the past decade. Supported by targeted incentives and favourable Total Cost of Ownership (TCO) dynamics for e-2W and e-3W, India's EV sales grew at a significant ~93% CAGR from FY21 to FY25. The EV sales penetration also reached 5.8% (7.8% including hybrid EVs) in FY25 from 0.3% in FY21 with the country aiming to achieve 30% sales penetration by 2030. Based on the EV sales and average battery size of various vehicle categories, the battery demand from EVs has reached ~17.5 GWh in FY25.

Figure 10: India EV sales of last five years, Mn



Source: Vahan Dashboard, VAHAN portal

Figure 11: India's battery usage in EVs in the last five (5) years, GWh



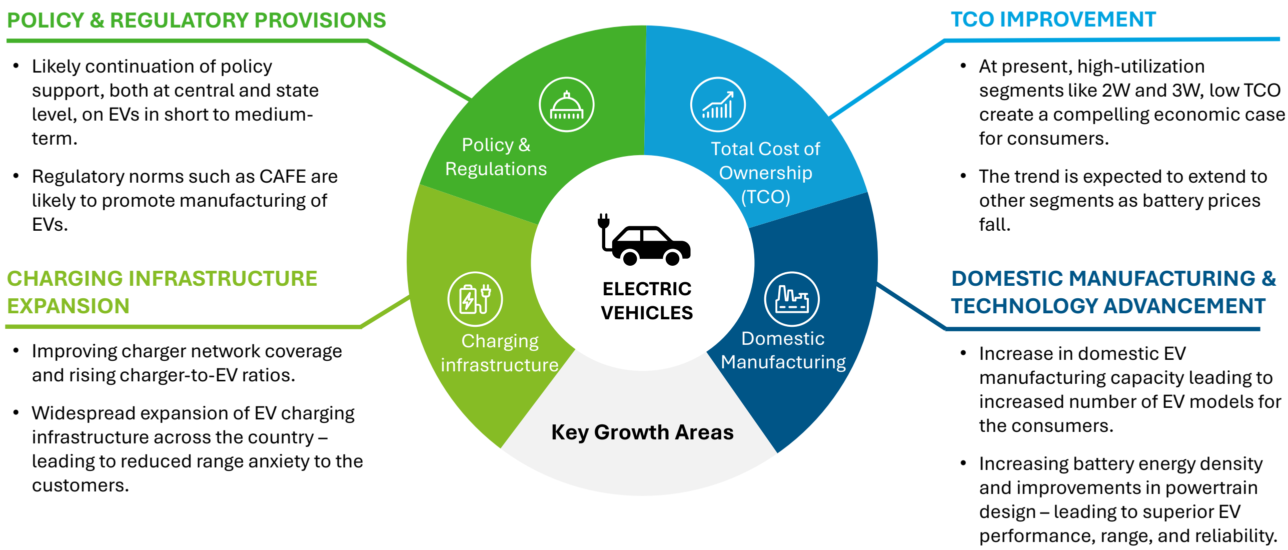
Source: Deloitte analysis

The EV sector has been the strongest contributor to incremental battery demand growth in recent years and is expected to be the largest source of demand in the future as well.

3.3.1.1. Growth drivers

Future battery demand will be driven by rising adoption of electric vehicles and battery-based systems, supported by improving cost economics, better usability through expanded charging infrastructure, wider product availability, and ongoing technology improvements. These factors together enable mass-market adoption across segments and translate into sustained, predictable growth in battery demand over the medium to long term.

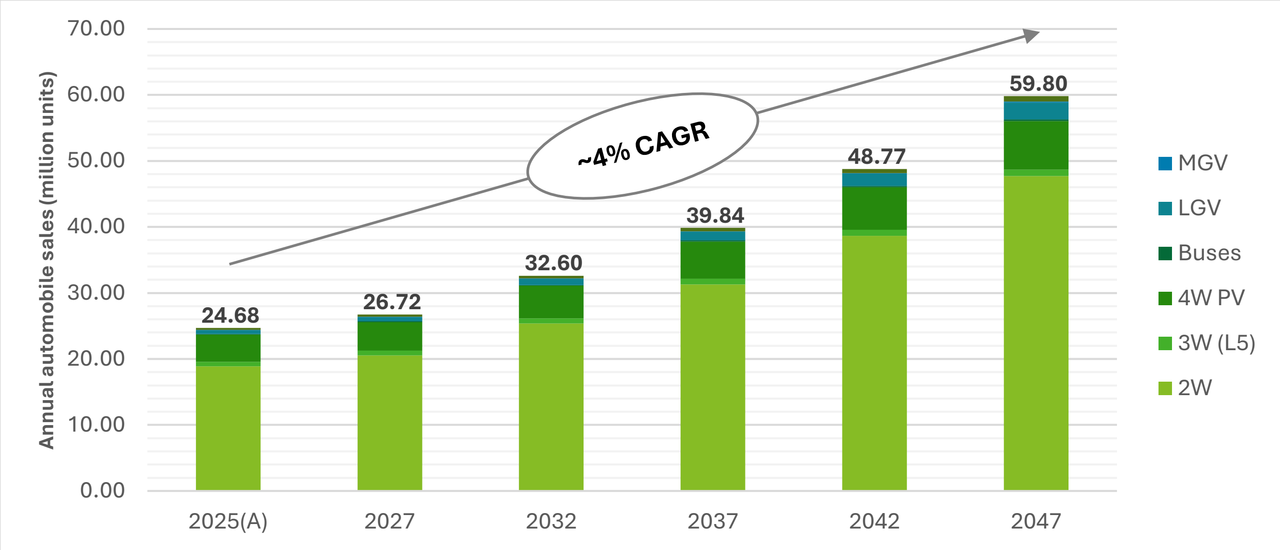
Figure 12: Key growth drivers in EV sector



3.3.1.2. Projections and Outlook

NITI Aayog projects that the demand for passenger road transport in the country (in terms of vehicle-kms) will grow at a CAGR of ~4% up to 2047, reflecting the economic growth and changes in modal share expected with the advent of Viksit Bharat. Similarly, the demand for freight road transport (in terms of tonne-kms) by light goods vehicles and medium/heavy goods vehicles is expected to grow at ~5.6% and ~4.25% respectively. Projected automobile sales as per these requirements are as follows:

Figure 13: Actual (2025) and projected annual automobile sales (2027 to 2047), million units

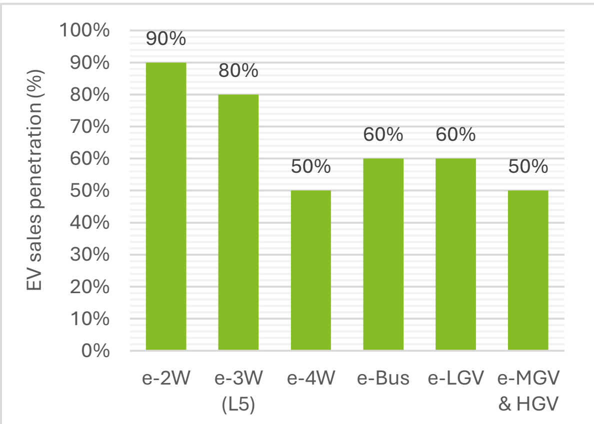


Source 3 Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Acronyms- HGV: Heavy Goods Vehicle, MGV: Medium Goods Vehicle, LGV: Light Goods Vehicle, 4W PV: 4-wheeler passenger vehicle, 3W (L5): 3-wheeler (L5)

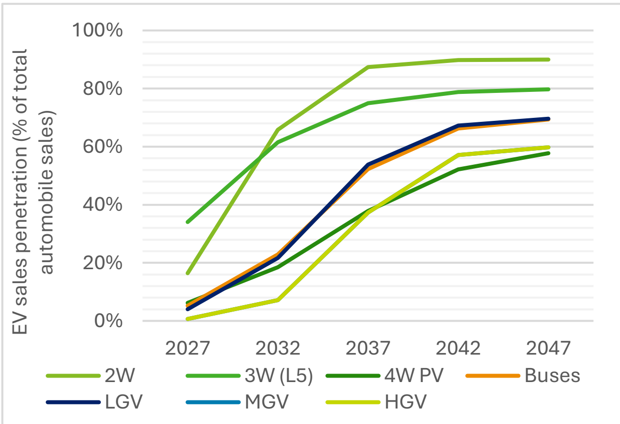
NITI Aayog further estimated the target modal share for EVs in 2047, aligned with the development trajectory of Viksit Bharat @2047. Using these targets, the annual EV sales penetration for each segment has been projected as follows:

Figure 14: EV modal share in each segment by 2047, percentage



Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Figure 15: Projected annual EV sales penetration (2027 to 2047), percentage of total automobile sales

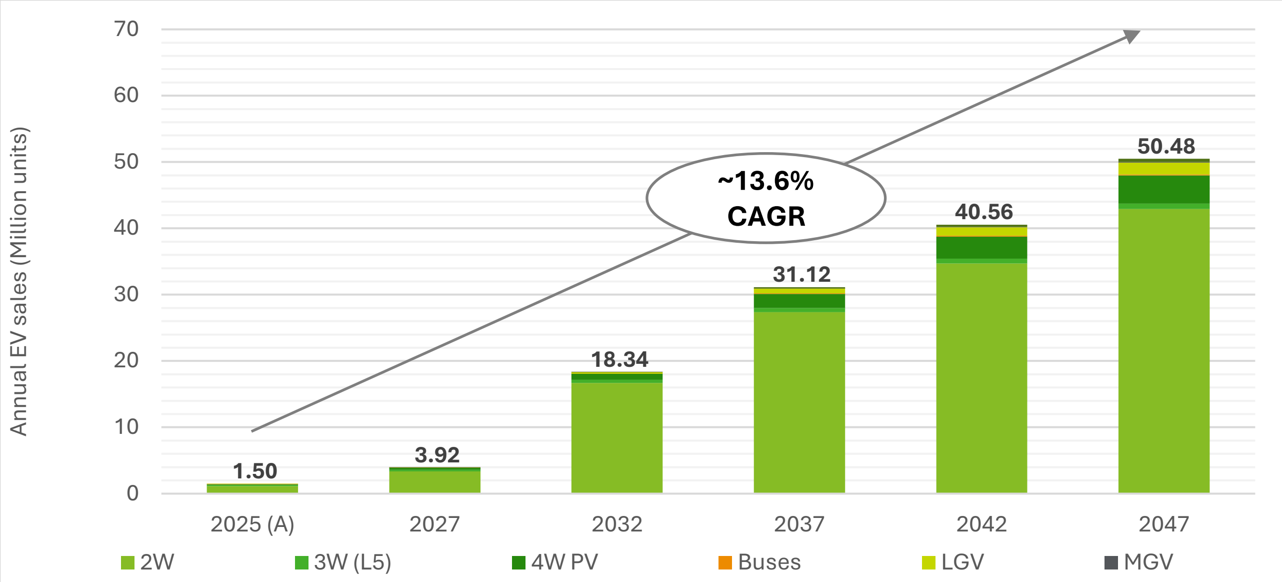


Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Acronyms- HGV: Heavy Goods Vehicle, MGV: Medium Goods Vehicle, LGV: Light Goods Vehicle, 4W PV: 4-wheeler passenger vehicle, 3W (L5): 3-wheeler (L5)

The corresponding EV sales for this trajectory are as follows:

Figure 16: Actual (2025) and projected annual EV sales (2027 to 2047), million units

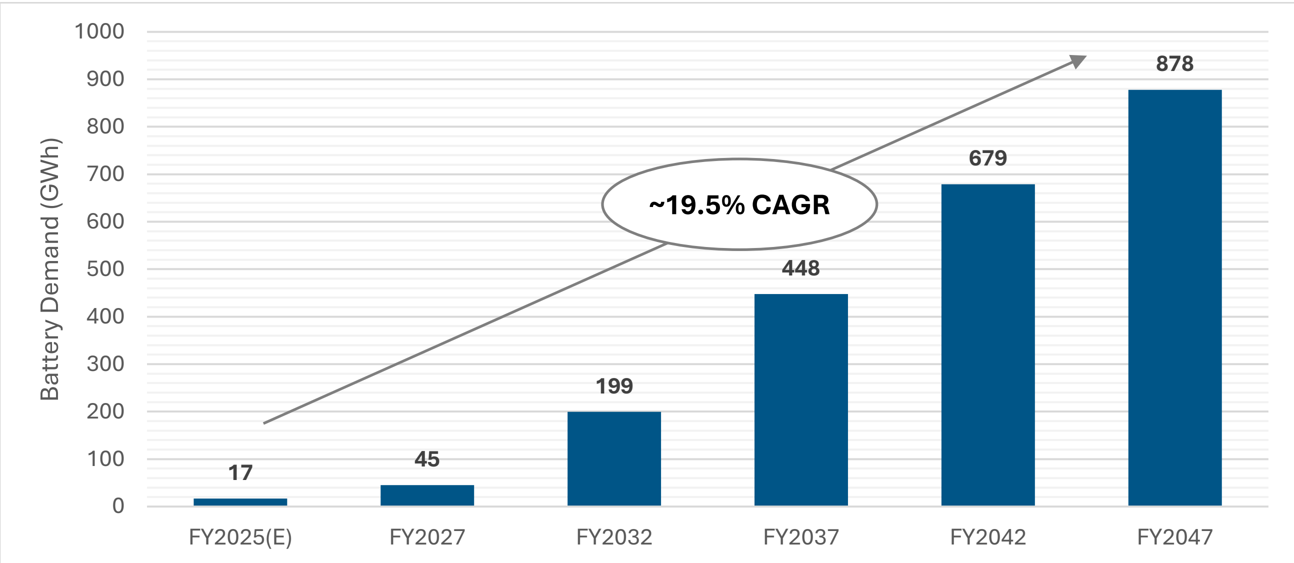


Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Acronyms- HGV: Heavy Goods Vehicle, MGV: Medium Goods Vehicle, LGV: Light Goods Vehicle, 4W PV: 4-wheeler passenger vehicle, 3W (L5): 3-wheeler (L5)

The corresponding annual battery demand from new EV sales is projected to grow from 17.1 GWh in FY2025, to 878.1 GWh in FY2047 at a CAGR of ~19.5%.

Figure 17: Projected annual battery demand from EVs up to FY2047, GWh



Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

3.3.2. Grid-connected stationary storage

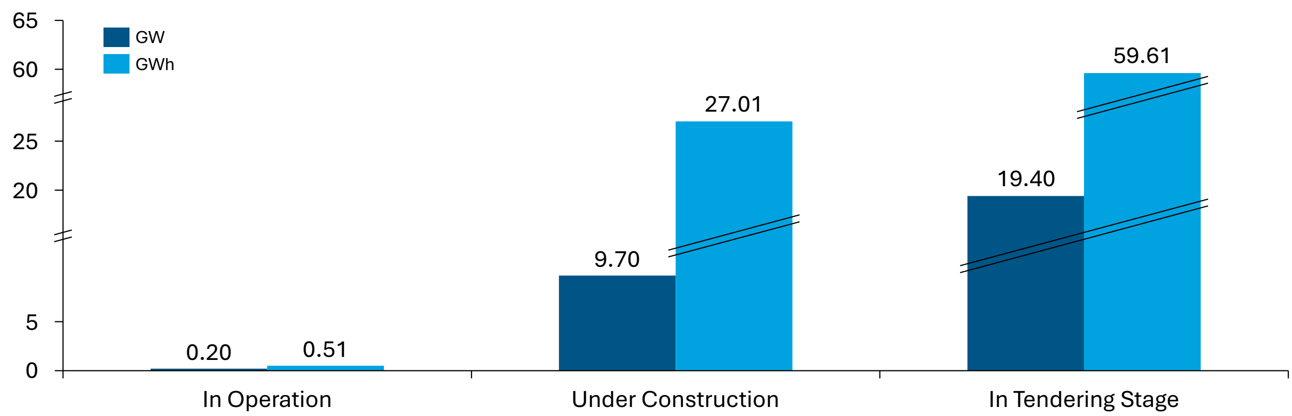
The Indian power sector is experiencing rapid growth in consumption underpinned by economic growth and electrification across sectors. In FY25, total electricity requirement reached ~1,696 terawatt-hours (TWh), at a ~7.5% CAGR over ~1,276 TWh in FY21, while the peak demand rose to ~250 GW, at a ~7% CAGR from FY21. To meet the growing demand, India is also expanding its power generation capacity with concerted focus on renewable energy. In FY25, India's power installed capacity was ~475 GW, up from ~382 GW in FY21 (~5.5% CAGR); however, in the same period renewable installed capacity grew at ~12% CAGR.

India has committed to reducing the emissions intensity of its GDP by 45% by 2030 from 2005 level and has reached its goal of 50% cumulative installed capacity from non-fossil fuel-based energy resources in 2025. The non-fossil fuel-based energy has a very large share of solar and wind, which are intermittent & variable sources of energy. The variability and intermittency of these variable renewable energy (VRE) sources lead to voltage and frequency fluctuations in the grid.

Grid connected Battery Energy Storage Systems (BESS) help stabilize VRE sources like wind and solar by storing excess energy during surplus RE generation and providing backup power during periods of deficient RE generation.

To date, India has deployed 205.10 MW/508.6 MWh of grid-scale BESS capacity, with a further 29.1 GW/ 86.6 GWh in various stages of development[3].

Figure 18: Current state of BESS deployment in India (>1 MWh)



Source: Central electricity authority (CEA)
*All the projects with PPA signed are considered under construction
Also includes FDRE projects whose storage (BESS/PSP) capacity is yet to be finalized.

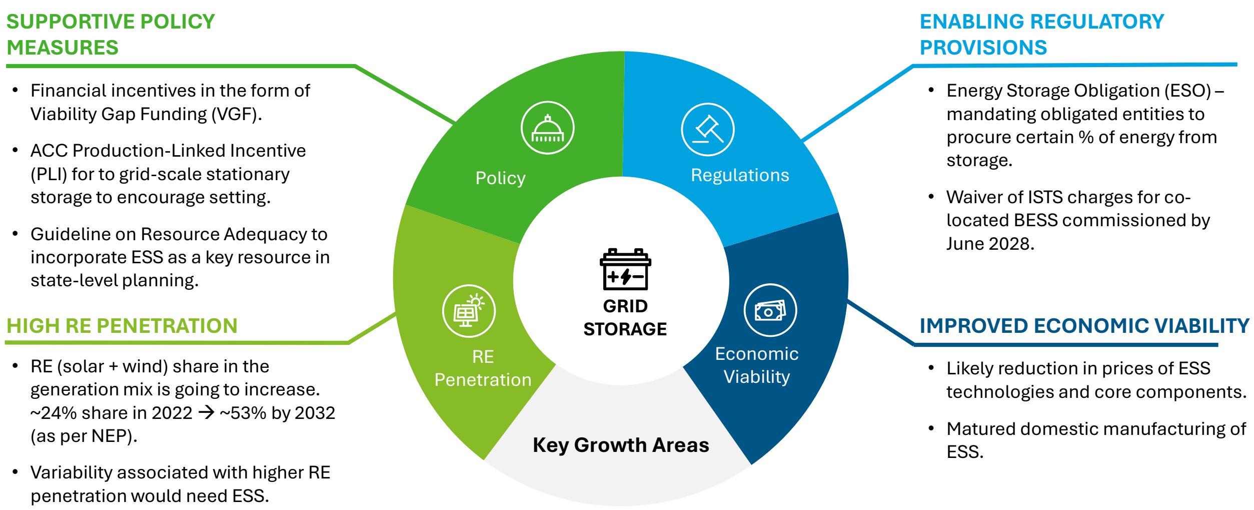
3.3.2.1. Growth drivers

Future grid-scale battery demand will be driven by the rapid growth of renewable energy, which increases the need for storage to manage intermittency and maintain grid stability. Supportive policies and incentives for ACC manufacturing, renewable bundling, and capacity deployment provide strong backing for BESS adoption. Clear regulatory frameworks and mandated integration of storage into projects reduce investment uncertainty and accelerate deployment. Additionally, grid modernization efforts enhance flexibility and resilience, further

[3] As per Central electricity authority (CEA)

expanding opportunities for battery-based storage solutions and driving sustained long-term growth in grid battery demand.

Figure 19: Key growth drivers in grid storage sector



3.3.2.2. Projections and Outlook

The outlook for grid storage is directly tied to India's national climate and energy targets. The Central Electricity Authority (CEA), in its National Electricity Plan (NEP) 2023, has laid out a clear and ambitious trajectory for storage deployment. Aligned with the Viksit Bharat @2047 goal, CEA has projected the requirement of 360 GW/ 1984 GWh BESS by 2047:

Figure 20: India's cumulative BESS installation (2025-26) and requirement by 2047 (GW)

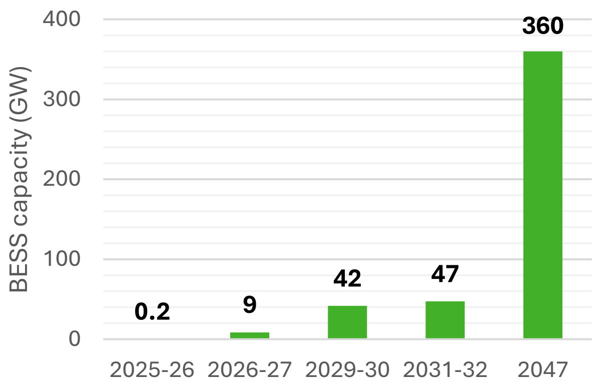
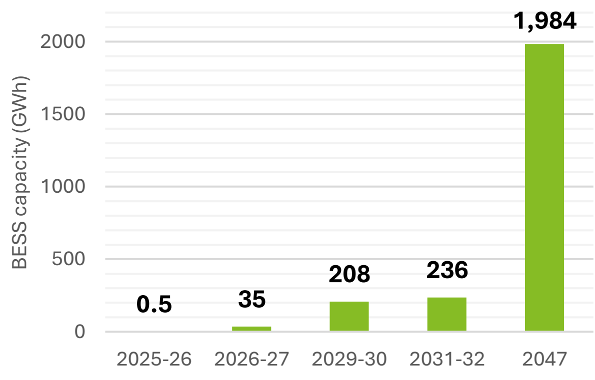


Figure 21: India's cumulative BESS installation (2025-26) and requirement by 2047 (GWh)

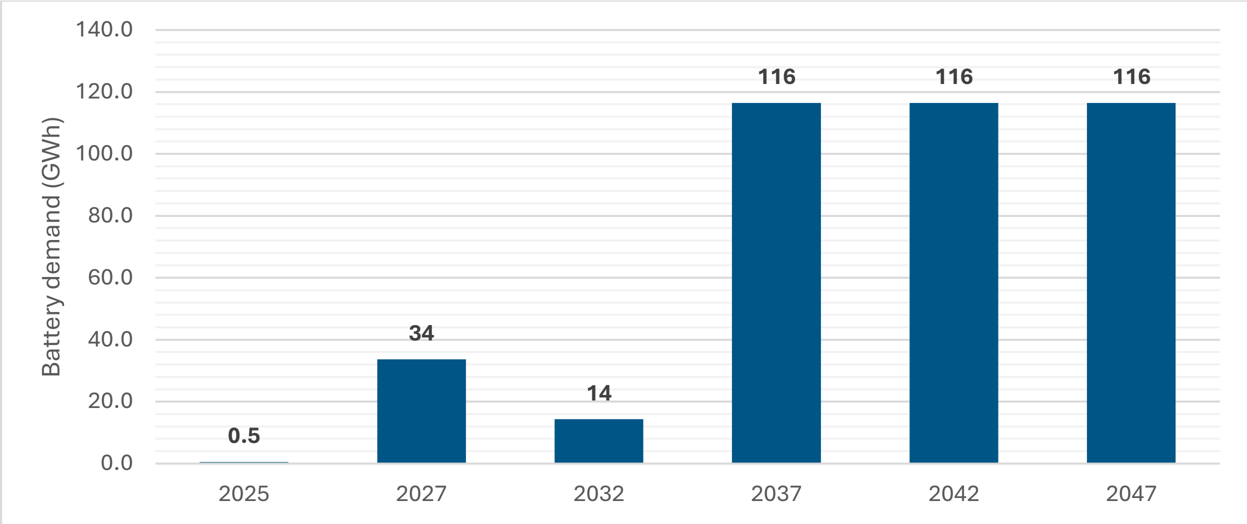


Source: Central Electricity Authority (CEA)

The average duration of energy storage, as indicated by the ratio of total storage capacity (GWh) to throughput (GW), is also expected to increase from ~2.5 hours (as of November 2025) to ~5.5 hours in 2047.

The annual battery demand against these requirements is charted as follows:

Figure 22: Annual battery demand from grid up to 2047, GWh



Source: Central Electricity Authority (CEA)

3.3.3. Consumer electronics

Consumer electronics has been the largest and most stable source of battery demand historically. Rising smartphone penetration, growth in laptops and tablet sales, and shorter device replacement cycles steadily expanded annual battery consumption through the 2010s and early 2020s. High energy density lithium-ion chemistries became the standard, replacing earlier nickel cadmium-based batteries. NITI Aayog estimated demand of lithium-ion batteries from consumer electronics to be ~2.1 GWh in 2022.[4]

This steady increase is driven by higher digital penetration, shorter device replacement cycles, the shift toward high performance smartphones and laptops, and the rapid adoption of wearables and connected devices. Mobile phone shipments remained broadly stable over 2017-2025, rising from ~229[5] million units in 2017 to ~271[5] million units by 2025. However, the mix is changing sharply: the share of premium phones increased from 8%[5] in 2017 to 25%[5] in 2025, while utility phones fell from 56%[5] to 18%[5].

PC shipments show clearer growth, increasing from ~6.2[6] million units in 2017 to ~13.6[6] million units in 2025. PC penetration has nearly doubled from 2019 to 2025, reflecting wider adoption of personal computers in households, driven mainly by online learning, hybrid work models, and the shift to remote education during the COVID period. This trend is likely to continue as digitization deepens across education, work and public services, and as AI-enabled applications increase everyday computing needs pushing more households to adopt PCs and upgrade to higher performance devices.

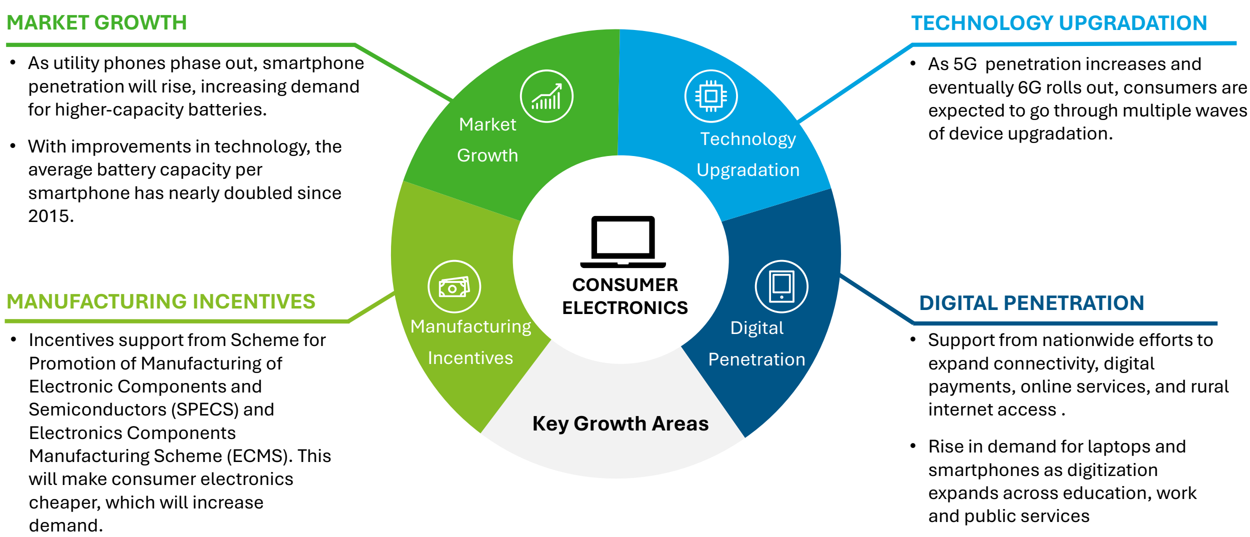
3.3.3.1. Growth drivers

Future battery demand in the consumer electronics segment will be driven by the rapid adoption of smartphones, tablets, and connected devices, supported by faster upgrade cycles and the growing digital user base. Demand for high performance, energy-intensive devices with advanced features are increasing the need for larger, higher energy density batteries. Nationwide digital inclusion initiatives and expanding IoT ecosystems are creating new, high-volume segments for long-life, small format batteries.

