Bharat Cleantech Manufacturing Platform: Batteries and Energy Storage Systems Indigenisation Pathways

Accelerating an Aatmanirbhar, Green and Viksit Bharat

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Council for International Economic Understanding

Dalberg

As India rapidly moves towards meeting its NDCs, indigenisation of cleantech manufacturing is critical for an *Aatmanirbhar* and *Viksit Bharat*

India has national targets and projections across renewable energy and e-mobility for 2030…

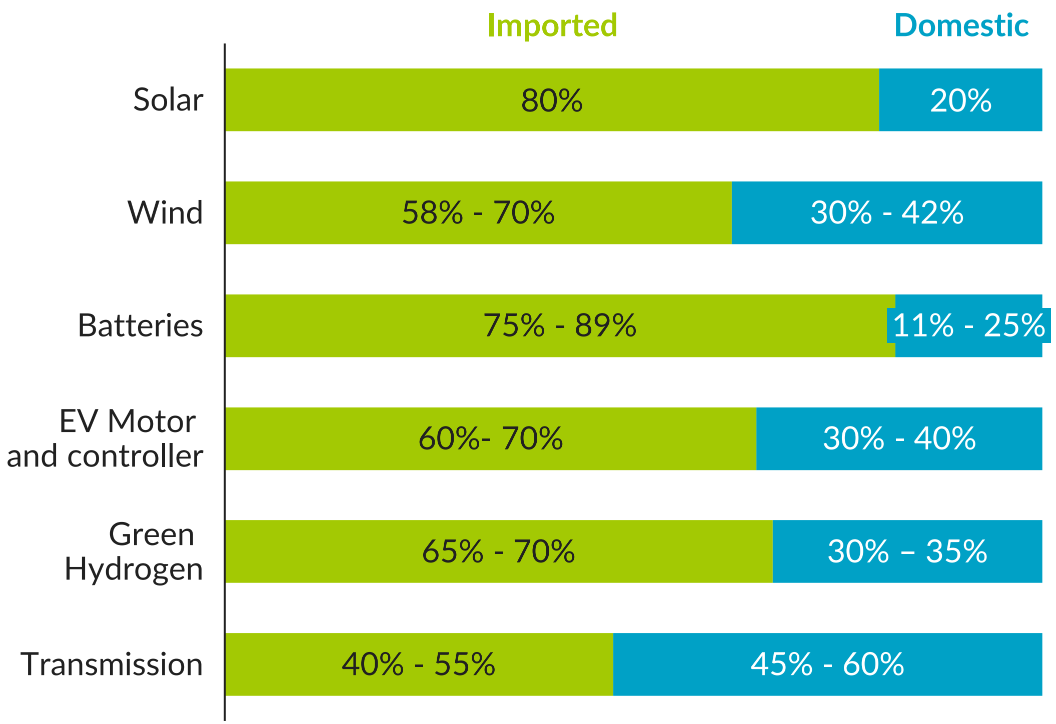
300 GW Solar *installed capacity*[1]

30% EV *sales penetration*[2]

100 GW Wind *installed capacity*[3]

5 MTPA Green Hydrogen *production*[4]

… but cleantech supply chains are heavily import-dependent and need to be indigenised for an Aatmanirbhar Bharat



Cleantech manufacturing import dependence across the value chain, 2023

Source: (1) MNRE; Solar capacity projection extrapolated from CEA's 2032 Solar capacity projections, assuming linear growth in capacity; (2) NITI Aayog ; (3) ET ; (4) MNRE - NGHM; MNRE, Ministry of Power; Economics Times; BNEF's installed and announced capacity; IEA, India – World Energy Investment 2024 – Analysis; NITI, India's Power Sector | Capacity & Generation Mix; PIB, India's Ethanol Push: A Path to Energy Security, CEEW, Strengthen India's Clean supply chain, 2024; Bain, India Electric Vehicle Report, 2023; Policy circle; Economist Impact, Scaling clean energy: financing and transition strategies for India's sustainable future

The Platform could support the National Manufacturing Mission to target at least 50% indigenisation of cleantech manufacturing value chains by 2030 enabling net-zero ambition with indigenous production

The Platform's potential to accelerate development of incremental indigenous capacity can be observed across sectors

Sector-wise goals	**Solar**	**Wind**	**BESS**	**E-mobility**	**Green Hydrogen**	**Transmission**
Installed capacity						
2030 targets	300 GW[1]	100 GW[2]	230-240 GWh[3]	30@30[4]	5 MTPA[6]	648,190[7] ckm
% value chain indigenisation*						
Current levels (est.)	~20%	~35%	~20%	~35%[5]	~35%	~55%
2030 target (Proposed)	~50%	~60%	~45%	~50%	~60%	~70%

May decline due to shifting and unstable demand of domestic components amid intensified global competition

Note: *Indigenisation is domestic value contribution across cleantech value chain from raw materials to end production for all components; : (1) MNRE; (2) ET; (3) Estimated requirements under National Electricity Plan (NEP) 2023 of CEA; (4) NITI Aayog ; (5) For EV Motors and controllers; (6) MNRE - NGHM (7) 2032 target from National Electricity Plan Volume II – Transmission of CEA

Source: MNRE, Ministry of Power; Economics Times; BNEF's installed and announced capacity; IEA, India – World Energy Investment 2024 – Analysis; NITI, India's Power Sector | Capacity & Generation Mix; PIB, India's Ethanol Push: A Path to Energy Security, NEP 2023 of CEA; EV Reporter, India's electric vehicle supply chain landscape | An overview, 2024

A detailed strategy and action plan for the focus sectors would be developed to achieve these goals and objectives and build the cleantech indigenisation pathways for these sectors

Sector-wise gaps would be identified and addressed with all stakeholders across each cross-cutting theme in alignment with the National Manufacturing Mission

Enablers:
Policy recommendations; Trade partnerships; Public and private stakeholder recommendations; Demand and supply drivers; Leveraging AI for Climate and cleantech manufacturing

Sectors

- Solar
- Wind
- BESS
- E-mobility
- Green Hydrogen
- Transmission

Cross-cutting themes

Demand Acceleration	*Drive demand and adoption of output, incl.* ***Quality Control Orders (QCOs)***
R&D Ecosystem	*Drive technology sharing, adoption and indigenous R&D*
Upstream Raw Materials	*Streamline raw material sourcing (e.g. critical rare earth elements; bio-energy feedstock etc.)*
Capex & Infra	*Address machinery sourcing & infrastructure requirements (e.g., grid connectivity)*
Skilled Workforce	*Bridge skilling gaps for specialised and non-specialised workforce*
Financing	*Identify financial instruments and mechanisms to reduce the funding gap* *Identify levers to improve* ***Ease of Doing Business*** *to attract investments*

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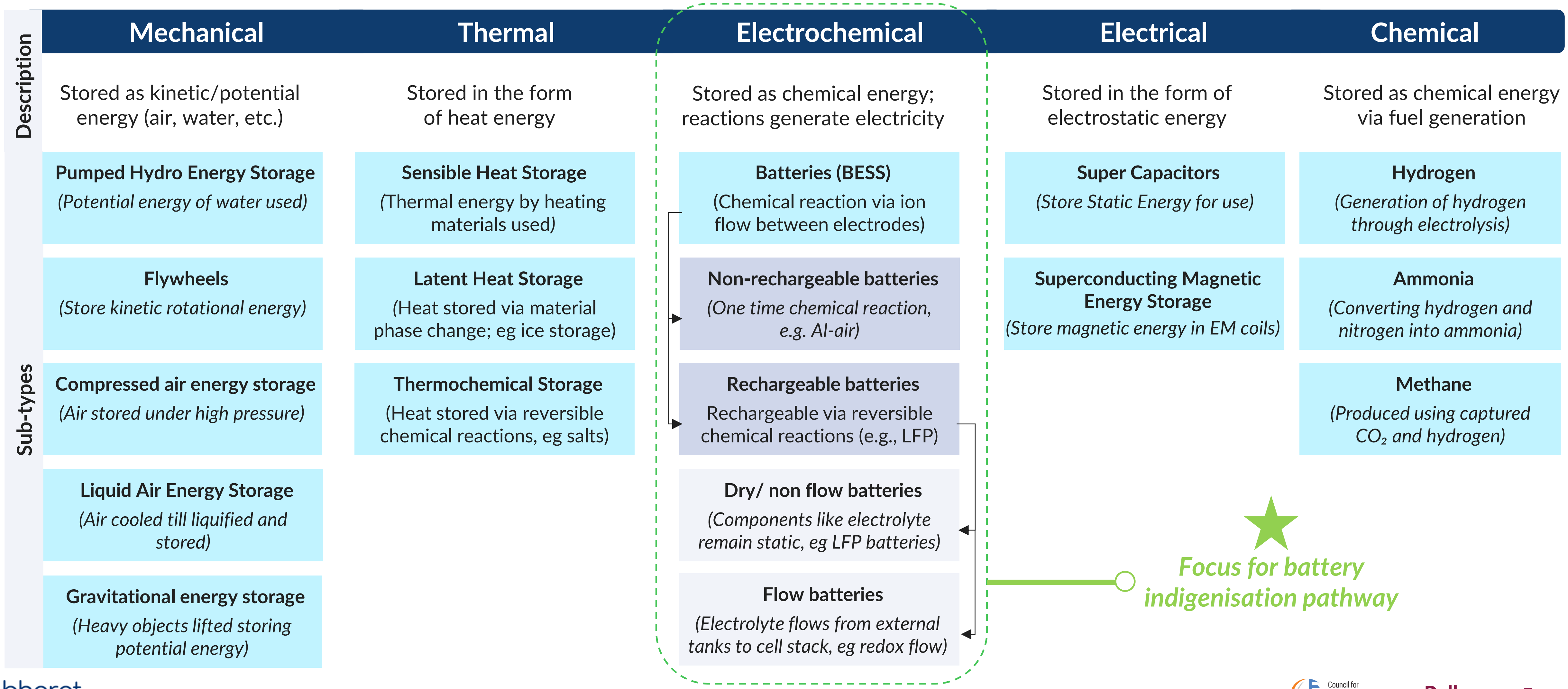
SECTION ONE

CURRENT BATTERY LANDSCAPE: GLOBAL AND INDIA

The outlined battery indigenisation pathway focuses on electrochemical energy storage systems which primarily include advanced chemistry cell batteries – used for mobility and stationary storage applications

Energy Storage Types (based on type of energy stored)



	Mechanical	Thermal	Electrochemical	Electrical	Chemical
Description	Stored as kinetic/potential energy (air, water, etc.)	Stored in the form of heat energy	Stored as chemical energy; reactions generate electricity	Stored in the form of electrostatic energy	Stored as chemical energy via fuel generation
Sub-types	**Pumped Hydro Energy Storage** *(Potential energy of water used)*	**Sensible Heat Storage** (Thermal energy by heating materials used*)*	**Batteries (BESS)** (Chemical reaction via ion flow between electrodes)	**Super Capacitors** *(Store Static Energy for use)*	**Hydrogen** *(Generation of hydrogen through electrolysis)*
	Flywheels *(Store kinetic rotational energy)*	**Latent Heat Storage** (Heat stored via material phase change; eg ice storage)	**Non-rechargeable batteries** *(One time chemical reaction, e.g. Al-air)*	**Superconducting Magnetic Energy Storage** *(Store magnetic energy in EM coils)*	**Ammonia** *(Converting hydrogen and nitrogen into ammonia)*
	Compressed air energy storage *(Air stored under high pressure)*	**Thermochemical Storage** (Heat stored via reversible chemical reactions, eg salts)	**Rechargeable batteries** Rechargeable via reversible chemical reactions (e.g., LFP)		**Methane** *(Produced using captured CO_2 and hydrogen)*
	Liquid Air Energy Storage *(Air cooled till liquified and stored)*		**Dry/ non flow batteries** *(Components like electrolyte remain static, eg LFP batteries)*		
	Gravitational energy storage *(Heavy objects lifted storing potential energy)*		**Flow batteries** *(Electrolyte flows from external tanks to cell stack, eg redox flow)*		

★ *Focus for battery indigenisation pathway*

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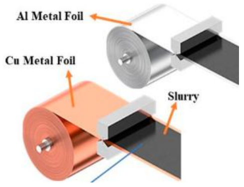
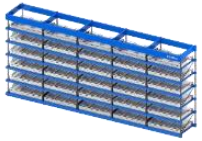
(1) EM: Electromagnetic

Battery manufacturing value chain extends from raw material processing to pack manufacturing; upstream segments like Cathode and Anode Active Material Processing are key elements of value addition

Lithium-ion Battery Manufacturing Process

	Raw Material Processing	Cathode & Anode Active Material Processing	Electrode Manufacturing	Cell Assembly	Cell Formation and Aging	Module & Pack Manufacturing
			 			
Key activities	Lithium (Li), Nickel (Ni), Cobalt (Co), & graphite mined & refined into battery-grade inputs	Li, Ni, Co salts & graphite processed into usable forms	CAM[1]/AAM[2] slurry made; coated, dried, compressed & cut	Anode, separator & cathode layered & inserted into casing	Cells cycled to form chemistry, then rested for stability	Cells modularized, BMS[3] integrated, & enclosed in packs
Output	Battery grade Li, Ni, Co salts & graphite (Li_2CO_3, $NiSO_4$ etc.)	Powdered materials used to make cathodes & anodes	Finished anode and cathode sheets ready for assembly	Sealed battery cell structure ready for first-time charging	Fully functional cells tested for safety and reliability	Battery packs ready for use in mobility or stationary applications (ESS[4])

(1) CAM: Cathode Active Materials (2) AAM: Anode Active Materials (3) BMS: Battery Management System (4) ESS: Energy Storage System

Source: Hioki, Lithium-ion Battery Production and Testing, Laserax, EV Battery Manufacturing Process

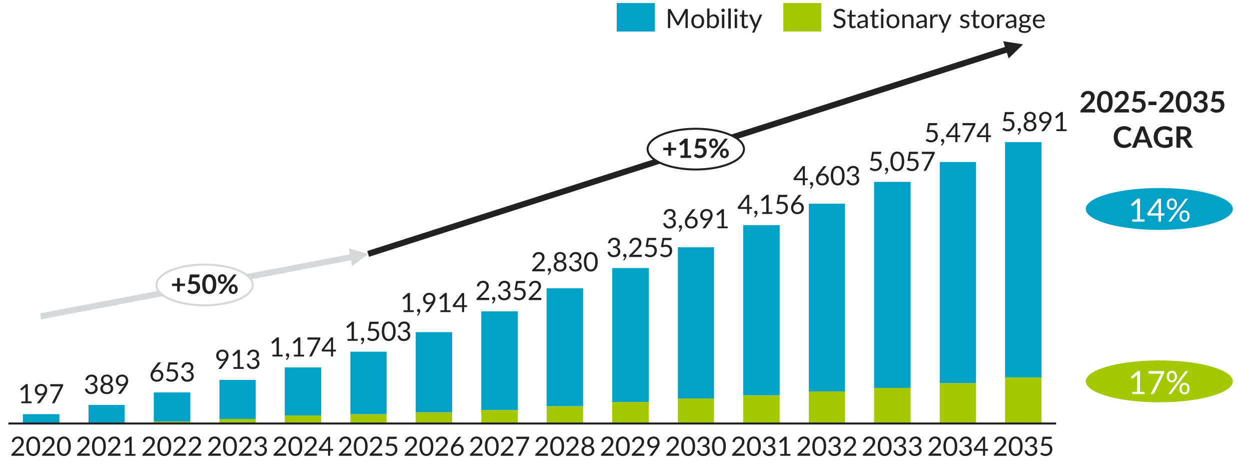
Global battery demand could reach ~6 TWh by 2035 growing at 15% CAGR from 2025 to 2035 fueled by e-mobility penetration and increasing demand for stable renewable energy

High-performing LFP batteries dominate global demand with prices falling ~65% from 2020 to 2025 – this trend is expected to continue, along with emergence of newer chemistries which promise efficiency/cost benefits

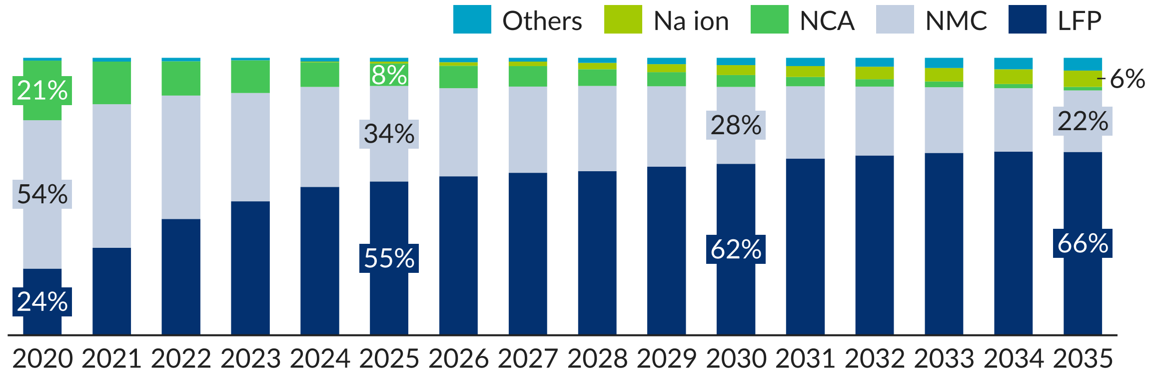
Current deployment landscape

- Key growth drivers:
  - Increased adoption of e-mobility and renewable energy
  - Reducing battery costs (LFP at USD 55/KWh in 2025 from USD 160/KWh in 2020)
  - Mobility: Total Cost of Ownership (TCO) improvements for EVs globally driving faster EV adoption and battery demand
  - Stationary storage: Grid stability and variable to stable RE supply requirements driving demand for BESS and Pumped Hydro storage
- Cell Chemistries:
  - LFP expected to remain the dominant battery chemistry supported by reducing prices, improved performance and stability
  - Alternate chemistries with potential performance and cost improvements could further accelerate battery adoption but would remain a smaller share. e.g. sodium-ion, solid state, redox flow batteries (only for stationary storage) etc.

Global battery demand (2020-2035), GWh



Global cell chemistry share (2020-2035), %



Source: BNEF, IEA, Trends in electric car affordability

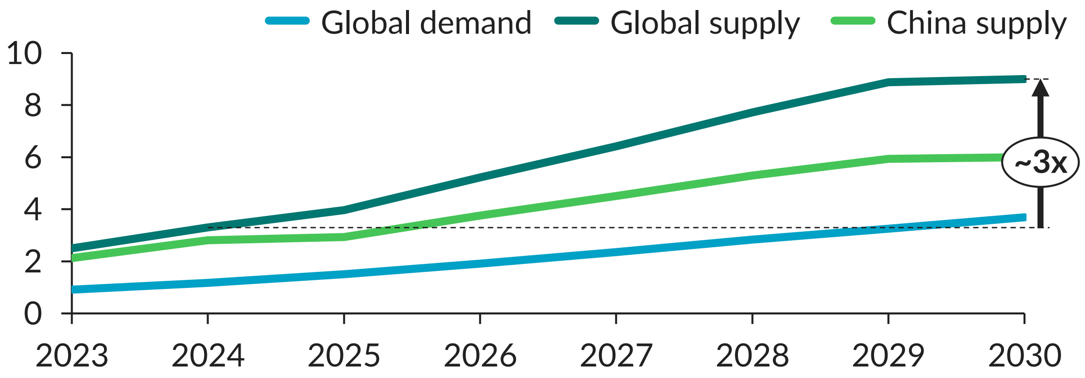
Global battery manufacturing capacity stood at 3 TWh in 2024 and is expected to triple over the next 5 years

China’s control over majority of global manufacturing capacity and critical mineral supply chain is pushing other regions to boost local production, to reduce foreign dependency and vulnerability to supply risks

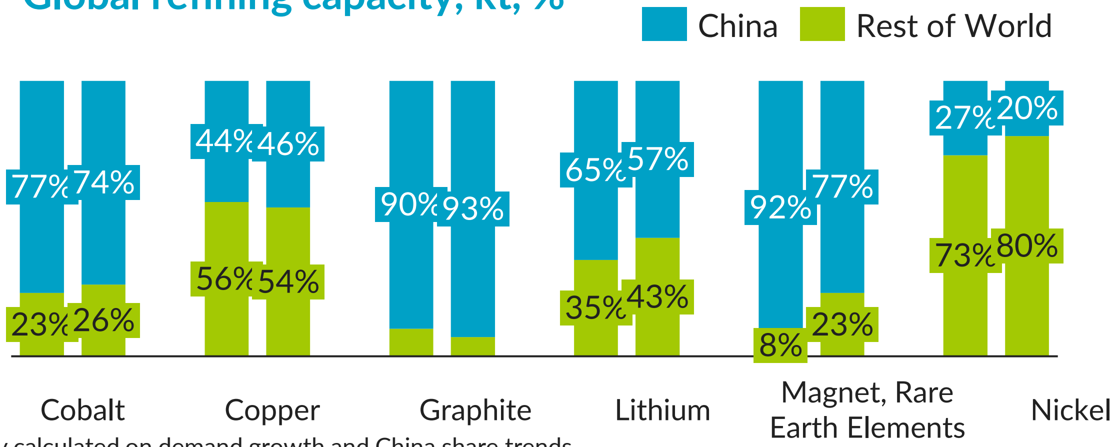
Current manufacturing landscape

- **China’s dominance over supply chain** is expected to continue:
  - **Significant over-capacity, potentially under-utilized assets**: 85% of current global battery production[1]; ~2x manufacturing capacity of global battery demand until 2027
  - **Control over end-to-end supply chain:** ~70% rare earth mining rights globally and 65% refining share enabling supply chain and battery prices dominance
  - **Large, integrated gigafactories, supportive government policies** and subsidies have led to this scale and growth in China
- **Ongoing global on-shoring efforts aim to diversify supply chains, build supply resilience** and **reduce overdependence on one country.** For instance:
  - **US: USD 100 Bn** (current and planned) private sector investment in domestic cell and module manufacturing
  - **EU**: Supportive policies such as **Green Deal Industrial Plan**, 2023 and **Critical Raw Materials Act**, 2024 boost production; but comparatively higher production costs could still lead to implementation delays

Global battery demand and manufacturing capacity, TWh[2]



Global refining capacity, kt, %



(1) 2024 data; (2) 2025 data based on total Li-ion battery manufacturing capacity; 2026-2029 global supply calculated on demand growth and China share trends

Source: BloombergNEF – China’s Cleantech Dominance Grows Despite Onshoring Push, 2024; IEA; ITIF, How Innovative Is China in the Electric Vehicle and Battery Industries?; TechCrunch; EU; Transport & Environment report; CNBC; IEA: The battery industry has entered a new phase

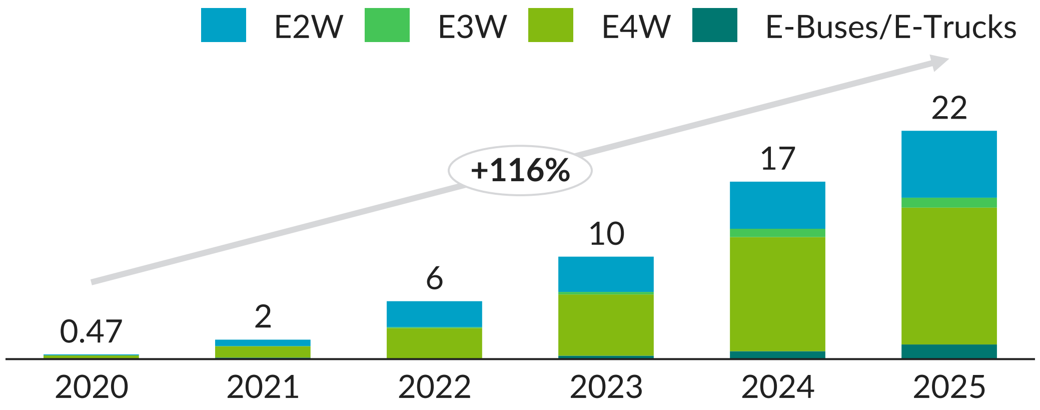
India’s battery demand has increased to 22 GWh in 2025 for mobility, while stationary demand is still nascent (500 MWh) but growing fast

Reducing global costs and supportive policies are fueling domestic demand as well, however, charging infrastructure and TCO (for E4W) needs to be improved to ensure stable growth for mobility applications too

Current deployment landscape: India

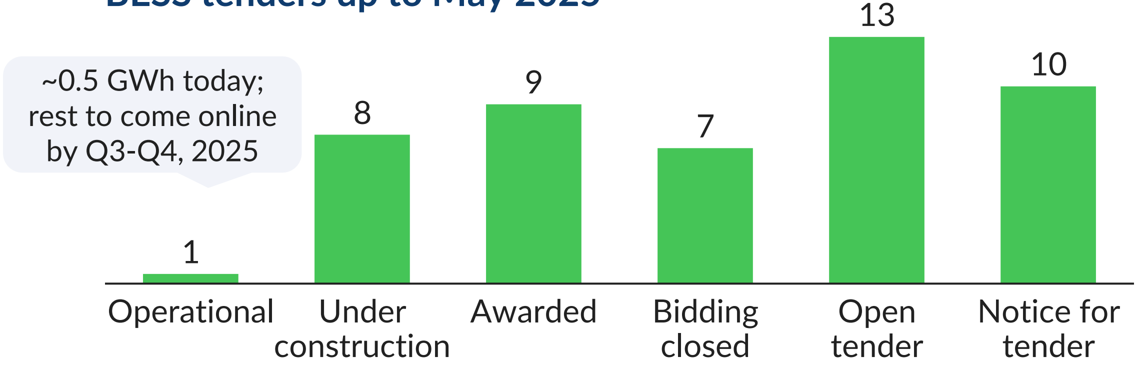
- **Tailwinds:**
  - **Mobility: Increase in EV sales penetration** (7.5% in 2024 from 0.65% in 2020) **driving battery demand**
    - **Policy support:** National EV30@30 target along with financial incentives under FAME I and II, PM E-Drive[1], SPMEPCI (upcoming) pushing EV adoption
    - **Cost benefits:** Lower TCO of electric two- and three-wheelers (E2W/ E3W) vs. ICE models boosting uptake
  - **Stationary storage:** RE supply stability needs for India’s 500 GW target boosting demand for energy storage including BESS
    - **Policy support:** MoP mandate for 2-hour BESS co-location in upcoming solar projects and Viability Gap Funding (VGF) supporting BESS deployment `
- **Potential headwinds:**
  - Slower charging infrastructure ramp-up impacting e-mobility growth and subsequently battery demand
  - Higher TCO for E4W potentially leading to slower adoption
  - Global supply constraints / geopolitical shifts could impact domestic deployment

India’s battery requirement in mobility, GWh



Current and upcoming BESS capacity, GWh

BESS tenders up to May 2025



~0.5 GWh today; rest to come online by Q3-Q4, 2025

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(1) PM E-Drive scheme currently covers only 2W/3W and E-Buses

Source: PV Magazine; GoI, Ministry of Road Transport and Highways, Parivahan Analytics and Reporting Portal

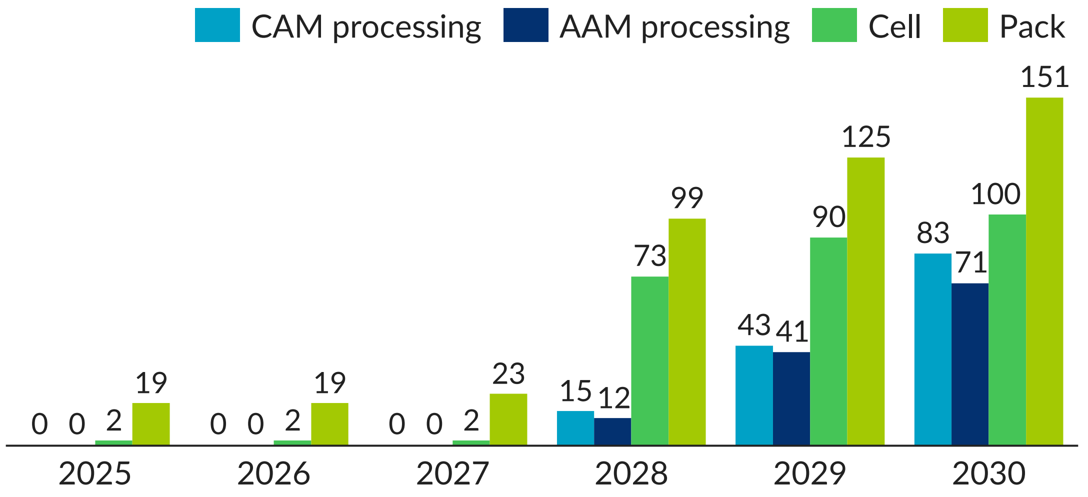
India's battery manufacturing ecosystem is nascent and heavily import dependent; reducing global prices are also delaying domestic investments in announced capacity for cell and pack manufacturers

Falling prices for LFP globally, fast-paced global R&D and battery evolution and large-scale multi-gigafactories out-compete Indian investment case

Current manufacturing landscape: India

- **Current capacities (19 GWh) on battery pack assembly** use imported cells as domestic **cell manufacturing capacity is limited**
  - **Announced projects** across battery manufacturing value chain **delayed** (including ACC PLI beneficiaries) due to global LFP price drop making domestic investments non-competitive, further complicated by capital equipment sourcing restrictions and delays
- **Past and recent policies to promote EV demand,** e.g. FAME II, PM E-Drive, and SPMEPCI **contain DVA requirements**
- **Headwinds for domestic capacities investment:**
  - Domestic policies mainly support battery pack set up (e.g., DVA requirements for PM E-Drive and SPMEPCI), however, no drivers for upstream integration e.g. Cells
  - China's majority control on extraction and refining leading to overall supply chain control and pricing dominance
  - Capital equipment and technical knowledge gaps for domestic capacity setup

Current and announced battery manufacturing capacity in India, GWh[1]



Large scale players
With existing and announced capacities

OLA, AGRATAS A TATA Enterprise, AMARA RAJA, ATHER, EXIDE
Cell to pack capacities

Himadri, ALTMIN, Reliance NEW ENERGY, LOHUM
CAM/ AMM

Startups
R&D on innovative battery solutions

GODI, INDI ENERGY
Na-ion batteries

Sthyr Energy
Zinc-air batteries

DELECTRIK, ARKLE
Vanadium flow batteries

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(1) 2025: Current capacity; 2026-2030: Announced, assuming 2-year delay as per current trend; Pack includes cell and pack capacity given integrated facilities; (2) CAM: Cathode Active Material; (3) AAM: Anode Active Material

Source: Business Standard; PMP PM E-Drive; PIB; PV Magazine; Economic Times

There are several opportunities that could be captured through battery value chain indigenisation – the battery indigenisation pathway could help capture these opportunities till 2030

INR 1.8-2.8 Lakh Cr

Annual battery domestic market potential by 2030

USD 18-28 Bn

(INR 1.5 - 2.3 Lakh Cr)

Cumulative import bill savings from 2025-30

58,000-91,000 jobs

Across battery manufacturing value chain[1] by 2030

USD 0.98-1.27 Bn

(INR 8,100 - 10,500 Cr)

Annual export potential for refined battery-grade Graphite by 2040

Up to INR 1.6 Lakh Cr

Capex financing gap[2] closure for battery manufacturing across value chain by 2030

Detailed in Annex: *Domestic Market Potential*; *Import Bill Savings*; *Potential Jobs*; *Export Potential*; *Capex Financing*

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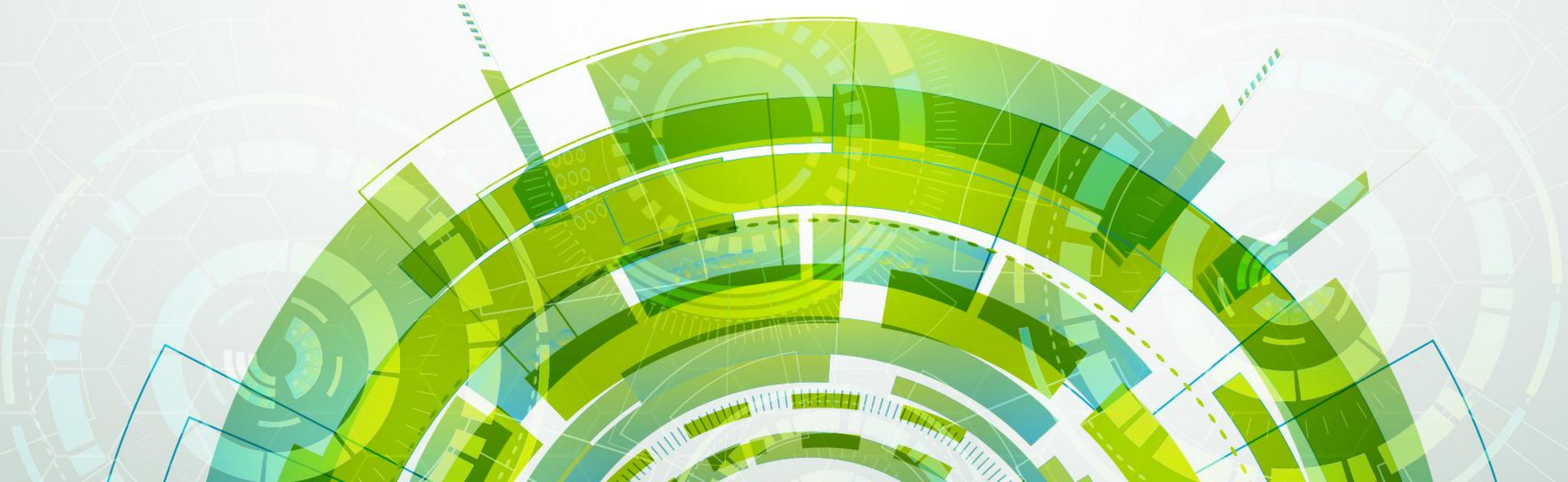
(1) Includes additional jobs for Pack, Cell, and Cathode and Anode Active Materials manufacturing; (2) Capex financing gap refers to additional capex investment needed to meet 45% DVA indigenisation target by 2030. Source: Dalberg analysis; Bloomberg NEF, Energy Transition Investment trend, 2024

SECTION TWO

BATTERY AND ENERGY STORAGE SYSTEMS INDIGENISATION PATHWAYS FOR INDIA



The battery indigenisation pathways have been built on two demand scenarios – conservative and optimistic – to identify potential pathways and key enablers to achieve 45% indigenisation by 2030

	CONSERVATIVE SCENARIO	OPTIMISTIC SCENARIO
Scenario criteria		
1 Government policy landscape	Extension of ACC PLI and support for implementation	Extended support for battery manufacturers across entire value chain (refining to pack)
2 BESS adoption	40 GWh BESS demand as per CEA NEP by 2030 with additional demand to ensure grid stability	Extended coverage of VRE[3] generation with 2-hour BESS co-location by 2030
3 E-mobility adoption	Achievement of EV 30@30 Goals for India	Increased adoption of EVs across E 2/3W beyond 30@30 goals
Cumulative battery demand 2025-2030, GWh	**527 GWh**	**824 GWh**
Incremental capex investment required for 45% indigenisation by 2030, INR Cr	**INR 76,000 – 103,500 Cr[1]**	**INR 115,300-158,300 Cr[1]**
Cumulative upstream investment (refining, circularity) till 2030, INR Cr	**INR 142,900 Cr[2]**	**INR 146,600 Cr[2]**
Total government support needed till 2030, INR Cr	**INR 64,800 Cr**	**INR 92,200 Cr**
Potential import bill savings (2025-2030), INR Cr	**INR 147,700 Cr**	**INR 234,000 Cr**

Detailed in Annex

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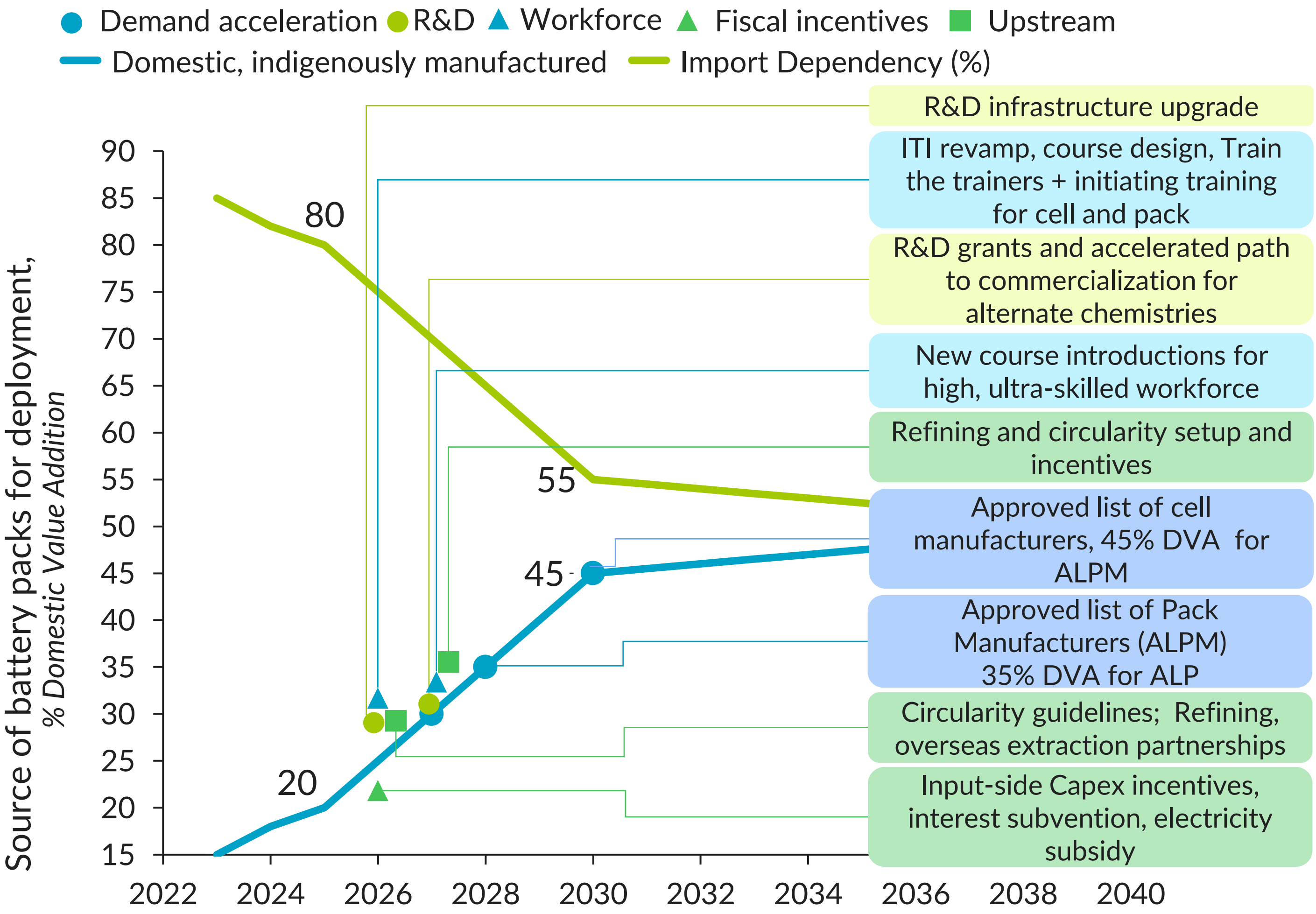
(1) Does not include input side capex subsidies and does not include investment required for upstream ecosystem of refining and circularity

(2) Investment required for front-loaded capex for setting up 85 kTPA Graphite refining capacity by 2030 and accelerating circularity ecosystem to achieve 2040 targets on refining and circularity

India could achieve 45% indigenisation on battery manufacturing by 2030 across the value chain from electrode to pack and circularity through focused interventions, fiscal and non-fiscal incentives

Battery Indigenisation Pathway



R&D infrastructure upgrade

ITI revamp, course design, Train the trainers + initiating training for cell and pack