[4] NITI Aayog, Advanced Chemistry Cell Battery Reuse and Recycling Market in India
[5] MeitY, Forecast: PCs, Tablets and Mobile Phones, Worldwide, Gartner Market Analysis
[6] Forecast: PCs, Tablets and Mobile Phones, Worldwide, Gartner Market Analysis

Additionally, local manufacturing and PLI-driven electronics production are strengthening domestic supply chains and further driving battery demand, ensuring sustained growth across the consumer electronics sector.

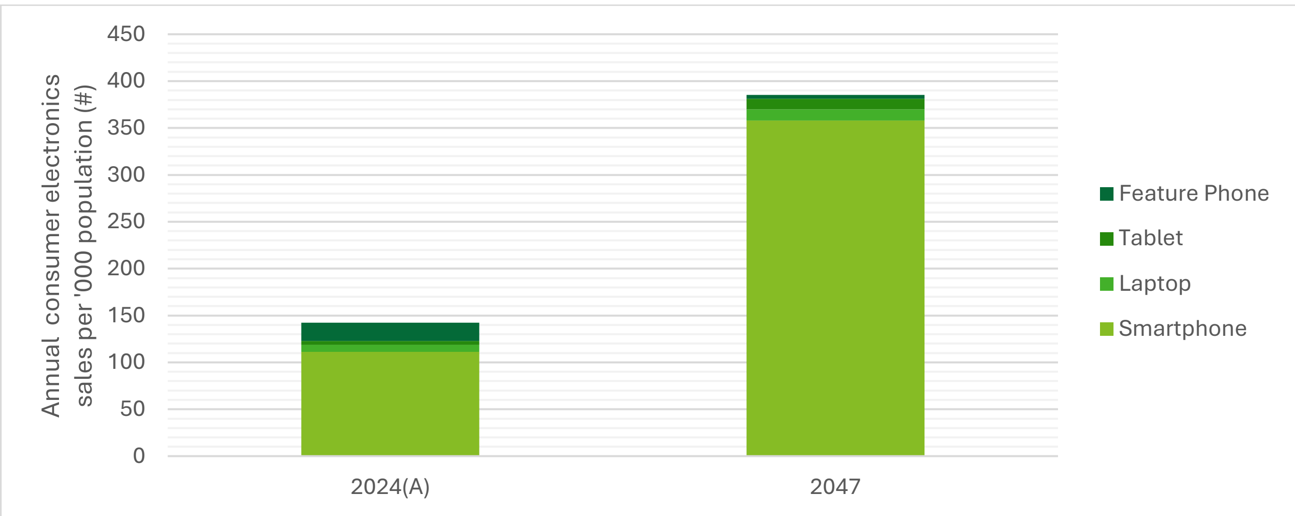
Figure 23: Key growth drivers in consumer electronics sector



3.3.3.2. Projections and Outlook

Rising GDP per capita[7] and associated incomes are expected to drive up sales per capita of smartphones, laptops, and tablets while the share of low-end feature phones is expected to reduce. As India approaches its goal of Viksit Bharat @2047, the sales per capita for these battery-powered consumer electronics items is likely to change as follows:

Figure 24: Annual consumer electronics sales per '000 population, 2024 and 2047

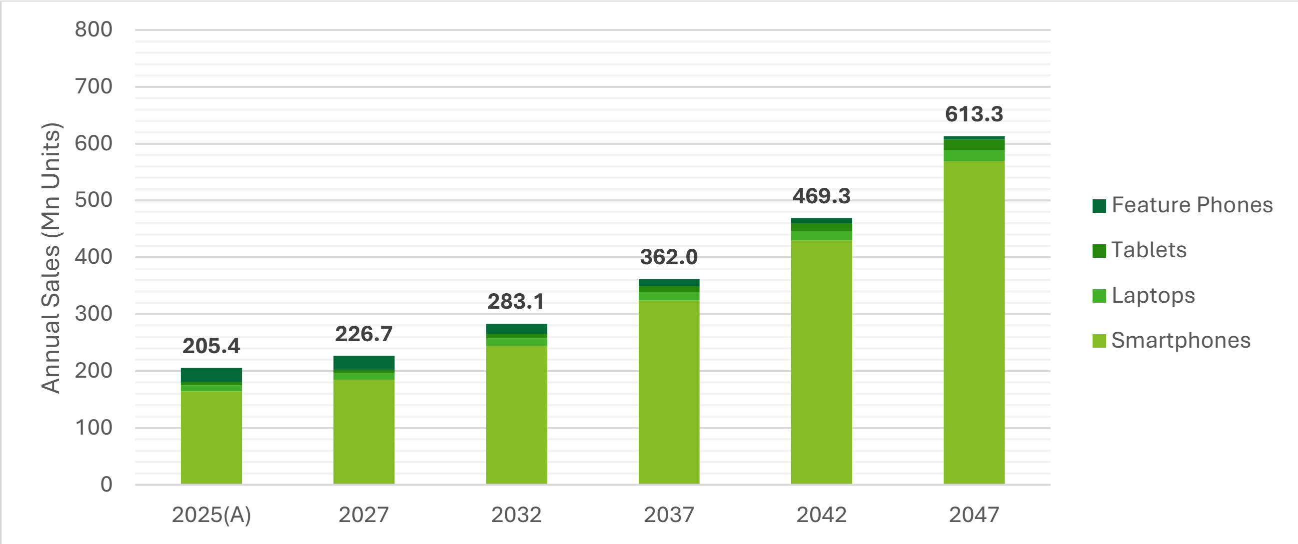


Source: MeitY, Gartner Market Statistics, analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Combined with the expected rise in population[8], overall sales are expected to grow as follows:

[7] As per NITI Aayog's IESS 3.0
[8] As per NITI Aayog's IESS 3.0

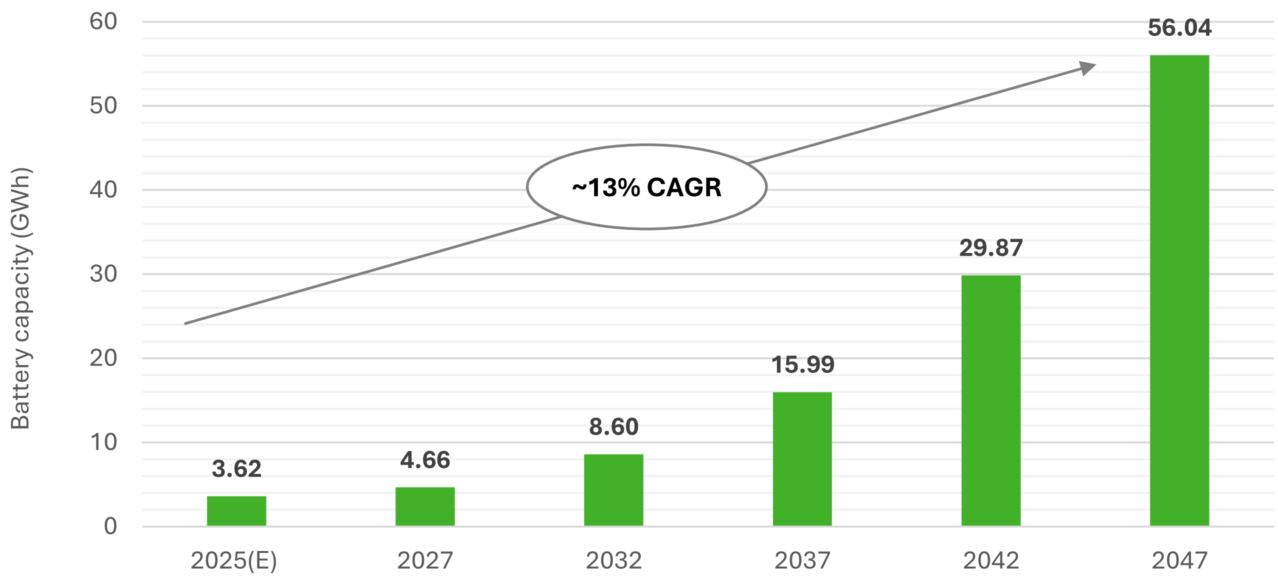
Figure 25: Actual (2025) and projected annual sales (2027 to 2047), million units



Source: Gartner Market Statistics, analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Based on the assumptions on battery capacity (in kWh) and annual capacity growth (mentioned in the Annexure section), the associated annual battery requirement from consumer electronics sector is expected to reach ~**56 GWh** by 2047.

Figure 26: Projected annual battery demand from consumer electronics sales, GWh



3.3.4. Telecom towers

India's telecom infrastructure has expanded rapidly over the last decade, reflecting a shift from voice-centric networks to data-intensive digital connectivity. As of 2025, India is the second-largest telecommunication market and has the second-highest number of internet users in the world.[9] In 2020, the country had about 2.25 million base transceiver stations (BTS) supported by nearly 0.63 million towers, largely built to deliver nationwide 4G coverage. By 2025, this installed base has grown to around 3.16 million BTS on roughly 0.85

[9] IBEF's Telecommunications Industry Report (Nov 2025)

million towers[10]. At present, the urban and rural segments account for 56.1% and 43.9% of the total Indian telecom market, respectively.

Figure 27: Number of towers installed in last 5 years, 000s

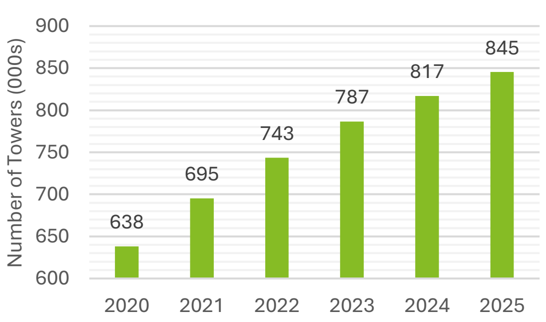
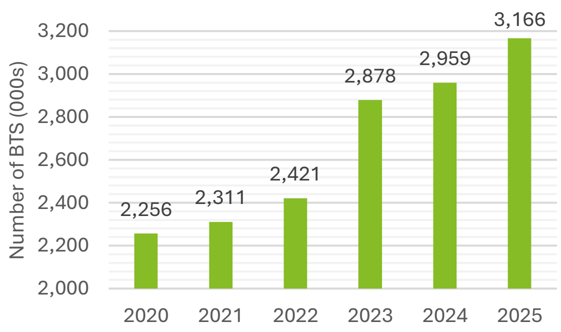


Figure 28: Number of BTS installed in last 5 years, 000s



Source 4: Department of Telecommunications (DoT)

This expansion has been driven by strong growth in mobile data demand, the early rollout of 5G, and network densification in urban areas, transport corridors, and enterprise clusters. The current network is therefore significantly denser and more capacity-oriented than in the past, marking a clear structural evolution in India's telecom infrastructure. However, the need for round-the-clock power has also led to dependence on diesel generator sets to provide backup power for multiple hours in the day- ranging from an average of ~9.5 hours in urban areas to ~13.5 hours in rural areas in 2022.[11]

3.3.4.1. Growth drivers

India's telecom sector is witnessing strong, transformational growth driven by four key factors – rapid 5G rollout, rising digital adoption, increasing data consumption, and supportive government policies. The expansion of 5G networks now covers almost all districts and reaches around 85% of the population, supported by more than five lakh" base stations[12]. The continued push under the Digital India initiative is further expanding connectivity, digital services, and digital payments across both urban and rural regions. As connectivity improves, data consumption is also rising rapidly; as per IBEF's Telecommunications Industry Report (Nov 2025), monthly smartphone data usage expected to increase from about 36 GB to nearly 65 GB by 2031.

Government support has been playing a crucial role in development of the sector. INR 12,195 crore PLI scheme for telecom equipment is encouraging domestic manufacturing and reducing import dependence. Additionally, initiatives like the Telecom Technology Development Fund (TTDF) Scheme are promoting innovation in areas such as indigenous telecom technologies and 6G research.

[10] Department of Telecommunication (DoT)
[11] India Energy Security Scenarios (IESS) 2047, NITI Aayog
[12] 2025 Year End Review for Department of Telecommunications (PIB)

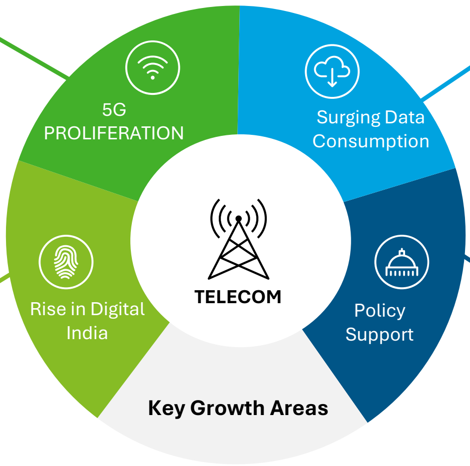
Figure 29: Key growth drivers in the Telecom sector

5G PROLIFERATION

- Increased use of 5G enabled devices.
- Increased preference towards advanced smartphones, faster processors, and AI-enabled features.
- India has established of 100 5G labs across academic institutions nationwide.

RISE IN DIGITAL INDIA

- Support from nationwide efforts to expand connectivity, digital payments, online services, and rural internet access.
- Tele-density of rural subscribers is currently 59.52% (2025) and is expected to rise considerably in the next 5-10 years.



SURGING DATA CONSUMPTION

- Mobile data usage per active smartphone is expected to rise from 36 GB per month to 65 GB per month by 2031 (Ericsson Mobility Report).
- India is projected to surpass one billion 5G subscriptions by the end of 2031 (Ericsson Mobility Report).

POLICY SUPPORT

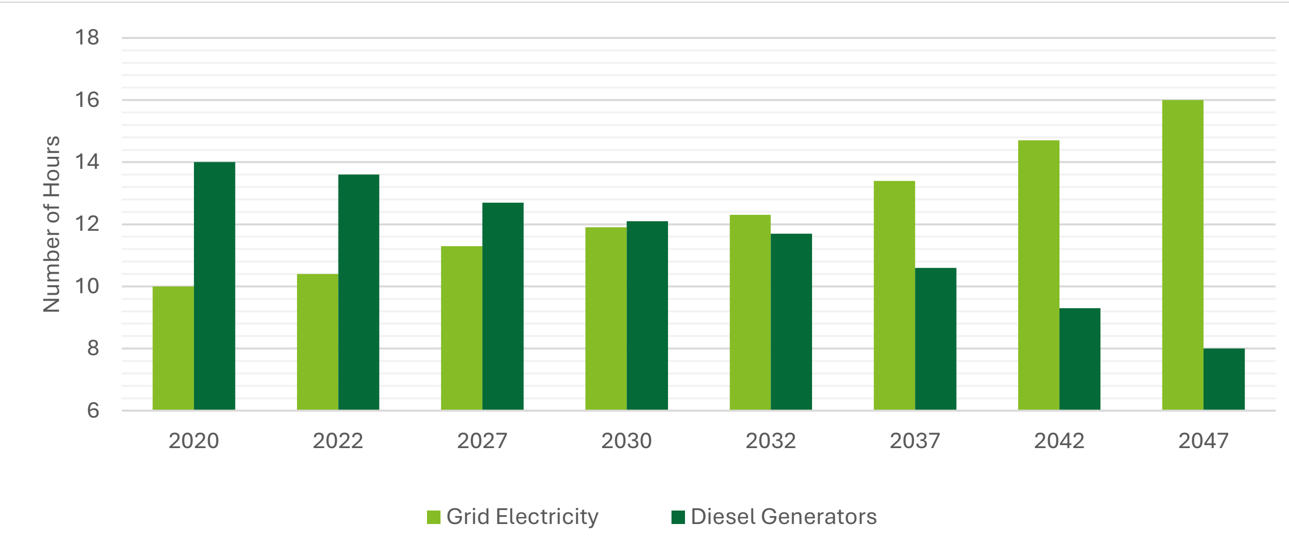
- Production-linked incentive (PLI) scheme for telecom & networking products with an outlay of ₹12,195 crore.
- Launch of Telecom Technology Development Fund (TTDF) scheme aims to accelerate innovation and R&D in telecom, including 6G technologies.

3.3.4.2. Projections and Outlook

The projected outlook indicates a sustained and structural expansion of India's telecom infrastructure over the long term. Both BTS and tower deployments are expected to grow steadily, reflecting rising data demand, deeper network densification, and the progressive evolution of mobile technologies. This expansion is gradual in the near term and accelerates over time, underscoring the increasing infrastructure intensity of future networks.

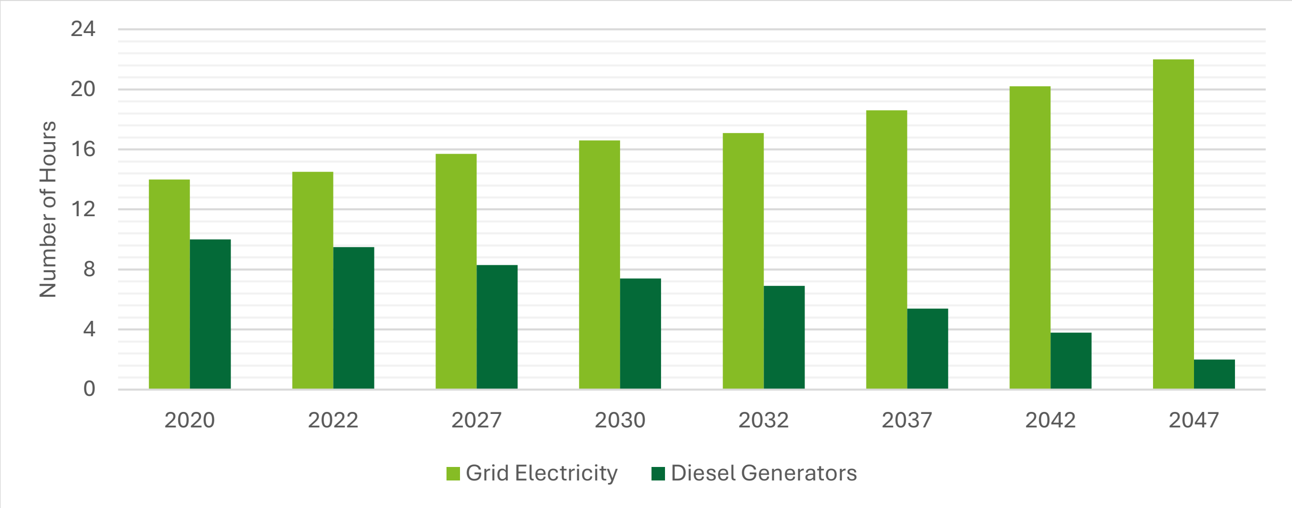
The operating profile of telecom towers in both rural and urban areas show a clear shift in energy use. Improving grid availability has increased the number of hours towers operate on grid electricity, making it the dominant power source, while reliance on diesel generators is steadily declining. This shift is raising overall electricity consumption, especially as network density and traffic loads continue to grow. As a result, the need for batteries is increasing to manage grid intermittency and to provide reliable backup in place of diesel generators during outages, load variations, and peak demand hours.

Figure 30: Hours of operation of telecom towers on various energy sources per day in rural areas



Source: India Energy Security Scenarios (IESS) 2047, NITI Aayog

Figure 31: Hours of operation of telecom towers on various energy sources per day in Urban areas

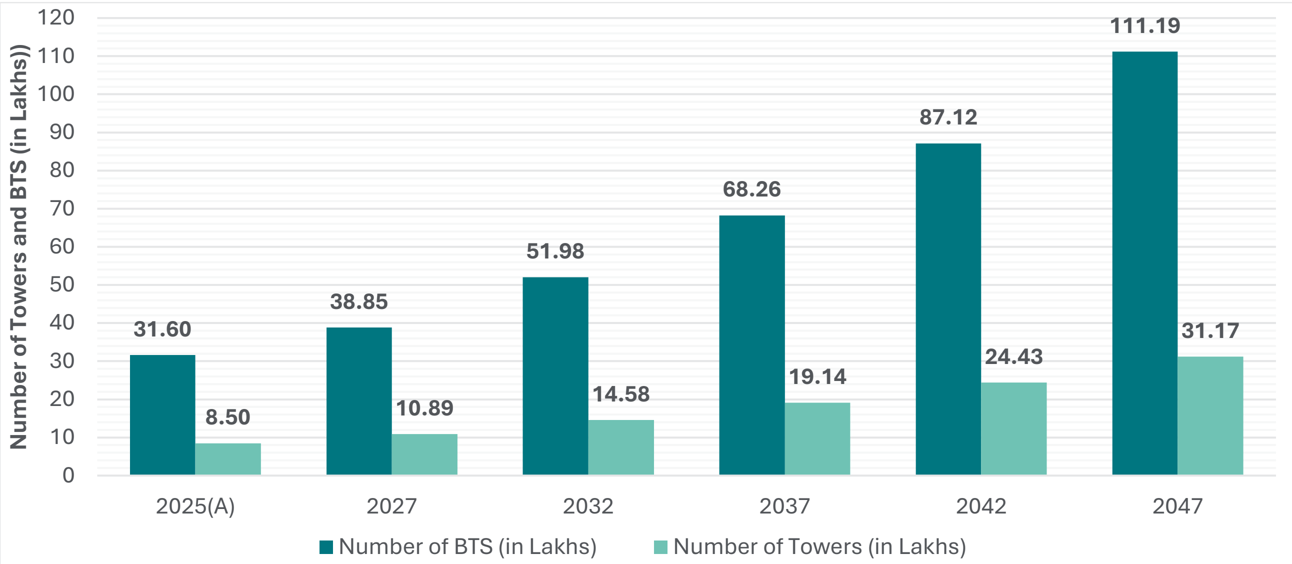


Source: India Energy Security Scenarios (IESS) 2047, NITI Aayog

Electricity consumption for telecom infrastructure is expected to increase steadily over the long term, reflecting network densification, higher BTS intensity, and rising data traffic. At the same time, dependence on grid electricity will continue to deepen, as improved availability and policy-driven decarbonization reduce reliance on diesel-based generation. This shift will make grid power the primary energy backbone for tower operations, increasing exposure to grid outages, variability, and peak demand charges.

In 2027, the number of BTS is projected at 38.85 lakh, supported by 10.89 lakh towers. By 2047, this is expected to rise sharply to 111.19 lakh BTS and 31.17 lakh towers, highlighting a near threefold increase over two decades.

Figure 32: Actual (2025) and projected growth in total BTS and Towers (in Lakh)

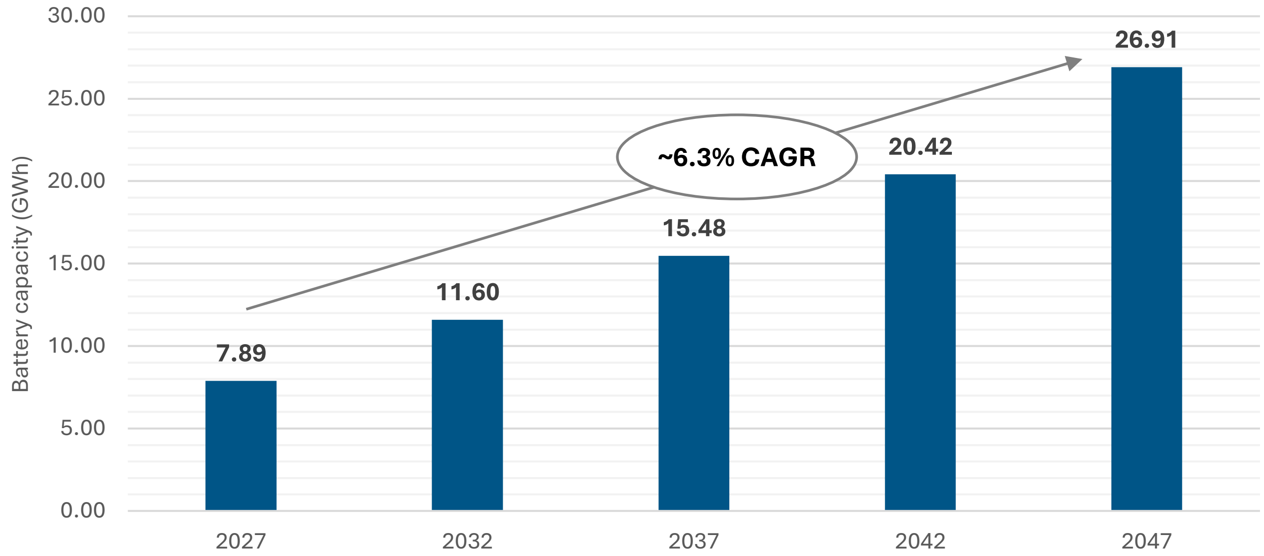


Source: India Energy Security Scenarios (IESS) 2047, NITI Aayog

The combined battery demand for BTS and towers reaches about **9.40 GWh by 2030**, reflecting higher power needs, increasing network density, and the growing role of 5G equipment. Over the long term, this requirement rises sharply to around **26.91 GWh by 2047**, underscoring the critical role of batteries in ensuring reliable, continuous,

and resilient telecom operations as networks become more power-intensive and always-on. Overall, battery backup systems are becoming a core part of India's telecom power infrastructure rather than a supporting asset.

Figure 33: Projected annual battery demand from telecom sector up to 2047, GWh

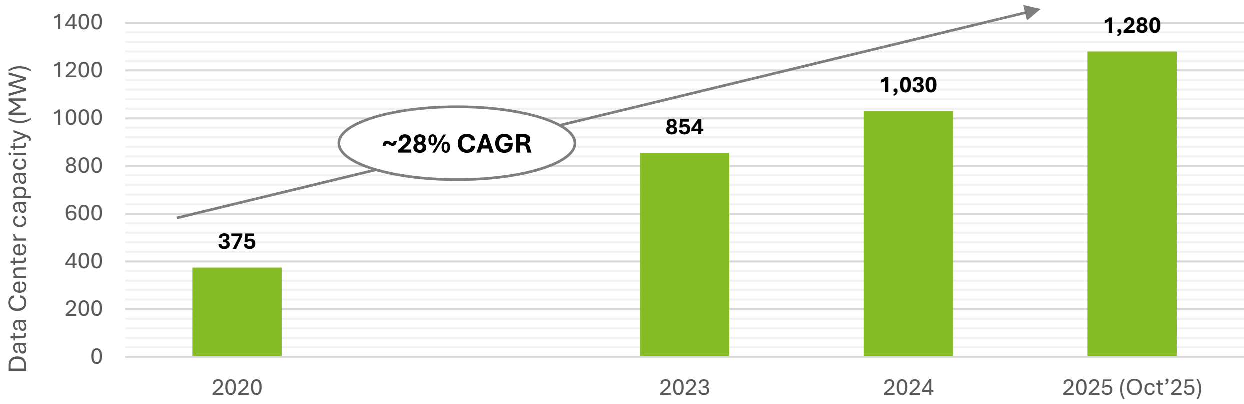


Source: India Energy Security Scenarios (IESS) 2047, NITI Aayog, Department of Telecommunications (DoT)

3.3.5. Data centers

India's rapid growth in AI and cloud services is driving an unprecedented expansion of data centers, turning them into one of the country's most power-dense and energy-critical infrastructures. As these facilities scale to handle massive computational loads and continuous data flows, the need for reliable, high-capacity energy storage becomes central to their resilience. Advanced battery systems are increasingly essential to support uninterrupted operations, manage power quality, and enable a smoother integration of renewable energy. With data centers set to multiply in size and complexity, their long-term storage requirements will expand sharply, adding substantial demand to India's overall battery ecosystem.

Figure 34: India's Data center industry growth – 2020 to 2025, MW



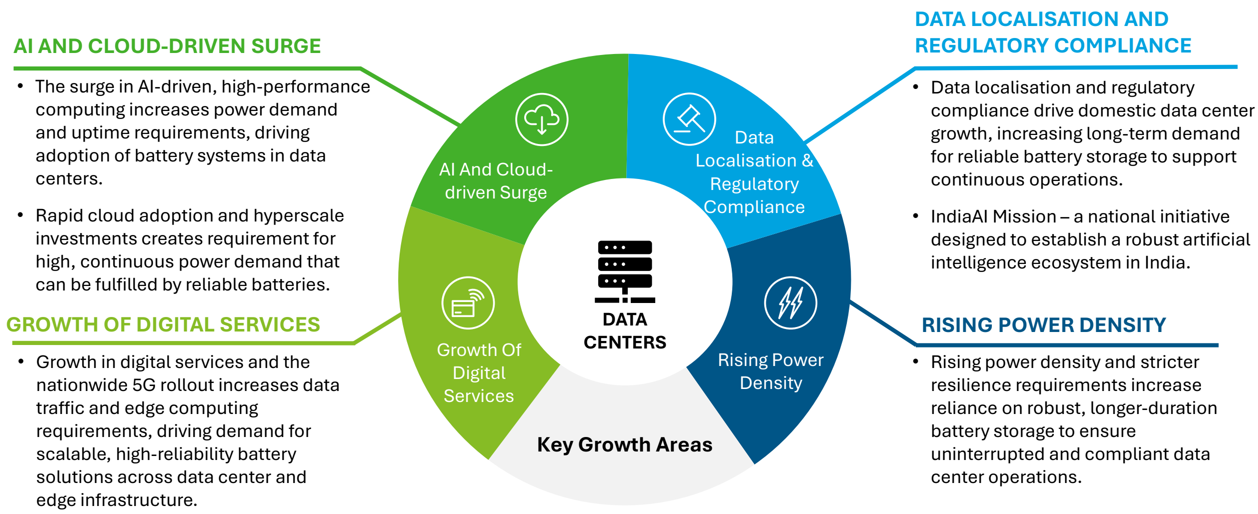
Source: MeitY

3.3.5.1. Growth drivers

Future battery demand in data centers will be driven by the rapid scale-up of AI-driven, high-performance computing and the associated need for continuous uptime at significantly higher power densities. Data localization requirements and regulatory compliance will accelerate domestic data center capacity additions, directly increasing long-term demand for high-quality battery-backed power systems.