R&D grants and accelerated path to commercialization for alternate chemistries

New course introductions for high, ultra-skilled workforce

Refining and circularity setup and incentives

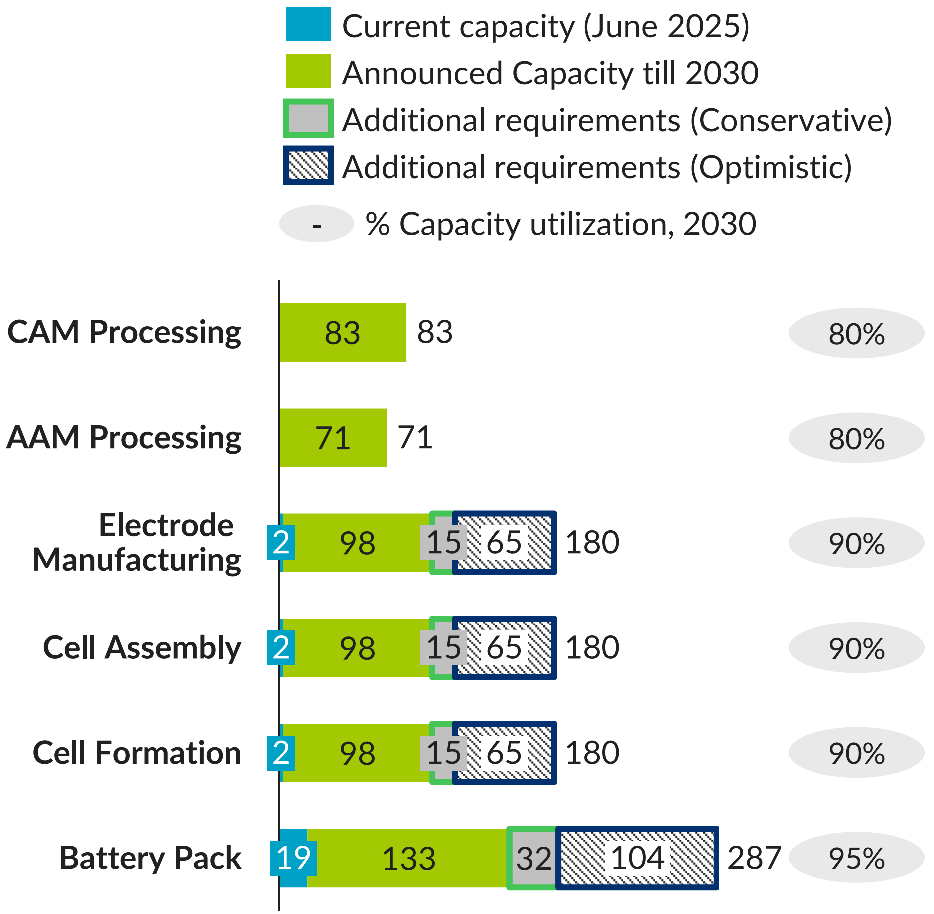
Approved list of cell manufacturers, 45% DVA for ALPM

Approved list of Pack Manufacturers (ALPM) 35% DVA for ALP

Circularity guidelines; Refining, overseas extraction partnerships

Input-side Capex incentives, interest subvention, electricity subsidy

Manufacturing capacity required to achieve 45% indigenisation, 2030, GWh[1,2]



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(1) CAM and AAM refer to Cathode Active Material and Anode Active Material; (2) Have assumed 2–3-year delay in announced timelines due to global market conditions and that Cell capacity announcements refer to 'cell to pack' manufacturing

Source: Company announcements; Ministry of Heavy Industries, PM E-Drive Portal; CEA, National Electricity Plan Vol I; Industry experts; Dalberg analysis

Detailed in Annex

Demand acceleration interventions such as introducing domestic sourcing and DVA mandates could fuel domestic manufacturing, investment in R&D and upstream raw materials could drive innovation and self-reliance

Demand & Market Architecture

- Introduce **Approved List of Pack and Cell Manufacturers** for pack by 2028, cell by 2030 with DVA of 45% by 2030
- **Increase BCD on battery raw materials and components** over time
- **Integrate phased DVA requirements into existing policies and mandates** on EVs (55% by 2028, 60% by 2030) and BESS (35% by 2028, 45% by 2030)
- **VGF**[1] of **INR 4,500-6,500Cr** for domestic e4W to minimize TCO impact

Overall **Government** fiscal incentives required:

INR 4,500-6,500 Cr

R&D & Product Innovation

- **50-50 co-financing** from government and private sector to scale battery R&D ecosystem[2]
- **Develop shared, open labs**[3] for R&D on **10-20 indigenous battery technologies**
- **Efforts led by a Core Working Group**[4] with industry-academia-government representation

Overall **Government** investment (50% of total investment required):

INR 900-1,800 Cr

Upstream Raw Materials & Critical Inputs

- **Provide ~INR 16,300 Cr**[5] electricity, capex subsidies, interest subvention and import duty waiver to drive cost competitiveness
- Invest **INR 1,200-1,500 Cr** to develop battery waste collection centres
- Provide **INR 12,000-12,500 Cr worth upfront capex subsidies** to support development of cumulative 2040 refurbishment and recycling capacity
- Invest **INR 50-60 Cr** in development of stockpile storage capacities

Overall **Government** investment required:

INR 29,400 – 30,400 Cr

Detailed in Annex: *Demand Acceleration*; *R&D Ecosystem*; *Upstream Raw Materials*

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(1) VGF – Viability Gap Funding of 50% of imported vs domestic battery cell cost difference for domestic manufactured e4W; (2) Infrastructure and project grants; (3) Upgrading current/ building new labs; (4) Potentially set up by MNRE/ANRF; (5) Incentives required for setting up 85 kTPA Graphite domestic refining capacity by 2030; (6) Cell efficiency for Utility scale solar for c-Si modules compared to 20% today (target efficiency for other applications, e.g. rooftop/ off-grid could be adjusted in-line)

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Fiscal incentives combined with public-private partnerships for R&D and workforce skilling could accelerate indigenisation at cost-competitive prices for integrated cell and pack manufacturing in India

Capital Equipment & Infrastructure

- **Support MSMEs and existing capital equipment manufacturers to indigenise building up to 60% equipment** for battery manufacturing domestically
- **Leverage bi-lateral G2G partnerships** to enable accelerated capital equipment import for battery (highly specialised, advanced equipment with no domestic synergy)

Incremental capex investment required:

INR 76,000 – 158,000 Cr

(Does not include subsidies)

Talent & Workforce

- Launch **"Train the Trainer" program**, dedicated master's programs, and industry-government funded **on-the-job training** with global exposure to retain ultra-skilled talent
- **Start certificate, specialization courses**, industry co-delivered modules, internships for high skilled
- Develop **standardized courses**, demo labs and allocate **<1% ITI upgradation budget** to train low-skill workforce

Overall **Government** investment :

INR 3000-5500 Cr

Financing & Taxation

- Driving **additional investment for capacity expansion** across value chain
- **Targeted input subsidies** on electricity, capex, interest subvention to improve cost competitiveness for Indian battery cells of **INR 27,000-48,000 Cr** till 2030
- Proposed import duty waivers on key raw materials, and BCD increase on cells with **potential net tax revenue increase of INR 800-3000 Cr**

Overall **Government** fiscal incentives required:

INR 27,000-48,000 Cr

*Achieving **45% indigenisation** across the battery value chain requires **INR 64.8-92.2K Cr** total government investment by 2030 and could result in **USD 18-28 Bn (INR 1.5- 2.3 Lakh Cr) of** total import bill savings.*

Detailed in Annex: *Capex and Infra*; *Workforce*; *Financing*

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Increasing battery value chain indigenisation to 45% could support cumulative import savings of USD 18-28 Bn by 2030, excluding capital equipment imports for domestic manufacturing

Battery imports could increase from ~USD 3.7-4.4 Bn in 2024 to USD 27-42 Bn by 2030 without increased indigenisation across the battery value chain from CAM/AAM processing till battery pack assembly (not including pre-cursor minerals)

Key insights

Comparison of cumulative import bill savings of USD 18-28 Bn till 2030:

Legend: 🟢 Potential Savings/Income 🔵 Cost/Investment

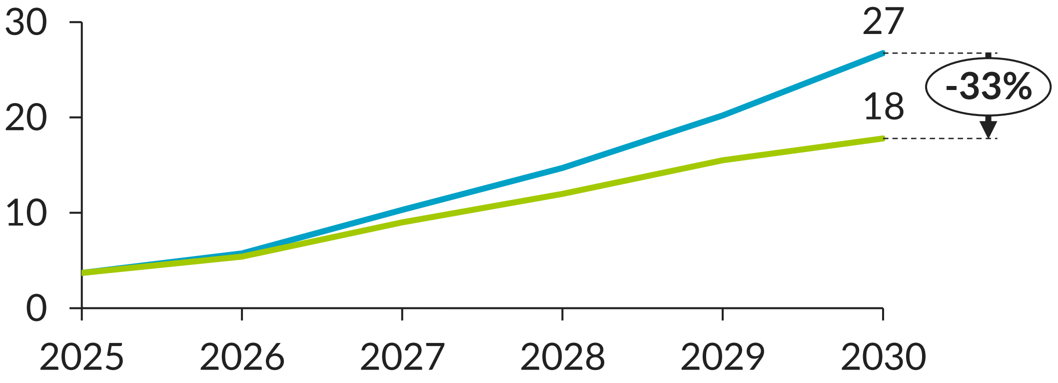
Import savings comparison	**Cumulative impact 2025-2030, USD Bn**	
Cumulative import bill savings	USD 18-28 Bn	🟢
Cumulative investment required for 45% indigenisation*	USD 31-33 Bn	🔵
Government investment / fiscal incentive support	USD 8 - 11 Bn	🔵
Potential GST income with indigenous battery sales	USD 11-16 Bn	🟢

* - Up to 60% of this capex investment could be indigenously sourced / commissioned which would further improve the import bill savings

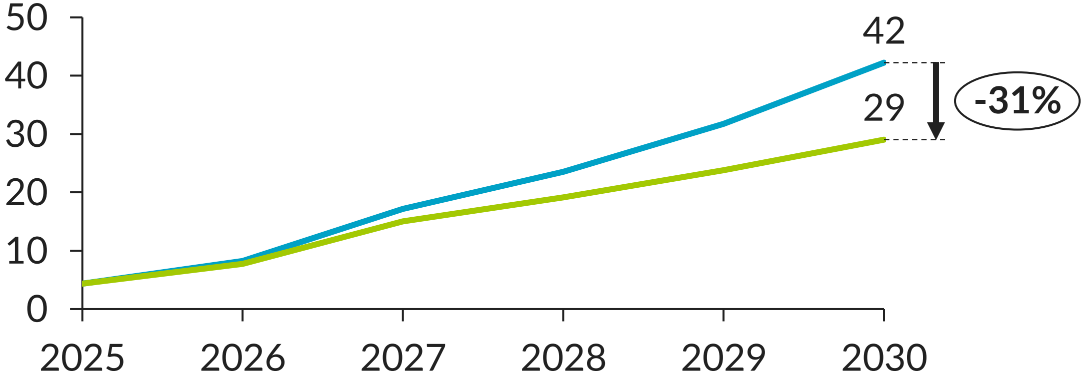
Expected annual import for ACC batteries, USD Bn

Current + Announced capacities — 45% indigenization

Conservative Scenario



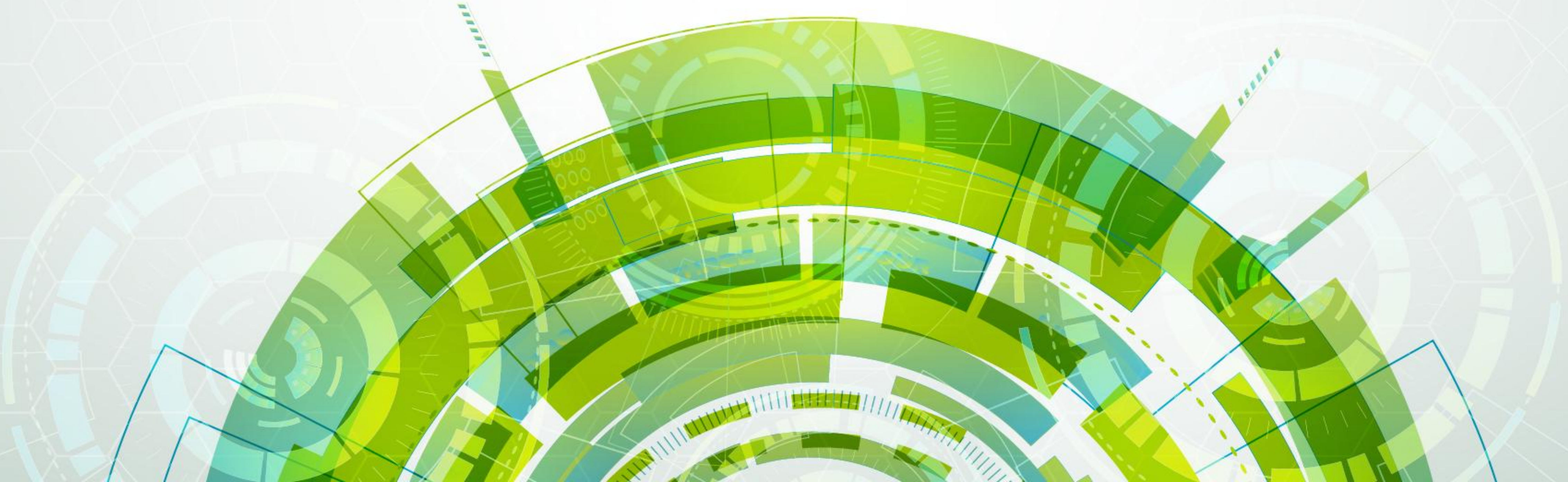
Optimistic Scenario



Sources: EXIM bank database, Fortune India, Economic Times

SECTION TWO, SUB-SECTION A

BATTERY AND ENERGY STORAGE SYSTEMS INDIGENISATION PATHWAYS FOR INDIA: DETAILED BY CROSS-CUTTING THEMES

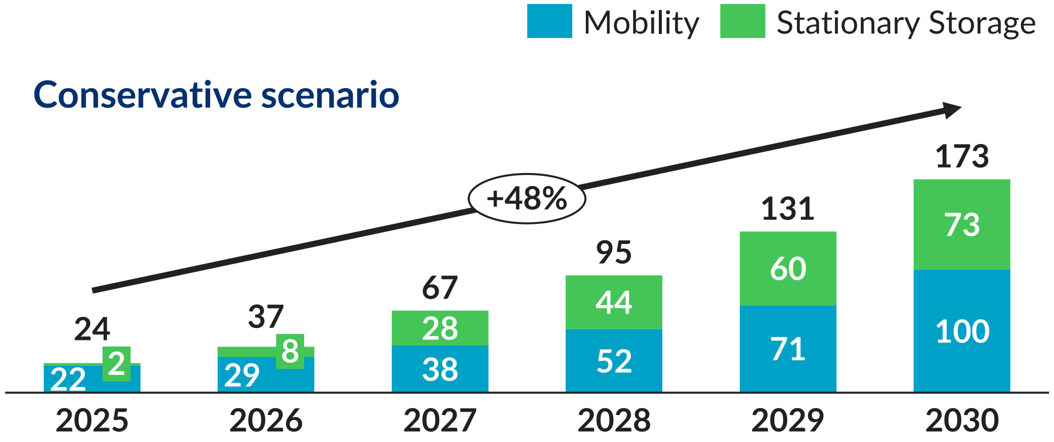


1 **Demand |** Annual demand for indigenous battery packs could increase to 173-273 GWh by 2030 driven by EV sales penetration, utility scale RE storage mandates and grid stabilization and peak load management needs

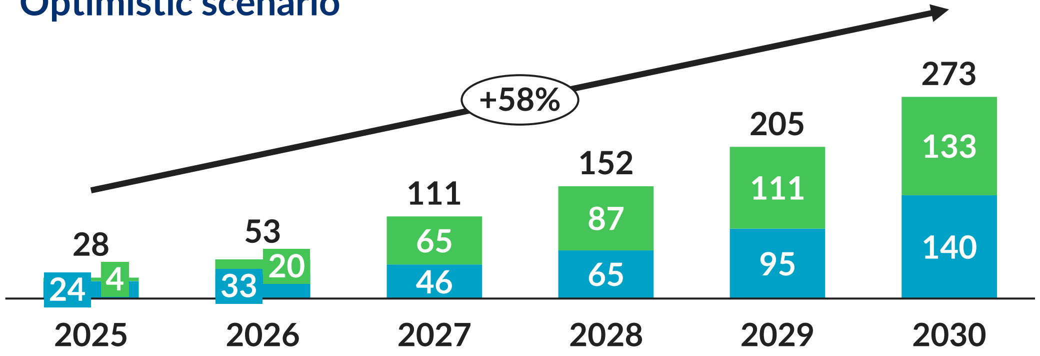
Policy interventions such as an approved list of pack and cell manufacturers, phased DVA requirements in existing policies and extending BESS mandates for utility scale RE could fuel domestic battery demand

Annualized Battery Pack demand 2025 -2030, GWh

Conservative scenario



Optimistic scenario



Key insights

India needs large-scale integrated gigafactories from electrode to cell to pack manufacturing, and other facilities focusing on cathode and anode active material processing to achieve 45% indigenisation by 2030

Demand drivers required:

- Approved list of battery manufacturers to ensure domestic players are prioritised (like ALMM for Solar PV) for pack by 2028, cell by 2030 with DVA of 45% by 2030
- **Mobility**:
  - Phased introduction of DVA mandate in PM E-Drive for e2W/3W/Buses of 55% by 2028 and 60% by 2030
  - Launch DVA mandate for domestic 4W of 55% by 2028 and 60% by 2030 with potential cumulative Viability Gap Funding (2027-30) of INR 4,500-6,500 Cr to reduce TCO[3] impact
- **Stationary storage**: Extending BESS co-location to 100% of incremental utility scale RE deployment with integration of phased DVA requirements for utility scale BESS

Detailed in Annex

(1) CAM and AAM refer to Cathode Active Material and Anode Active Material; (2) Have assumed 2–3-year delay in announced timelines due to global market conditions and that Cell capacity announcements refer to 'cell to pack' manufacturing; (3) TCO – Total Cost of Ownership

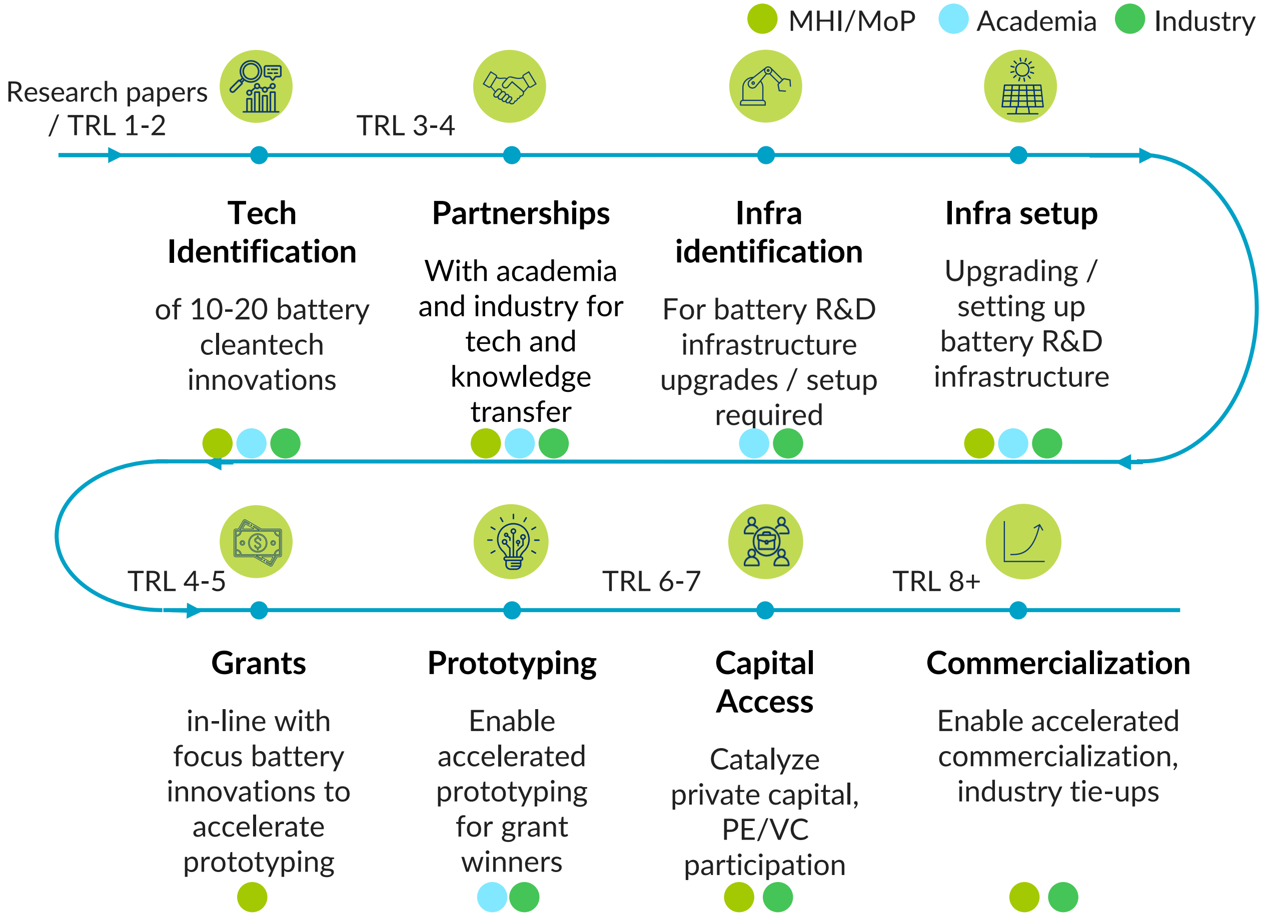
Source: Company announcements; Ministry of Heavy Industries, PM E-Drive Portal; CEA, National Electricity Plan Vol I; Industry experts; Dalberg analysis

2

R&D | Build a collaborative R&D ecosystem with industry-academia-government collaboration to support prototyping to commercialization for 10-20 indigenous innovations across the battery value chain

The R&D ecosystem would require industry and academia participation and shared investment of INR 1,800-3,600 Cr on infrastructure investment, grants and capital access to fuel R&D and innovation for indigenous battery-related technologies

Steps for battery cleantech R&D acceleration



🟡 MHI/MoP 🔵 Academia 🟢 Industry

Research papers / TRL 1-2

Tech Identification

of 10-20 battery cleantech innovations

🟡🔵🟢

TRL 3-4

Partnerships

With academia and industry for tech and knowledge transfer

🟡🔵🟢

Infra identification

For battery R&D infrastructure upgrades / setup required

🔵🟢

Infra setup

Upgrading / setting up battery R&D infrastructure

🟡🔵🟢

TRL 4-5

Grants

in-line with focus battery innovations to accelerate prototyping

🟡

Prototyping

Enable accelerated prototyping for grant winners

🔵🟢

TRL 6-7

Capital Access

Catalyze private capital, PE/VC participation

🟡🟢

TRL 8+

Commercialization

Enable accelerated commercialization, industry tie-ups

🟡🟢

Key insights on R&D ecosystem development

- **MHI/MoP and ANRF could set up a Core Working Group** with industry-academia-government representation **to lead efforts on** infrastructure set up, grants, private participation[1]
- **Industry participation crucial** from beginning to identify the right, focus 10-20 innovations where industry could support commercialisation
- **INR 1,800-3,600 Cr[2]** total battery R&D investment required
    - **R&D infrastructure:** INR 1,200-2,400 Cr (Battery technology: INR 1,100-2,000 Cr; Battery recycling technology: INR 100-400 Cr)
    - **Project grants:** INR 600-1,200 Cr
    - **50:50 co-financing** from **private sector and government (INR 900-1,800 Cr fund share each)**
- **Distinct, open-access R&D labs to be set up under PPP structure** across public and private sector[3] focusing on **select, high-quality labs** maximising resource efficiency and public-private collaboration

Detailed in Annex:* *Steps*; *Infrastructure*; *Funding

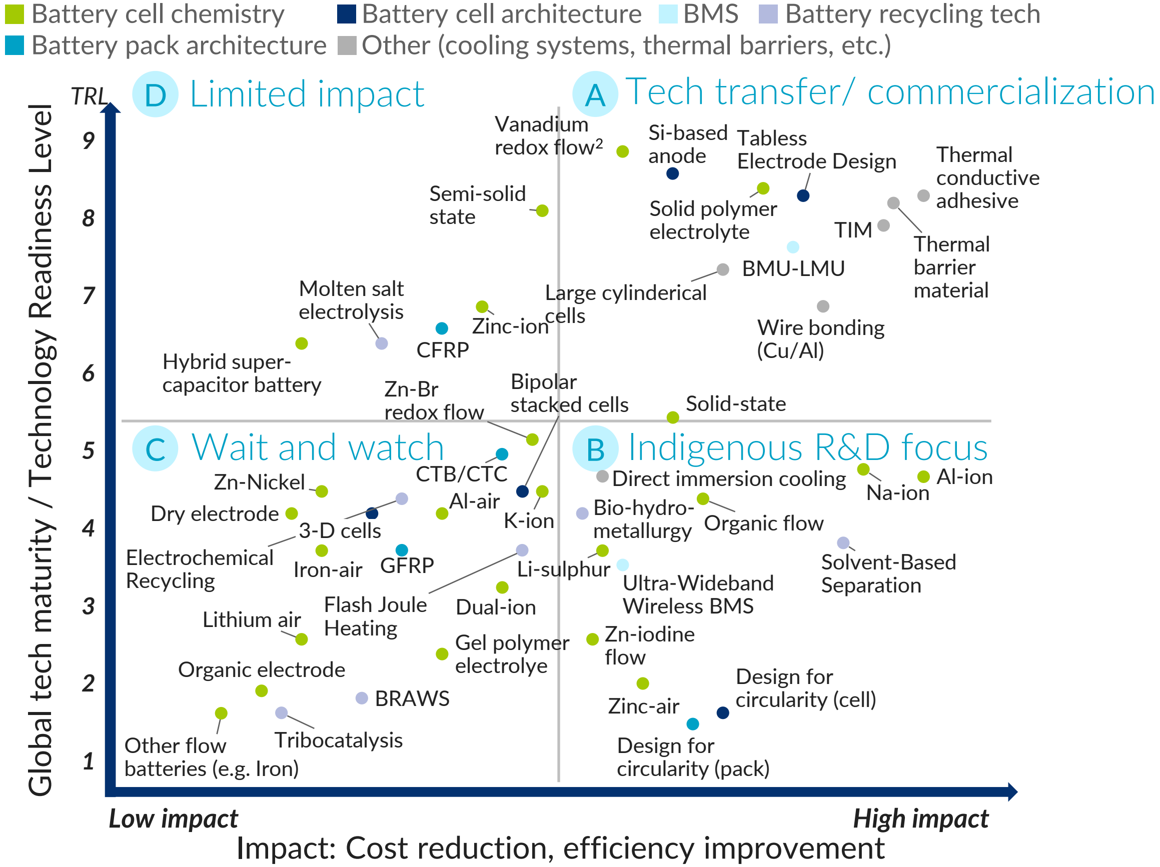
(1) Tech identification and funding; (2) Grant estimates based on USA's Small Business Innovation Research (SBIR) program; (3) Upgrading existing/ building new

Source: Academia and industry experts; US Small Business Administration, Annual Report, 2022

2 R&D | Focus R&D and innovations across the battery value chain and required infrastructure could be aligned with industry and academia to ensure commercialization potential and pathways prior to investment mobilization

Potential focus technologies for tech-transfer / indigenous R&D could be identified basis impact potential and global TRL levels

Focus R&D and innovation technologies: Battery



***Prioritized technologies could be integrated** into battery **R&D infrastructure planning**, aligning with TRL requirements*

India could invest in 12-16 battery R&D labs to upgrade existing labs, set up new ones, and ensure efficient operations

	Battery tech development and testing	Battery recycling tech development and testing
Number of labs	**10-12 labs** *7-8 small labs (TRL 4-5) and 3-4 large labs (TRL 5-8)*	**2-4 labs** *Upgrades to 1-2 current labs; set up of 1-2 new labs*
Cost of labs, INR Cr	**INR 1,100-2,000 Cr** *INR 50-100 Cr/small; INR 250-300 Cr/large lab (setup/upgrades)*	**INR 100-400 Cr** *INR 50-100 Cr/ lab for upgrades/ new setup*
Existing infra for upgrade	*IIT Delhi Research Park* *IIT Madras Research Park* *Social Alpha lab*	*IIT Madras Research Park*
Machinery needs	• Material R&D and chemical wet-lab equipment • Coating, precision cutting machines; testers	• Battery grinders, shredders and crushers • Air flow separators • Fume hoods, battery testers
Manpower and support needs	• **Trained manpower** with ability to use advanced equipment • **Independent management team** to ensure maximum utilization, efficient operations • **Market needs assessment** of upcoming tech trends to inform relevant research	

***Detailed in Annex:** Technologies; Infrastructure*

Source: PV Magazine, Saur Energy, Battery tech online, NITI Aayog, Future Battery Lab, Company websites, Startup websites, Research lab websites, The EV Report, Sodium battery hub, Technology Review, Science Direct, IITs, expert inputs

3

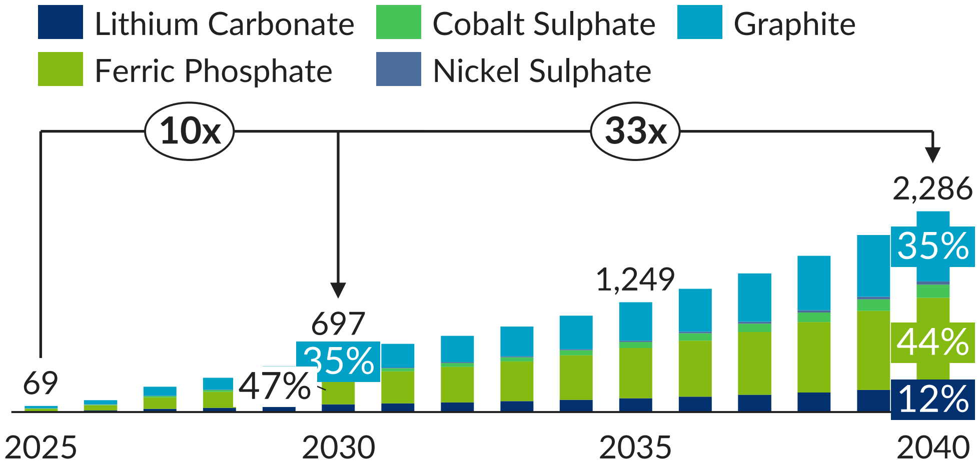
Upstream: Raw Materials | India could meet ~80% critical mineral demand domestically by 2040 with INR 143-147K Cr cumulative investments in domestic refining, circularity and stockpiling

Parallel efforts across stockpiling, developing domestic mineral extraction and refining capacity and scaling circularity infrastructure are required to safeguard supply of critical minerals and increase self-reliance

Raw-material supply landscape and current progress in diversifying supply:

- China holds **60-96% of global critical mineral refining** and **20-80% of global extraction capacity**
- India is **actively establishing G2G partnerships** to secure access to minerals through **overseas extraction** and **refining tech partnerships**
  - **KABIL** acquired mining rights and **COAL India** established JV to access **Argentina Lithium resources**
- India's **mineral demand** could grow **~33x till 2040** – key to accelerate these efforts to safeguard mineral supply and increase self-reliance

India's critical minerals demand, 2025-2040, kTPA



Key pathways for increased self-reliance include stockpiling efforts and investments in domestic refining and circularity capacities:

	Ⓐ Domestic mineral refining	Ⓑ Scaling Circularity	Ⓒ Import diversification and stockpiling
Details	Global and domestic mineral extraction with domestic refining	Closed loop recycling for metal recovery and battery refurbishment	Stockpiling up to 25% of annual demand for critical minerals
Cumulative Investment by 2030	**~INR 75,000 Cr** total upfront capex and government support worth **~INR 16,300 Cr**[1] (for graphite refining only)	**INR 68,400-72,000 Cr** upfront capex (collection, refurbishment and recycling) and government support worth **INR 12,000-12,500 Cr**[2]	**INR 50-60 Cr** upfront capex investment required (stockpiling)

Detailed in Annex

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(1) Includes cumulative upfront capex subsidy and interest subvention till 2030, as well as electricity subsidy and impot duty waiver in 2030 (detailed ahead); (2) Refers to capex subsidies for refurbishment and recycling facilities; Sources: IEA, Global Critical Minerals Outlook, 2025; CFR, China in Africa: March 2025, 2025; USGS, Mineral Commodity Summaries, 2025; Dalberg Analysis

3A

Upstream - Domestic Refining | ~INR 16,300 Cr cumulative input subsidies till 2030 could support development of 85 kTPA domestic refining capacity for Graphite till 2030 and increase cost competitiveness

Developing domestic refining capacities would require significant government support to reduce cost differential between imported refined minerals and domestically refined minerals by easing high electricity and upfront capex costs

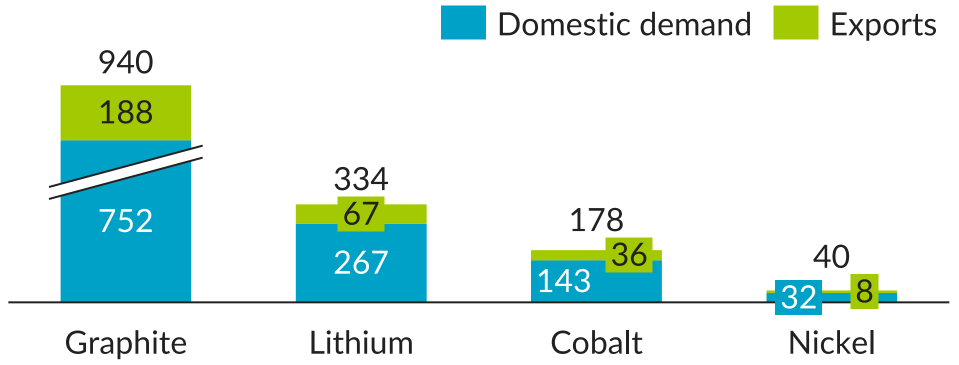
Pathway for developing domestic refining capacities:

Timeline	Refining	Extraction
2025-2030	Tech transfer & initiate industry setup	Scale overseas mining rights, leverage graphite extraction
2030-2035	Infrastructure setup and capacity scale-up (initiated in 2025-2030)	Expedite domestic exploration, initiate extraction
Beyond 2035	Leverage G2G partnerships to become global refining hub with **USD 0.98-1.2 Bn** export potential	

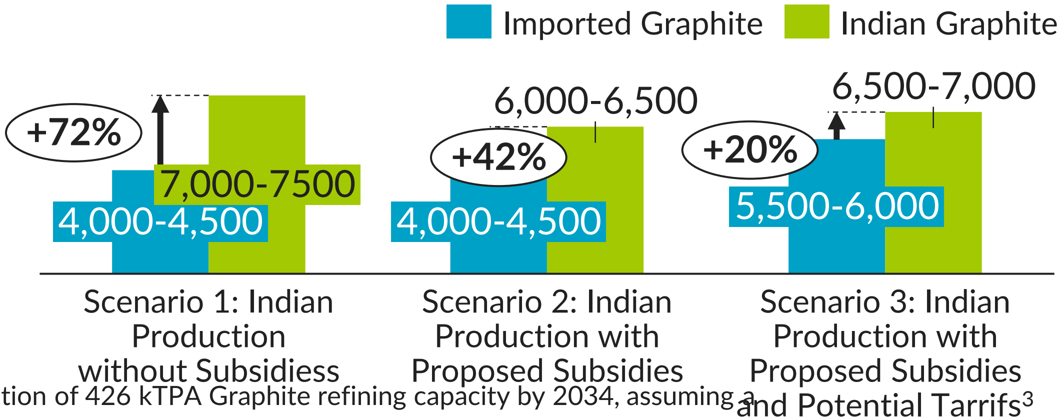
Developing domestic Graphite refining capacities would require policy support to improve cost-competitiveness and reduce cost by 13-17%:

Proposed interventions[1, 2]	Cumulative Impact (INR Cr)
Upfront capex subsidy of **20%** from 2026 to 2030	~14,900
Interest subvention of **20%** from 2026 to 2030	~680
Electricity price subsidy of **30%** in 2030	~670
Import duty waiver on raw material inputs in 2030	~20
Total targeted subsidies till 2030	~16,300[2]

Domestic refining capacity targets, by 2040, kTPA



Illustrative comparison of imported and domestic battery grade Graphite cost, USD/MT, ex-GST



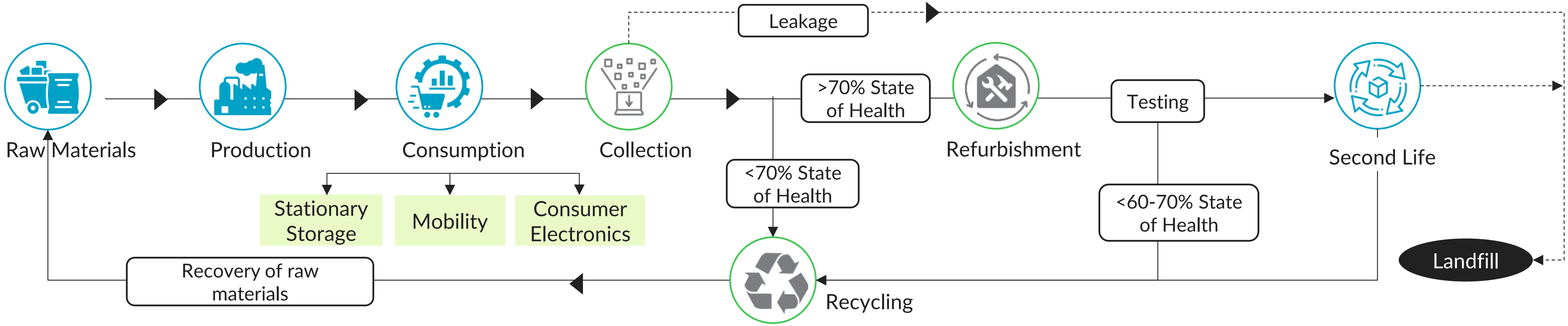
(1) Upfront capex subsidies and interest subvention proposed from 2026 to facilitate construction of 426 kTPA Graphite refining capacity by 2034, assuming a lead time of 3 years in capacity development; (3) Electricity price subsidy and import duty waiver on raw materials proposed from 2030 – as refining capacity is expected to come online by 2030; (2) Based on 30% country of origin tariffs expected on imports from China and lower tariffs on India (10%);

Source: Dalberg analysis, expert consultations

3B

Upstream - Circularity | Capex investments in collection, refurbishment and recycling facilities could support meeting 96 GWh second-life batteries demand and 970 kTPA recycled material recovery by 2040

Simultaneous efforts required across key pillars of circularity – collection, refurbishment and recycling to meet battery mineral demand through recycling and minimize leakage of battery waste into landfills



Leakage

Raw Materials

Production

Consumption

Collection

>70% State of Health

Refurbishment

Testing

Second Life

Stationary Storage

Mobility

Consumer Electronics

<70% State of Health

<60-70% State of Health

Landfill

Recovery of raw materials

Recycling

Key interventions and enablers across collection, refurbishment and recycling required by 2030:

XX – Projected annual potential by 2040

Collection

1,738 kTPA waste collected

- Cumulative **INR 1,200-1,500 Cr capex investment** by 2030 to develop **160-180 battery waste collection centers**, enabling high waste collection rates
- Integrate battery waste collection with existing **Material Recovery Facilities**

Refurbishment

96 GWh second-life batteries

- **Second-life battery certification** regulations under **ICAT** and **ARAI** to ensure safety and quality
- Upfront **capex subsidies of INR 2,900-3,100 Cr** to support cumulative capex investment required till 2040

Recycling

970 kTPA waste recycled

- **Setup:** **Exception approvals**, **subsidized land and working capital loans** and **upfront capex subsidies of INR 9,000-9,500 Cr,** deferred GST on capital equipment
- **Scale-up:** Continued policy support (working capital loans) to support scale up

Source: Dalberg Analysis, expert consultations

3C

Upstream – Stockpiling | Stockpiling up to 25% of annual demand for select critical minerals (cathode and anode precursor materials) could ensure supply consistency and protection from price fluctuations for India

Presently, India lacks domestic cathode and anode manufacturing capacities but as they develop, mineral stockpiling could safeguard supply of feedstock precursor materials[1] such as Graphite, Cobalt Sulphate and Lithium Carbonate

Key Benefits:

- **Continued access to minerals** during global supply constraints
- **Protection of domestic battery manufacturing ecosystem** against global mineral price fluctuations

Focus materials for stockpiling[2]:

- **Battery-grade Graphite**, owing to China's stronghold on global refining (96%), **Cobalt Sulphate** and **Lithium Carbonate** due to lack of both domestic extraction and refining capacity

Secure 25% of annual demand:

- Establish stockpiling targets of **25% of 2030's annual raw material demand (90 kTPA)**