Large hyperscale investments and rapid cloud adoption will further elevate the requirement for high-capacity, high-reliability energy storage to support uninterrupted operations. At the same time, growth in digital services, edge computing, and nationwide 5G rollout will expand distributed data center infrastructure, strengthening demand for scalable battery solutions.

Figure 35: Key growth drivers in data centers

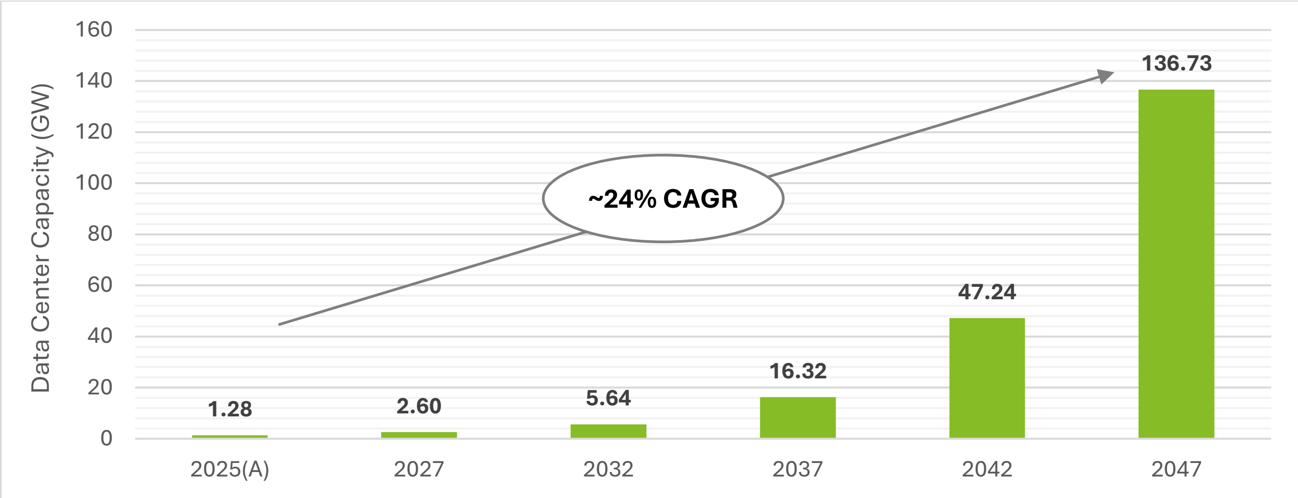


3.3.5.2. Projections and Outlook

As per inputs from MeitY, power demand from the data center industry in India has grown from 375 MW[1] in 2020 to 1280 MW[2] by October 2025. In addition, Ministry of Power in its response to a Rajya Sabha question, submitted that power demand due to upcoming data centres in India is likely to rise and is estimated to reach 5,640 MW by FY 2031-32.[13] This represents a ~24% CAGR in data centre requirements. As per this trajectory, the total data centre capacity is expected to reach ~136 GW by 2047.

[13] Ministry of Power - Rajya Sabha Unstarred Question No.798 answered on 10.02.2025

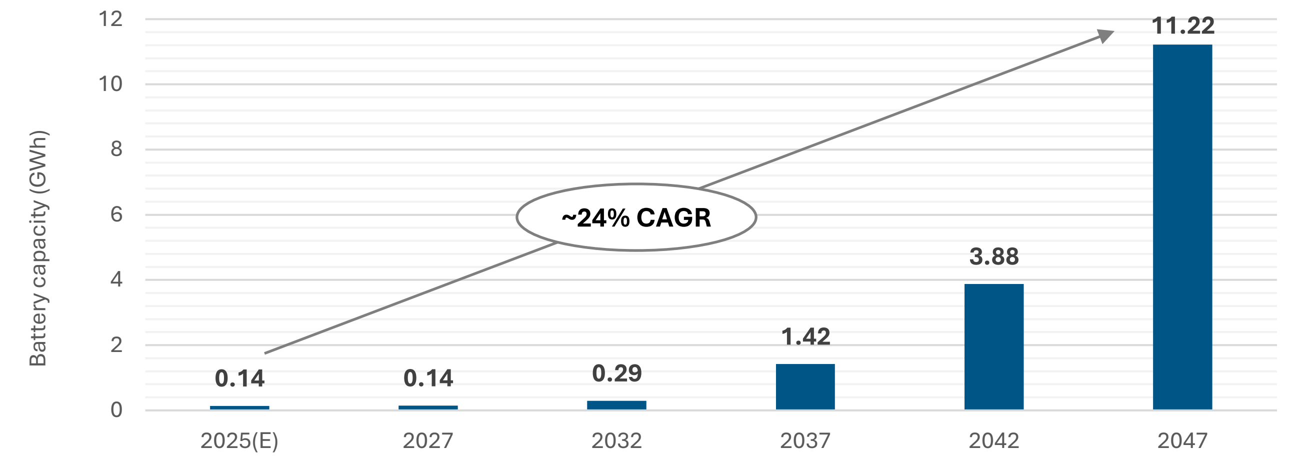
Figure 36: Actual (2025) and projected Data Center capacity (2027 to 2047), GW



Source: Analysis based on data from MeitY and MoP

It is assumed that the data centres will procure 50%, 75% and 100% of their power requirement from renewable sources by 2030, 2035 and 2040, respectively. Considering 30 MWh BESS requirement per 100 MW RE Round-the-Clock (RTC)[14], annual battery requirement for the telecom sector is projected as follows:

Figure 37: Projected annual battery demand from data center sector up to 2047, GWh



Source: India Energy Security Scenarios (IESS) 2047, NITI Aayog, Department of Telecommunications (DoT)

3.3.6. C&I power backup

The C&I segment is the largest power consumer representing ~50% of country's annual energy demand.[15] Over the last five (5) years, energy requirement from the C&I segment has grown at ~4% CAGR. The total energy requirement, in case of industrial consumer, is met through two (2) arrangements – (1) supply from utility/ DISCOM, and (2) supply from captive generation plant. Within captive generation, the RE sources currently represent ~11% share in the total installed capability.

[14] WBCSD - Business guide to energy storage adoption in India (2023)
[15] CEA General Review Report (2025)

Figure 38 All India energy demand from C&I sector (FY20-24), BUs

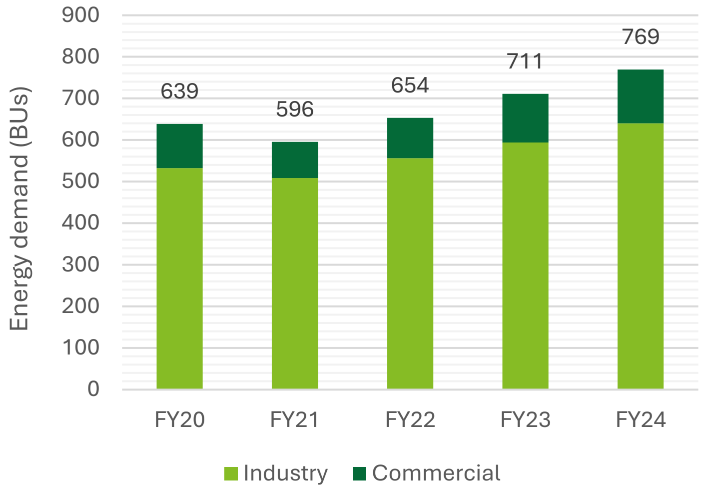
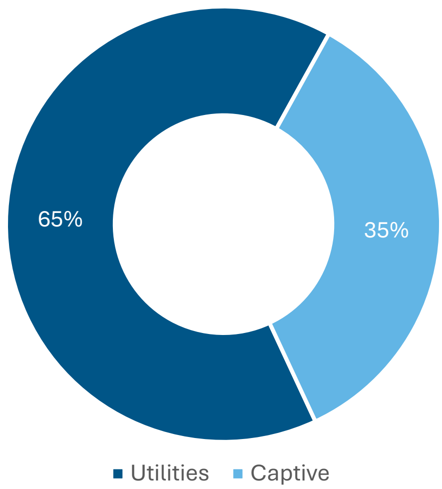


Figure 39 Share of utility and captive consumption in HT Industrial sector FY24, %



Within C&I, the industry sector accounted for the largest share of 42 percent of the total electricity consumption in 2023-24. Electricity consumption in the industrial sector increased from 440[16] TWh in 2016-17 to 645 TWh in 2023-24. Over the last few years, industrial production, urban infrastructure, data centers, and commercial real estate have expanded rapidly. This steady growth reflects rising automation, electrification of industrial processes, and the expansion of service-based infrastructure such as IT parks and retail chains, all of which depend on reliable power supply.

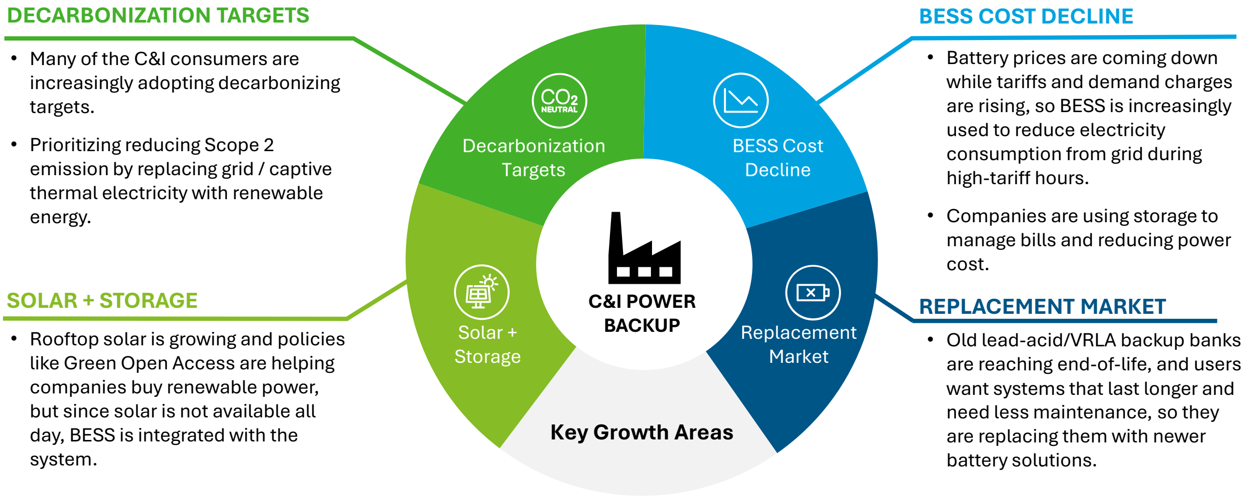
Battery energy storage plays an increasingly vital role in C&I operations for ensuring power reliability and integrating renewable sources.

3.3.6.1. Growth drivers

Battery demand in the C&I sector will be driven by the decarbonization mandate and targets, need for reliable power, cost control and the shift toward cleaner energy. C&I consumers are expected to adopt battery storage as an alternative to diesel backup, while falling battery costs and rising power tariffs are improving the economics for peak management. The expansion of rooftop solar and renewable procurement is further accelerating demand for co-located storage. In parallel, replacement of legacy lead-acid systems and diesel generator sets is creating a steady base of recurring demand.

[16] (MoSPI, 2024), (CEA, 2024), and (MoPNG, 2024) BEE_India_Energy_Scenario_Report-2024_web_version-rev2.pdf

Figure 40: Key growth drivers for storage in C&I Sector

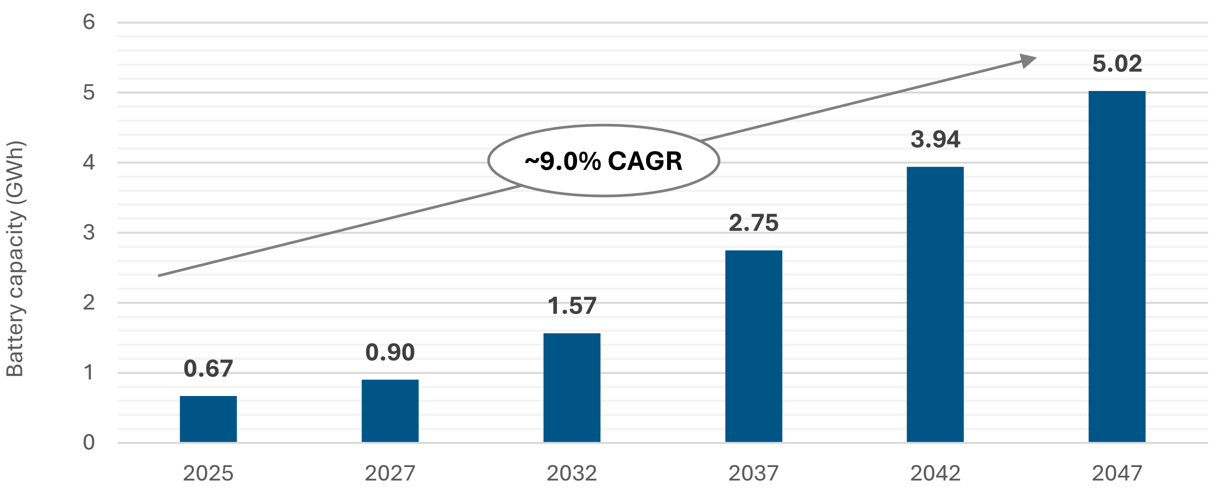


3.3.6.2. Projections and Outlook

To determine the BESS requirement from the C&I segment, it is assumed that by 2047, 90% of the captive generation of the C&I consumers will have moved to renewable energy sources. In addition, 25% of the utility-based procurement companies will have also moved to captive RE generation.

Considering a 30 MWh BESS requirement per 100 MW RE RTC[17], cumulative BESS requirement from C&I segment by 2047 is projected to be ~61 GWh with the following annual BESS demand:

Figure 41: Projected annual battery demand from C&I up to 2047, GWh



[17] WBCSD - Business guide to energy storage adoption in India (2023)

3.3.7. Railways

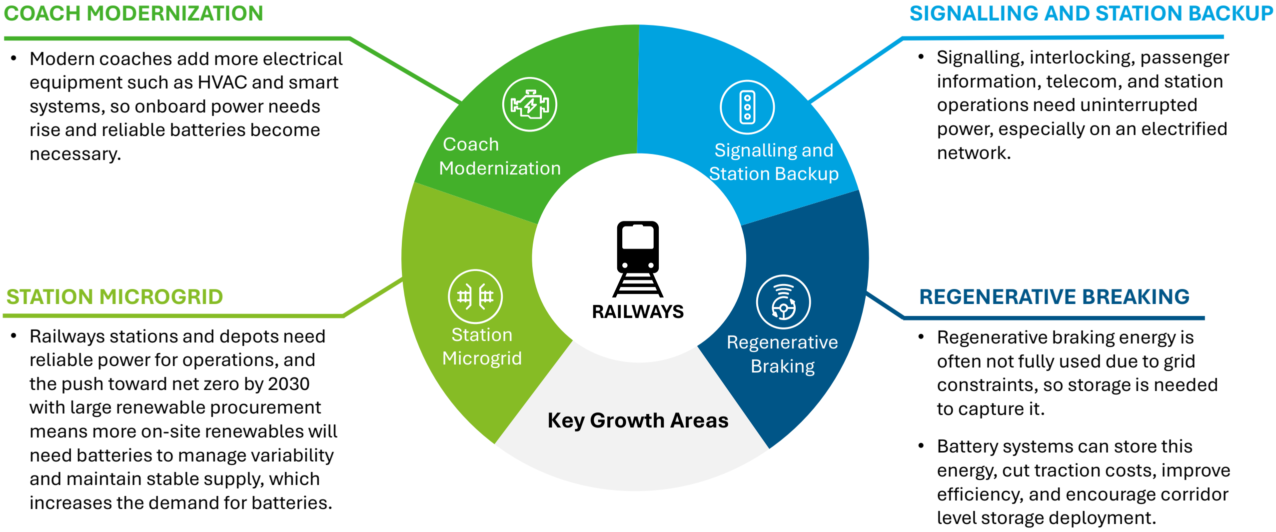
Indian Railways is completing an ambitious electrification program and is now close to 100 percent electrification of its broad-gauge network. Rail electrification has accelerated since 2014, and roughly 94 percent of track-km was electrified by early 2024. Indian Railways is one of the largest single consumers of electricity in India, using on the order of more than 30[18] TWh annually for traction and non-traction needs. These facts underscore the sector's scale and the strategic importance of efficient energy management across traction, stations, yards and workshops.

Batteries serve four core roles for rail systems such as short-term bridging of power during supply disturbances at station/yard equipment, wayside energy capture and reuse of regenerative braking, auxiliary power and microgrid support for stations and depots, and resilience for operations (for example, backup for signaling, telecom and station services). UPS banks for signaling/station critical loads commonly range from a few hundred kWh to 1-2 MWh depending on site scale. Government and industry reports also note that not all regenerative energy is currently captured and a significant share is dissipated unless returned to the grid or stored.

3.3.7.1. Growth drivers

Future battery demand in the railways sector will be driven by coach modernization and higher onboard power loads, upgrades in signaling and telecom systems, and the need for reliable station backup to avoid service disruptions. Battery systems are increasingly preferred because they provide instant backup for critical operations, reduce dependence on diesel generator sets, and help improve energy efficiency through regenerative braking by storing recovered braking energy for later use. As more stations adopt microgrids and on-site renewables, batteries will play a larger role in storing VRE and power from regenerative braking, smoothing supply fluctuations, and ensuring uninterrupted rail operations.

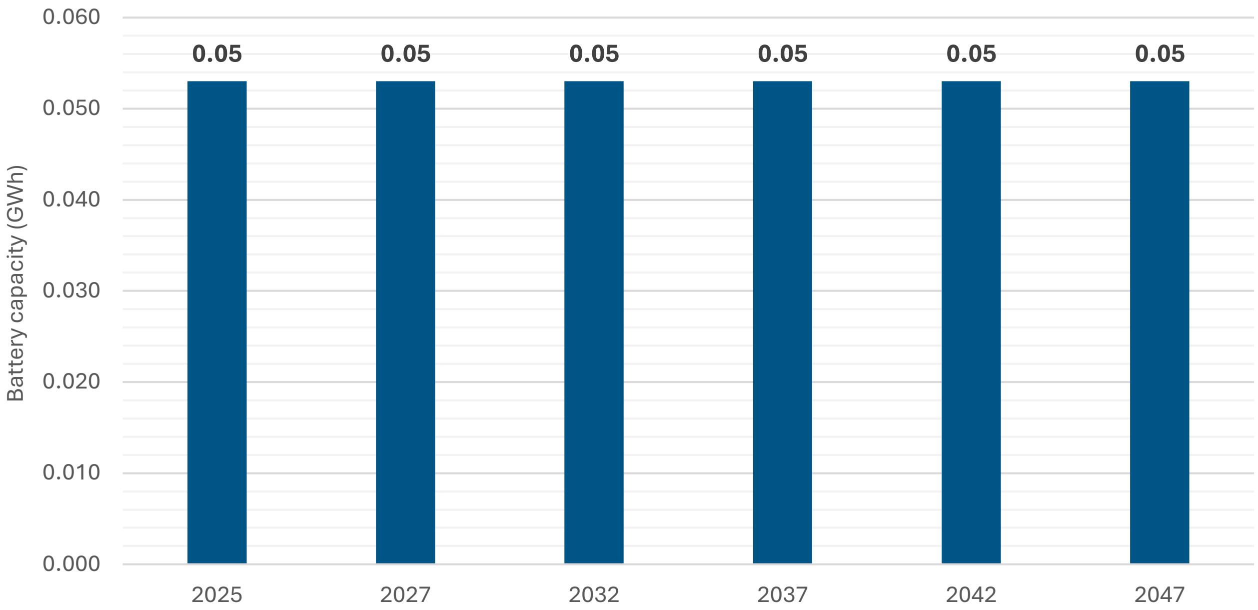
Figure 42: Key growth drivers in railways sector



Based on the inputs received from the Ministry of Railways, the current battery capacity per coach in Vande Bharat Trains is approximately 17.68 kWh, and in view of the envisaged induction of modern passenger coaches till 2047, the total battery requirement up to 2047 from Railways is expected to be 1060.80 MWh.

[18] BEE- Impact of Energy measures

Figure 43: Projected annual battery demand from Railways (passenger coaches) up to 2047, GWh



Source: Ministry of Railways

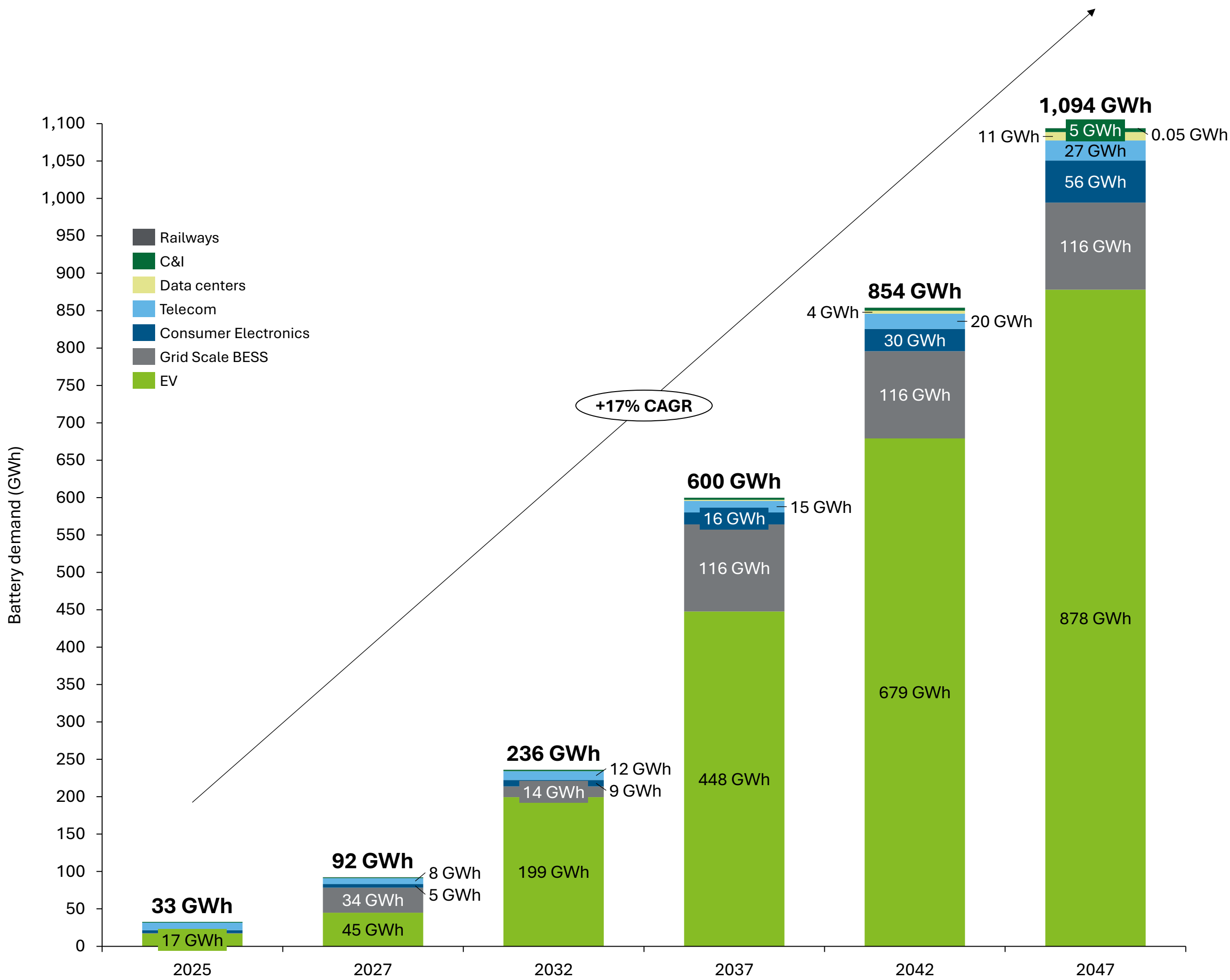
Additional sources of demand are also emerging, including the potential replacement of lead-acid batteries within the existing fleet with ACC batteries, deployment of BESS at traction substations, and the development of state-of-the-art hydrogen trains.

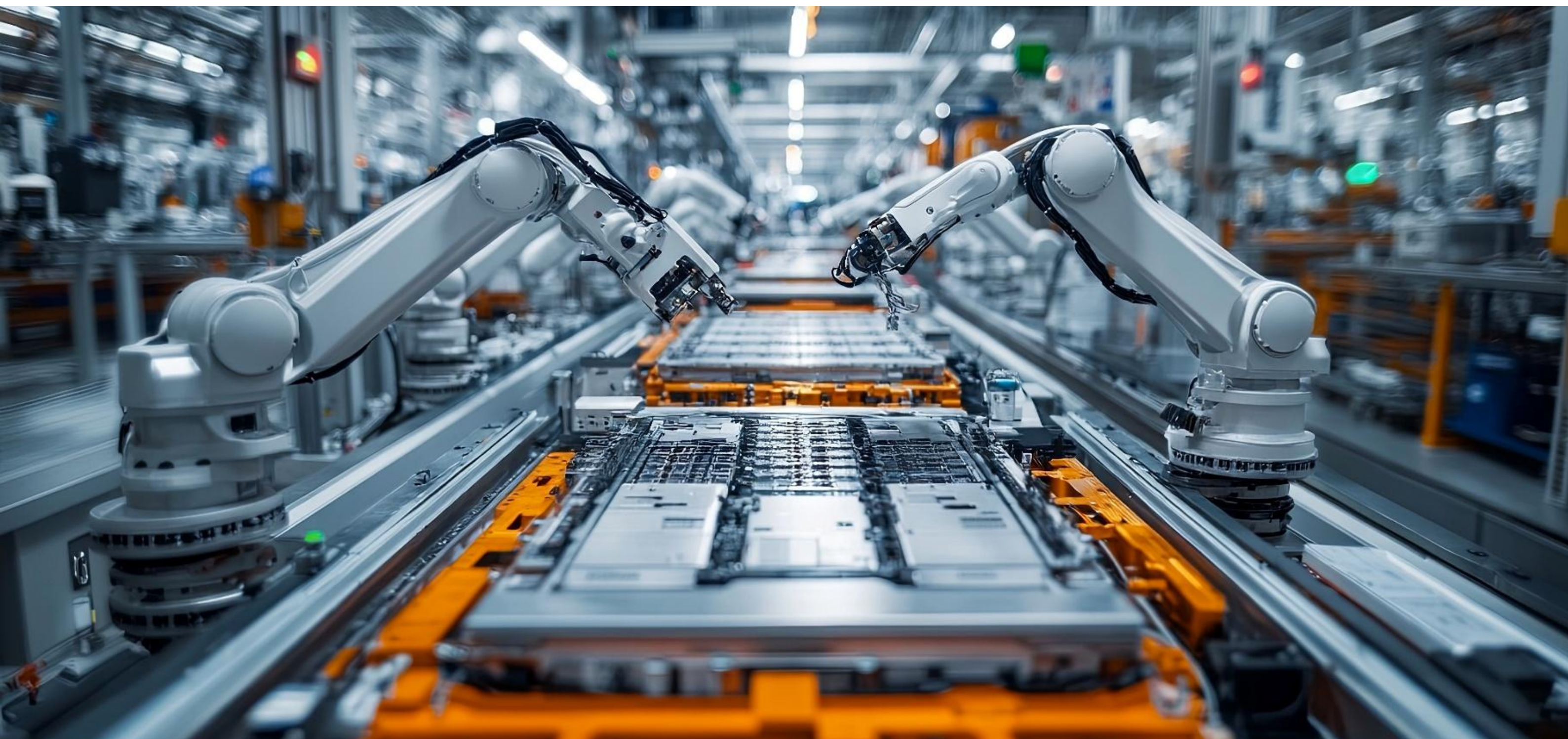
3.4. Aggregated multi-sectoral battery demand @2047

By 2047, total battery demand across key sectors is estimated at 1,094 GWh. EVs account for majority with ~80% (878GWh) of total demand, which is driven by large-scale electrification of the passenger road transport sector. Grid-scale BESS demand will represent ~11% of the overall demand followed by consumer electronics representing ~5% share in 2047 demand.