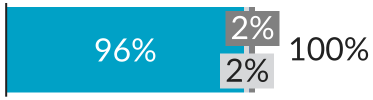
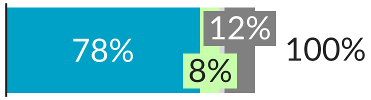
Leverage either of 2 existing models for stockpiling:

Public-sector led	**ISPRL (India)** - PSU-led acquisition of oil resources, government funded storage infrastructure that can be leased to private sector
Public-private	**JOGMEC (Japan)** - Government mineral stockpile mandate for private sector, supported by interest subvention for private sector

Potential stockpiling partnerships/sources for India

🟦 China 🟦 US 🟩 Chile ⬛ Rest of the world

⬜ Japan 🟩 Argentina 🟩 Finland

Key materials	Target stockpile, 2030, kTPA	Value of stockpile (INR Cr)[3]	Global refining capacity, %
Battery-grade Graphite	60	~3600	
Cobalt Sulphate	8	~890	
Lithium Carbonate	22	~2600	
TOTAL	**90**	**~7100**	

Upfront capex investment required

INR 50-60 Cr[3]

for developing **90-100 kTPA** storage capacity

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(1) Precursor materials can be stored for long durations without suffering material degradation; (2) Stockpiling refers to the accumulation of raw materials beyond regular demand to ensure uninterrupted access during future supply disruptions or shortages. Storage infrastructure costs for the ISPRL Padur reserve have been considered as a reference to compute mineral storage infrastructure costs; (3) Value computed as per current international metal prices on Shanghai Metal Market, accessed in January 2026 ;
Sources: ISPRL, Detailed project report for phase II of strategic storage program for crude oil, 2013

4 **Capital equipment & infrastructure** | India could reduce capital equipment import dependence by up to 60% across cell formation, module assembly, CAM Processing (80%) manufacturing by building select equipment (1/2)

Domestic capacity for capital equipment manufacturing could be built for equipment with cross-sector synergies and economies of scale potential, low tech expertise needs, along with high efficiency and cost effectiveness

Potential pathways for catalyzing India's capital equipment manufacturing:

🟢 High 🟡 Medium 🔴 Low

Pathway criteria	1 **Domestic manufacturing** for *select battery equipment with existing industry synergies*	2 **Import** *highly specialized, advanced battery capital equipment with no industry synergy*
Synergies with other sectors	🟢 **Existing synergies** with adjacent industries (similar machine/ components/ processes like solar)	🔴 No existing synergies
Tech expertise	🟢 Need **marginal improvements**/ tweaks to existing machines	🔴 Germany, Korea lead in technical expertise; India to face very long lead time to build comparable domestic know-how
Efficiency and costs	🟡 Potential to attain global competitiveness in tech and cost efficiencies	🔴 Highly tech and cost-efficient imported capital equipment
% Capex contribution	**50-60%** **across CAM to final pack assembly** (Up to 80 % for **CAM processing**; Up to 100% for **pack assembly and cell formation**) ***Examples:*** Calcination Furnace, Aging Chamber, Clean room	**40-50%** **across CAM to final pack assembly** (Up to 80% for **AAM processing and electrode formation**: up to 100% for **Cell Assembly**) ***Examples:*** Carbon Coating Furnace, Electrolyte Filling Machine

Sources: Money Control; BHEL, Renewables Solar, 2025; Business Standard, "L&T's first electrolyser factory to start commercial operations soon", 2024; Bharat Forge, Power Business; SolarPower Europe, Solar Production Equipment – Key players in the EU's industrial ecosystem for solar PV, 2025 ; SaurEnergy; Industry experts

4 **Capital equipment & infrastructure |** India could reduce its capital equipment import dependence by up to 60% across cell formation, module assembly, CAM Processing (80%) manufacturing by building select equipment (2/2)

Domestic capacity for capital equipment manufacturing could be built for equipment with cross-sector synergies and economies of scale potential, low tech expertise needs, along with high efficiency and cost effectiveness

Potential pathways for catalyzing India's capital equipment manufacturing:

1 Domestic manufacturing for ***select battery equipment with existing industry synergies***

2 Import ***highly specialized, advanced battery capital equipment with no industry synergy***

Key Benefits

1:
- Potential to repurpose and build on **existing capacity**
- Reap benefits of **economies of scale and long term market opportunity**
- Initiate building resilience against foreign supply shocks

2:
- **Leverage existing foreign capabilities** to procure at effective costs and diversify supplier base
- **Quick access** to capital equipment supports rapid production ramp up

Pathway unlocks

1:

Identify equipment synergies for battery equipment with other sectors

Synergies with other industries, e.g.,
- Calcination furnace with ceramic industry
- Grinding mill & drying oven with pharma industry
- Ball mill with mining industry
- Coating machine with paper industry
- Laser welding machine with aerospace industry

2:

Potential to deepen current, and explore new partnerships for capital equipment sourcing across battery value chain

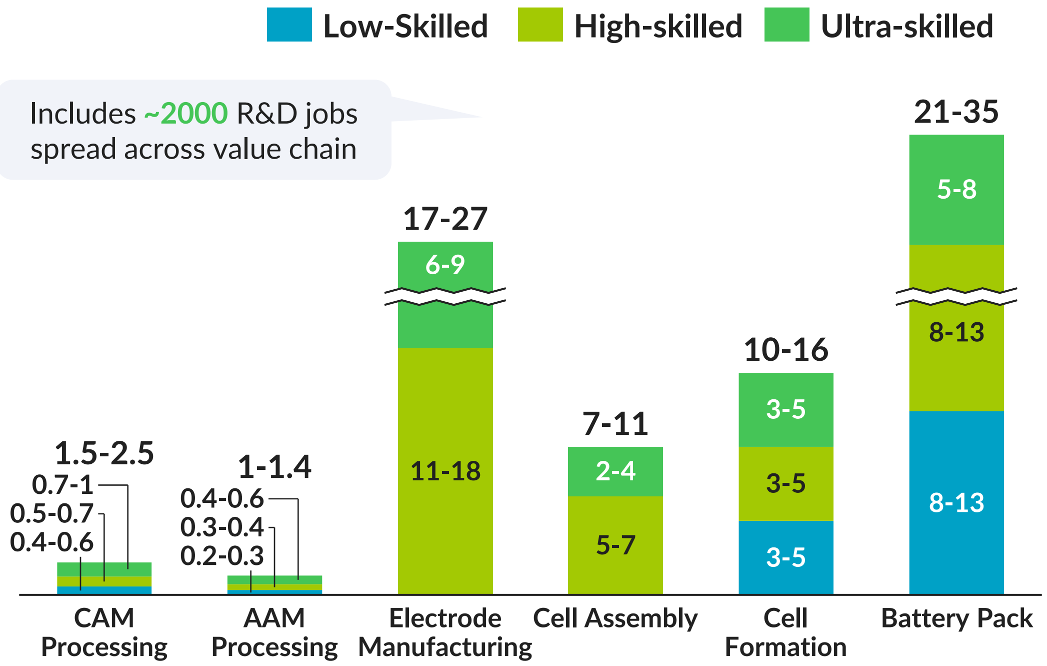
Existing capacities present in

Sources: Money Control; BHEL, Renewables Solar, 2025; Business Standard, "L&T's first electrolyser factory to start commercial operations soon", 2024; Bharat Forge, Power Business; SolarPower Europe, Solar Production Equipment – Key players in the EU's industrial ecosystem for solar PV, 2025 ; SaurEnergy; Industry experts

5 **Workforce** | India would require 58,000-91,000 additional ultra, high, and low-skilled workers across battery manufacturing value chain by 2030 with priority to train Ultra and High-Skilled workforce

To build a ready workforce, targeted interventions would be required across four critical levers including trainers, course design, employability, finance; with skilling efforts focusing on strengthening industry linkages and global partnerships

Projected (2030) additional workforce requirement for battery manufacturing value chain, in '000



Includes ~2000 R&D jobs spread across value chain

Total budget[1]
INR 4000-7500 Cr

Total government share
INR 3000-5500 Cr

Levers: 🟢 Trainer 🟡 Course Design 🔵 Employability 🟦 Finance

Focus

Ultra Skilled

- 🟢 Develop "Train the Trainer" program for 200 – 300 trainers / academicians / professors from Top 100 engineering colleges[1]
- 🟢 Attract global battery and cleantech experts to train faculty at Tier 1 engineering colleges (Top 20)
- 🟡 🔵 Launch master's programs in battery technology in tier 1 colleges with demo and R&D labs
- 🔵 Develop industry-government funded on-the-job training initiatives with global exposure to retain R&D talent in India

High Skilled

- 🟡 🔵 Introduce battery manufacturing certification and specialization courses in Top 100 engineering colleges with demo, R&D labs
- 🟡 🔵 Co-deliver cleantech manufacturing modules, and internships at manufacturing plants for engineering students

Low Skilled

- 🟡 Create standardized courses and qualification packs aligned with industry-defined competencies
- 🟦 Repurpose <1% of the ITI upgradation scheme to promote public-private skilling partnerships (apprenticeship – using NAPS, joint trainings by ITIs and manufacturers)
- 🟡 Develop modules for retraining workers from adjacent industries like automobile, electronics (for pack) or chemicals (for CAM/AAM)

Detailed in Annex

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(1) The total budget covers training costs and demo and R&D facility investment, across skill levels

6

Financing | INR 2.6-3.7 Lakh Cr would be required during 2025-30 to achieve 45% cost-competitive indigenisation across the battery value chain, build a cohesive R&D ecosystem and train the required workforce

Government funding of INR 64.8-92.2K Cr would be required across demand acceleration, R&D, workforce skilling and subsidies on electricity, capex and interest by 2030 to achieve these goals

Theme	Total Funding Required (INR Cr)	Government Funding Required (INR Cr)	Key Activities	Potential outcomes
Demand & Market Architecture	4,500-6,500	4,500-6,500	Introduction of Approved List of Pack and Cell Manufacturers, DVA requirements for EV and BESS supported by VGF for domestic e4W	Increased demand for domestically produced battery cells
R&D & Product Innovation	1,800-3,600	900-1,800	12-16 R&D development and testing labs for battery technology, battery recycling R&D; INR 600-1,200 funding for project grants	Indigenous development of battery technologies; accelerated adoption of early-stage innovative global technologies
Upstream Raw Materials & Critical Inputs	143,000-146,600[1]	29,400-30,400	Input subsidies on capex for refining, refurbishment and recycling capacity; investment in collection facilities and mineral storage facility	Reduce import dependency on refined raw materials; meet mineral demand through recycled materials and use 21 GWh refurbished batteries
Capital Equipment & Infrastructure	76,000-158,000[2]	Detailed in cost competitiveness below	Support timely deployment of announced capacities through incentives; Indigenous production of up to 55% of capital equipment	Reduce import dependence for capital equipment where feasible; Ensure accelerated capacity expansion to meet 45% indigenisation target
Talent & Workforce	4,000-7,500	3,000-5,500	Training additional 58,000-91,000 ultra, high, and low skilled workers across the value chain and setting up demo training and R&D facilities	Ensuring a stable supply of workers, reducing attrition and lowering training costs for manufacturers
Cost Competitive-ness Ⓐ	27,000-48,000[3]	27,000 – 48,000[3]	Input subsidies on electricity, capex and interest subvention till 2030; import duty exemption [4] and increased BCD on imported cells leading to INR 800-3000 Cr potential net tax revenue increase	Increased cost competitiveness of domestic battery cells – potentially bringing within 23% of Chinese landed costs
TOTAL	256,200-370,200	64,800-92,200		

Ⓧ *Detailed ahead*

(1) Refers to investments required for domestic refining, circularity and stockpiling (2) Capex for CAM, AAM, Cell and Pack Manufacturing for announced and additional capacities required (3) Includes Input side electricity, capex subsidy and interest subvention till 2030; (4) On select raw materials – PVDF Binder and Electrolytes

6A

Cost Competitiveness | INR 27,000-48,000 Cr of targeted electricity, capex subsidies, and low-cost financing could narrow cost competitiveness gap for indigenous battery cells to 13% of potential Chinese landed cost

Mix of input subsidies, import duty waivers, tariff barriers and establishing global partnerships on technology and raw material sourcing could lead to long term cost-competitiveness for domestic manufacturers

Current landscape indicates major challenges to cost competitiveness

- **Potential 40% cost–gap** between landed costs for Chinese LFP cells[1] and Indian cells from large scale integrated manufacturing facilities[3] potentially due to Chinese over capacity
- **Cost-competitiveness unlikely in short term** – need for tariff (e.g. raising BCD on cell imports) and non-tariff barriers (e.g. ALMM, DVA mandates)
- Limited impact of existing **State-level incentives** on capex, interest subsidies for large manufacturers due to **low ceilings**

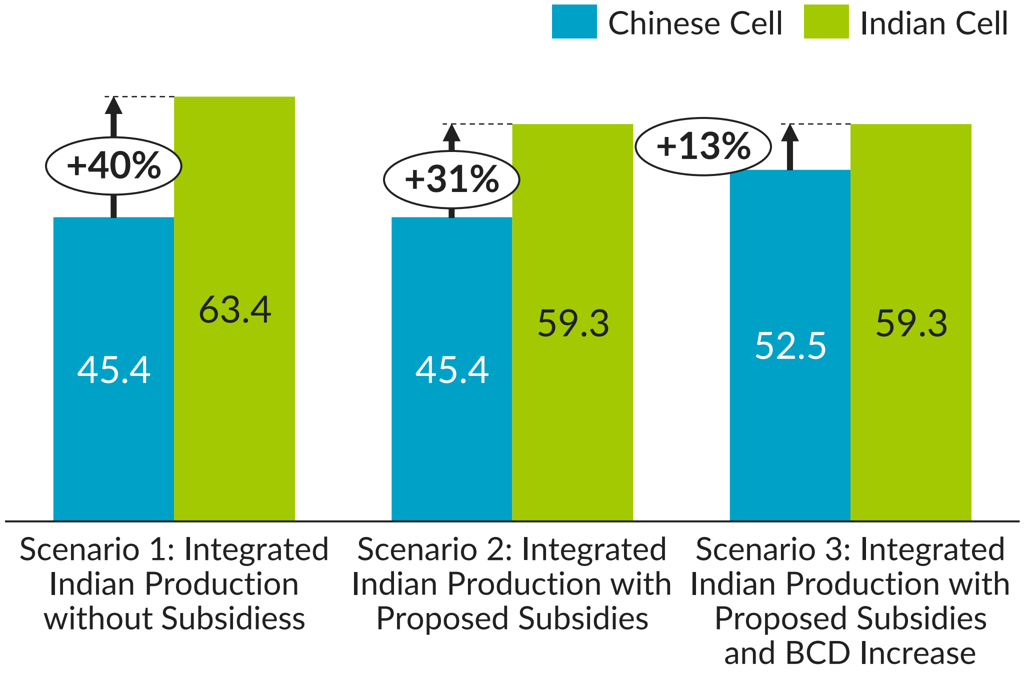
Proposed interventions could limit potential LCOE impact of 45% battery indigenisation to 7-10%[4]:

Intervention type	Impact (INR Cr)
Electricity price subsidy of **20%** till 2030	10,500-16,500
Upfront capex subsidy of **15%**	12,500-25,000
Interest subvention of **15%** till 2030	4000-6500
Import duty exemption on key raw materials[5] till 2030	1500-3000
Increased BCD to **20%** on imported cells till 2030	2500-5500[5]

Geopolitical shifts, price increases could give opportunity for domestic firms

- Need to lay groundwork via R&D investment, G2G partnerships on tech. and raw materials sourcing, and co-evolution with electronics industry

Comparison of Chinese and Indian Battery Cell Landed Cost[1,2], USD kWh, ex-GST



Targeted subsidies on electricity, capex and interest subvention

INR 27,000-48,000 Cr till 2030

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(1) Landed costs for Cells for stationary applications potentially 5-7% lower, average cell price assumed; (2) Chinese cell landed cost assumed to remain consistent via interventions like BCD; (3) Cost estimates assume optimized integrated production at multi-GWh scale, costs for smaller plants could be 20-25% higher; (4) Refers to Solar LCOE; (5) On PVDF and Electrolytes; (6) Potential additional revenue

Source: Shanghai Metal Market, Industry experts (industry associations, key manufacturing players), Dalberg Analysis

Detailed in Annex

ANNEX

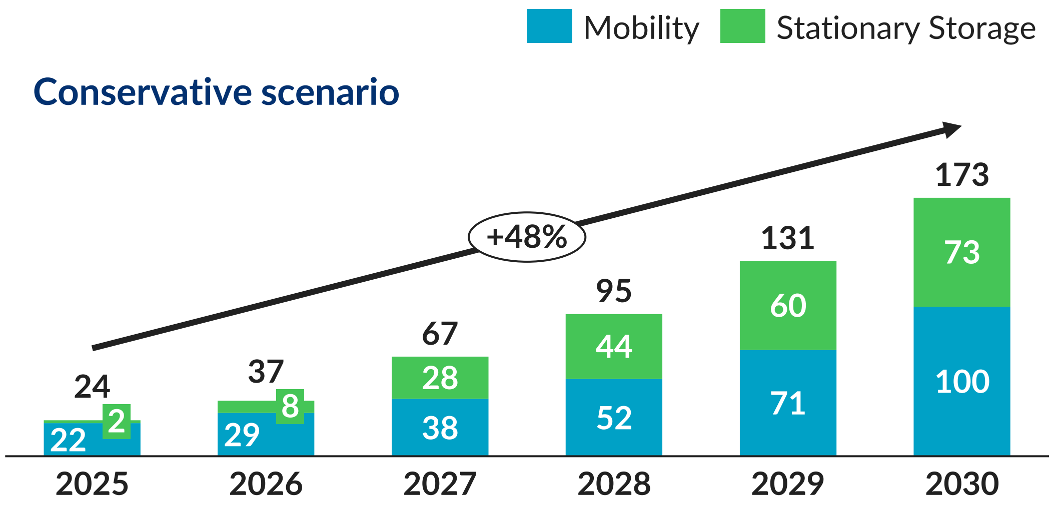
SUB-SECTION ONE

DEMAND & MARKET ARCHITECTURE

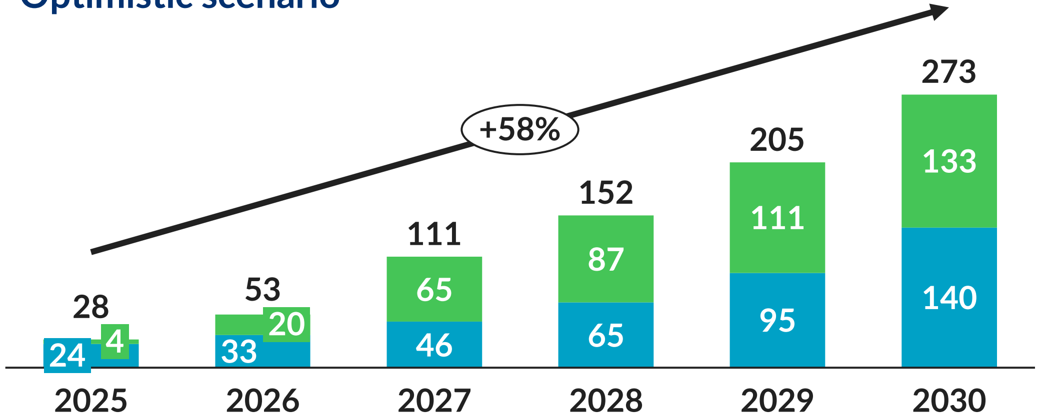
Annual demand for indigenous battery packs could increase to 173-273 GWh by 2030 driven by growing EV sales penetration, utility scale RE storage mandates and grid stabilization and peak load management needs

Annualized Battery Pack demand 2025 -2030, GWh

Conservative scenario



Optimistic scenario



Scenario description for first life applications

Conservative scenario

Mobility

- Achievement of EV30@30 target with **30% EV sales penetration** of total annual new vehicle sales by 2030 with policy support from PM E-Drive, SPMEPCI[1]

Stationary Storage

- **2-hour BESS colocation** covering 40% of incremental installed VRE[2] capacity in line with **current mandates** and **NEP[3]** BESS targets
- **Grid stabilization and peak load management (PLM)** based on existing electricity generation and peak demand
- C&I demand for storage not included – assumed to import dependent or under second life applications for batteries

Optimistic scenario

Mobility

- **Exceeding EV30@30 targets** with higher EV penetration among 2 and 3-wheelers (both 47%) with **overall EV new vehicle sales penetration at 38%** by 2030 through additional policy support

Stationary Storage

- Coverage of **100% of Solar and Wind utility scale generation** with 2-hour BESS co-location by 2030
- No change for grid stabilization, PLM and C&I demand **as conservative scenario**

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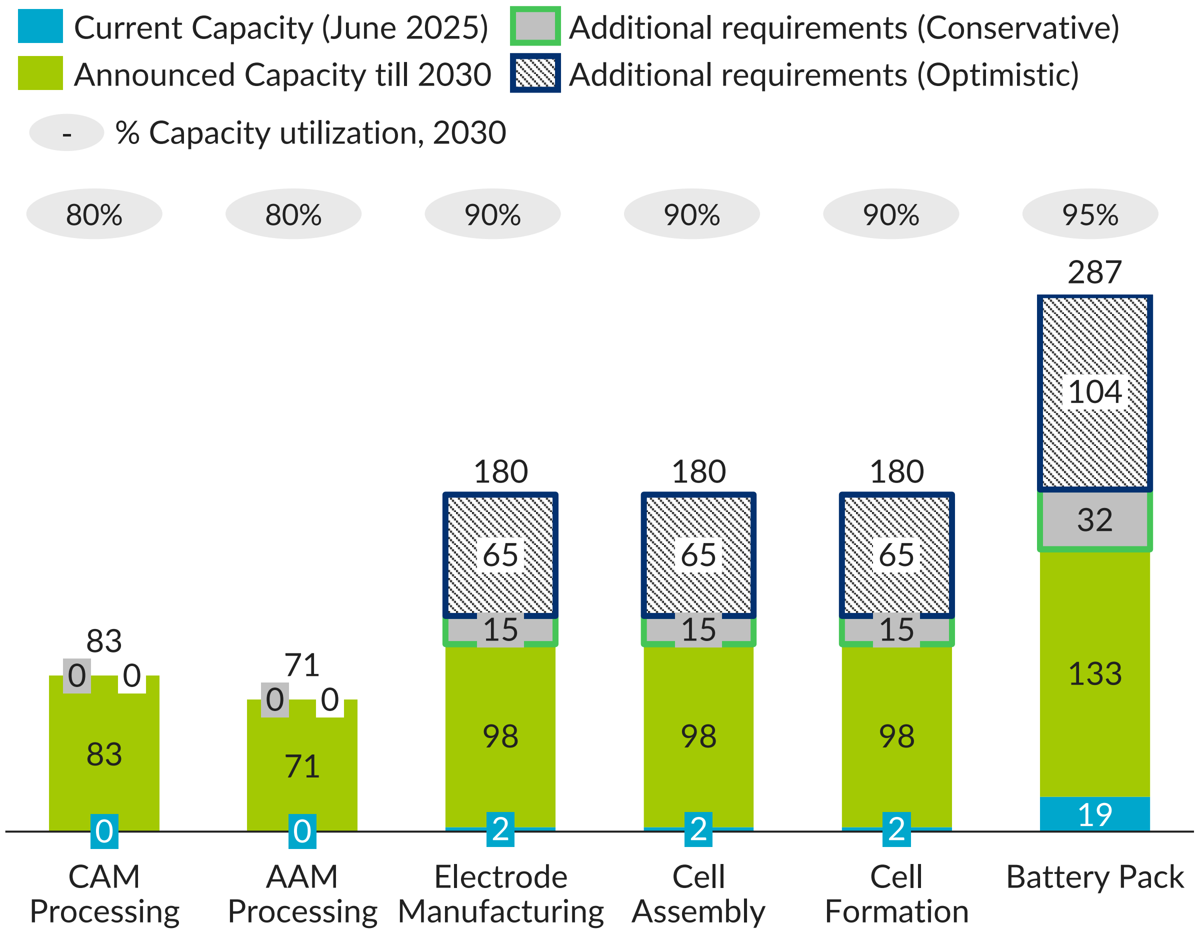
(1) SPMEPCI - Scheme to Promote Manufacturing of Electric Passenger Cars in India offering global EV makers customs duty concessions on import of CBUs in return for setting up domestic manufacturing capacity within 3 years; (2) VRE – Variable Renewable Energy; (3) National Electricity Plan

Source: PIB Press Release, December 2024; CEA Advisory Notice, Feb 2025; PIB Press Release, May 2025; Industry experts (industry associations; Dalberg analysis

Cumulative 287 GWh domestic battery pack capacity of which 180GWh would be integrated capacity along with 71-83 GWh CAM/AAM processing could help achieve 45% indigenisation across the value chain by 2030

Manufacturing capacity required to achieve 45% indigenisation, 2030, GWh[1,2]



Key insights

India needs large-scale **integrated gigafactories** from electrode to cell to pack manufacturing, and other facilities focusing on **cathode and anode active material processing** to achieve 45% indigenisation by 2030

Demand drivers required:

- **Approved list of battery manufacturers** to ensure domestic players are prioritised (**like ALMM for Solar PV**) in stages as domestic manufacturing capacity increases
- **Mobility**:
  - **Phased extension of Domestic Content Requirements** in PM E-Drive to include battery components (cells, electrodes),
  - Introduction of **DVA mandate for 4W** with potential Viability Gap Funding (VGF) of INR 4500-6500 Cr to reduce TCO impact
- **Stationary storage**: Extending **BESS co-location to 100%** of incremental utility scale RE deployment with integration of **phased DVA requirements** for utility scale BESS

Detailed on next slide

(1) CAM and AAM refer to Cathode Active Material and Anode Active Material; (2) Have assumed 2–3-year delay in announced timelines due to global market conditions and that Cell capacity announcements refer to 'cell to pack' manufacturing

Source: Company announcements; Ministry of Heavy Industries, PM E-Drive Portal; CEA, National Electricity Plan Vol I; Industry experts; Dalberg analysis

Policy interventions such as an approved list of pack and cell manufacturers, phased DVA requirements in existing policies and extending BESS mandates for utility scale RE could fuel domestic battery demand

Manufacturing

Value chain demand drivers

Recommendations

- Introduce **Approved List of Pack and Cell Manufacturers** (like ALMM for Solar PV) in stages (pack by 2028, cell by 2030)
- **Phased Domestic Value Addition (DVA) requirements** as integrated capacities increase (from 35% in 2028 to 45% in 2030)
- **Increase BCD** on battery raw materials and components (e.g., BMS, Electrodes, CAM, AAM) over time

Rationale

- Could enable prioritization of domestic firms, driving demand for domestic packs and cells
- Could drive deeper indigenisation progressively across the value chain
- Could enhance the cost-competitiveness of domestic manufacturers and develop ecosystem

Deployment

Mobility

Recommendations

Increase DVA requirements by **5pp by 2028** and up to **8-10pp by 2030** across EVs as per targets below:

EV type	DVA (2028)	DVA (2030)	Supportive Policy
e2W/3W/Buses	55%	60%	PM E-Drive
e4W: Domestic OEM	55%	60%	-
e4W: Global OEM	No change		SPMEPCI

- **Domestic e4W** to be supported with cumulative VGF[2] of **INR 4500-6500 Cr from 2027 to 2030** to minimise TCO impact

Rationale

- Phased Manufacturing Program under PM E-Drive mandates only domestic assembly of battery packs without specific DVA requirement for components
- VGF for e4W conditional on global battery price difference vs. domestic to minimize TCO impact
- Existing DVA requirements under SPMEPCI (25% in Y3, 50% in Y5)

Stationary Storage

Recommendations

- Increase coverage of **BESS co-location to 100%** of incremental Solar and Wind utility scale deployment and explore increasing **storage duration mandate from 2 to 4 hrs**
- Integrate **phased DVA requirements** for utility scale BESS colocation (35% by 2028, 45% by 2030)

Rationale

- Currently estimated 2032 ESS requirements (80 GW/411 GWh) cover ~40% of incremental utility scale solar and wind capacity
- No DVA requirement in current storage mandate

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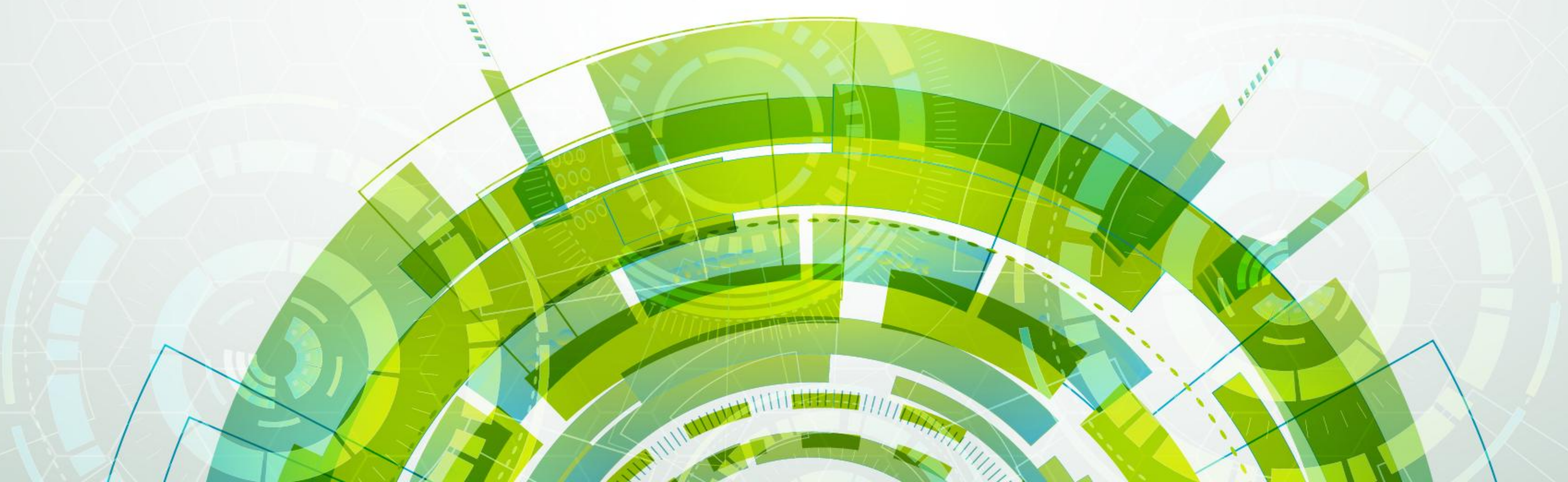
(1) Based on 50% localisation rate required under FAME II; (2) VGF – Viability Gap Funding based on assumption of 50% coverage of price difference between domestic, imported cells, covering domestic OEM share of e4W demand (assumed 70%), estimated from 2027 to 2030

Source: Ministry of Heavy Industries, PM E-Drive Portal; CEA, National Electricity Plan Vol I; Industry experts; Dalberg analysis

SUB-SECTION TWO

BATTERY R&D & PRODUCT INNOVATION

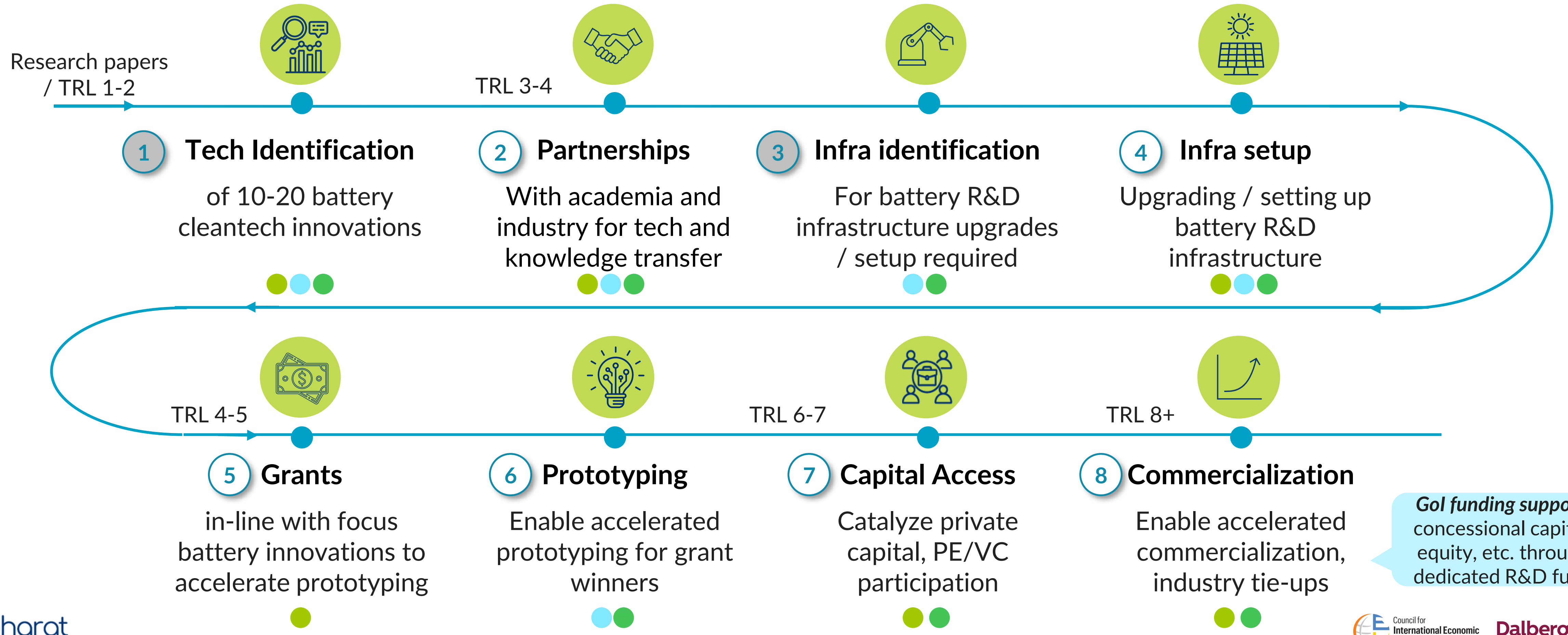


India could accelerate indigenous innovation across the battery value chain from identification to prototyping and commercialization through an industry-academia-government collaborative approach

MHI / MoP and ANRF could establish a Core Working Group (with representation from industry, academia, government) to spearhead this effort and engage relevant stakeholders across various steps

Steps for battery cleantech R&D acceleration

● MHI/MoP and other line ministries ● Academia ● Industry (x) Detailed ahead



Research papers / TRL 1-2

1 Tech Identification

of 10-20 battery cleantech innovations

TRL 3-4

2 Partnerships

With academia and industry for tech and knowledge transfer

3 Infra identification

For battery R&D infrastructure upgrades / setup required

4 Infra setup

Upgrading / setting up battery R&D infrastructure

TRL 4-5

5 Grants

in-line with focus battery innovations to accelerate prototyping

6 Prototyping

Enable accelerated prototyping for grant winners

TRL 6-7

7 Capital Access

Catalyze private capital, PE/VC participation

TRL 8+

8 Commercialization

Enable accelerated commercialization, industry tie-ups

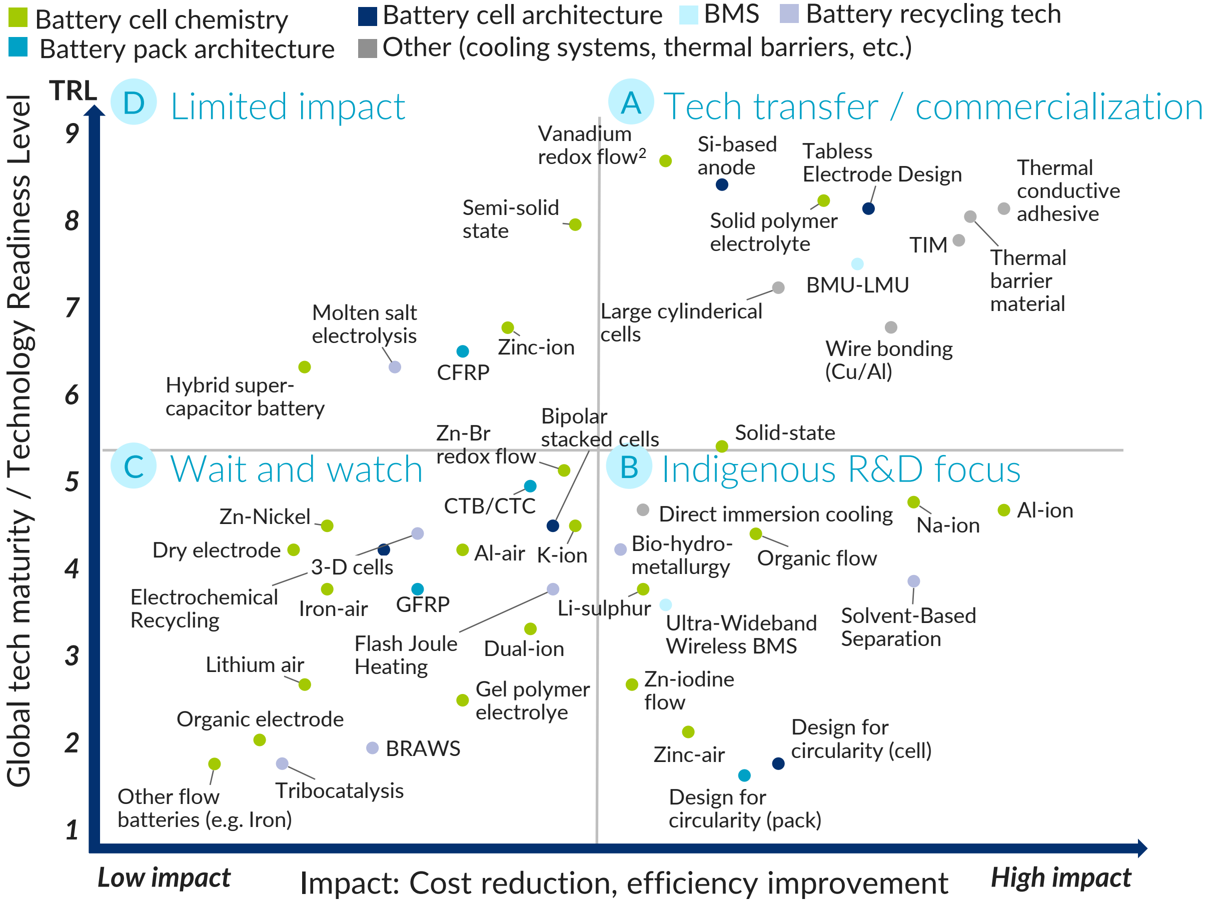
GoI funding support: concessional capital, equity, etc. through dedicated R&D fund

Identification and discoverability | It is critical to identify key battery technologies with inputs from relevant stakeholders for targeted R&D efforts and pathways to commercialisation

NON-EXHAUSTIVE

Battery technologies can be prioritised based on their impact potential and TRL levels globally to identify focus technologies for tech-transfer or indigenous R&D and innovation

Focus R&D and innovation technologies: Battery [1]



Key Insights

Identification of focus battery R&D technologies based on:

- **Landscape assessment:** Technology mapping (R&D to commercialisation stage) and sector-specific stakeholder input to build validated pipeline of potential technologies
- **Prioritization based on TRL and impact (cost and efficiency):**
    - ○ Efficiency: Energy efficiency, energy density, safety
    - ○ Cost: $/kWh, raw material and production cost, etc.

Top 10-20 technologies across battery cell chemistry, architecture and cooling systems etc. could be focused on for commercialization / tech-transfer and indigenous R&D:

- **Tech transfer:** Solid polymer electrolyte batteries, Thermal conductive adhesives, tabless electrode design, etc.
- **Indigenous R&D:** Sodium-ion batteries, Lithium-sulphur, Zinc-air batteries, direct immersion cooling, solvent-based separation (non-toxic solvents should be explored), etc.