Finally, the remaining demand is driven by segments such as Telecom (~27 GWh, 2%), supported by continuous network expansion and backup needs, Data centres (~11 GWh, 1%), Commercial & Industrial (C&I) power backup (~5 GWh, 0.5%) and Railways (~0.05 GWh).

Figure 44: Projected all India annual multi-sectoral battery demand till 2047, GWh





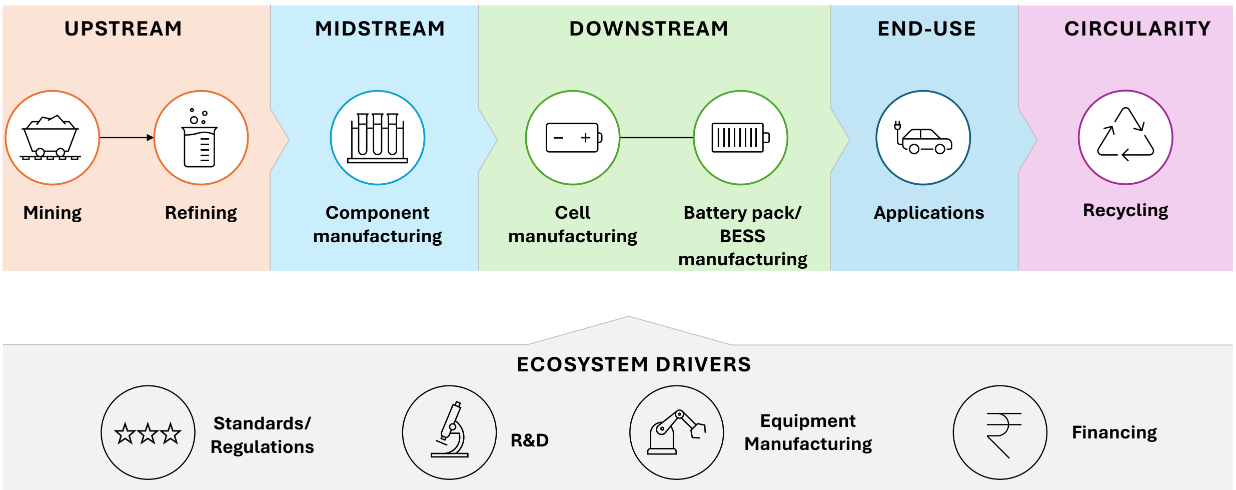
4

Chapter 4. India's battery ecosystem current state assessment

4.1. Battery ecosystem

The battery ecosystem consists of the manufacturing value chain for batteries, further divided into upstream, midstream, and downstream segments, along with supportive elements such as R&D, skilling, and equipment manufacturing.

Figure 45: The battery manufacturing ecosystem



Mining refers to the extraction of minerals such as lithium, nickel, cobalt, manganese, graphite and copper needed for the production of advanced chemistry cells. **Refining** involves processing these raw materials to achieve the required purity and quality for battery-grade materials. For example, metals such as lithium, nickel, manganese, and cobalt must be refined into high-purity salts suitable for cathode production, while mined graphite must undergo purification, spheroidization, and surface coating to serve as anode material.

Component manufacturing represents the second highest value share in the ACC value chain. These components consist primarily of cathode active materials, anode active materials, and other electrochemically active materials that contribute to the electrochemical processes necessary for energy storage- such as electrolytes, separators, solvents, additives, binders, and catalysts.

ACC manufacturing is the highest value addition step in the ACC value chain, involving the production of a functional cell from ACC components through a number of complex chemical and mechanical processes- such as electrode assembly, cell assembly, cell formation, and aging. **Equipment manufacturing** refers to the design and production of specialized machinery and tools required to manufacture ACCs.

Pack/ BESS manufacturing involves the assembly of a functional battery pack from ACCs, including the necessary battery management systems, thermal management systems, wiring, etc. Packs are designed according to end-use applications, with size, shape, and control systems varying as per their use in EVs, electronics, or stationary storage.

Battery recycling includes collection and reprocessing of used batteries to recover key input materials such as lithium, cobalt, nickel, and other metals.

4.2. Indian battery ecosystem assessment

4.2.1. Mining

Globally, lithium-ion technology has emerged as the gold standard for ACCs. Across both electric mobility and grid-scale stationary storage, lithium-ion continues to dominate due to its superior energy density, power output, and cycle life. The figure below illustrates Li-ion's significant market share in both these applications as of 2024[19].

Figure 46: Technology break-up of battery chemistry used in global EV industry (2024)

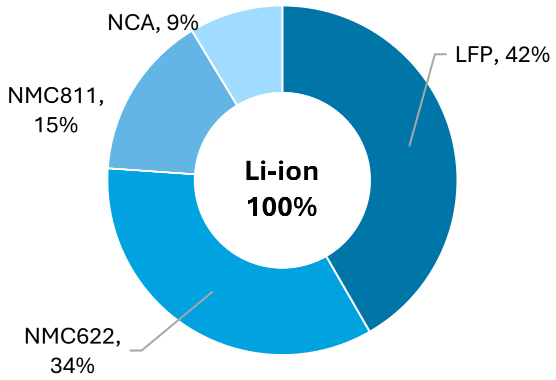
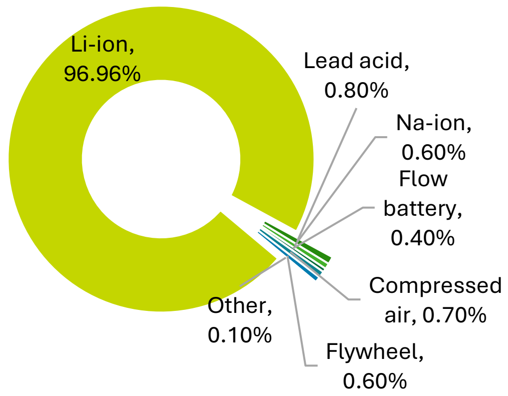


Figure 47: Technology break-up of grid-scale battery stationary storage deployed globally (2024)



Source: IEA, Bnef, EV Volume, Analyst Reports, CNESA Energy Storage Industry White Papers, Analyst reports

Lithium-ion batteries use several critical minerals for manufacturing; mass of these minerals in 1 kWh of various Li-ion chemistries is provided in the following table.

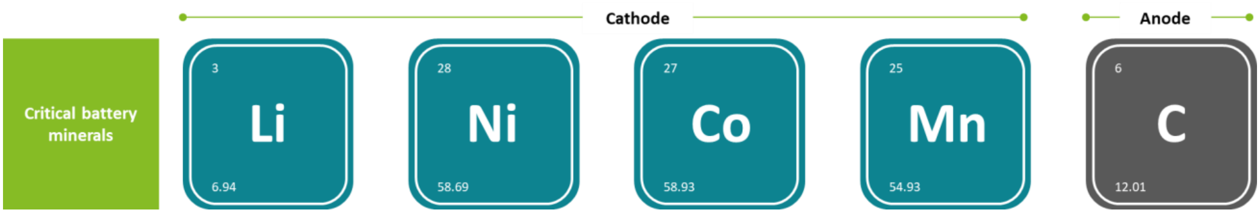
Table 2: Metal content in different lithium-ion chemistry, kg/kWh

Cathode type	Lithium	Nickel	Cobalt	Manganese	Graphite
LFP	0.10	-	-	-	1.05
NMC811	0.09	0.64	0.08	0.07	0.92

Source: NITI Aayog, Materials Research Society, atomic weights

The critical minerals present in these chemistries are **lithium, nickel, cobalt, manganese, and graphite**.

Figure 48: Critical minerals for lithium-ion battery technology



Of the above-mentioned critical minerals, the global supply of lithium, nickel, cobalt, manganese, and graphite is geographically concentrated, with a few countries most notably China, the Democratic Republic of Congo (DRC), Australia, South Africa, and Indonesia controlling significant portions of extraction capacity.

[19] IEA, Bnef, EV Volume, Analyst Reports, CNESA Energy Storage Industry White Papers, Analyst reports, Deloitte analysis

India does not have commercially viable reserves of lithium, cobalt, or nickel, but does possess large deposits of manganese and natural graphite. In FY2024, India produced 800,000 tonnes of manganese and 27,800 tonnes of natural graphite.

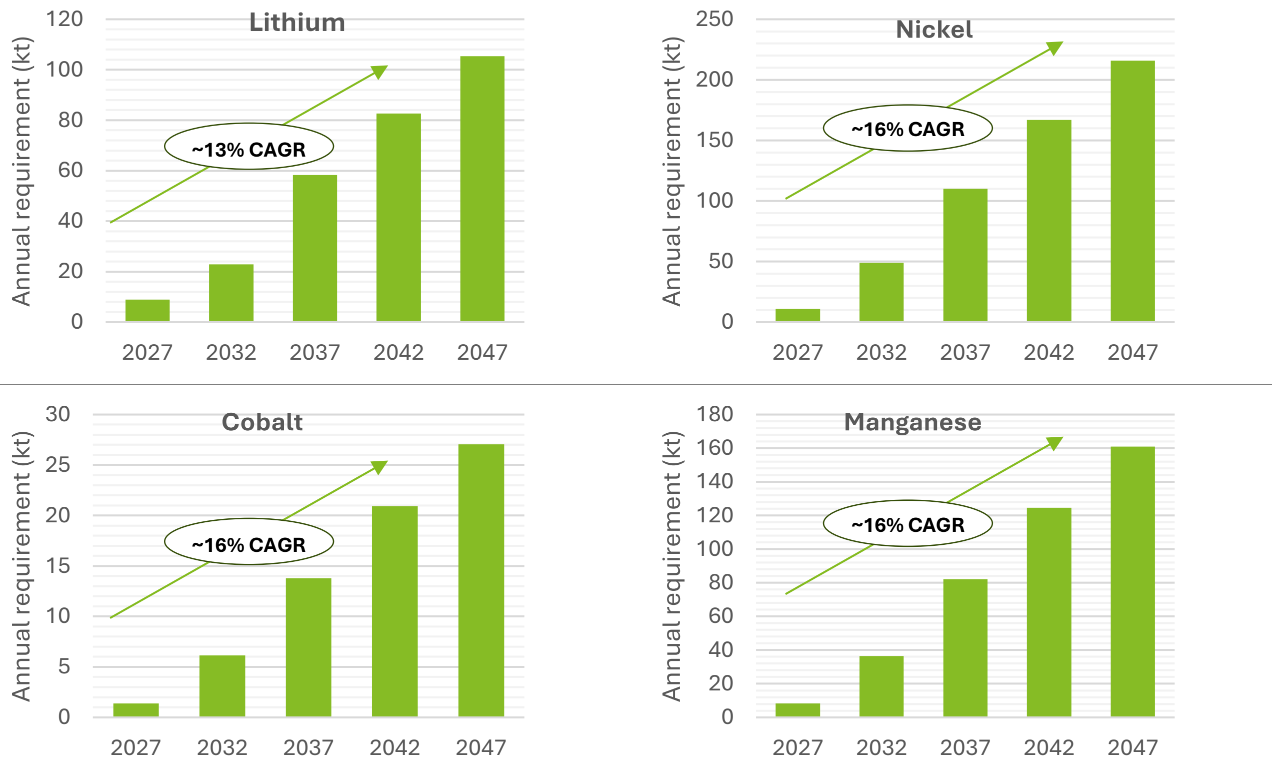
Table 3: Domestic production and reserves of critical battery minerals in India, metric tonnes (mt)

Particulars	Lithium	Nickel	Manganese	Cobalt	Graphite (Natural)	Copper	Aluminium
India production in 2024 *(global share)*	N/A	N/A	8,00,000 mt (4%)	N/A	27,800 mt (1.7%)	30,000 mt (0.1%)	42,00,000 mt (6%)
India reserves as in 2024 *(global share)*	N/A	N/A	3,40,00,000 mt (2%)	N/A	86,00,000 mt (3%)	22,00,000 mt (0.2%)	6,50,000,000 mt (2%)

Source: Indian Minerals Yearbook 2023, Ministry of Mines

Based on the projected battery demand in India by 2047, the following figures provide the corresponding requirement of critical battery materials:

Figure 49: Projected annual requirement of critical battery minerals associated with battery demand until 2047, kilotonnes per annum



Note: Quantities of minerals are shown in terms of weight of pure metal/graphite

Source: NITI Aayog, Argonne National Laboratory, IEA Global EV Outlook 2025, Shanghai Metals Market, Winack Battery, Deloitte analysis

4.2.1.1. Key challenges

Key challenges faced by the industry players:

- Limited proven reserves of key battery minerals such as lithium, nickel, and cobalt in the country leading to high dependency on mineral rich nations such as Australia, Argentina, Chile, etc. for access of battery minerals.
- For other battery minerals that are present in the country, for e.g. graphite: current total graphite production is much lower than the requirement from the battery sector by 2030. India also lacks battery-grade manganese reserves due to high phosphorous and iron contents.[20]

In order to secure the supply of such critical raw materials for Indian industries, the government has launched the National Critical Mineral Mission (NCMM)[21] in 2025 with an allocation of INR 16,300 crore. The NCMM supports domestic and international mineral exploration, acquiring stake in foreign assets, recycling, R&D, skilling, and the development of a strategic stockpile of critical minerals. It also calls on PSUs to invest a further INR 18,000 crore towards critical mineral projects, in cooperation with the private sector.

Agencies such as Khanij Bidesh India Ltd (KABIL) under the Government of India are conducting negotiations and entering MoUs with nations in mineral rich regions such as South America and Africa. For example, KABIL has acquired mining and exploration rights for 15,700 ha in Catamarca province of Argentina for exploration and mining of Lithium.[22]

Transnational platforms such as the Minerals Security Partnership and the U.S.-India Initiative on Critical and Emerging Technology (iCET) are also helping develop alternate supply chains for these key minerals.

[20] Indian Minerals Yearbook 2023, Ministry of Mines
[21] Press Information Bureau (Link)
[22] Ministry of Mines

4.2.2. Refining

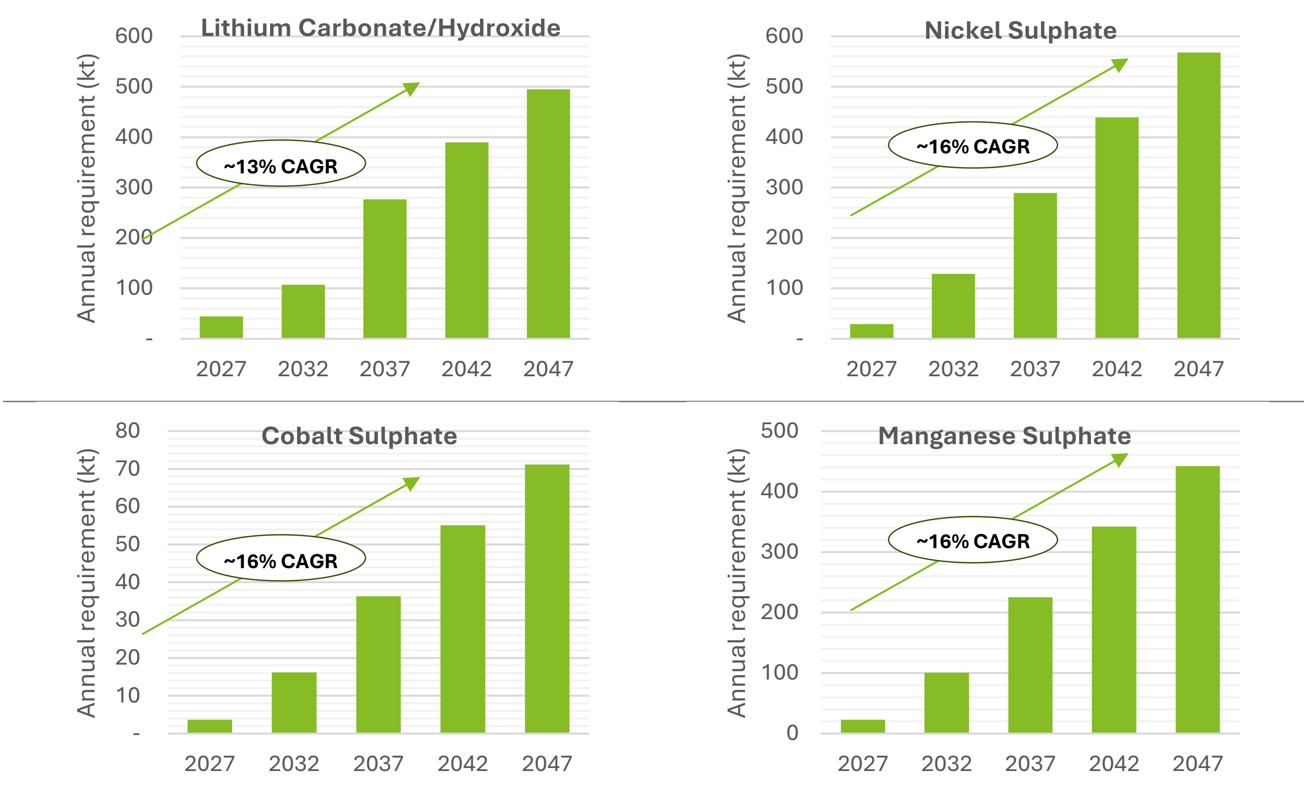
Compared to mining, the refining of battery grade materials is even more concentrated in certain geographies. Indonesia leads in Nickel refining (~41% global share), while China controls the majority of lithium (~65%), cobalt (~77%), manganese (~96%), and natural graphite (~99%) refining[23].

Table 4: Current and announced battery grade refined material capacity, MTPA

Particulars	Lithium	Nickel	Manganese	Cobalt
Current battery grade capacities, 2025	1,000 MTPA	1,000 MTPA	N/A	1,200 MTPA
Announced battery grade capacities	40,000 MTPA	40,000 MTPA	N/A	25,000 MTPA

Based on the projected battery demand in India by 2047, the following figures provide the corresponding requirement of battery grade refined materials:

Figure 50: Projected annual requirement of battery grade refined materials associated with battery demand until 2047, kilotonnes per annum



Source: NITI Aayog, Argonne National Laboratory, IEA Global EV Outlook 2025, Shanghai Metals Market, Winack Battery, Deloitte analysis

4.2.2.1. Key challenges

Key challenges faced by the industry players:

- Lack of technical know-how for battery mineral refining. Based on industry feedback, the technology licensing fee is around 30% of the capex at the 5,000-10,000-tonne scale, significantly affecting project economics.

[23] IEA

- Majority of technology providers are based in China which has imposed export controls on lithium refining technologies in July 2025, making the access more difficult for Indian players.
- Based on industry feedback, the domestic lithium refining from ore is currently unprofitable, due to availability of limited domestic cell manufacturers (low demand). Also, the industry faces high-cost disability vis-à-vis leading global players due to prevalence of domestic subsidies.

In order to overcome limitations in supply, companies are now working to source raw materials from foreign mineral assets and long-term supply agreements. Altmin Pvt. Ltd[24]. has partnered with lithium mines in Brazil and Bolivia and has signed an MoU to establish a lithium refinery in Telangana, while Lohum Cleantech Private Ltd. has acquired a lithium mining asset in Africa.

4.2.3. ACC component manufacturing

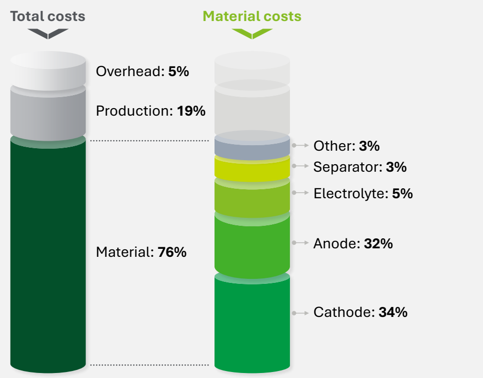
ACC components include cathode, anode, separator, electrolyte, foil and other electrochemically active materials.

Cathode includes cathode active material (CAM), binders, and current collectors (Al foil) whereas anode electrode materials include anode active material (AAM), binder, and current collector (Cu foil).

Electrochemically active materials are those materials that contribute to the electrochemical processes necessary for energy storage. These materials may include solvents, additives, electrolyte salts, catholytes, anolytes, separators, and metal salts/oxides.

In terms of contribution on overall ACC manufacturing cost, cathode and anode represent the highest share followed by components such as electrolyte, separator etc. Absolute share of each component varies basis ACC chemistry. Cost break of an LFP chemistry ACC is provided in the figure alongside.

Figure 51: General cost breakup of an LFP cell (2025), percent



Source 5 Analyzing material and production costs for lithium-ion and sodium-ion batteries using process-based cost modeling - CellEst 3.0 (Ruppert, Janik et. al., 2025)

Table 5: Categorization of ACC components

ACC cell component							
Component Category -1	**Cathode**			**Anode**			**Electrochemically active materials**
Component Category -2	Cathode active material (CAM)	Binder	Current collector (Al foil)	Anode active material (AAM)	Binder	Current collector (Cu foil)	Solvents, additives, electrolyte salts, catholytes, anolytes, separators and metal salts and oxides

At present, the conversion of battery grade refined materials into specialized ACC components takes place largely in China. For example, the majority of the production of cathode active material (CAM) for two of the world's leading ACC chemistries- Lithium-Iron-Phosphate (LFP) and Nickel-Manganese-Cobalt (NMC)- takes place majorly in China, with ~96% and ~66% global share respectively. Similarly, ~90% of the world's graphite-based anode active material (AAM) production also takes place in China. Other countries with capabilities in ACC component manufacturing include South Korea, Japan, USA, France, and Finland.

India remains heavily dependent on imports for key cell components such as cathodes, anodes, electrolytes, and foils to support its expanding ACC manufacturing- creating significant exposure to global supply chain risks. In view of this gap in the supply chain, several companies have announced plans to localize component manufacturing,

[24] Altmin and SCCL to setup ₹2,250 crore lithium refinery project in Telan/gana • EVreporter

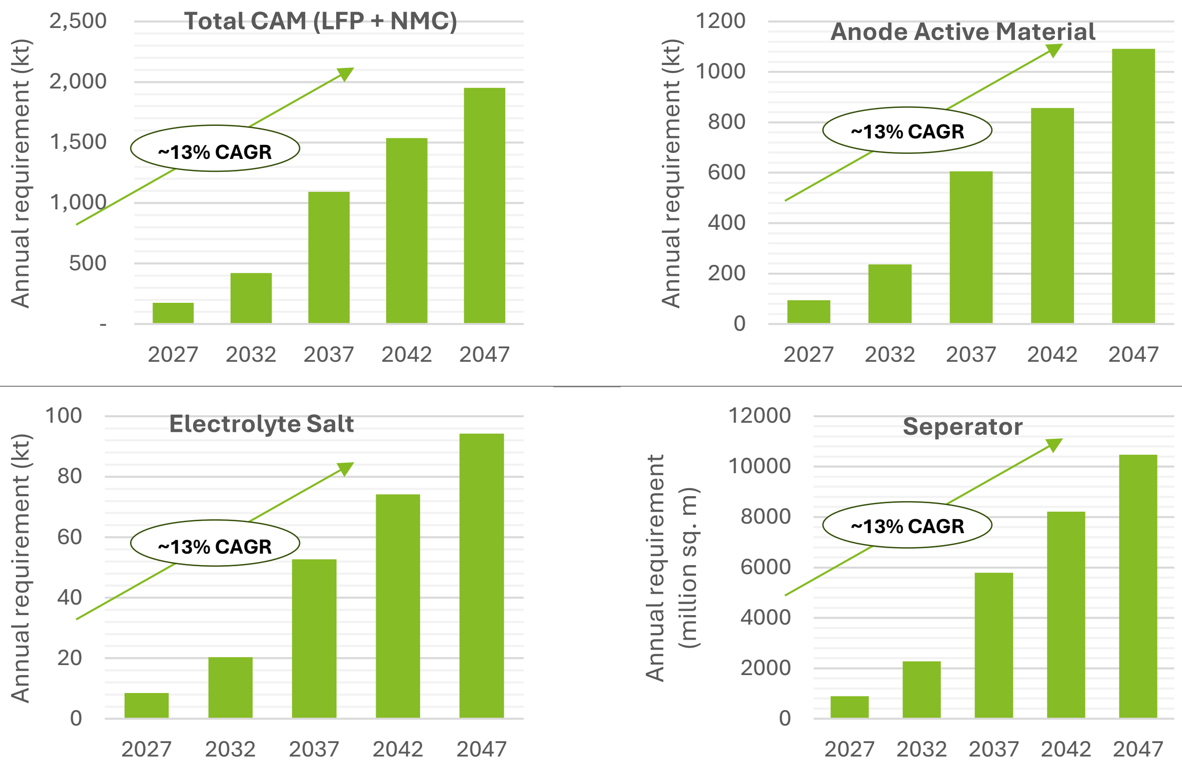
and few pilot-scale facilities for cathode active material, anode active material (natural and synthetic) and electrolytes are already operational. These announcements involve production at large scales, to cater to both domestic and overseas markets.

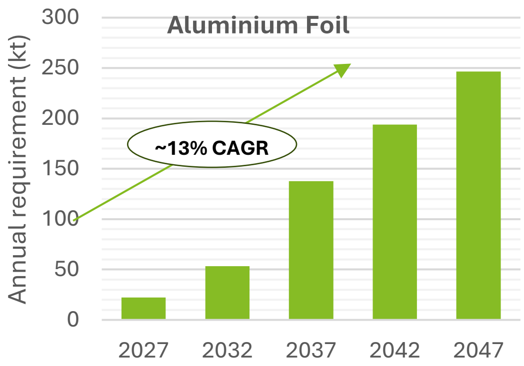
Table 6: Summary of ACC component capacities- current and planned, MTPA

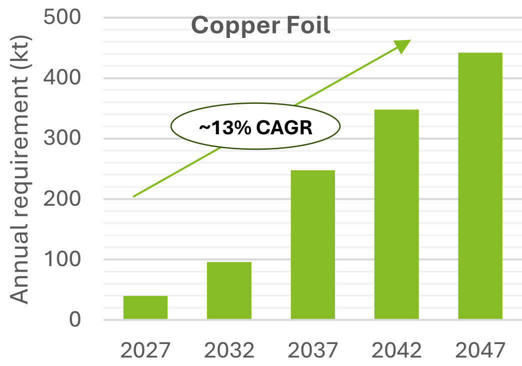
Cell component	Cathode	Anode	Separator	Electrolyte	Foil/Casing
Current capacity	220 MTPA	260 MTPA	Not any	400 MTPA of Salts 2,000 MTPA of Electrolyte	Not any
Planned capacity	420,000 MTPA	320,000 MTPA	Not any	7,300 MTPA of Salts 32,000 MPTA of Electrolyte	25,000 MTPA of Al Foil 40,000 MPTA of Cu Foil

Based on the projected battery demand in India by 2047, the following figures provide the corresponding requirement of ACC components:

Figure 52: Projected annual requirement of ACC components associated with battery demand until 2047, kilotonnes per annum







Source: NITI Aayog, Argonne National Laboratory, IEA Global EV Outlook 2025, Shanghai Metals Market, Winack Battery, Deloitte analysis

4.2.3.1. Key challenges

Key challenges faced by the industry players:

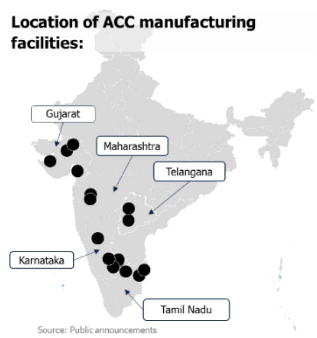
- High cost of input raw materials to the tune of 20-30% due to limited supply of domestic precursor manufacturers (lithium carbonate/hydroxide, calcium carbide, etc.). In addition, the Chinese suppliers enjoy high margins due to their economies of scale, compounding incentives across the value chain, and 2-4% lower financing costs.
- For Anode Active Material (AAM) manufacturing, access to raw material is highly limited. Calcined pet coke (one of the key input materials) is a licensed activity in India and needle coke (another specialized raw material), is not yet produced in India. Due to this, there is an import dependence of 70-95% for raw materials for AAM manufacturing.
- CAM and AAM manufacturing are an energy intensive process and high differential with subsidized tariff received by Chinese players further increases the cost differential.
- China imposed export controls on natural graphite in October 2023, limiting global supply. It also imposed controls on technologies to produce high density LFP (>= 2.58 g/cc) and LMFP (>=2.38 g/cc) cathode materials.

The Union Budget 2025-26 strengthened support for ACC manufacturing by removing customs duties on 35[25] types of machinery used in EV battery production, including equipment for ACC components. Previously, the Union Budget 2024-25 also lowered the cost of imported raw materials by removing basic customs duty on critical minerals and their compounds, including lithium, cobalt, nickel, and graphite.

4.2.4. ACC manufacturing

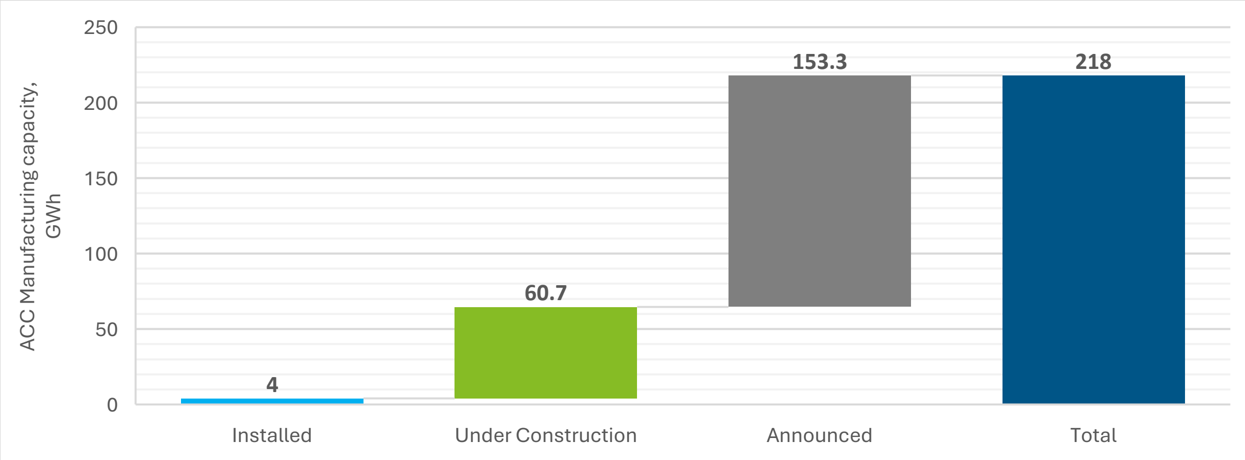
With a supportive policy ecosystem from central and state governments, ACC manufacturing in India is making steady progress. The Production Linked Incentive (PLI) scheme has provided the necessary momentum, leading to the announcement of over 218 GWh of manufacturing capacity by industry players (including 40 GWh allocated under the PLI scheme). As of November 2025, 4 GWh of capacity has been installed and 45.7 GWh is under various stages of development.

Figure 53: Locations of announced ACC manufacturing facilities



25 Press Release: Press Information Bureau

Figure 54: Status of ACC manufacturing capacities (As of November 2025) and projected demand in 2032, GWh



Source: Stakeholders consultations and company announcements

4.2.4.1. Key challenges

Key challenges faced by the industry players:

- With the continued dependence on imported components, overall value addition remains limited to below the target threshold of 60% outlined in the PLI ACC scheme. Further localization up the value chain is required to boost local value addition.
- Capex per GWh in India is estimated to be about 20% higher than in China.
- Currently, there is high import dependence on plant & machinery equipment. Equipment from China is facing delivery delays and uncertainty regarding export controls, while equipment options outside China are 50-70% more expensive leading to increased capital cost.
- Lengthy visa approval process for bringing foreign experts to setup the facility and train the manpower is another major bottleneck during installation and ramp up stage.
- In terms of opex, the material costs are estimated to be 15-20% higher due to extreme import dependency. Materials typically make up roughly 70% of total cell cost, translating into a significant disadvantage on the final cell price.
- Power cost is a major cost contributor in an ACC manufacturing facility, contributing 20-30% of gigafactory operating costs.
- Due to higher capex and opex, as well as smaller scales, domestic ACC manufacturers find themselves unable to match Chinese prices. Since most Indian end-users (for example grid scale BESS, where prices are tender driven) are highly price sensitive, it becomes difficult to secure customers.

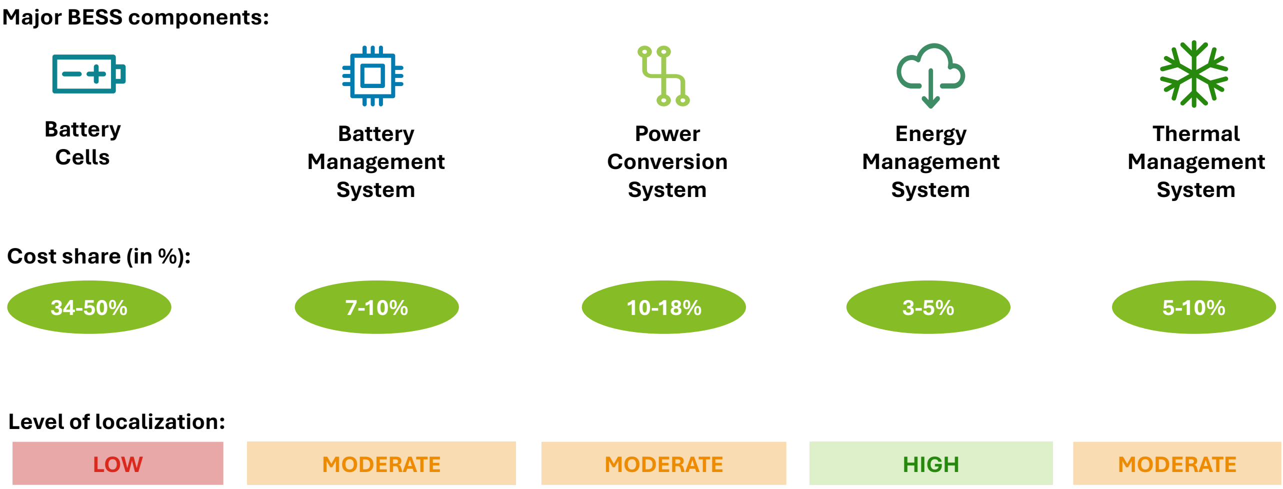
India launched the Advanced Chemistry Cell (ACC) Production Linked Incentive (PLI) scheme in May 2021 with an outlay of ₹18,100[26] crore to promote large-scale domestic cell manufacturing and reduce dependence on imports. The scheme ties incentives to actual production, driving faster scale-up and higher local value addition. Of the 50 GWh ACC capacity targeted, 40 GWh has been awarded to four companies, with Ola commissioning the first 1 GWh and other players advancing their projects, indicating strong momentum in India's ACC manufacturing ecosystem.

4.2.5. Pack and BESS manufacturing

Pack manufacturing is already taking place at a large scale in India, along with further assembly into BESS containers to achieve higher storage capacities, however, multiple critical components such as the ACC, BMS microcontroller, etc. continue to be imported.

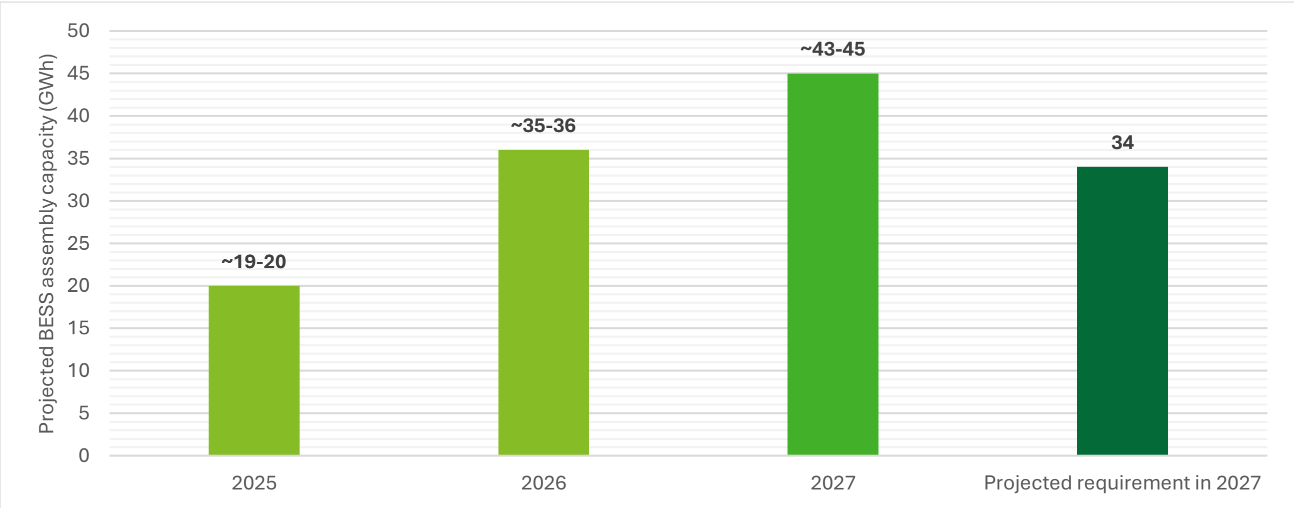
[26] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2202973&lang=1&reg=3

Figure 55: Major BESS components, their cost share and level of localization in India



BESS assembly capacities have been set up by 14+ companies, with plans for further large-scale expansion.

Figure 56:Projected BESS assembly capacity in India, GWh



Source: Ministry of Power

4.2.5.1. Key challenges

Key challenges faced by the industry players:

- Gaps in domestic capabilities for battery management and power conversion systems, for components such as PCBs, Switch Mode Power Supplies (SMPS), etc. along with electronics needed for high-precision testing equipment for BESS.
- Tender-driven pricing is forcing grid-scale BESS integrators to opt for cheaper, imported ACCs, reducing the opportunity for domestically produced ACCs to serve the market. Price gap with domestic players is estimated at $8-10 per kWh (15-20%) for energy storage applications.
- Limited access to system level testing and validation facilities delays certification and slows scale-up of BESS deployment.

In 2024, To boost the financial viability of BESS projects in India, the Ministry of Power implemented the Scheme for Viability Gap Funding for development of BESS. The first tranche provided support for 13.2 GWh of projects with an allocation of INR 3,760 crore, while the second tranche will support 30 GWh of projects with an allocation of INR

5,400 crore. Furthermore, the Ministry of Power has implemented a minimum 20% local content requirement for participation under the VGF scheme.

The Central Electricity Authority also issued an advisory in February 2025, recommended the co-location of ESS with solar power projects to incorporate a minimum of 2-hour co-located ESS with a capacity equivalent to 10% of the installed solar project capacity in future solar tenders.

4.2.6. Recycling

India currently possesses small-scale battery-grade refining capacity through recycling of used batteries, with plans to expand the same. Since the supply of used batteries is limited compared to the demand for refined material, companies also plan to import concentrated ores to support larger refining capacities.

Table 7: Recycling current and planned capacity of major players in India (ktpa)

Particulars	Current Capacity (ktpa) (2024)	Planned Capacity (ktpa)
LiB Recycling capacity of major players in India	68.2	289.5

Source: Current LIB recycling landscape in India, EV reporter

4.2.6.1. Key challenges

Key challenges faced by the industry players:

- High GST (18%) on battery scrap compared to concentrated ores (5%) is discouraging organized collection.
- A lack of clear, lithium-ion specific standards around collection, testing, dismantling, and black mass are leading to further ambiguity for recyclers.
- Extended Producer Responsibility (EPR) floor prices currently do not support advanced recycling.
- Requirement of regulatory approval (under Hazardous Waste Management Rules) and prior informed consent from exporting countries for importing lithium-ion battery scrap.

In order to ensure the proper tracking, collection, and eventual recycling of used batteries, India's Battery Waste Management Rules 2022 have included a system of Extended Producer's Responsibility (EPR) for waste batteries. It calls for manufacturers to register with the Central Pollution Control Board (CPCB), meeting certain collection and recycling targets, and obtain EPR certificates from registered recyclers to fulfill their obligations in a documented fashion. The National Critical Mineral Mission has also allocated INR 1,600 crores towards the recycling of critical minerals, including from battery waste.

4.2.7. R&D and innovation

The R&D, innovation, and talent development ecosystem for ACCs is still in the nascent stage in India. Most companies are reliant on technology partnerships, in-house training, and foreign experts to commission and ramp up their facilities.

4.2.7.1. Key challenges

Key challenges faced by the industry players:

- Absence of sufficient pilot lines and demonstration plants to develop the latest advanced chemistries.
- Limited academia-industry collaboration for developing next-gen batteries.
- Domestic LFP cathode material manufacturers are working with third generation technologies, while Chinese players have moved on to fifth-generation technologies that offer at least 14% higher energy densities.

- Limited access to specialized testing and reliability validation facilities delays certification and slows scale-up.

The National Critical Mineral Mission has allocated INR 1,600 crores towards the development of patents along the critical mineral value chain, training and upskilling the workforce, and the establishment of centers of excellence for the sector. In addition, multiple private players in the ACC ecosystem are setting up their own R&D facilities and skilling programs to keep up with advancements in the industry and meet their manpower requirements.

5

Chapter 5. National battery roadmap for Viksit Bharat @2047

5.1. India Battery Vision 2047

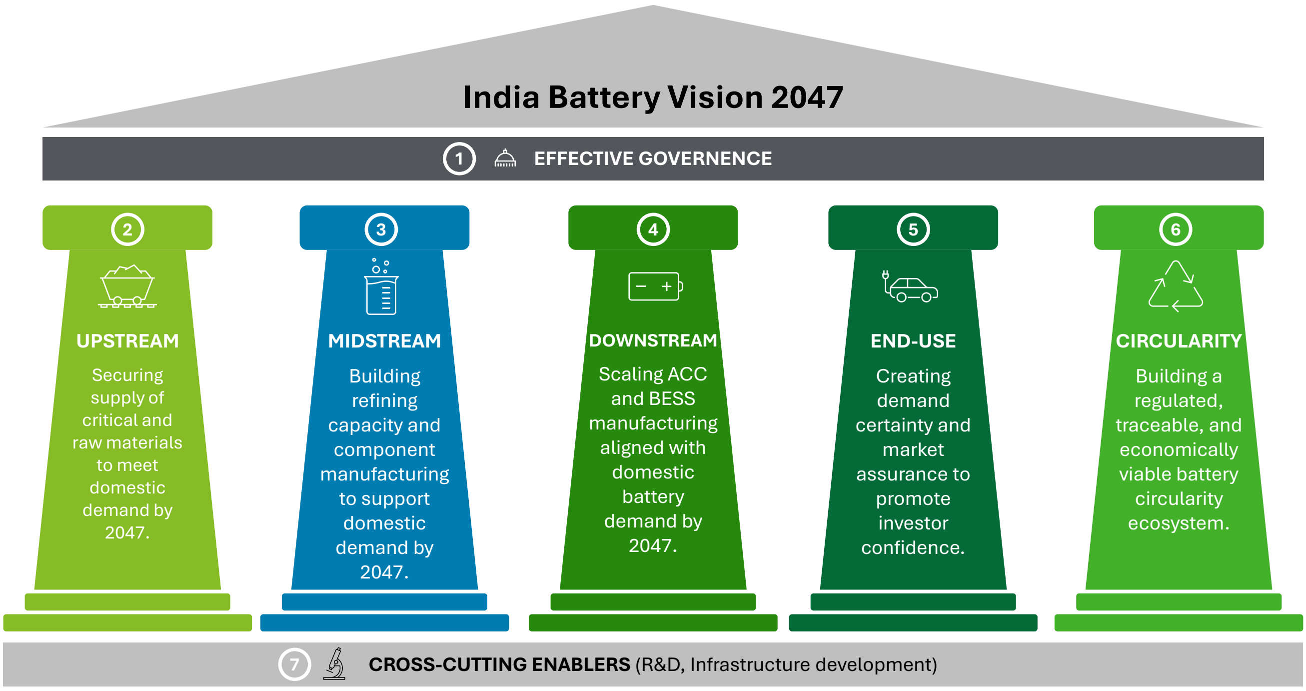
By 2047, India will be a global hub for competitive, sustainable battery manufacturing and innovation, with an end-to-end, secure, and circular battery value chain, creating skilled jobs, achieving strategic autonomy & energy security, and contributing to global net zero ambitions.

5.2. Pillars of National Battery Roadmap @2047

To achieve the Battery Vision 2047, India will need coordinated efforts across the entire battery value chain. A holistic, long-term action plan is essential to strengthen self-reliance and advance the vision of Atmanirbhar Bharat in this sector.

In view of this, seven (7) pillars of national battery roadmap have been identified:

Figure 57: Seven pillars of national battery roadmap



5.3. Stakeholder feedback

Ministry of Heavy Industries have conducted multiple rounds of stakeholder consultations with 50 stakeholders including ministries, government departments, industry players to identify the key challenges and capture action items.

Table 8: Coverage of the stakeholder consultations

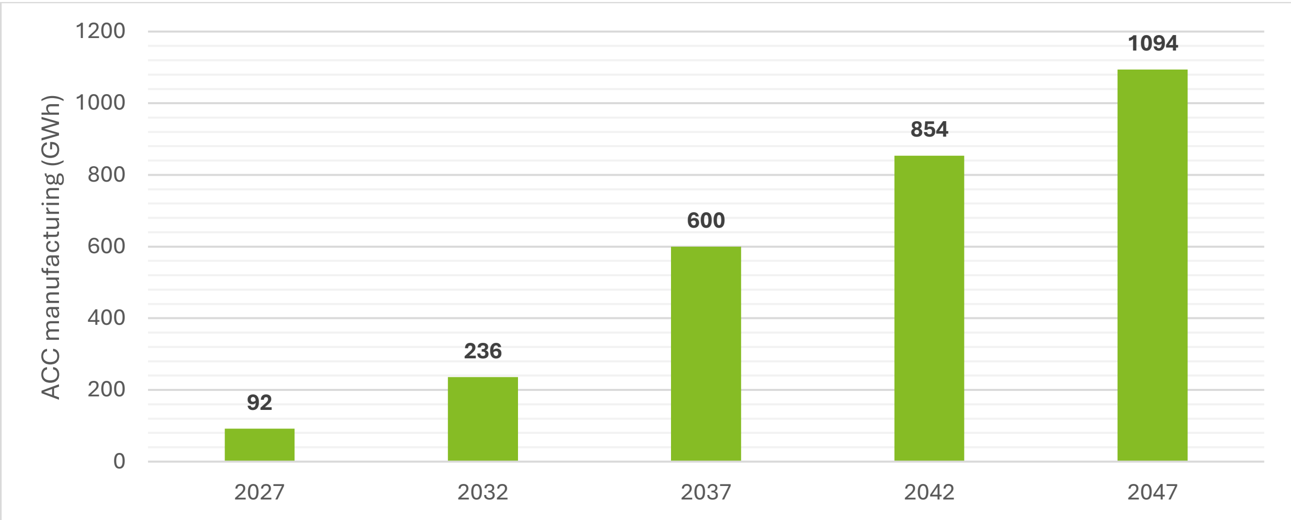
11	9	9	8	4	9
Ministries/ Departments	ACC manufacturers	ACC component manufacturers	BESS manufacturers	Recyclers	Other ecosystem players

Details of the inputs received from the stakeholders are provided in Annexure.

5.4. Action items for National Battery Roadmap @2047

To realize the Battery Vision 2047, India needs to develop end-to-end manufacturing ecosystem capable of meeting 100% of national battery demand by 2047, as indicated in Figure 44. Accordingly, the target domestic ACC manufacturing capacity till 2047 is presented in the following figure:

Figure 58 Target domestic ACC manufacturing capacity to achieve Battery Vision 2047



Taking into account the targeted domestic ACC manufacturing capacity and based on the inputs received from the stakeholders, the action items under the National Battery Roadmap @2047 have been developed across the 7 (seven) pillars.

Figure 59: Summary of key action items across all pillars

1 EFFECTIVE GOVERNANCE

- ✓ Setup a **High-level Task Force (HTF)** to monitor the overall progress of the industry.

2 UPSTREAM	3 MIDSTREAM	4 DOWNSTREAM	5 END-USE	6 CIRCULARITY
✓ Developing (i) **critical battery mineral pipeline**, and (ii) a **centralized battery refining hub** to support domestic manufacturing of battery demand *(FY30-32)*	✓ Launch a **Component Manufacturing incentive scheme** offering a combination of sales-linked incentives and CAPEX subsidies to bridge the cost gap for ACC components *(FY27)*	✓ Implement the **5 GWh** capacity allocated under the PLI ACC scheme for **niche technologies** *(FY27)* ✓ **Financial incentives** for domestic manufacturing of **BESS components** and **sub-components** *(FY28)*	✓ **Phased rollout of Approved List of Battery Manufacturers (ALBM)** for all public battery storage procurement *(FY27)* ✓ Promote adoption of **Long-duration Energy Storage (LDES)** projects through policy measures and targeted incentives *(FY28)*	✓ Building a **regulated, traceable, and economically viable** battery circularity ecosystem by FY32 *(FY32)*

7 CROSS-CUTTING ENABLERS

- ✓ **R&D:** Implement a **50% co-funding R&D model** (government grants + industry funding) for mission-mode projects focused on next-gen battery technologies *(by FY28)*
- ✓ **Industrial cluster development:** Develop at least **five (5) integrated "Plug-and-Play" Industrial Clusters** for battery ecosystem development *(FY28)*
- ✓ ***GST rationalization**: Rationalization of GST rates applicable to the ACC ecosystem (FY27)*

These action items are grouped into two categories: (1) value chain specific action items that pertain to a particular value chain segment such as upstream, midstream, downstream, end-use, and circularity, and (2) cross-cutting enabler action items that will play key role across multiple value chain segments.

5.4.1. Value chain specific action items:

UPSTREAM (MINING & REFINING)

Action item 1: Developing (i) critical battery mineral pipeline, and (ii) a centralized battery refining hub to support domestic manufacturing of battery demand

Battery minerals viz. Lithium, Nickel, Cobalt and Graphite are categorized as 'Critical and Strategic Minerals' under Part D of the First Schedule of the Mines and Minerals (Development and Regulation) Amendment Act, 2023[27], due to their limited availability and strategic importance. Therefore, securing access to these minerals will support domestic manufacturing of ACC and ACC components.

Creating a raw material pipeline is recommended to reduce exposure to supply shocks, export controls and price spikes. It is proposed that the government should facilitate building the raw material pipeline for at least 50% of the domestic ACC manufacturing capacity from 2032 onward.

[27] Ministry of Mines - The Mines and Minerals (Development and Regulation) Amendment Act, 2023 dated 9th August, 2023.

Table 9: Target for developing critical battery mineral pipeline till 2047

Mineral	Unit	2032	2037	2042	2047
Lithium	*ktpa*	11	29	41	53
Nickel	*ktpa*	24	55	83	108
Cobalt	*Ktpa*	3	7	10	14
Graphite	*ktpa*	118	303	429	546
Corresponding ACC mfg. *(50% of total demand)*	***GWh***	**118**	**300**	**427**	**547**

Note: Quantities of minerals are shown in terms of weight of pure metal/graphite

To ensure offtake for the secured raw material, developing a robust refining capability is paramount. Based on stakeholder inputs, setting up multiple small refining units is highly uneconomical. Technology cost alone makes up to 30% of capex for the smaller refining units, and in addition, low volumes limit their bargaining power leading to reduced priority from global critical mineral suppliers.

Therefore, establishment of a centralized national refining hub is proposed that will meet 50% of battery grade material requirements from the domestic ACC ecosystem till 2047.

Table 10: Target capacity for national refining hub

Mineral	Unit	2032	2037	2042	2047
Lithium Carbonate/ Hydroxide	*ktpa*	53.52	138	195	247
Nickel Sulphate	*ktpa*	64.46	145	220	284
Cobalt Sulphate	*Ktpa*	8.08	18	28	36
Manganese Sulphate	*ktpa*	50.21	113	171	221
Corresponding ACC mfg. *(50% of total demand)*	***GWh***	**118**	**300**	**427**	**547**

Creation of the critical minerals pipeline and national refining hub can be achieved through the following approaches:

- Empowering KABIL with simplified approvals, political-risk insurance, and provisions for private co-investment to accelerate overseas mining and processing projects.
- Pursuing G2G partnerships and long-term offtake agreements with Argentina, Chile, Australia, Canada supported through KABIL.
- Leveraging India-EU, India-US, and India-Japan critical mineral partnerships to co-invest in mining assets.
- Establishing a critical minerals strategic reserve to maintain at least 6-month buffer stock to manage supply chain disruptions and global market price volatility.
- Establishing low-cost sovereign / EXIM-backed financing windows for Indian companies acquiring overseas mineral and processing assets.
- Provide adequate fiscal support for critical mineral refining and precursor projects, given their high CAPEX and technology intensity.
- Aggregate refined material demand across the fragmented and growing ACC component manufacturing space to achieve a viable scale.
- Other support for the upstream in the form of tax holidays, interest subvention, accelerated depreciation, and tax pass-through on share sales, etc.

Development of the mid-stream (ACC component manufacturing) industry is a prerequisite for the upstream interventions; accordingly, the timeline for these action items shall be post-2030.

Implementing Ministry: Ministry of Mines	**Timeline:** FY2030

MIDSTREAM (COMPONENT MANUFACTURING)

Action item 2: Launch a component manufacturing incentive scheme offering a combination of sales-linked incentives and CAPEX subsidies to bridge the cost gap for ACC components

At present, ACC components (cathode, anode, electrolyte, separator, foils, etc.) are primarily imported due to the unavailability of domestic manufacturing capacity. As a result, the value addition from domestic ACC manufacturing is limited to a mere 25-30%. To improve value addition in India and move up the global value chain, local manufacturing of ACC components is imperative.

ACC components require a long, multi-stage testing and qualification process before being used in EVs or stationary energy storage batteries. Including the gestation period, the testing and qualification process can take up to 4 years.

Therefore, it is critical to support the development of the ACC component manufacturing ecosystem in FY27 so that the country has the necessary capacity to meet the 2032 demand. ACC component capacities required to support domestic ACC manufacturing by 2032 are outlined in the following table:

Table 11: ACC component capacity required by 2032

Mineral	Unit	Existing capacity	Capacity required by 2032
Cathode Active Material	*ktpa*	0.22	422
Anode Active Material	*Ktpa*	0.26	237
Electrolyte Salts	*Ktpa*	0.40	20
Separator	*Million sq. m.*	N/A	2,278
Aluminium Battery Foil	*Ktpa*	N/A	53
Copper Battery Foil	*ktpa*	N/A	96
ACC manufacturing	***GWh***	**4**	**236**

As per industry feedback, there exists a 15-25% cost disability for Indian component manufacturers vis-à-vis global manufacturers. To bridge this cost gap, the following may be considered:

- Sales-linked incentives to bridge cost disability gaps vis-à-vis established global competitors due to import costs, financing, technology royalties, etc.
- Capital subsidies to support the setting up of plant and machinery, the establishment of R&D infrastructure, and technology transfer costs.
- Other benefits such as assured supplies of raw materials.
- Development of state-of-the-art testing labs to facilitate the timely completion of product qualification processes.

Implementing Ministry: Ministry of Heavy Industries	**Timeline:** FY2027

DOWNSTREAM (ACC MANUFACTURING)

Action item 3: Implement the 5 GWh capacity allocated under the PLI ACC scheme for niche technologies

At present, the global battery industry is highly dominated by lithium-ion technology. However, relying solely on conventional lithium-ion batteries carries key risks for the country, such as high import dependence, geopolitical supply risk, and high price volatility.

In this context, next-generation technologies or niche technologies such as metal-ion (e.g., sodium-ion), metal-air, flow batteries (e.g., vanadium redox), zinc-based batteries, and solid-state variants offer a promising route to diversify India's energy storage base (kindly refer Figure 8). These technologies offer unique advantages, such as long cycle life, higher energy density, diversified resource availability etc. over conventional ACCs (lithium-ion technology).

Key differences between niche ACCs and conventional ACCs are outlined in the following table:

Table 12: Key difference between conventional ACCs and niche ACCs

Particular	Conventional ACCs	Niche ACCs
Manufacturing	Giga-scale production	Mega-scale production
Technology stage	Fully commercialized and widely adopted	Under development, with extensive ongoing R&D efforts
Capital requirement	Medium to high with standard capital costs	Very high and uncertain in the initial stage
Deployment timeline	Present to up to 10-year technological and manufacturing focus	Long term focus with future technological breakthroughs

As these technologies are still under development or in the early stages of commercial production, their per unit cost is much higher compared to conventional ACCs. Fiscal support in the form of sales-linked incentive can be provided to the manufacturers of niche technologies. It is therefore proposed that the 5 GWh capacity allocated for Niche ACCs under the PLI Scheme 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage' should be implemented.

Implementing Ministry: Ministry of Heavy Industries	**Timeline:** FY2027

Action item 4: Financial incentives for domestic manufacturing of BESS components and sub-components

BESS systems are vital for achieving high VRE (variable renewable energy) penetration in the Indian grid. Beyond battery cells and packs, a BESS system includes multiple components and sub-components as outlined in the following table:

Table 13: Key BESS components and sub-components

Sr. No.	Component	Sub-components
1.	Power Conversion System (PCS)	Bi-directional inverter, electrical protection
2.	Battery Management System (BMS)	Monitoring and control electronics
3.	Thermal Management System (TMS)	HVAC systems, liquid/air cooling
4.	Energy Management System (EMS)	Control software, SCADA integration
5.	Balance of System (BOS)	Container, electrical and distribution control, fire suppression, isolators, busbars and power cabling

These components represent 35-40% of the total cost of BESS and currently are largely being imported (except EMS). High import dependence on key BESS components limits overall domestic value addition. Furthermore, components that are domestically manufactured are priced higher than their imported counterparts, making it difficult for BESS developers to use them in projects awarded through competitive bidding.

Therefore, support is required to achieve indigenization and cost-competitiveness for BESS components and sub-components. For the same, the following measures may be considered:

- Undertake a study to identify priority components for indigenization, related cost disability faced by Indian manufacturers, and the support required by the industry.
- Provide CAPEX and OPEX incentives in line with industry requirements for players planning to indigenize identified BESS components.
- Provide interest subvention incentives to promote financing of such projects.
- Such incentives may be limited to domestic sales, in order to promote local content in Indian BESS projects.

Implementing Ministry: Ministry of Power (MoP)	**Timeline:** FY2028

END USE

Action item 5: Phased rollout of Approved List of Battery Manufacturers (ALBM) for all public battery storage procurement

Low battery prices offered by Chinese players are leading to a rapid fall in tariffs discovered in ESS tenders. Standalone BESS tariffs have dropped by 75% in the last 2 years and solar + BESS tariffs fell by ~52% from 2021 to 2025 – due to aggressive bidding by Indian players in anticipation of falling battery prices in China. Due to the narrow margins earned by players in these bids, a geopolitical disruption affecting supply or prices can jeopardize the successful commissioning of projects.

Aggressive market pricing by Chinese players is making Indian players uncompetitive in public procurement tenders for batteries:

- Artificially low battery prices – driven by subsidies offered to Chinese manufacturers (subsidized power cost, concessional finance, subsidies, etc.).
- In 2024, ~330 GWh of ESS batteries were sold/shipped globally; Chinese players accounted for 97% of these sales.[28]
- The price gap with domestic players is estimated at $8-10 per kWh (15-20%).

To promote domestic manufacturers, creation of a list of Approved List of Battery Manufacturers (ALBM) is proposed. A minimum DVA requirement (gradually increasing) should be set and only ALBM players should be considered eligible to participate in the government battery procurement tenders.

Implementing Ministry: Ministry of Power (MoP)	**Timeline:** FY2027

Action item 6: Promote adoption of Long-duration Energy Storage (LDES) projects through policy measures and targeted incentives

India has been at the forefront of adding renewable energy in its generation mix. From FY19 to FY25, the RE share (excluding hydro) in the installed capacity mix has increased from 11% to 18%. The associated variability with higher RE penetration has so far been managed primarily through short duration energy storage solutions (i.e. 2-hour and 4-hour)[29].

High reliance on short duration energy storage could lead to reduced energy security, increased system cost and limit the feasibility of achieving 100% RE penetration. Long-Duration Energy Storage (LDES) such as compressed air energy storage (CAES), sensible heat storage, flow batteries, pumped storage etc. can play a critical role in addressing these challenges.

However, the majority of LDES technologies currently require high capex – leading to high Levelized Cost of Storage (LCOS), low maturity (compared to Li-ion technology) and low round-trip-efficiency (RTE). Therefore, policy support and targeted incentives are required to ensure increased adoption of LDES in the country. To promote uptake of LDES in the Indian storage ecosystem, the following measures may be considered:

- Finalizing a standard, technology-agnostic definition for LDES that is aligned with the Indian grid context.
- Creating a national plan for LDES adoption and incorporate LDES requirement into the NEP (National Electricity Plan) and Energy Storage Obligation (ESO) framework.
- Rolling out nationwide pilots to establish LDES use cases and to validate technical performance in different grid environments.
- Announcing targeted VGF for promising LDES technologies to make their LCOS competitive and drive early-stage deployment.
- Provide interest subvention incentives to promote financing of LDES projects.
- Developing a robust market framework allowing LDES assets to monetize their full range of capabilities such as frequency regulation, voltage support, black start, etc.

Implementing Ministry: Ministry of Power (MoP)	**Timeline:** FY2028

28 JP Morgan Asia Pacific Equity Research (May 2025)

29 IESA – Energy Storage Market Report 2025

CIRCULARITY

Action item 7: Building a regulated, traceable, and economically viable battery circularity ecosystem by FY32

Until battery grade refining capacities become available at scale, recycling represents one of the major pathways to supplement the supply of key raw materials for ACCs. The increasing battery demand would also lead to a surplus of used batteries in the Indian market, which need to be properly tracked, collected, classified, and then recycled safely and efficiently.

Fragmented and disorganized collection of battery waste reduces the availability of recycling feedstock and necessitates additional sorting and classification by the recycler, increasing costs. Therefore, in order to prevent such outcomes and build a regulated, traceable, and economically viable battery circularity ecosystem, the following measures may be taken:

- Mandate battery passports and digital lifecycle tracking systems to strengthen EPR compliance and traceability under the Battery Waste Management Rules 2022.
- Create a public EPR credit[30] trading platform to incentivise over-achievement of recycling targets and reward private investment in recycling capacities in consultation with MoEFCC.
- Use recycling mandates to improve feedstock availability and reduce long-term material cost volatility for domestic cell manufacturers.
- Support shared pilot lines and testbeds, co-located with national labs or private manufacturers' gigafactories, to de-risk and accelerate the scaling-up of recycling technologies.

Implementing Ministry:	Timeline:
M/o Mines	FY2032

5.4.2. Cross-cutting enabler action items:

Research and Development (R&D)

Action item 8: Implement a 50% co-funding R&D model (government grants + industry funding) for mission-mode projects focused on next-gen battery technologies

Developing a new battery chemistry from the lab (TRL 4) to a commercial-scale factory (TRL 8) is a process with huge risks. This phase requires massive investment in pilot plants and months of physical testing to optimize cell design, manufacturing processes and quality control.

- Cost: Building a single pilot line can cost a significant amount.
- Time: Each iteration of physical testing can take 6-12 months.
- Data Silos: Critical data on cell degradation and manufacturing tolerances remain locked within individual companies or research labs.

To enable indigenous development of next-gen battery technologies (niche technologies), R&D institutes need to be enabled through financial means. This can be achieved through:

[30] Extended producer responsibility credits certify that a certain quantity of waste has been recovered and recycled. These may be submitted against recycling targets or traded to other parties on a platform.

- Implementing a co-funding R&D model where the government will provide limited funds (up to 50%) in the form of grants, remaining funding to be provided by industry bodies.
- Establishing 4-5 battery prototyping centers to facilitate the transition of R&D to commercialization.
- Supporting capacity building to meet manpower requirements for GWh-scale production lines.
- Developing standardized methodologies for accelerated life-cycle testing.
- Introducing specialized skills and training programmes for battery materials science.

Applicability:
☑ Component manufacturing | ☑ ACC manufacturing

Implementing Agency: Department of Science & Technology (DST)	**Timeline:** FY2028

Industrial cluster development

Action item 9: Develop at least five (5) integrated "Plug-and-Play" Industrial Clusters for battery ecosystem development

At present, the battery ecosystem players face high capital expenditure, complex and lengthy statutory approvals, and long gestation periods for land acquisition and infrastructure setup. Setting up industrial parks/ clusters as a plug-and-play model will de-risk investment and accelerate project timelines for investors.

These parks will provide pre-approved sites with all necessary utilities and infrastructure, enabling companies to start construction of their facilities within 60 days of land allocation.

The same can be achieved through the following approaches:

- **Develop integrated infrastructure:** The hubs/parks must provide complete ecosystem of specialized infrastructure, including:
  - High-capacity, reliable power supply.
  - Water supply and effluent treatment plants.
  - Common facilities for testing, certification, and calibration.
  - On-site logistics and warehousing with customs clearance facilities.
  - Dedicated housing and social infrastructure for the workforce.

The hubs/parks should allow the complete value chain to be set up including processing units, component manufacturing, cell and BESS manufacturing, equipment manufacturing, testing and validation labs. This will create a localized supply chain, reduce logistics costs and improve efficiency.

States should develop these industrial hubs/ parks with financial support from Central ministries. A state grand challenge may be conducted to invite states to set up these industrial hubs/ parks.

Applicability:
☑ Refining | ☑ Component manufacturing | ☑ ACC manufacturing | ☑ BESS manufacturing | ☑ Recycling

Implementing Agency: DPIIT	**Timeline:** FY2028

Action item 10: Rationalization of GST rates applicable to the ACC ecosystem

Standalone batteries currently attract an 18% GST compared to 5% GST on EVs[31] and RE devices[32]. This is acting as a significant barrier in their widespread adoption. Additionally, EV batteries supplied as part of a subscription or battery swapping service also attract a GST of 18% while EVs themselves attract a lower GST rate of 5%.

Due to this, the working capital of OEMs gets tied up in the form of unutilized Input Tax Credit (ITC), as input GST is high while the lower output GST accumulates slowly over the term of a multi-year vehicle lease.

Similarly, a high GST of 18% on battery scrap is making it costlier for recyclers to recover battery minerals from used batteries. This is much higher than the GST of 5% on ore concentrate, despite the need for battery circularity to bolster the ACC supply chain. To promote the manufacturing and end-use of ACC batteries and prevent similar input-output mismatches, the following measures may be taken:

- Rationalize HSN codes for products across the ACC value chain, in order to enable targeted GST and trade related measures.
- Applicable GST rates may be set at the lower slab of 5% across the ACC value chain for refined materials, components, ACCs, BESS, and EVs.

Applicability:
☑ ENTIRE BATTERY ECOSYSTEM

Implementing Ministry: Ministry of Finance	**Timeline:** FY2027

Governance

Action item 11: Setup a High-level Task Force to monitor the overall progress of the industry

Establish a High-level Task Force under NITI Aayog to regularly monitor the status of the industry, including but not limited to the progress of gigafactories, upstream-midstream projects, skill programmes, the supply-chain landscape, tariff and non-tariff measures, GST rates etc.

This High-level Task Force shall be empowered to remove any obstacles or difficulties in the development of the battery ecosystem in the country.

Applicability:
☑ ENTIRE BATTERY ECOSYSTEM

Implementing Agency: NITI Aayog	**Timeline:** FY2027

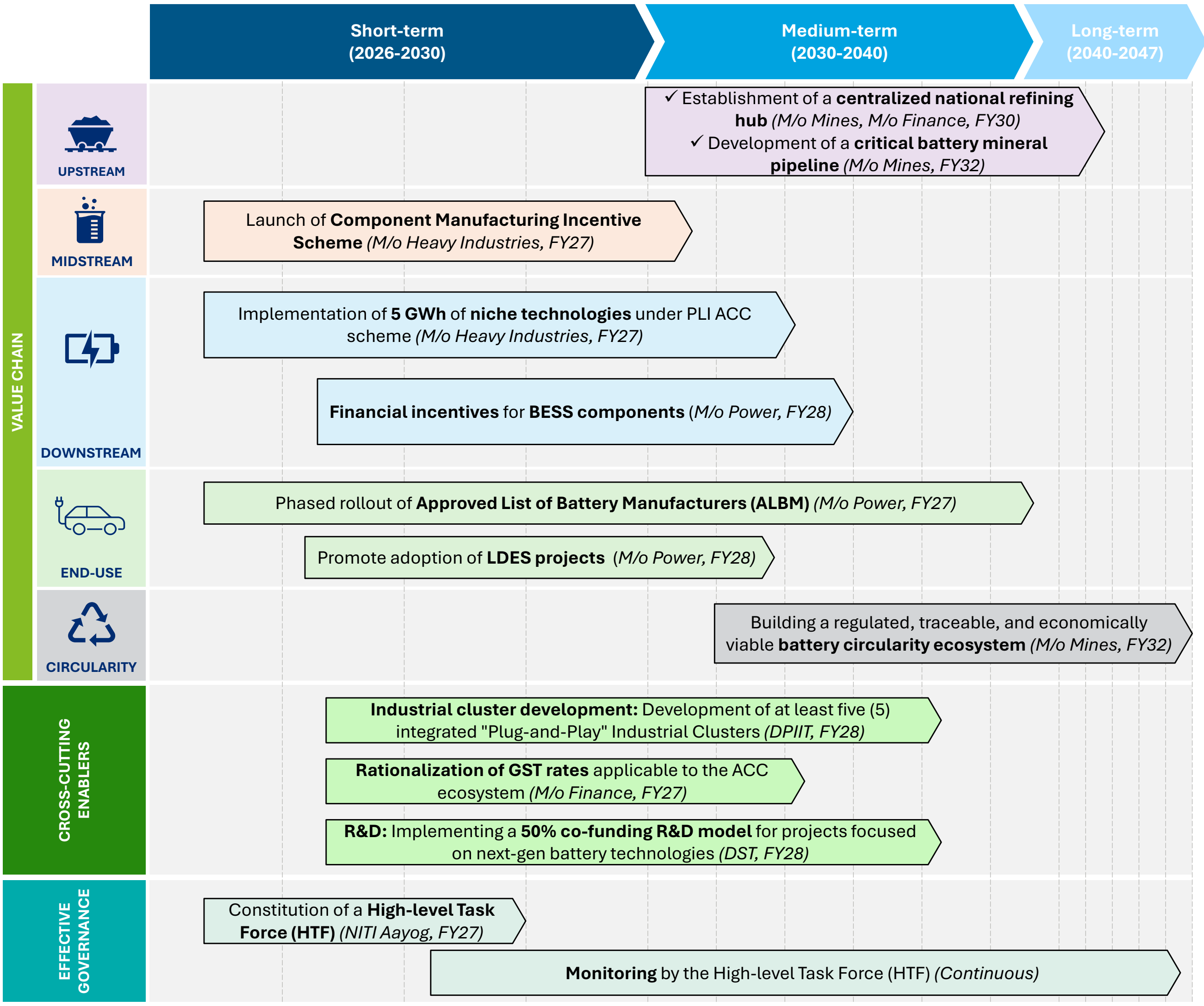
[31] https://www.pib.gov.in/PressReleasePage.aspx?PRID=1797676&reg=3&lang=2
[32] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2167486&reg=3&lang=2

5.5. National Battery Roadmap @2047

India requires a phased approach for achieving its Battery Vision 2047. The immediate priorities for the country are to develop a robust domestic manufacturing 'core' that includes – ACC manufacturing and ACC component manufacturing.

India's strength lies in its rapidly growing domestic market and the country must capitalize on this demand to anchor investments in ACC and ACC component manufacturing. To provide assurance and demand certainty to investors, end-use interventions should also be implemented in parallel. Implementing cross-cutting enablers alongside will help create a globally competitive manufacturing ecosystem.

After establishing this manufacturing core, India should then pivot towards upstream integration and circularity. This will ensure stable domestic demand from ACC and ACC component manufacturers leading to economic viability for upstream investments. Similarly, the battery circularity ecosystem becomes strategically critical once a significant quantum of batteries starts reaching end-of-life.



The proposed roadmap aims to enable India to achieve self-reliance across the battery ecosystem by the time the country reaches its Viksit Bharat @2047 milestone.

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6

Chapter 6. Annexures

6.1. Stakeholder consultations

6.1.1. List of stakeholders

Sr. No	Stakeholder name
	Ministries/ Departments
1.	Ministry of Heavy Industries (MHI)
2.	Ministry of New and Renewable Energy (MNRE)
3.	Ministry of Power (MoP)
4.	Ministry of Mines (MoM)
5.	Ministry of Railways (MoR)
6.	Ministry of Electronics and Information Technology (MeitY)
7.	NITI Aayog
8.	Central Electricity Authority (CEA)
9.	Department of Telecommunications (DoT)
10.	Department of Science and Technology (DST)
11.	Bureau of Indian Standards (BIS)
	ACC manufacturers
12.	Agratas Energy Storage Solutions Private Ltd.
13.	Amaraja Advanced Cell Technologies Private Ltd.
14.	Exide Energy Solutions Ltd.
15.	JSW Energy Ltd.
16.	Lucas TVS Ltd.
17.	Nash Energy Private Ltd.
18.	Ola Cell Technologies Private Ltd.
19.	Reliance New Energy Battery Storage Ltd.
20.	Waaree Energies Ltd.
	ACC component manufacturers
21.	Altmin Private Ltd.
22.	Epsilon CAM Private Ltd.
23.	GFCL EV Products Ltd.
24.	Hindalco Industries Ltd.
25.	LNJ Bhilwara/ TACC Ltd.

Sr. No	Stakeholder name
26.	Molecular Synthesis Private Ltd. (MolSynth)
27.	Neogen Chemicals Ltd.
28.	NPSPL Advanced Materials Private Ltd.
29.	PCBL Chemical Ltd.
	BESS manufacturers
30.	Delectrik Systems Private Ltd.
31.	Good Enough Energy Private Ltd.
32.	L&T Ltd.
33.	Luminous Power Technology Private Ltd.
34.	Maestrotech Systems Private Ltd.
35.	Pace Digitek Ltd.
36.	Replus Engitech Private Ltd.
37.	Vikram Solar Ltd.
	Recyclers
38.	Attero Recycling Private Ltd.
39.	Lico Materials Private Ltd.
40.	Lohum Cleantech Private Ltd.
41.	Trishulavel Eshan Private Ltd. (LiCircle)
	Other ecosystem players
42.	Bharat Heavy Electricals Ltd. (BHEL)
43.	IFCI Ltd.
44.	India Energy Storage Alliance (IESA)
45.	International Copper Association India (ICA India)
46.	Net Zero Energy Transition Association (NETRA)
47.	NTPC Ltd.
48.	Semco Infratech Private Ltd.
49.	Society of Indian Automobile Manufacturers (SIAM)
50.	Solar Energy Corporation of India Limited (SECI)

6.1.2. Stakeholder feedback summary

Summary of key interventions suggested by stakeholders:

<table>
<tr><th>Sr. No.</th><th>Intervention</th></tr>
<tr><td></td><td>a. UPSTREAM (Mining)</td></tr>
<tr><td>1.</td><td>Create a critical minerals strategic reserve
• Like India’s Strategic Petroleum Reserves (SPR), establish a critical minerals strategic reserve to maintain 6-month buffer stock of the domestic demand to manage supply chain disruptions and global market price volatility.</td></tr>
<tr><td>2.</td><td>Secure diversified and integrated critical mineral supply chains
• Accelerate exploration and licensing under the National Critical Mineral Mission (NCMM) with clear timelines for lithium, cobalt, nickel, graphite, and manganese. (IESA)
• Enact a Critical Raw Materials Act (CRMA) to define strategic minerals, ensure long-term supply security, and enable private participation across mining, processing, recycling. (IESA)
• Empower KABIL with simplified approvals, political-risk insurance, and provisions for private co-investment to accelerate overseas mining and processing projects (NETRA).</td></tr>
<tr><td>3.</td><td>Develop domestic needle coke ecosystem for battery-grade applications
• Promote Public-Private Partnership (PPP) models for needle coke production in India, with multiple global technology providers ready to enter. (NPSPL)</td></tr>
<tr><td>4.</td><td>Explore international collaboration in critical minerals
• Pursue G2G partnerships and long-term offtake agreements with Argentina, Chile, Australia, supported through KABIL. (IESA)
• Leverage India-EU, India-US, and India-Japan critical mineral partnerships to co-invest in assets recognised as strategic projects under the EU CRMA. (NETRA)</td></tr>
<tr><td>5.</td><td>Financial support to Indian companies acquiring foreign assets
• Establish low-cost sovereign / EXIM-backed financing windows for Indian companies acquiring overseas mineral and processing assets (NETRA).</td></tr>
<tr><td></td><td>a. UPSTREAM (Refining)</td></tr>
<tr><td>6.</td><td>Financial incentives for setting up refining and precursor facilities
• Establish battery-grade refining hubs for lithium carbonate/hydroxide, cobalt sulphate, nickel sulphate, synthetic graphite, supported by PLI/ capital subsidy mechanisms. (IESA)
• Create a national or PSU-led stockpiling mechanism for refined critical minerals to mitigate extreme price volatility and provide long-term demand visibility to domestic processors. (LOHUM)
• Provide up to 50% fiscal support for critical mineral refining and precursor projects, given their high-CAPEX and technology intensity. (IESA)</td></tr>
</table>

Sr. No.	Intervention
7.	**Making India regional processing hub by 2032** • Encourage **joint-venture–based technology transfer** with **global refiners**, ensuring ESG-compliant operations. *(NETRA)* • Commission **refining and precursor plants** during 2028-2032, with India emerging as a regional processing hub beyond 2032. *(IESA)*
	b. MIDSTREAM (Component Manufacturing)
8.	**Financial incentives for setting up ACC component facilities** • Incentivize **domestic production of cathode, anode, electrolyte, and separator precursors** to enable backward integration. *(IESA)* • Launch **dedicated PLI / capital subsidy support (30-40%)** for upstream components including cathodes, anodes, separators, electrolytes, foils, and casings. *(NETRA)* • Introduce **Capex PLI for ACC component manufacturers** to ensure project viability. *(NPSPL, PCBL)* • Explicitly include battery-grade CPC (Calcined Petroleum Coke) under the component manufacturer scheme. *(NPSPL)* • Recognize new battery-grade CPC plants as eligible projects under Capex PLI. *(NPSPL)* • Provide enhanced **CAPEX subsidy for graphitization furnaces** and allied equipment critical for anode manufacturing. *(TACC)* • Introduce **PLI-2.0 specifically for raw materials**, including anode-grade materials. *(TACC)* • Introduce a separate PLI scheme for battery raw material and material suppliers, as they are currently excluded from existing PLI frameworks. *(PCBL)* • Provide **capex support for CAM and cell manufacturing** to bring Indian production costs closer to global benchmarks. *(Epsilon)* • Launch a targeted PLI or component incentive stream for copper foil, recognising it as a critical upstream battery material. *(Hindalco)* • Provide CAPEX, OPEX and technology-acquisition support to bridge the cost gap with Chinese manufacturers. *(Hindalco)* • Provide **30-50% capital subsidy for cathode active material (CAM)** manufacturing, aligned with China's gigafactory subsidies and the US IRA model. *(Exide)* • Deploy **viability gap funding** and infrastructure subsidies for new manufacturing plants to reduce initial capital burden. (Altmin) • Provide capital subsidy for cleanroom-dependent infrastructure, critical for copper foil manufacturing. (Hindalco) • Introduce PLI-like production support for initial years of operation to bridge the cost gap with imported cells until domestic manufacturing achieves scale efficiencies. (Altmin) • Extend **targeted incentive schemes, including PLIs**, to cathode active material (CAM) and precursor manufacturing to address under-development of India's downstream battery-materials ecosystem. *(LOHUM)* • **Strengthening domestic CAM and precursor capacity** will reduce import dependence, anchor demand for domestically recycled and refined minerals, and ensure that upstream investments translate into sustained domestic value addition. *(LOHUM)*

Sr. No.	Intervention
9.	**Provide opex subsidy** • Provide **central-level electricity cost subsidy** for battery component manufacturers to offset India's power cost disadvantage versus China (~₹3/kWh). *(NPSPL)* • Ensure affordable **industrial power tariffs** to reduce operating costs. *(NETRA, IESA)* • Classify battery materials under a special industrial power tariff category with reduced electricity cost. *(TACC)* • Provide interest subvention of 3-4% to align Indian financing cost with global benchmarks. *(TACC)* • Offer power subsidy (~30%), freight subsidy and low-interest funding to improve global cost competitiveness. (Hindalco) • Introduce **income-tax incentives for the first 10 years** for strategic battery component manufacturing projects. (Hindalco)
10.	**Customs duty waivers on import of equipment and raw materials** • Remove **import duties on capital goods** required for battery component manufacturing. *(NPSPL)* • Eliminate **duties on needle coke** and battery-grade CPC, which are essential inputs for anode materials. *(NPSPL)* • Relax anti-dumping duty on calcium carbide (10%), a key input for acetylene black manufacturing, to enable localization. *(PCBL)* • **Reduce customs duty on acetylene black** to zero from the current 7.5% to improve cost competitiveness. *(PCBL)* • Allow zero import duty on specialised machinery and equipment, particularly Japanese technologies with 40-50% cost premium. (Hindalco) • Reduce GST on equipment and key inputs and ensure expedited refunds to ease working-capital pressure. (Hindalco)
11.	**Increasing tariff barriers on imported ACC components** • **Increase import duties** on battery components and cells from 5% to at least 20% to counter predatory pricing and dumping. *(Exide)* • Introduce **minimum import floor price (MIP)** mechanisms to prevent below-cost imports of CAM and cells from monopolistic suppliers. *(Exide)* • **Increase customs duty** to 15% on copper foil and exclude this product from all FTAs to protect domestic industry. *(Hindalco)* • Apply anti-dumping and anti-predatory pricing measures to counter unfair trade practices. *(Hindalco)* • **Impose tariff and non-tariff barriers** to prevent dumping of below-cost imported cells and components. *(NASH Energy)* • Shield emerging Indian manufacturers from **predatory pricing** during scale-up phase. *(NASH Energy)* • **Impose anti-dumping duty** on acetylene black imports to counter predatory pricing and dumping. *(PCBL)* • Implement **anti-dumping duties** on Chinese anode imports to prevent market distortion. *(TACC)* • Introduce **tariff barriers on imported CAM and cells** to prevent below-cost dumping, particularly from China. *(Epsilon)*

Sr. No.	Intervention
	• Implement non-tariff measures such as a **minimum import floor price** for LFP and CAM to avoid market distortion by monopolistic suppliers. *(Epsilon)*
12.	**Effective monitoring and quality control** • **Enforcing mandatory quality standards and Quality Control Orders (QCOs)** for copper foil imports. *(Hindalco)* • Implement **strict monitoring of under-invoicing** to prevent price circumvention. *(Hindalco)* • Set up dedicated facilities for testing and measurement equipment for batteries and BESS to encourage domestic ACC design development and manufacturing. (*Semco Infratech*)
13.	**Facilitate international collaboration and partnerships** • Encourage **joint-venture–based technology transfer** with **component manufacturers**, ensuring ESG-compliant operations. *(NETRA)* • Strengthen **international collaboration** to enable large-scale manufacturing, cost reduction, and subsystem localization across ESS technologies (*CEA*). • Enable expedited visas for Chinese nationals and other foreign experts critical to battery technology transfer and plant commissioning. (*NPSPL)*
14.	**Develop cluster-based industrial infrastructure for battery manufacturing** • Ensure affordable **industrial power tariffs** and promote **cluster-based co-location** of component units near gigafactories to reduce logistics and operating costs. *(NETRA, IESA)* • Ensure **land and infrastructure availability through cluster-based industrial zones** to reduce project timelines and upfront development costs. *(Epsilon)* • Roll out capex and tariff support immediately, while cluster infrastructure should be operational within 12-24 months. *(Epsilon)* • Develop dedicated industrial parks for battery component materials, enabling shared infrastructure and faster project execution. (*NPSPL)* • Provide preferential land **allotment in green-tech clusters** for battery component manufacturing. (*Hindalco)* • Enable **single window**, fast-track approvals, including priority environmental clearances and site inspections. (*Hindalco)* • Develop **integrated industrial clusters** co-locating battery recycling, critical-mineral refining, CAM and precursor manufacturing, and associated supply-chain activities. *(LOHUM)* • **Cluster-based development** will reduce logistics costs, streamline material flows, improve coordination, and accelerate scale-up of domestic capacity. *(LOHUM)*
15.	**Other measures** • Provide commercial-scale demonstration support for silicon-based anodes to improve material efficiency and long-term sustainability. (*TACC)* • Link component manufacturing projects with employment **subsidy schemes and skilling programs** to reduce initial workforce costs. (*Hindalco)*

Sr. No.	Intervention
	• Recognize Copper foil as a critical green-tech component essential for battery supply-chain resilience. *(Hindalco)* • Integrate copper foil into national battery and EV strategies to ensure upstream supply security and localization. *(Hindalco)*
	c. DOWNSTREAM (ACC Manufacturing)
16.	**Conclude the 10 GWh GSSS allocation under PLI ACC** • Government to finalize pending 10 GWh PLI for stationary storage. *(IESA)* • Implement **PLI ACC Scheme with 10 GWh** capacity earmarked for grid-scale stationary storage, as finalized by MNRE in consultation with CEA. *(CEA)* • Enforce **strict milestone-based monitoring** of ACC PLI projects, with quarterly public dashboards on capacity, investment, and domestic value addition (*NETRA*). • The implementation of the **PLI–ACC Scheme** may be **further enhanced** by earmarking an additional 40 GWh capacity specifically for grid-scale stationary energy storage, to catalyse the development of a domestic BESS ecosystem and strengthen indigenous manufacturing capabilities. (*MNRE)*
17.	**Provide incentives for brownfield ACC facilities in the country under PLI** • Launch a **dedicated incentive program for non-PLI ACC manufacturers**, including brownfield expansions. *(IESA)* • Include brownfield expansions under incentive schemes, like South Korea's K-Battery Strategy supporting new, existing and expansion projects. (*Exide)* • Reallocate **unutilised PLI incentives** from delayed projects to commercially ready manufacturers on a first-come first-serve basis (*NETRA*).
18.	**Financial support for setting up ACC manufacturing (non-PLI)** • Introduce **50% capital subsidy** for gigafactories and component units, aligned with Semicon India Programme type support. *(IESA)* • Provide interest subvention, credit guarantees, accelerated depreciation, and fast-track approvals for projects >1 GWh. *(IESA)* • Provide **30-50% capital subsidy** for cell manufacturing, aligned with China's gigafactory subsidies and the US IRA model. (*Exide*) • Provide CAPEX support to enable scale-up from pilot to GWh-scale plants, addressing the steep upfront investment barrier for new manufacturers. (*Altmin, NASH Energy)* • Integrate **explicit capex support within the ACC PLI framework**, including upfront grants, VGF or interest subvention for gigafactories and critical process infrastructure. (*Agratas)* • Use capex support to de-risk high upfront investments, accelerate commissioning timelines, and enable adoption of next-generation chemistries. (*Agratas, Epsilon*) • Anchor capex incentives to domestic value addition and technology outcomes while improving global cost competitiveness of Indian manufacturers. (*Agratas, Epsilon*) • Provide **subsidies to offset non-refundable VAT imposed by China** on key battery raw material exports, amounting to US$1.3-2.9/kWh cost disadvantage for Indian cell manufacturers. (*Exide*)

Sr. No.	Intervention
	• Introduce performance-linked demand incentives for OEMs using indigenous cells, subject to quality benchmarks. (*NASH Energy*)
19.	**Opex and infrastructure support to ACC manufacturers** • Offer interest subvention / low-cost debt to battery manufacturing projects to ease financing constraints during early scale-up. (*Altmin*) • Introduce **per-kWh production credits**, energy rebates and logistics subsidies to offset India's ~20% operating cost disadvantage versus China. (*Exide*) • Model operational support on US 45X production credits and EU IPCEI opex reimbursements. (*Exide*) • Provide strategic manufacturing electricity tariffs, subsidised water, and long-lease industrial land for gigafactories. (*Exide*) • Reduce logistics costs through dedicated transport corridors and port-linked battery clusters. (*Exide*) • Develop **fully integrated battery industrial parks**, benchmarked to Chinese battery clusters delivering 30-60% lower production costs. (*Exide*) • Introduce OPEX support linked to actual production volumes to bridge the cost gap between domestic cells and imports during early years. (*NASH Energy*) • Create **fast-track approval** and certification frameworks for Indian-made cells to enable quicker market entry and commercialization. (*NASH Energy*)
20.	**DVA relaxation/ support** • Relax Domestic Value Addition (DVA) norms progressively over 5-7 years to allow supply chains to scale sustainably. (*Exide*) • Target **25% local sourcing** in near term and 60% domestic value addition by 2032. (*IESA*)
21.	**Niche-ACC PLI** • Government to finalize **pending 5 GWh PLI** for niche technologies. *(IESA, NITI Aayog)*
22.	**Enabling ecosystem** • Promote modular 2-5 GWh regional gigafactories co-located with OEMs and state industrial parks (*NETRA*). • Establish **single-window clearance systems** with 6-month timelines and deemed approvals for gigafactory projects (*NETRA*).
23.	**Accelerate ACC manufacturing scale-up and ensure competitiveness across PLI and non-PLI projects** • Adopt long-term, scale-oriented support approaches inspired by China's sustained subsidies and R&D-backed manufacturing strategy. *(Epsilon)*
24.	**Increasing tariff barriers**

Sr. No.	Intervention
	• Apply **tariff barriers** to ensure **imported cells** are priced above domestic manufacturing cost, enabling viable domestic component and cell manufacturing. *(Altmin)*
	c. DOWNSTREAM (BESS Manufacturing)
25.	**Financial support for manufacturing of BESS/ BESS components** • Introduce **PLI support for all battery value-chain components**, including cells, packs, BMS, cooling systems, fire suppression systems and BESS containers, not only cell manufacturing. (*Replus, NITI Aayog*)
26.	**Customs duty waivers for machinery imports** • Extend **0% customs duty on CAPEX machinery** to all battery value-chain manufacturing equipment, including anode, cathode, electrolyte, separator, cell, pack, BMS and BESS systems. (*Replus, JSW*)
27.	**Tariff barriers on imported BESS components** • Apply **higher customs duty** on imported finished BESS containers and BMS to encourage domestic manufacturing. *(Replus, JSW)*
28.	**Other measures** • Link battery manufacturing and ESS deployment with renewable energy and green hydrogen clusters, enabling carbon credits or tax benefits for low-carbon production. *(NETRA)* • Develop **national testing and validation centres** for battery packs at ARAI, ICAT, CPRI, aligned with AIS-156, UN 38.3, IEC standards. (*IESA*) • Introduce **specific HSN codes** for battery packs, modules, and BESS enclosures to enable targeted tariff and GST policy. *(IESA)* • Provide interest subvention for MSMEs adopting energy storage solutions in industrial applications. (*NASH Energy*)
	d. End Use
29.	**Preferential treatment for domestic manufacturers/products** • Extend preferential procurement for domestically manufactured battery packs and BESS under Make in India (PPP-MII Order, 2017). *(IESA)* • Mandate **domestic sourcing thresholds** in government EV fleets, e-bus programmes, and grid-scale BESS tenders. (*NETRA*) • Mandate use of domestically manufactured cells and packs for national-critical infrastructure such as telecom, railways, data centers and PSU fleets. (*Exide*) • Enforce progressively increase in DVA thresholds in public procurement, e.g., +10% every 24 months. (*Exide, JSW*)

Sr. No.	Intervention
	• Mandate domestic **content-based procurement** for cells, packs and BESS in government and PSU tenders. (*Replus*) • Align domestic content thresholds with phased duty structures to ensure predictable demand for Indian manufacturers. (*Replus*) • Implement **demand aggregation for grid-scale storage** using a SECI-style procurement model. (*TACC*) • Government can enforce **mandatory localisation thresholds in OEM procurement**, ensuring domestic batteries are prioritized in EV and ESS deployment. (*Altmin*) • Ensure government and PSU procurement prioritises domestic content, including CAM, cells, BMS, and battery pack assembly. *(Epsilon)* • Mandate **at least 50% Domestic Value Addition under MoP VGF and PM E-DRIVE** schemes, aligned with global domestic-content multipliers. (*Exide*) • Mandate **Domestic Value Preference (DVP) in government** and PSU procurement across EVs, Railways, Telecom, Defence and stationary storage. (*NASH Energy*) • Mandate **minimum Domestic Value Addition (DVA)** for batteries used in EVs and stationary storage systems. (*TACC*)
30.	**Approved List of Models and Manufacturers for Batteries** • Establish an **Approved List of Battery Manufacturers** (ALBM), like MNRE's ALMM, to ensure safety, traceability and domestic value addition. (*Exide, JSW*) • **Mandate ALBM-certified batteries** across FAME-type schemes, PM E-Drive, and state EV policies. (*Exide*) • Introduce an **approved list of Models and Manufacturers for Batteries** (ALMM-B) for EV cells and packs, aligned with public procurement and incentive-linked schemes. (*Agratas*) • Implement ALMM-B jointly by MoF and MHI/MNRE to ensure quality-assured and domestically anchored battery supply for government-supported programs. (*Agratas*)
31.	**Create demand certainty and market assurance** • Update tender guidelines to match technological developments taking place in the market. (*NITI Aayog*). • Re-examine the tariff approval mechanism for grid-scale energy storage projects to ensure timebound deployment. (*NITI Aayog*) • Encourage **renewable energy + storage integration**, especially through DISCOM storage obligations, to boost demand for domestically manufactured batteries and recycled materials. (*LICO Materials*) • Introduce time-of-day tariffs and storage-friendly regulations to improve economics for industrial and grid-scale storage. *(Epsilon)* • Accelerate nationwide rollout of **Time-of-Day (TOD) tariffs** to unlock commercial and residential ESS demand. (*Exide*) • Use TOD price signals to enable peak-shaving, arbitrage and behind-the-meter storage adoption aligned with Australia and California markets. (*Exide*)

Sr. No.	Intervention
	• Enable standardized long-term offtake contracts for domestic suppliers to provide revenue visibility and bankability. (*NASH Energy*)
32.	**Improve export readiness** • Align India's **demand creation strategy with global frameworks** such as the US IRA, EU Battery Regulation, and OBBB-style unified incentives to improve export readiness and competitiveness. *(Epsilon)*
33.	**Promoting adoption of Long Duration Energy Storage (LDES)** • **Adoption of Long Duration Energy Storage (LDES)** to be included as part of the Long-Term Action Plan. *(NITI Aayog)*
	e. CIRCULARITY
34.	**Strengthen domestic recovery of critical minerals through recycling** • Support localization of lithium, graphite and phosphate supply through domestic recycling and secondary material recovery, reducing import dependence. *(NASH Energy)* • Create a material-return loop by aligning recycling regulations with cell manufacturers to ensure assured offtake of recovered materials. *(NASH Energy)*
35.	**Build a regulated, traceable, and economically viable battery circularity ecosystem** • Recycling of battery-grade materials may be supported through appropriate policy measures and financial incentives. (*MNRE*) • Mandate **battery passports and digital lifecycle tracking systems**, aligned with EU regulations, to strengthen EPR compliance and traceability *(NETRA)*. • Support establishment of at least **10 large-scale recycling plants** (>10,000 tonnes/year) near industrial and gigafactory clusters through concessional finance and tax incentives *(NETRA)*. • Promote **on-site recycling units** within gigafactories to recover cathode and anode materials and reduce raw material import dependence *(NETRA)*. • Create a public **EPR credit trading platform** to incentivise over-achievement of recycling targets and private investment *(NETRA)*. • Establish a sector-wide battery recycling framework to reduce lifecycle costs and improve adoption of domestically manufactured batteries using recycled materials. *(Epsilon)* • Support shared pilot lines and testbeds, co-located with national labs or ACC-PLI gigafactories, to de-risk scale-up of recycling flowsheets. (*LICO Materials*) • **Reduce GST on battery scrap from 18 percent to 5 percent** to incentivise formal transactions and redirect material flows from the informal to the regulated ecosystem. *(LOHUM)* • **GST rationalisation** will improve traceability, enhance feedstock availability for authorised recyclers, and ensure that higher-quality material reaches compliant recycling and processing facilities. *(LOHUM)* • Strengthen battery recycling regulations to ensure systematic recovery of lithium, graphite and phosphates. (*NASH Energy*)

Sr. No.	Intervention
	• Use **recycling mandates to improve feedstock availability** and reduce long-term material cost volatility for domestic cell manufacturers. (*NASH Energy*) • Implement targeted **tariff measures to protect domestic refiners and processors** from persistent under-pricing and dumping of battery-material intermediates, particularly from China. *(LOHUM)* • **Rationalise Basic Customs Duty (BCD)** on key intermediates such as nickel sulphate, cobalt metal, cobalt sulphate, and lithium carbonate, and initiate safeguard or anti-dumping actions where warranted. *(LOHUM)* • Correcting **tariff distortions is critical to restoring fair market pricing**, improving capacity utilisation, strengthening investor confidence, and enabling scale-up of domestic refining and processing in line with NCMM objectives. *(LOHUM)*
36.	**Strengthen EPR enforcement and long-term feedstock assurance** • Move Extended Producer Responsibility (EPR) from paper compliance to enforceable OEM-recycler tie-ups with long-term volume commitments. (*LICO Materials*) • Enable recyclers to secure locked-in feedstock volumes, critical to justify high-capex investments in hydrometallurgy and refining. (*LICO Materials*)
37.	**Second-life battery market development** • Promote **second-life storage** as a cost-effective, low-carbon solution for off-grid, residential and small commercial applications. (*LICO Materials*)
38.	**Strengthen regulatory oversight and compliance frameworks** • Strengthen the **regulatory and compliance framework** governing battery recycling and mineral processing to ensure ecosystem credibility and environmental integrity. *(LOHUM)* • Introduce **stricter pre-approval norms**, mandatory independent **technical audits**, and continuous **monitoring of material flows** and recovery efficiencies to eliminate non-compliant operators, curb practices such as fake EPR credit generation and misreporting and improve traceability across the value chain. *(LOHUM)* • **Standardised national enforcement** will ensure that only technically capable and environmentally compliant facilities remain operational. *(LOHUM)*
39.	**Integration of recycled materials into domestic battery value chain** • **Create a** regulatory push **for the use of domestically recovered cathode and other** materials in EVs, ESS and government procurement. (*LICO Materials*) • Enable **OEM recycler integration** to ensure stable demand for recycled battery materials. (*LICO Materials*) • Align recycled-material usage with DVA norms and localization frameworks to incentivise circular supply chains. (*LICO Materials*)
40.	**Improve access to domestic and international feedstock**

Sr. No.	Intervention
	• **Address feedstock constraints** by establishing predictable, policy-backed channels for access to battery waste, black mass, and recyclable intermediates. *(LOHUM)* • Pursue **bilateral arrangements with the EU, US, and key Asian partners** to enable controlled and compliant movement of recyclable materials, within the constraints of the Basel Convention, EU Waste Shipment Regulation, and OECD rules. *(LOHUM)* • Secured **feedstock access is critical for plant utilisation**, long-term capacity planning, and reducing dependence on informal domestic sources. *(LOHUM)*
41.	**Rationalize Extended Producer Responsibility (EPR) timelines for lithium batteries** • Amend **EPR timelines for lithium-ion batteries** by shifting recycling liability to the 9th, 10th and 11th year from date of sale, reflecting actual battery life cycles. (*Replus*) • Recognise long-life BESS batteries (15-25 years) within EPR regulations to enable realistic compliance and circularity planning. (*Replus*)
42.	**Provide targeted CAPEX support for recycling and critical-mineral processing** • Establish targeted **CAPEX support mechanisms** for **battery recycling and mid-stream critical-mineral** processing facilities, recognising the high upfront investment required for EHS-compliant infrastructure, HAZMAT handling systems, and advanced hydrometallurgical refining equipment. *(LOHUM)* • Provide support to de-risk early investments, address India's capital cost disadvantage vis-à-vis large state-backed Chinese facilities and accelerate domestic capacity creation in critical-mineral recovery and processing. *(LOHUM)*
	f. ECOSYSTEM DRIVERS (R&D and Skill Development)
43.	**Promote R&D in next-generation ACCs through collaboration** • Promote **alternative energy storage technologies** to reduce dependence on lithium-based mineral supply chains through MAHIR funding (*CEA*). • Establish a **National Battery Technology Centre** under an IIT-CSIR-NITI consortium, allocating at least 10% of ACC PLI outlay for applied R&D and pilot manufacturing (*NETRA*). • Provide **relaxation on the three-year eligibility requirement** for **DSIR**-recognized laboratories for emerging battery technologies where research is nascent. (*Agratas*) • Establish a collaborative **R&D ecosystem** with IITs, CSIR and BARC focused on next-generation anode chemistries. (*TACC*) • Encourage collaboration between leading institutes, PSUs and private players to set up shared R&D and training infrastructure in battery clusters. (*LICO Materials*)
44.	**Financial support in setting up R&D facilities** • Reimburse minimum **50% of testing and certification costs** for qualifying battery products. (*Replus*) • Allow **duty-free imports of R&D equipment** to enable creation of world-class battery material laboratories. (*PCBL*)

Sr. No.	Intervention
	• Provide **minimum 50% capex subsidy** for battery R&D infrastructure to bridge cost competitiveness gaps with China and accelerate indigenous cell development. (*Agratas*) • Provide capital subsidy and incentives for setting up test laboratories for cells, packs and BESS. (*Replus*) • Extend R&D tax incentives and benefits beyond DSIR-approved labs, allowing collaboration with academia, contract R&D facilities and global technology partners. (*Agratas, JSW*) • Extend **tax relief and CAPEX incentives** for R&D activities. (*PCBL*) • Provide dedicated R&D grants and infrastructure support for advanced cell chemistries, including LFP performance enhancement (higher energy density, fast charging), LMFP, sodium-ion and solid-state batteries. (*Altmin, JSW*) • Provide **R&D incentives to accelerate LFP product development**, including improvements in performance, energy density, and safety. (*Epsilon*) • Draw lessons from Japan's public funding for next-generation battery R&D, particularly in solid-state technologies. (*Epsilon*) • Allow 100% tax benefit on R&D investments for battery materials and component manufacturing. (*NPSPL*) • Provide direct government contribution to R&D expenditure to accelerate technology development. (*NPSPL*) • Support R&D across advanced chemistries, materials, recycling and manufacturing processes to reduce external dependencies. (*Exide*) • Integrate **R&D incentives with domestic refining and processing** of critical materials, aligned with European Battery Alliance principles. (*Exide*) • Provide funding at least **75% of R&D capex and 50% of annual R&D opex through grants,** aligned with Japan's NEDO and EU IPCEI models. (*Exide*) • Support R**&D for alternative chemistries** such as sodium-ion, LMFP and solid-state, reducing long-term dependence on lithium-intensive supply chains and improving lifecycle resilience. (*Altmin*) • Provide targeted **R&D grants** or **tax credits** for hydrometallurgy processes and safe dismantling automation to improve recovery yields. (*LICO Materials*) • Prioritize recycling R&D as LFP volumes grow, where economics depend strongly on process efficiency. (*LICO Materials*) • **Support R&D and pilot-scale projects** for recycling of critical materials, low-grade ore beneficiation, and alternative battery chemistries. (*IESA*) • Expand **targeted R&D support** for **critical-mineral processing, advanced refining, and next-generation battery materials** to reduce technology dependence and close the innovation gap with global leaders. *(LOHUM)* • Priority areas include hydrometallurgical refining, purification and separation technologies, and advanced CAM development for LFP and NMC chemistries. *(LOHUM)* • Support should include **pilot-scale plants, accredited testing and characterisation centres**, and specialised skills and training programmes to generate domestic IP, improve process efficiencies, and build a sustainable technology base. *(LOHUM)*
45.	**Setting up of pilot facilities/ test lines/ shared testing infrastructure**

Sr. No.	Intervention
	• Fund **1-2 MWh pilot manufacturing lines for sodium-ion**, solid-state, metal-air, and alternative chemistries within institutions such as BHEL and CSIR (*NETRA*). • Establish **Centres of Excellence (CoEs)** and pilot-scale facilities under Skill India for cell manufacturing, electrochemistry, automation, and BMS (*IESA*). • Support creation of large-scale indigenous cell R&D centres covering research, design-to-manufacturing and engineering validation to build end-to-end Make-in-India capabilities. (*Agratas*) • Support scale-up of R&D infrastructure beyond lab level, enabling pilot-to-pre-commercial validation for next-generation chemistries. (*Altmin, NASH Energy*) • Support establishment of in-house and shared testing infrastructure to meet global quality benchmarks. (*Hindalco*) • Establish dedicated R&D, testing and certification facilities for battery recycling, materials recovery and safety validation. (*LICO Materials*) • Establish **national testing and validation labs** to reduce dependence on overseas certification and accelerate product validation. (*NASH Energy*) • Under this section, at least 4–5 battery prototyping centres may be established in the country to facilitate the transition of start-up-led R&D to commercialization. (*MNRE)* • A standardized accelerated life cycle testing methodology, acceptable to all stakeholders, may be developed. (*MNRE)*
46.	**Skill development** • Develop a **Battery Manufacturing Skill Initiative** in partnership with the **Skill Council for Green Jobs** and the Ministry of Skill Development and Entrepreneurship. Key actions: Establish dedicated training centres in major battery hubs; promote inclusive training for women and marginalised groups; incorporate hands-on modules on safe handling of hazardous materials, battery management systems and ESG reporting requirements (*NETRA*) • Support to capacity building may be considered for large scale GWh-level production lines. (*MNRE)* • To provide the guidelines to **simplify visa and workforce regulations** to enable global experts to contribute to domestic capability building (*IESA*). • Enable academia-industry co-patenting, faculty exchange programmes, and PhD/post-doctoral fellowships in battery science and engineering (*NETRA*). • **Allow visa facilitation for Chinese technical experts** for setting up manufacturing across anode, cathode, cell, pack, BMS and BESS, not limited to PLI cell manufacturers. (*Replus*) • Provide training schemes and incentives to build **local technical capability** supporting recycling, dismantling and refining operations. (*LICO Materials*)
	f. ECOSYSTEM DRIVERS (Standards & Regulations)
47.	**Establish Standards and Regulations** • Notify standards and regulations for refurbished and second-life battery systems to formalise the sector. (*LICO Materials*) • Mandate **quality, process and material standards** for copper foil to ensure long-term battery performance and safety. (*Hindalco*)

Sr. No.	Intervention
	• Introduce **mandatory BIS standards for BMS** and require use of India-made BMS in EVs and BESS. *(Replus)*
48.	**Other measures** • Introduce **specific HSN codes** for battery packs, modules, and BESS enclosures to enable accurate classification, data monitoring, and targeted tariff policy formulation. (*IESA*) • Mandate **safety, quality, cybersecurity and traceability** screening for imported batteries used in telecom, railways, data centers and BFSI infrastructure. (*Exide*) • Treat batteries for **digital and power infrastructure** as strategic assets, aligned with US and EU practices. (*Exide*)
	f. ECOSYSTEM DRIVERS (Financing)
49.	**Creation of a Battery Manufacturing Development Fund (BMDF)** • Establish a **Battery Manufacturing Development Fund (BMDF)** with an initial corpus of ₹10,000 crore to provide low-interest loans (3-5 % interest) and credit guarantees for battery manufacturing and component projects. (*NETRA*)
50.	**Other measures** • Establish **dedicated funds / Viability Gap Funding (VGF)** to de-risk early investments in recycling and precursor synthesis. (*IESA*) • Establish a **national battery materials innovation fund** to support high-impact, high-risk R&D projects. (*PCBL*)
51.	**Financial support** • Provide low-interest, long-tenure loans across EV and battery value-chain participants. (*PCBL*) • Enable long-term offtake contracts with credit guarantees through IIFCL and PFC to reduce buyer risk (*NETRA*). • Establish a **₹10,000 crore Battery Manufacturing Development Fund** (BMDF) providing 3-5% low interest loans and guarantees (*NETRA*). • Establish a **green financing framework** to support battery material and storage projects. (*TACC*) • Offer green financing and lower GST slabs for products using Indian-manufactured battery cells. (*NASH Energy*)
	g. EFFECTIVE GOVERNANCE
52.	**High-level Task Force** • Establish a **high-level task force** (NITI Aayog, MHI, MNRE, MoP, M/o Mines, M/o Environment, industry associations) to regularly monitor the status of the industry incl. but not limited to progress of gigafactories, upstream-midstream projects, skill programmes, supply-chain landscape, etc. *(NETRA)*

6.2. India macro-economic data

Table 14: India historical macro-economic data

Indicator	GDP growth rate	GDP	GDP per capita	Inflation Rate	Urbanization	Household savings	Energy demand	Energy growth rate
Unit	**%**	**$Tn**	**$**	**%**	**% of Population**	**% of GDP**	**BUs**	**%**
2016	8.26	2.29	1707.50	4.94	32.86	38.0	1,142.93	5.8
2017	6.80	2.65	1950.10	3.32	33.18	39.8	1,213.33	5.35
2018	6.45	2.70	1966.25	3.93	33.498	34.7	1,274.60	5.19
2019	3.87	2.83	2041.42	3.72	33.81	37.6	1,291.01	0.95
2020	-5.78	2.67	1907.04	6.62	34.12	42.5	1,275.53	-0.52
2021	9.69	3.16	2239.61	5.13	34.44	43.5	1,379.81	7.96
2022	7.61	3.34	2347.44	6.69	34.75	42.0	1,513.50	8.89
2023	9.19	3.63	2530.12	5.64	35.06	41.1	1,616.13	7.06
2024	6.49	3.90	2694.73	4.95	35.37	41.1	1,693.96	5.21

6.3. Growth- historical and projected

6.3.1. Automobile industry

Table 15: Historical sales CAGR for different automobile segments (FY15 to FY25), percent

Category of Vehicle	10-yr sales CAGR (%) from FY15 to FY25
2-Wheeler	2.38%
4-Wheeler Passenger Vehicle	4.99%
Bus	0.31%
Light Goods Vehicle	1.96%
Medium Goods Vehicle	4.84%
Heavy Goods Vehicle	3.55%
Total	2.8%

Source: VAHAN 4.0 Portal

Table 16: Passenger vehicle and road transport vehicle demand up to (FY2022 to FY2047); billion vehicle-kms, billion tonne-kms

	Passenger Vehicle Demand (Billion Vehicle-kms)				Road Transport Vehicle Demand (Billion Tonne-kms)	
Year	**2W**	**3W**	**4W**	**Bus**	**LCV**	**HCV**
2022	955.36	201.81	357.83	101.06	309.4	1713.4

	Passenger Vehicle Demand (Billion Vehicle-kms)				Road Transport Vehicle Demand (Billion Tonne-kms)	
Year	2W	3W	4W	Bus	LCV	HCV
2027	1591.40	317.37	575.98	165.07	449.7	2322.4
2032	1939.41	364.72	678.38	197.32	638.7	3085.9
2037	2226.88	394.40	752.88	222.32	869.5	3941.5
2042	2440.41	406.47	797.56	239.15	1121.0	4778.9
2047	2566.23	401.31	810.78	248.31	1286.2	5144.9
CAGR	4.03%	2.79%	3.33%	3.66%	5.86%	4.50%

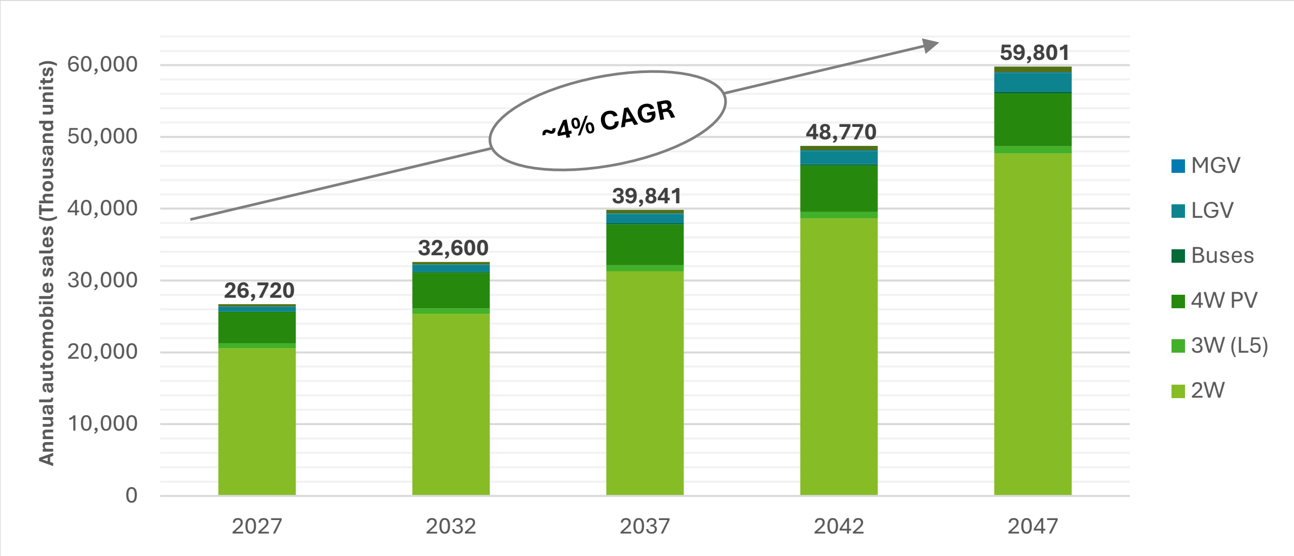
Source: NITI Aayog Indian Energy Security Scenarios 3.0

Table 17: Annual sales growth % for various automobile segments from FY26 to FY47 as per projected growth in demand, percent

Year	Sales Growth %
2W	4.30%
3W	1.75%
4W	2.70%
Bus	3.00%
LGV	7.00%
MGV+HGV	5.00%

Source: Authors' analysis, in line with NITI Aayog Indian Energy Security Scenarios 3.0

Figure 60: Projected annual automobile sales (2027 to 2047), thousand units

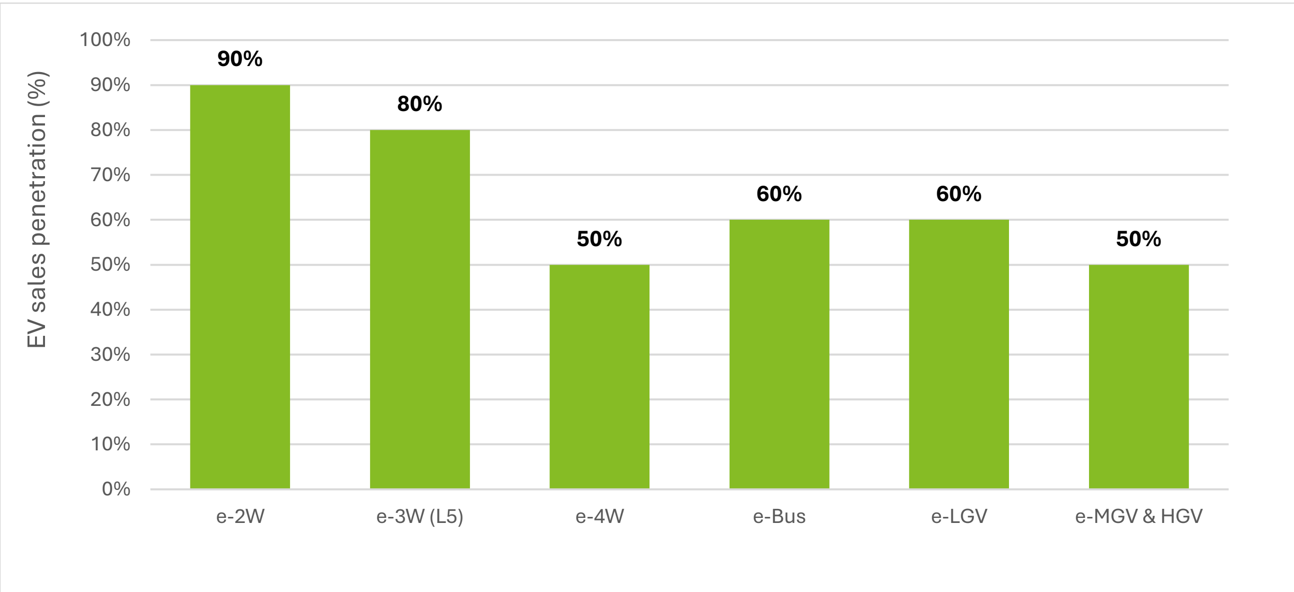


Source: Authors' analysis, in line with NITI Aayog Indian Energy Security Scenarios 3.0

***Acronyms**- HGV: Heavy Goods Vehicle, MGV: Medium Goods Vehicle, LGV: Light Goods Vehicle, 4W PV: 4-wheeler passenger vehicle, 3W (L5): 3-wheeler (L5)*

6.4. EV projections – Key inputs/ assumptions/ calculations

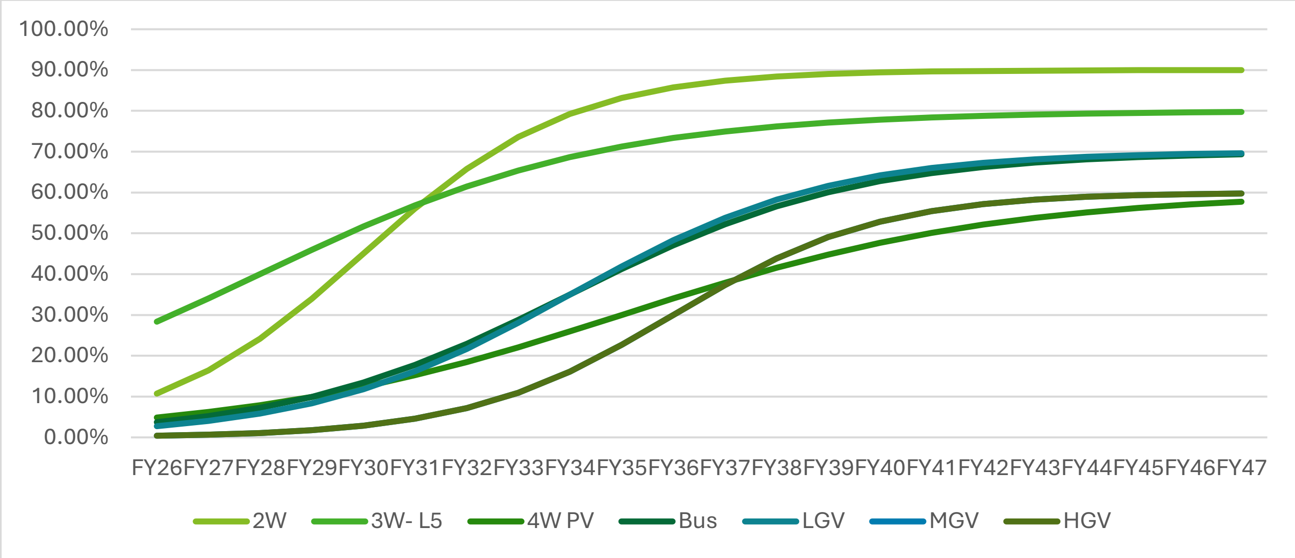
Figure 61: EV modal share in each segment by 2047 in line with NITI Aayog's IESS 3.0, percentage[33]



[33] NITI Aayog, authors' analysis

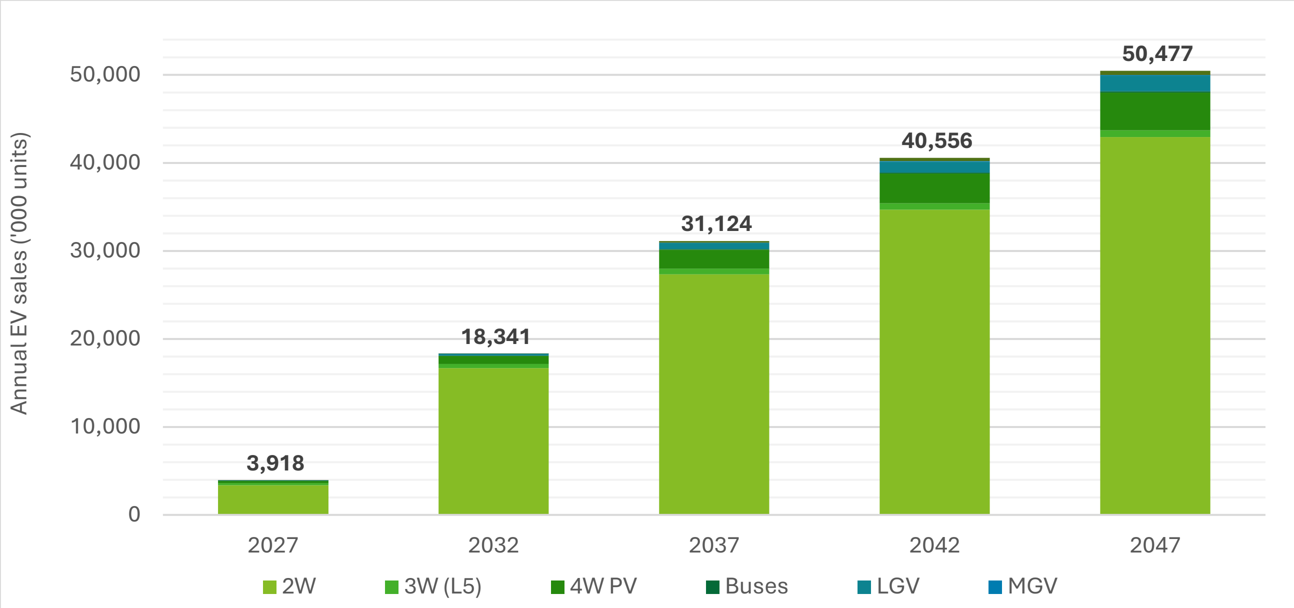
Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Figure 62: Projected sales penetration % for different EV segments to achieve target modal share, %



Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

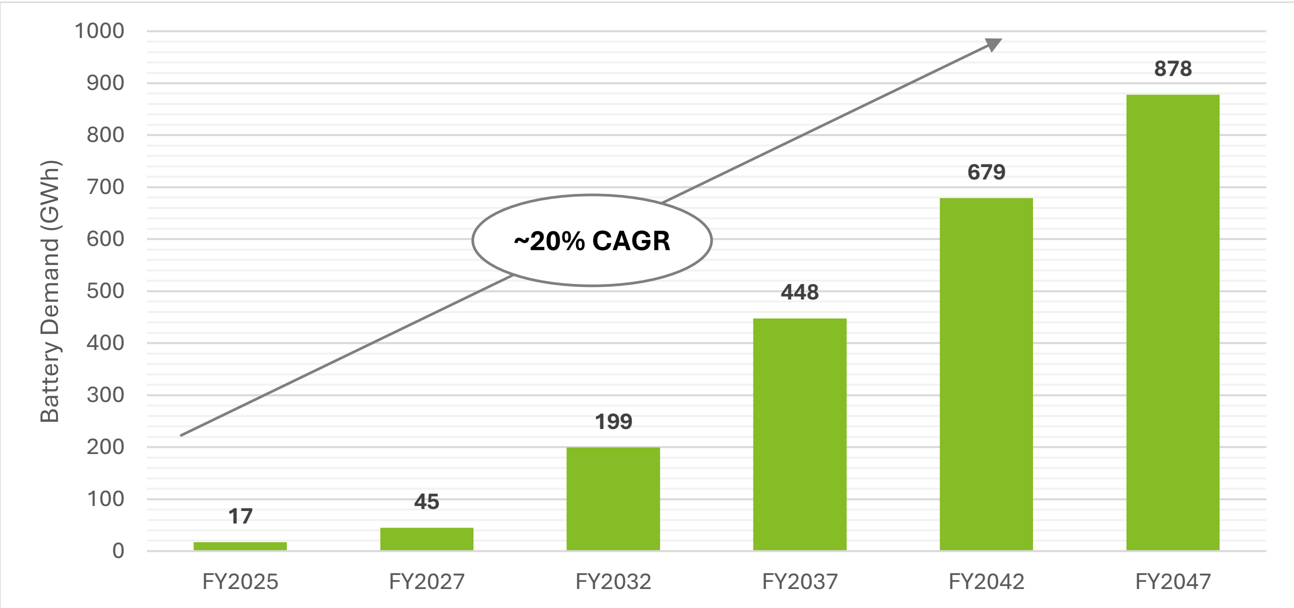
Figure 63: Projected annual EV sales (2027 to 2047), thousand units



Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

Acronyms- HGV: Heavy Goods Vehicle, MGV: Medium Goods Vehicle, LGV: Light Goods Vehicle, 4W PV: 4-wheeler passenger vehicle, 3W (L5): 3-wheeler (L5)

Figure 64: Annual battery demand from EVs up to FY2047, GWh



Source: Analysis based on India Energy Security Scenarios (IESS) 2047, NITI Aayog

6.5. Telecom projections - Key inputs/ assumptions/ calculations

6.5.1. Inputs from DoT

Inputs from Department of Telecommunications (DoT) for High-Level Committee for Viksit Bharat (HLC-VB) recommendation on multi-sectoral long-term battery storage capacity demand by 2047

1. **Please provide historical data on the deployment of Telecom Towers (In Nos.), year-wise and technology-wise(from 2018 onwards).**

   Data available for calendar years from 2020 onwards is as below.

   Year-wise

Financial Year (Historical up to FY2025)	Cell on wheels (COW)	Ground based mast (GBM)	Ground based tower (GBT)	Low power BTS (LPBTS)	Roof top pole (RTP)	Roof top tower (RTT)	Total Towers
As of 31 Dec,2020	4474	25673	369225	66863	73637	98264	638136
As of 31 Dec,2021	4821	30065	393178	65815	103757	97502	695138
As of 31 Dec,2022	4923	31718	414776	62716	130725	98581	743439
As of 31 Dec,2023	5008	32855	443140	60569	145523	99552	786647
As of 31 Dec,2024	4941	33643	467099	58789	151161	101254	816887
As of 31 Nov,2025	4898	34474	489353	57898	155582	104350	**845331**

Technology-wise

Financial Year (Historical up to FY2025)	2G BTS	3G BTS	4G BTS	5G BTS	Total BTS
As of 31 Dec,2020	508526	226809	1520891	0	2256226
As of 31 Dec,2021	480967	164245	1665323	0	2310535
As of 31 Dec,2022	492922	134377	1751083	42406	2420788
As of 31 Dec,2023	520387	124077	1821561	412214	2878239
As of 31 Dec,2024	539785	72145	1882168	464990	2959088
As of 30 Nov,2025	569340	56891	2025180	514742	**3166153**

2. Please provide projections for the deployment of Telecom Towers up to 2047, year-wise and technology-wise.

Since the telecom industry is a **service industry** and technology-driven, future deployments of telecom infrastructure (Tower and BTS) are dynamic and dependent largely on consumer requirements, evolution of technology and availability of power. Therefore, Telecom Service Providers (TSPs) have indicated that they are not in a position to provide projections beyond one year but can provide Telecom infrastructure wherever there is need of industry, government and population growth.

3. Please provide the power requirements of each of the above categories, and the number of hours of battery backup required. If these are expected to change in the coming years, please provide details of expected requirements as well.

Detail	Cell on wheels (COW)	Ground based mast (GBM)	Ground based tower (GBT)	Low power BTS (LPBTS)	Roof top pole (RTP)	Roof top tower (RTT)
Average power requirement (kW)	2.5–3.5	3.0–4.5	4.0–6.5	0.8–1.5	2.0–3.0	2.5–4.0
Average power backup requirements (Hours)*	4–6	4–6	4–6	2–4	4–6	4–6
What type of backup- battery (Lead acid, lithium-ion, etc.) or diesel generator is suited for these.	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set
Are there any units having ACC based power backups presently. If yes, what is their no. & percentage.	NA	NA	NA	NA	NA	NA

4. Also, it is requested to provide the above details for Base Transceiver Stations (BTS).

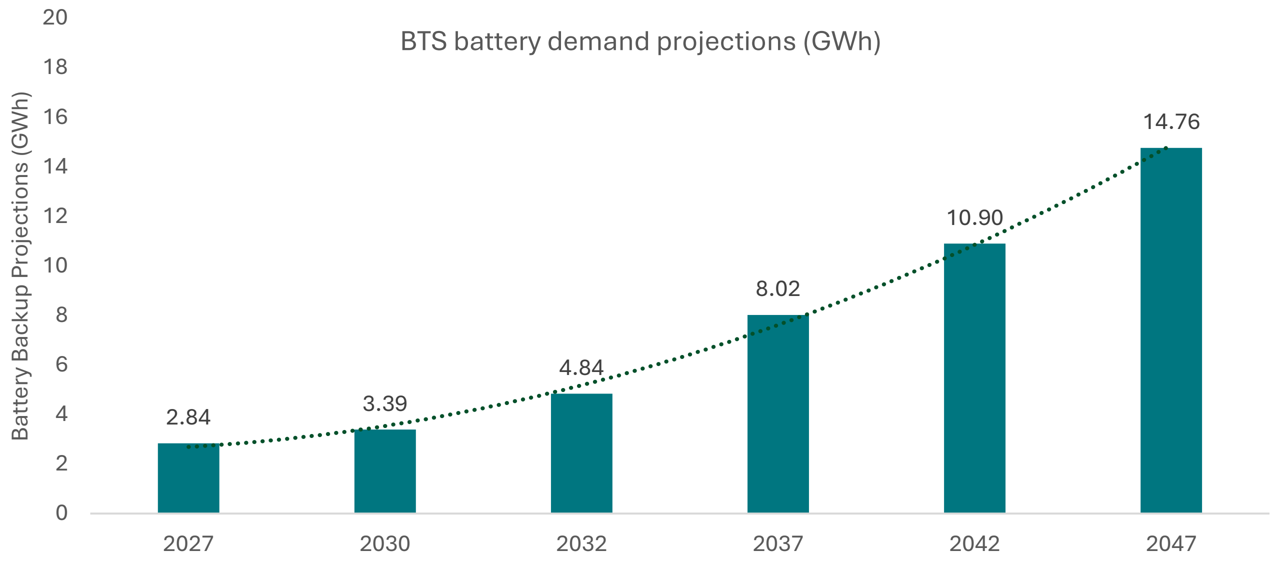
Detail	2G BTS	3G BTS	4G BTS	5G BTS	6G BTS (Future)
Average power requirement (kW)	0.5–1.2	0.8–1.5	1.0–2.0	1.5–5.0	2.0–6.0
Average power backup requirements (Hours)*	4–6	4–6	4–8	6–8	6–8

What type of backup- battery (Lead acid, lithium-ion, etc.) or diesel generator is suited for these.	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	VRLA or Li-ion+ DG set	NA
Are there any units having ACC based power backups presently. If yes, what is their no. & percentage.	NA	NA	NA	NA	NA

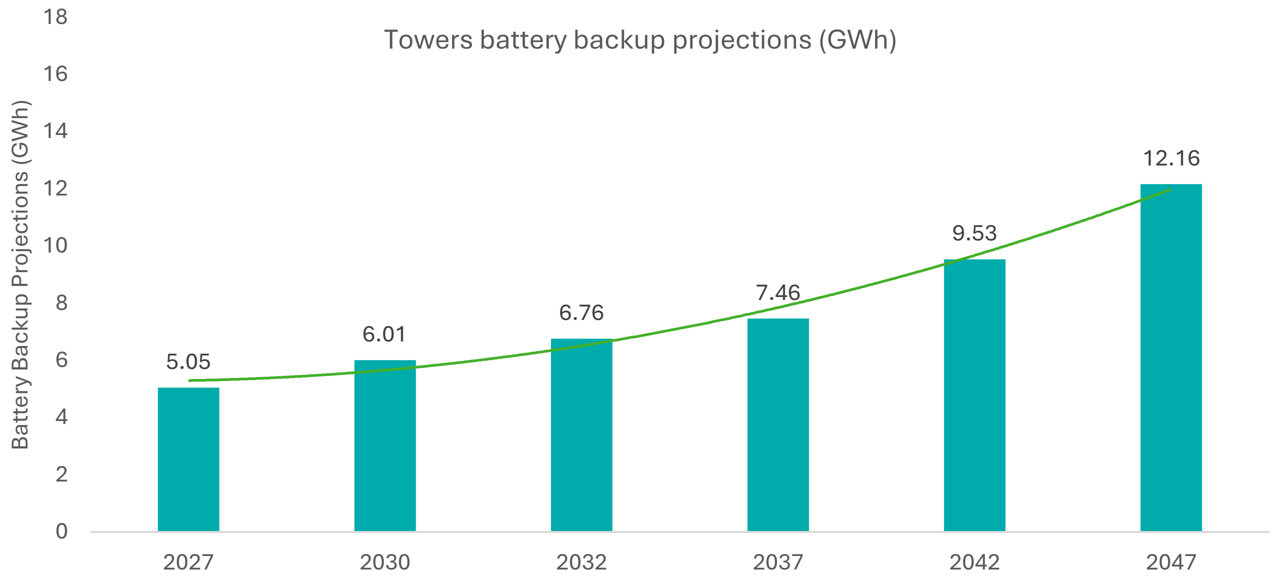
* Battery backup hours are dependent on the availability of power, which varies from place to place.

Key Assumptions	
New BTS Additions:	
2G	New 2G BTS additions are assumed at **10% share from 2025 to 2030**, only for limited legacy support, with **no new 2G additions beyond 2030.**
3G	**No new 3G BTS additions** are assumed across the entire projection period, reflecting complete network phase-out and spectrum refarming.
4G	4G remains the **primary technology for new BTS additions till 2030 (60% share),** after which its share **declines rapidly** and is **fully phased out by 2037.**
5G	5G additions **scale up from 30% till 2030**, become the **dominant technology during 2031-37,** and then **gradually decline** as 6G deployment accelerates.
6G	6G BTS additions begin after 2030, increase steadily through the 2030s, and dominate new BTS additions by 2047, reflecting long-term technology transition.
The forecast counts battery demand only from new telecom towers added from 2025 onwards, and excludes towers installed before 2025.	
Average power consumption per tower is taken as a weighted average of the DoT-provided range.	
The rural–urban split is assumed to be 55% rural and 45% urban.	
Battery demand is calculated for BTS as: New annual BTS (2G/3G/4G/5G) × weighted-average backup duration × average power requirement.	
Battery demand is calculated for Tower as: New annual towers (COW/GBM/GBT/LPBTS/RTP/RTT × weighted-average backup duration × average power requirement.	

BTS battery demand projections



Towers Battery demand projections



6.6. Consumer electronics projections - Key inputs/ assumptions/ calculations

6.6.1. Inputs from DoT

============ Forwarded message ============
From: Neeraj Nandal <neeraj.nandal@meity.gov.in>
To: "Coordination Division MeitY"<coorddivision@meity.gov.in>
Cc: "Sushil Pal"<spal.1999@meity.gov.in>, "Asha Nangia"<anangia@meity.gov.in>, "Nirmod Kumar"<nirmod.kumar@meity.gov.in>, "Dinesh Kumar Sagar"<dineshk.sagar@meity.gov.in>, "Dharmendra Kumar Verma"<verma.dk25@meity.gov.in>, "Pankaj Pankaj"<pankaj.chaddha95@meity.gov.in>
Date: Fri, 19 Dec 2025 17:38:59 +0530
Subject: Fwd: Most Immediate: High-Level Committee for Viksit Bharat (HLC-VB) recommendation on multi-sectoral long-term battery storage capacity demand by 2047.
============ Forwarded message ============

Sir/Madam,

Ref. trailing mail, please find below the relevant data as per industry estimates.

Volume in Mn

Market (India) - Volume	FY18-19	FY19-20	FY20-21	FY21-22	FY22-23	FY23-24	FY24-25	FY25-26 (P)
Laptop	5.82	7.20	9.15	12.36	9.37	9.43	10.15	11.80
Tablet	2.56	2.25	3.12	4.96	4.91	4.32	5.49	4.76
Smartphones Feature Phones	299	292	292	279	274	281	271	241

Across mobile phones, laptops, tablets and accessories, battery capacities are typically below 10,000 mAh.

6.6.2. Reference for sales per capita

1. 2024 sales per capita for smartphones, laptops, tablets, and feature phones was derived using actual sales and population figures for India.
2. 2047 sales per capita for the same was projected by matching projected GDP per capita (as per NITI Aayog's IESS 3.0) with existing developing countries. Accordingly, actual sales per capita figures for the United Kingdom were taken as a reference (average of past 4 years).

6.6.3. Assumptions/ inputs on battery capacity

The following table represents the battery capacity for each category along with capacity growth rate due to technological advancements:

Category	Unit	Capacity	Growth rate (%)
Smartphone	kWh	0.0167	7.62%
PC	kWh	0.0630	7.62%
Tablet	kWh	0.0210	7.62%
Feature phone	kWh	0.0032	7.62%

6.7. Railways projections - Key inputs/ assumptions/ calculations

6.7.1. Inputs from Ministry of Railways

The current battery capacity and chemistry deployed in Vande Bharat Trains on a per-coach basis in kWh.

Reply

The current battery capacity per coach in Vande Bharat Trains is approx. 17.68 kWh and Lithium Iron Phosphate (LFP) chemistry batteries have been deployed in Vande Bharat Trainsets.

The expected future requirement of batteries for Vande Bharat trains up to 2047 in kWh on annual basis, as per the projected scale-up in the number of trains and corresponding battery requirements.

Reply

In view of envisaged induction of modern passenger coaches till 2047, total battery requirement up to 2047 is likely to be 1060.80 MWh.

Railways plans/forecasts regarding the conversion of existing conventional train fleet batteries from lead-acid to Advanced Chemistry Cell (Lithium Iron Phosphate). If yes, what is the anticipated annual and aggregate demand in kWh up to 2047 annually?

Reply

With regard to the conversion of existing conventional train fleet batteries from lead-acid to Advanced Chemistry Cell (Lithium Iron Phosphate), IR is presently in the process of formulating specifications for the introduction of Lithium Iron Phosphate (LFP) .batteries in trains, which are likely to be finalized soon. Further, considering the codal life of 10 years for LFP batteries, anticipated aggregate battery energy demand is 768.16 MWh, with an annual demand of 76.81 MWh.

The long-term plan for deployment of BESS (Battery Energy Storage System) for addressing railway power requirements in MW/MWh, covering year wise expected annual capacity additions through 2047.

Reply

The works are envisaged to be undertaken for deployment of ACC batteries are:

1. Deployment of Battery Energy Storage System (BESS): 02 umbrella works have been sanctioned in FY 2025-26.

- **a.** Development of Advanced Chemistry Cell (ACC) based Battery Energy Storage System (BESS) for major installations for a capacity of 2 MWh for handling peak load requirements and emergency power backup in case of power failure for 10 Nos.
- **b.** Development of Advanced Chemistry Cell (ACC) based Battery Energy Storage System (BESS) for traction substations for a capacity of 02 MWh for 10 Nos. and upgradation of conventional traction substation to Smart Traction Sub-station for 50 Nos.

2. Conversion of existing batteries from lead-acid type to Advanced Chemistry Cell (ACC) batteries: Trials of ACC batteries are planned to be conducted in 10 electric locomotives (05 three phase locomotives & 05 Conventional locomotives).

Ministry of Railways has been allocated 2800 Cr. in FY23-24 for the development of 35 hydrogen fuel cells trains. Considering the recent pilot highlighted by Hon'ble Railway Minister, what is the long-term deployment plan for such Hydrogen train and what would be the associated battery requirement annually with this plan in kWh up to 2047.

Reply

Indian Railways has taken up a state-of-the-art project for running of its first hydrogen train, on pilot basis, as per specifications framed by the RDSO to demonstrate the use of hydrogen powered train technology In Railways.

Manufacturing of Hydrogen Train-set has been completed and a hydrogen plant has been conceived at Jind for providing hydrogen for use in this train-set. Prominent features of Hydrogen Train-set are as below:

- Designed and Developed in India demonstrating Indian Railways' commitment to Atmanirbhar Bharat.
- Presently, it is the world's longest (10 coaches) and most powerful (2400 kW) Hydrogen Train-set on Broad Gauge platform.
- The train-set comprises of two Driving Power Cars (DPCs) of 1200 kW each, totaling 2400 kW along with eight passenger cars.
- Fuel cell - 115 kW & Lithium Ferro Phosphate (LiFePo) battery - 185 kW.

This project involved first-time development of hydrogen traction technology for Railways in India, therefore the long term deployment plan for such hydrogen trains will depend on the outcome of pilot operation of this train. The annual battery requirement with this plan up to 2047 will depend on the future deployment and production plan of Hydrogen Trains in India.

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6.8. Conversion factors for arriving at demand along value chain

6.8.1. Demand of ACC component per kWh of ACCs

Table 18: Demand of ACC component per kWh of ACCs

Component	Unit	LFP	NMC
Cathode active material (CAM) (LFP)	*kg/kWh*	2.06	
Cathode active material (CAM) (NMC811)	*kg/kWh*		1.27
Anode active material (AAM)	*kg/kWh*	1.05	0.92
Electrolyte Salt- LiPF6	*kg/kWh*	0.1	0.06
Separator	*sq. m.*	9.67	9.67
Current collector (Alu foil)	*kg/kWh*	0.26	0.16
Current collector (Cu foil)	*kg/kWh*	0.47	0.28

Source: NITI Aayog Mine to Market study (2023)

6.8.2. Demand of battery grade refined material per tonne of ACC component

Table 19: Demand of battery grade refined material per tonne of ACC component

Material	Unit	Cathode active material (CAM) (LFP)	Cathode active material (CAM) (NMC)	Electrolyte
Li2CO3	*tonne/tonne output*	0.240	0	0.25
LiOH	*tonne/tonne output*	0	0.246	0
NiSO4	*tonne/tonne output*	0	1.273	0
CoSO4	*tonne/tonne output*	0	0.160	0
MnSO4	*tonne/tonne output*	0	0.992	0

Source: NITI Aayog, Argonne National Laboratory, IEA Global EV Outlook 2025, Shanghai Metals Market, Winack Battery

6.8.3. Demand of pure metal per tonne of battery grade refined material

Table 20: Demand of pure metal per tonne of battery grade refined material

Metals	Unit	Li2CO3	LiOH	NiSO4	CoSO4	MnSO4
Lithium	*tonne/tonne output*	0.188	0.3			
Nickel	*tonne/tonne output*			0.38		
Cobalt	*tonne/tonne output*				0.38	
Manganese	*tonne/tonne output*					0.364

Note: Requirement of pure metal was estimated as per atomic weight within battery grade refined material compounds. For example, lithium makes up 18.8% of lithium carbonate by mass.

Note: Requirement of graphite, copper, and aluminium are considered to be equal to the requirement of anode material, copper foil, and aluminium foil respectively, as these are already nearly 100% pure

NOTES

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