(1) Already mature and commercial technology in India (e.g. LFP) not featured; (2) Only for BESS applications; Zn-Br: Zinc-Bromine; CFRP: Carbon Fiber Reinforced Polymers; GRPF: Glass Fiber Polypropylene; K-ion: Potassium-ion; Si: Silicon; Na: Sodium; Zn: Zinc; TIM: Thermal Interface Material; Li: Lithium; CTB: Cell-to-Body; CTC: Cell-to-chassis; BRAWS: Battery Recycling and Water Splitting

Source: PV Magazine, Saur Energy, Battery tech online, NITI Aayog, Future Battery Lab, Company websites, Startup websites, Research lab websites, The EV Report, Sodium battery hub, Technology Review, Science Direct, IITs, expert inputs

R&D infrastructure | R&D infrastructure would need to be assessed and set up / upgraded to drive prototyping to commercialization for technologies across the battery value chain

NON-EXHAUSTIVE

Establishing select, high-quality open access R&D development and testing labs as independent facilities operated under a PPP structure to drive public-private collaboration and ensure maximum resource efficiency

	KEY LEVERS	RATIONALE
1	**Focus on select, state-of-the-art facilities**	• Advance multiple battery R&D ideas under one facility to reduce fragmentation of research across labs, optimize infrastructure and talent use (e.g. global labs such as Fraunhofer, Germany) • Enable financial efficiency by upgrading existing open-access labs where possible, e.g. R&D labs at incubation centers under IIT Madras Research Park[1]
2	**Create new, open-access infrastructure**	• Unlock greater lab accessibility overcoming existing issues of access to academic institution labs for external startups • Promote public-private collaborations and resource sharing in state-of-the-art labs for R&D infrastructure for startups and private sector access
3	**Establish as autonomous entity under PPP structure**	• Autonomous entity for open access R&D infrastructure could ensure unbiased resource allocation, high utilization rates and good maintenance of lab infrastructure
4	**Consistent, well-trained manpower**	• Fixed and well-trained manpower to ensure proper management and maintenance of state-of-the-art equipment

(1) Not shared infrastructure with students

Source: Academia and industry experts

R&D infrastructure | India could invest INR 1,200–2,400 Cr across 12-16 R&D labs to upgrade current battery R&D labs, establish new facilities, and ensure needed human resource and efficient lab operations

	Battery technology development and testing labs	Battery recycling technology development and testing labs
Number of labs	**10-12 development and testing labs** *7-8 small labs (TRL 4-5) and 3-4 large labs (TRL 5-8)*	**2-4 development and testing labs** *Upgrades to 1-2 current labs; set up of 1-2 new labs*
Cost of labs	**INR 1,100-2,000 Cr** *INR 50-100 Cr/ small lab; INR 250-300 Cr/ large lab for set up/ upgrades*	**INR 100-400 Cr** *INR 50-100 Cr/ lab for upgrades/ new setup*
Prospective existing infrastructure for upgrade	**IIT Delhi Research Park:** CoE and Incubation Centre **IIT Madras Research Park:** Labs, testing facilities, incubation centres, etc. **Social Alpha:** Energy lab	**IIT Madras Research Park:** R&D labs, testing facilities, incubation centres, etc.

Machinery needs

***High precision equipment** suited for R&D which is **customizable and agnostic** across different chemistries and materials:*

	Battery technology development and testing labs	Battery recycling technology development and testing labs
Machinery needs	- Material R&D and chemical wet-lab equipment - Coating and calendaring machines - Stacking/ winding machines - Battery testers	- Material R&D and chemical wet-lab equipment - Battery grinders, shredders and crushers - Air flow separators - Battery testers

Manpower and support needs

- **Trained manpower** with ability to use advanced equipment (separate upskilling for current researchers)
- **Independent management team** reporting to own Board vs. public/ private sector researchers to ensure maximum utilization, efficient operations
- **Market needs assessment** of upcoming tech trends to inform relevant research

Source: Academia and industry experts

The private sector (including large OEMs, battery players), with government support could invest INR 1,800-3,600 Cr cumulatively to orient battery R&D priorities to industry needs, and build shared R&D infrastructure

NON-EXHAUSTIVE

Private sector role

Key players: *Large OEMs (Ola, TATA Agratas, etc.), battery makers (Amara Raja, Exide, etc.) and other industry conglomerates (Reliance, Adani Green)*

Government support

Key players: *Relevant line ministries, e.g. MHI/MoP, and other related bodies driving R&D efforts, collaboration, and funding (e.g. ANRF)*

1 Provide strategic input for industry-aligned R&D

- **Support identification** of scalable, high-impact technologies across the battery value chain and **commercialization pathways**
- **Designate nodal representatives** in industry associations to drive battery R&D beyond firm-level efforts

Government support:

- Ensure **private sector inputs are incorporated** in decision-making; MHI/MoP could potentially coordinate and help **align government-industry priorities**

2 Increase private R&D investment

- **Invest in prototype development and commercialization,** and support **tech transfer** by investments in academia, R&D
- **Invest in shared infrastructure building** (e.g., setup of open-access labs in PPP mode with public sector players)

Government support:

- **Co-finance with private sector** basis alignment with focus battery technologies and clear TRL-based commercialization pathways

INR 600-1,200 Cr government funding *(grants, concessional capital, etc.) for battery R&D (e.g. from INR 1 lakh crore RDI scheme), as a* ***1:1 match*** *for equal* ***private sector contribution***[1]

3 Enable greater R&D infrastructure sharing

- **Enable shared access to existing R&D infrastructure** to maximise resource utility and collaboration

Government support:

- Create **public-private partnerships, joint R&D mechanisms**, etc. to **setup shared R&D labs**, accessible to start-ups
- Design **incentives/ mechanisms for shared use of private labs** while ensuring protection of intellectual property

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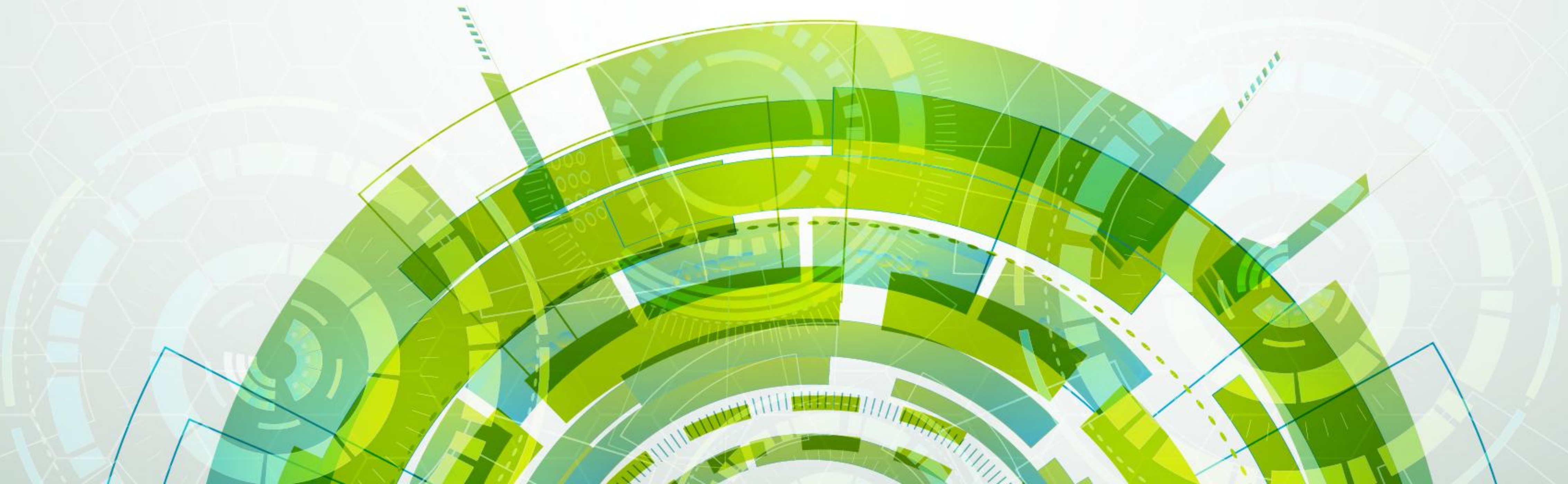
(1) Total investment required for battery R&D INR 1,800-3,600 Cr (R&D infrastructure: INR 1,200-2,400 Cr; Battery R&D grants: INR 600-1,200 Cr); Grant estimates based on USA's Small Business Innovation Research (SBIR) program; RDI scheme: Research Development and Innovation (RDI) Scheme, 2025- provision for Fund of Fund creation

Source: Academia and industry experts; US Small Business Administration, Annual Report, 2022; PIB report

SUB-SECTION THREE

UPSTREAM RAW MATERIALS & CRITICAL INPUTS



India's demand for critical minerals could increase by 10x in 2030 and 35x by 2040 vs. today which could lead to higher over-dependence on China which controls ~75% critical minerals global refining capacity

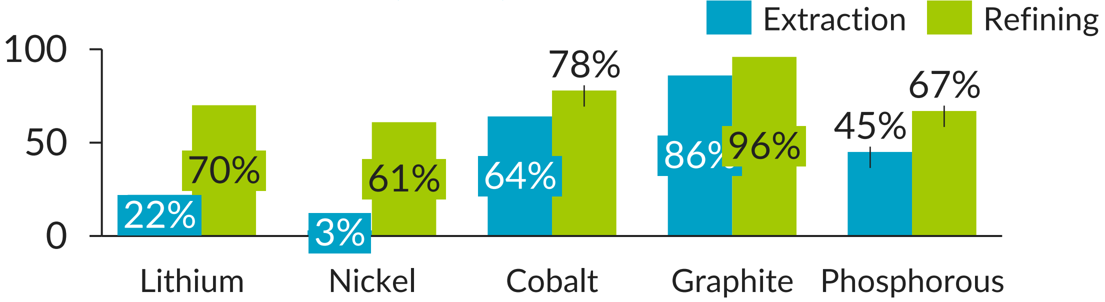
India has already started exploring potential mining agreements to leverage global reserves for Indian consumption; focusing on building domestic refining capacities would be crucial to reduce this over-dependence on China

Longer lead times for extraction and refining commercialization warrant **planning for 2040** requirements or beyond

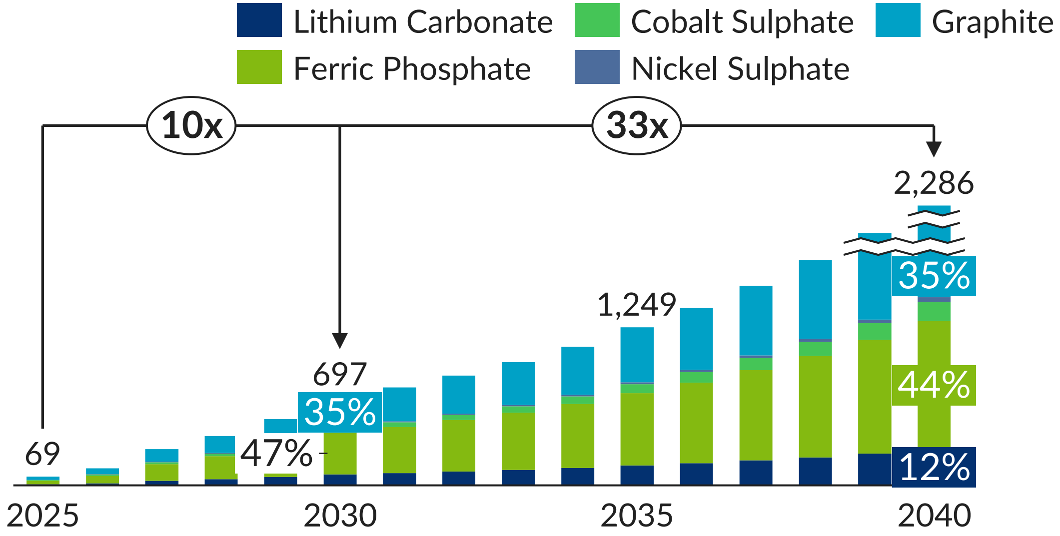
- **China's ~75% control** of critical minerals supply could lead to potential **pricing** and **supply stability challenges**
- **On-shoring trends** observed globally to address this dependence. (e.g., USA, EU, Japan)
- **India's recent efforts**:
  - **Extraction:** Exploring **mining agreements** with resource rich countries: E.g., **COAL India** working on a **JV with YPF (Argentina PSU); KABIL** acquired mining rights in **Argentina** for **Lithium exploration and extraction**
  - **Refining:** Targeting **partnerships** with prominent **players in mineral refining** (e.g., **Australia**) to:
    - Secure access to **overseas refining capacities**
    - **Facilitate technology transfer** with overseas refineries **(e.g., Australia's Tianqi Lithium Energy's refinery)** to foster establishment of domestic refining capacities

Significant acceleration and scaling-up of these efforts would be required to ensure self-reliance and sufficiency for critical minerals

China's share of global extraction and refining capacities for critical minerals, 2024, % kTPA



India's critical minerals demand, 2025-2040, kTPA



Sources: IEA, Global Critical Minerals Outlook, 2025; Reuters, EU picks 13 critical material projects, including in Greenland, 2025; Reuters, US open to minerals partnerships with DRC, 2025; Council on Foreign Relations, China in Africa: March 2025, 2025; USGS, Mineral Commodity Summaries, 2025; Dalberg Analysis

Stockpiling in short term and strategic investments in increasing domestic refining capacity and accelerating circularity in long term could meet ~80% of India's critical mineral demand by 2040 and reduce China dependence

Circularity and domestic refining capacity advancements could meet 85-90% of critical minerals demand for India by 2040 supported by key interventions taking place in 2025

Pathways for reducing India's critical minerals import dependance in battery value chain

SOURCES OF MINERALS

Pathway details	Details	2030 Potential *kTPA (% of demand)*	2040 Potential *kTPA (% of demand)*	Investment Required *INR Cr by 2030*	KEY ENABLERS
1 *Domestic mineral refining*	Global and domestic reserves extraction with domestic refining	**Graphite:** 752 (80%) **Lithium:** 267 (80%) **Cobalt:** 143 (80%) **Nickel:** 32 (80%)		**~INR 75,000 Cr** (upfront capex for Graphite refining only)	• G2G tech transfer partnerships with **Japan, South Korea and Australia** • Cumulative **~INR 16,300 Cr** electricity and capex subsidies, interest subvention, import duty waiver till **2030**
2 *Scaling circularity*	Closed loop recycling for metal recovery from battery waste	**Lithium:** 2 (2%) **Nickel:** 0.7 (6%) **Cobalt:** 3 (6%)	**Lithium:** 36 (13%) **Nickel:** 2 (7%) **Cobalt:** 10 (7%)	**INR 68,400-72,000 Cr** (cumulative upfront capex for circularity[1])	• Establishment of **160-180 collection centres, INR 1,200-1,500 Cr capex** • Refurbishment to address 2nd-life battery market worth **INR 1,500-1,600 Cr** by **2030** • **Ministry authorization** for recycling infrastructure development
3 *Import diversification & stockpiling*	Stockpiling up to 25% of annual demand for critical minerals	**Graphite:** 60 **Cobalt:** 8 **Lithium:** 22	**Graphite:** 200 **Cobalt:** 38 **Lithium:** 71	**~ INR 7,100 Cr** (including INR 50-60 Cr capex investment)	• Stockpiling targets for **25% of annual demand by 2030 for precursor forms** (e.g., Battery-grade graphite)

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(1) Capex investment for circularity includes cumulative upfront capital investment across collection (INR 1,200-1,500 Cr), refurbishment (INR 17,000-18,500 Cr) and recycling (INR 39,000-44,500 Cr)

1 **Domestic Refining** | Developing domestic mineral refining capacity could unlock long-term self reliance in sourcing battery grade raw materials for domestic consumption and potential exports

China controls 60-96% of global critical mineral refining capacity, however as countries look to diversify their raw material supply, there is an opportunity for India to emerge as a global refining hub for battery grade minerals

Concentration of global supply of refined minerals:

Up to **96%** of global **Battery-grade Graphite refining** capacity is **under China's ownership**

Potential pathway for India:

2025-2030

- **Refining tech-transfer and industry set-up:** Leverage experience in refining industry set up (e.g., **oil and gas, aluminium, iron**) to set up refining capacities for critical minerals.
- Targeted subsidies 2026 onwards to incentivize investment and ensure active refining capacity established by 2030
- **Extraction:** Leverage **existing Graphite extraction** for domestic battery grade graphite refining; Expedite commercialization of overseas mining blocks (e.g., **KABIL**, **COAL** India MOUs / deals)

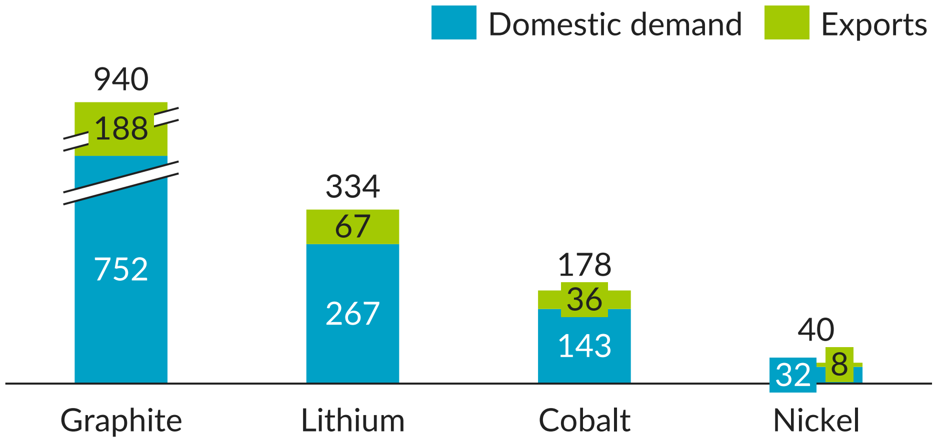
2030-2035

- **Refining:** Infrastructure setup and scale-up of capacities through subsidy support until 2030
- **Domestic exploration** and initiating **extraction**

Beyond 2035

- **Global refining hub for critical minerals** with potential to export refined critical minerals such as battery-grade Graphite worth **USD 980 Mn – 1.27 Bn** annually by leveraging G2G partnerships
- Eg., With US exploring "Country of Origin Clause"; with EU diversifying supply base through China plus one strategy

Domestic refining capacity targets, by 2040, kTPA[1]



Potential feedstock sources for refining, 2040, %

	Graphite	Lithium	Cobalt	Nickel
Overseas mining	77%	92%	48%	56%
Domestic extraction	23%	8%	52%	44%

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(1) Assuming 85% capacity utilization based on secondary sources and expert inputs;

Source: The Hindu, Initial findings positive for lithium blocks in Argentina, 2025; Reuters, Indian state firm's seek stake in SQM's Lithium projects in Australia, 2025

1

Domestic Refining | ~INR 16,300 Cr cumulative subsidies on electricity, capex and interest subvention till 2030 could support cost-competitive development of 85 kTPA domestic refining capacity for Graphite by 2030

High-electricity consumption and front-loaded capex investment in refining could lead to high domestic refining costs which would require government support for improved output costs

Key insights

High expected cost of domestically refined graphite driven by:

- High electricity costs (45% of total refining costs)
- High interest and capex costs for front-loaded investment (25% of total refining costs)

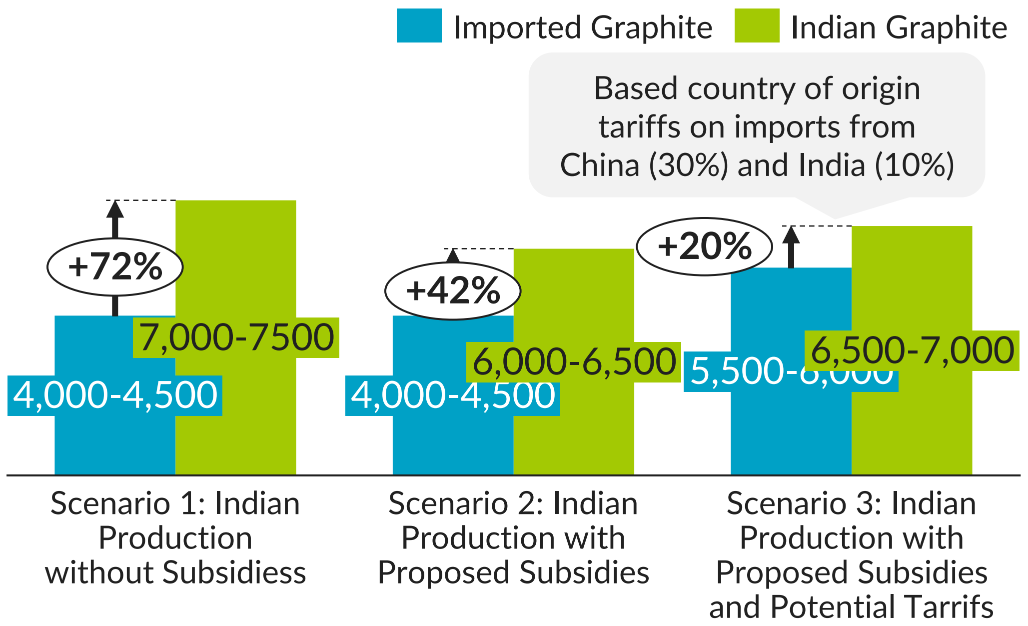
Proposed government support and interventions could reduce costs by 13-17%:

Intervention type	Cumulative Impact (INR Cr)
Upfront capex subsidy of **20%** from 2026 to 2030	~14,900
Interest subvention of **20%** from 2026 to 2030	~680
Electricity price subsidy of **30%** in 2030	~670
Import duty waiver on raw material inputs in 2030	~20

Potential pathways

Mineral prioritization	Initially develop **capacities for Graphite** (96% global capacity under China) and scale to Lithium, Nickel and Cobalt
Phased-capacity scaling	Support development of **initial capacity across minerals,** gradually scale to meet 2040 targets

Comparison of landed cost of imported and Indian battery grade Graphite cost, USD/MT, ex-GST



Based country of origin tariffs on imports from China (30%) and India (10%)

Required cumulative capex investment to begin development of **423 kTPA Graphite refining capacity** by 2030[1]: **INR 75,000 Cr**

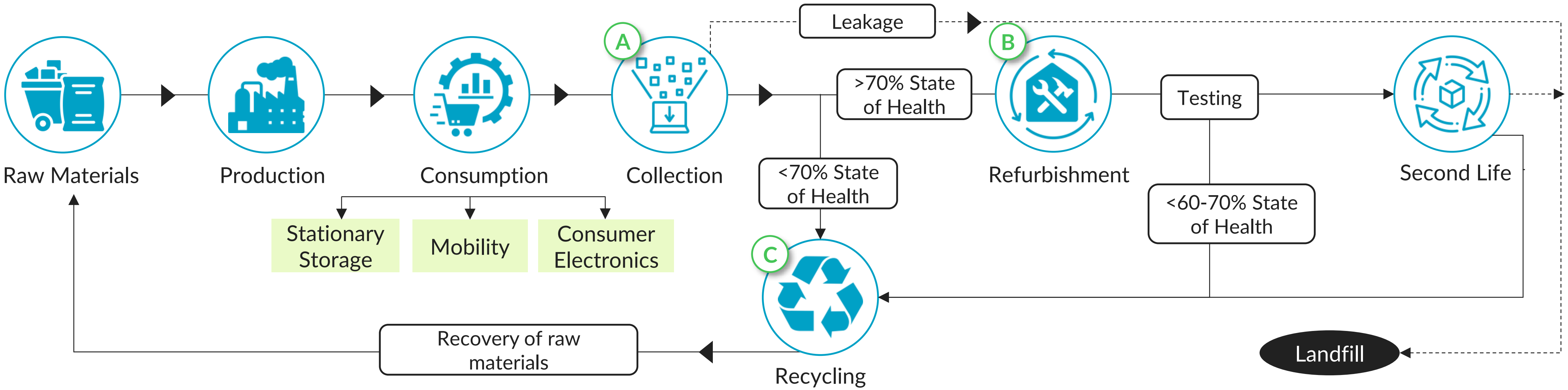
Cumulative targeted subsidies on electricity, capex, interest subvention and import waiver till 2030: **INR 16,300 Cr**

(1) Expected to come online by 2034-2035; Source: Dalberg analysis, expert consultations

②

Circularity | Beyond EPR mandated battery collection targets, scaling circularity potential requires policy interventions across collection, refurbishment (second life applications) and recycling

90-95% Battery waste collection targets by 2040 and interventions across collection, refurbishment and recycling could unlock battery circularity potential – 96 GWh refurbished batteries and 970 kTPA recycled waste by 2040



Raw Materials

Production

Consumption

Stationary Storage

Mobility

Consumer Electronics

A Collection

Leakage

>70% State of Health

<70% State of Health

B Refurbishment

Testing

<60-70% State of Health

Second Life

C Recycling

Landfill

Recovery of raw materials

Potential for waste collection, refurbishment and recycling, kTPA

	Waste collection	Waste refurbishment[1]	Waste recycling
2030	68	13	55
2035	533	221	313
2040	1,738	768	970

Proposed EPR targets on collection, by producer type, %

	BESS suppliers / RE developers (Stationary storage)	Automotive OEMs (Mobility)	Others (Consumer electronics and other e-waste producers)
2030	60-65%	90-95%	25-30%
2035	80-85%	90-95%	40-45%
2040	90-95%	95%	60%

Refurbishment and recycling: *100% of the battery waste collected in each year*

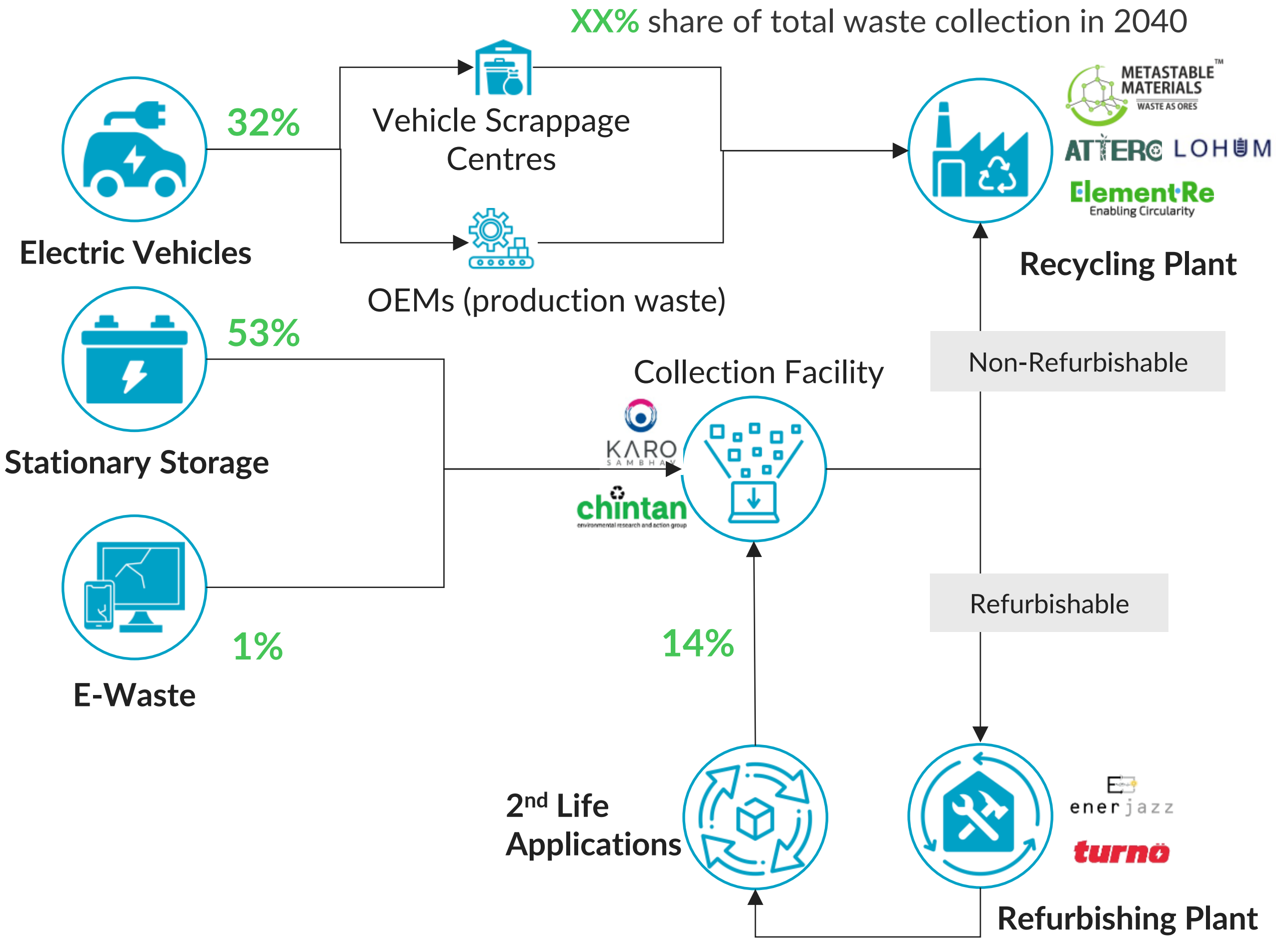
(1) Assuming refurbishment rates of 50% for 4W EV batteries, 15% for 2/3W EV batteries and 70% for stationary storage batteries out of annual waste collection

Source: Dalberg Analysis, expert consultations

2A **Collection** | Total capital investment of INR 1,200-1,500 Cr in development of 160-180 collection centres could support streamlined collection of battery waste

Achieving high collection rates for end-of-life batteries, especially for stationary storage and e-waste (laptops, cellphones) batteries would require dedicated collection facilities to streamline waste collection

Collection Streams Value Chain


XX% share of total waste collection in 2040

Required investment in collection infrastructure:

	Number of waste collection centres	Cumulative capex investment (INR Cr)
Tier 1 and Metro Cities	30-40	200-400
Tier 2 cities	130-140	1,000-1,100
Total	**160-180**	**1,200-1,500**

Enablers for development of collection infrastructure:

- **Integrate battery waste collection** with **existing and upcoming Material Recovery Facilities** (for e-waste only or multiple waste streams) by equipping them with requisite battery testing, storage and safety equipment
- **Extend Central Share budgetary assistance** under waste management programs such as **Swachh Bharat Mission – Urban 2.0**, to battery waste collection facilities
- Provide **land parcel identification support** and offer land at concessional rates for battery waste collection facilities

(1) Considering 2-4 collection centres for every Tier 1 and Metro city, and 1-2 centres for every Tier 2 city

Sources: Press Information Bureau, Management of Waste, Garbage and Sewage, 2025; Dalberg analysis, Expert consultations

2B Refurbishment | Second-life battery applications could be scaled by leveraging modified "Battery Passport" regime along with incremental supportive regulations to ensure quality

Annual potential of 96 GWh by 2040 to utilize >70% state of health batteries from mobility and stationary applications for low-cost urban mobility and small buffer storage applications by scaling up refurbishment systems in India

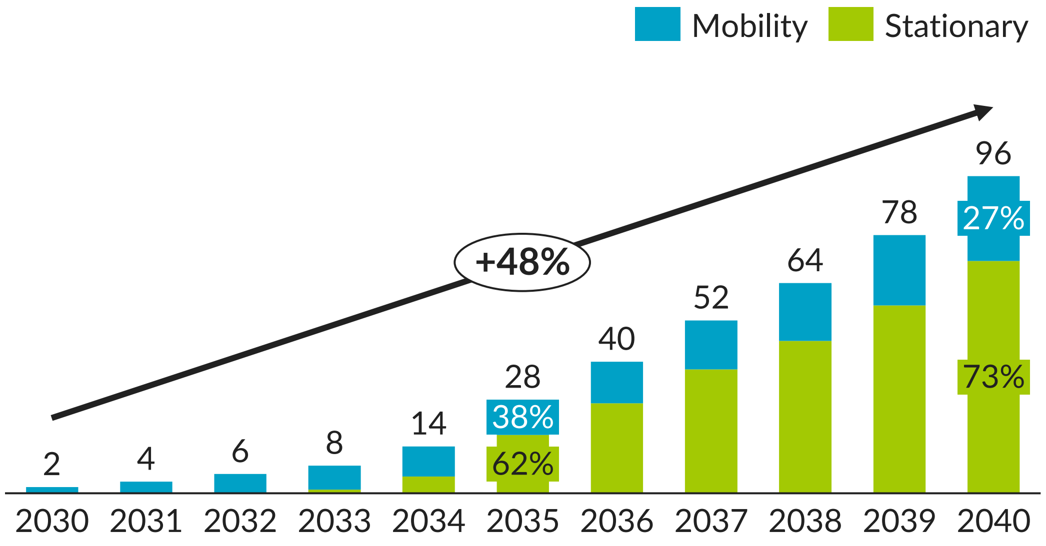
Key benefits of refurbishment for second-life applications:

- Maximum value extraction from materials with extended usage life
- Potential to cater to lower-cost battery demand as second life batteries cost **50-60% less than virgin batteries:**
    - **Mobility:** Last mile urban mobility with e-rickshaws (e3W L3), smaller electric 2-wheelers
    - **Stationary:** Solar street-lamps, storage for rooftop solar applications, buffer storage for EV charging stations

Interventions required:

- **Regulatory: Certification regulations** for second-life batteries developed under **ICAT** and **ARAI**
- **Infrastructure: Upfront capex subsidy** - **INR 2,900 – 3,100 Cr** on cumulative investment required by 2040 to meet annual potential of 96 GWh, disbursed at 20% of capex investment

Projected potential for second-life application of batteries, 2030-2040, GWh



	Annual market potential (INR Cr)[1]	Cumulative investment required (INR Cr)
2030	1,500-1,600	450-560
2040	77,000-81,000	16,200-17,400

(1) Market potential calculated basis current battery pack prices

Sources: Times of India, Centre plans battery passport to boost EV safety, quality and exports, 2025; Dalberg analysis, Expert consultations

2C

Recycling | Exception regulatory approvals and financial support at recycling infrastructure setting up stage could catalyse development of 1,200-1,250 kTPA recycling capacity by 2040

Large scale recycling capacity development would require policy interventions (exception approvals and financial subsidies) at the setting-up stage and continued financial support at the scaling-up stage

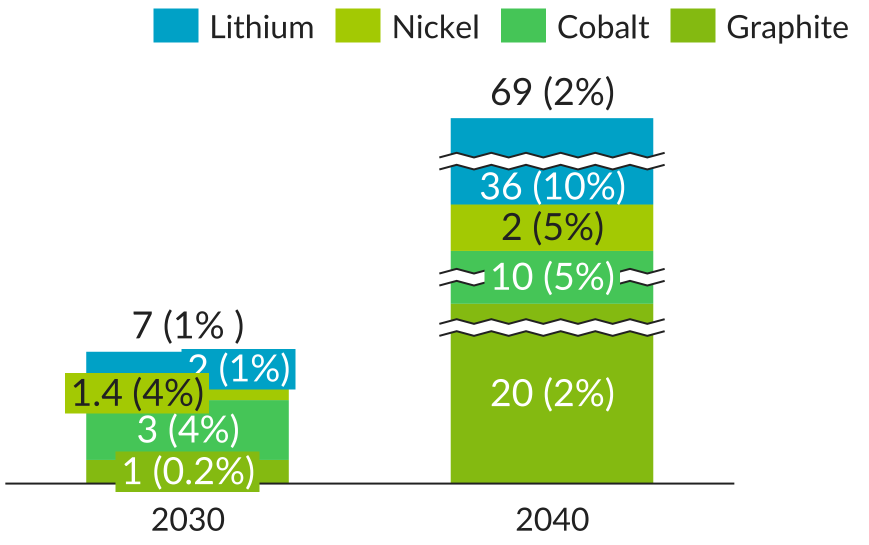
Key challenges in setting up recycling facilities impede a scaled battery recycling ecosystem:

Setting up recycling facilities:

Challenges	Potential Enablers
Long lead times in getting regulatory approvals – CTO, CTE, EC	Authorization by relevant ministry to grant **1-year exception CTO, CTE approvals** for up to 50 recycling startups[1]
High working capital requirements to ensure consistent feedstock supply	•Subsidized working capital loans to support 15 days feedstock inventory •2-year deferral on GST
Securing land as a Red Category Industries	Support on land parcel identification, prioritization in e-waste recycling parks
High upfront capex investment	Upfront subsidies - **INR 9,000-9,500 Cr[2]** for 2040 target capacity; Deferred GST on capital equipment till production

Scaling up recycling facilities: Continued policy support through working capital loans till 2030, gradually phased out by 2035

Projected mineral recovery potential, 2030 and 2040, kTPA (% of critical mineral demand)



	Target capacity (kTPA)[2]	Cumulative Investment required (INR Cr)
2030	90-100	3,900-4,500
2040	1,200-1,250	50,100-53,200

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(1) Exception approvals granted by relevant ministry for 1 year, post which due processes on audits and diligence can be carried out to grant permanent certificates; (2) Assuming a capacity utilization factor of 60% by 2030 and 80% by 2040 , to recycle 55 kTPA waste by 2030 and 970 kTPA waste by 2040; (2) Capex subsidies on cumulative capex investment required by 2040, disbursed at 20% of capex investment; Sources: Dalberg analysis, Expert consultations

3 Stockpiling up to 25% of annual demand for select critical minerals (cathode and anode precursor materials) could ensure supply consistency and protection from price fluctuations for India (1/2)

Presently, India lacks domestic cathode and anode manufacturing capacities but as they develop, mineral stockpiling could safeguard supply of feedstock precursor materials[1] such as Graphite, Cobalt Sulphate and Lithium Carbonate

Key Benefits:

- **Continued access to minerals** during global supply constraints
- **Protection of domestic battery manufacturing ecosystem** against global mineral price fluctuations

Focus materials for stockpiling[2]:

- **Battery-grade Graphite**, owing to China's stronghold on global refining (96%), **Cobalt Sulphate** and **Lithium Carbonate** due to lack of both domestic extraction and refining capacity

Secure 25% of annual demand:

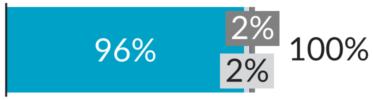
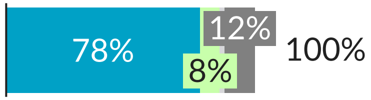
- Establish stockpiling targets of **25% of 2030's annual raw material demand (90 kTPA)**

Leverage either of 2 existing models for stockpiling:

Public-sector led	**ISPRL (India)** - PSU-led acquisition of oil resources, government funded storage infrastructure that can be leased to private sector
Public-private	**JOGMEC (Japan)** - Government mineral stockpile mandate for private sector, supported by interest subvention for private sector

Potential stockpiling partnerships/sources for India

🟦 China ■ US 🟩 Chile ■ Rest of the world
□ Japan 🟩 Argentina 🟩 Finland

Key materials	Target stockpile, 2030, kTPA	Value of stockpile (INR Cr)[3]	Global refining capacity, %
Battery-grade Graphite	60	~3600	
Cobalt Sulphate	8	~890	
Lithium Carbonate	22	~2600	
TOTAL	**90**	**~7,100**	

Upfront capex investment required

INR 50-60 Cr[3]

for developing **90-100 kTPA** storage capacity

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(1) Precursor materials can be stored for long durations without suffering material degradation; (2) Stockpiling refers to the accumulation of raw materials beyond regular demand to ensure uninterrupted access during future supply disruptions or shortages. (3) Storage infrastructure costs for the ISPRL Padur reserve have been considered as a reference to compute mineral storage infrastructure costs; (2) Value computed as per current international metal prices ; Sources: ISPRL, Detailed project report for phase II of strategic storage program for crude oil, 2013

3 Stockpiling up to 25% of annual demand for select critical minerals (cathode and anode precursor materials) could ensure supply consistency and protection from price fluctuations for India (2/2)

Globally, there are 2 stockpiling models that India could draw inspiration from to undertake stockpiling of critical minerals

	Public sector led stockpile	Public-Private Stockpile
Objective	• **Strategic** (to supply minerals during supply emergencies) and / or **economic** (to manipulate global mineral prices)	• **Strategic** (to ensure **continued mineral availability** during supply challenges)
Key responsible entity	• **Appointed government entity**	• **Individual private sector entities**, undertake stockpiling under **government mandates** and incentives
Source of funds	• **Budgetary allocation** and excess **funds from sale of additional stockpiled resources**	• **Private sector funds,** leverage **government incentives (e.g., interest subvention on finance** for resource acquisition and storage)
Investment required	• **Capital investment** in developing resource **storage & maintenance** infrastructure	• **Financial incentives** (e.g., interest subvention, capex subsidies for storage infrastructure)
Examples	**Indian Strategic Petroleum Reserve (ISPRL)**, *special purpose vehicle – based stockpile, PSUs fund acquisition of oil resources, government funds storage infrastructure*	**JOGMEC Rare Metals Stockpile**, *government mandated stockpile maintained by private sector which leverages government incentives on finance required*

Sources: Defense Logistics Agency, About Strategic Minerals; ASPI, China shows how Western governments should stockpile minerals, 2024; IEA, International resource strategy – National Stockpiling System, 2025

SUB-SECTION FOUR

CAPITAL EQUIPMENT & INFRASTRUCTURE

India’s battery manufacturing capital equipment is heavily import-dependent, particularly on China, which could impact capacity expansion due to sourcing complications

Indian battery manufacturers could leverage domestic manufacturing capabilities for clean room installations, however, capital equipment is import dependent

Current landscape

92% of global battery equipment made in Asia (China, Japan and Korea)

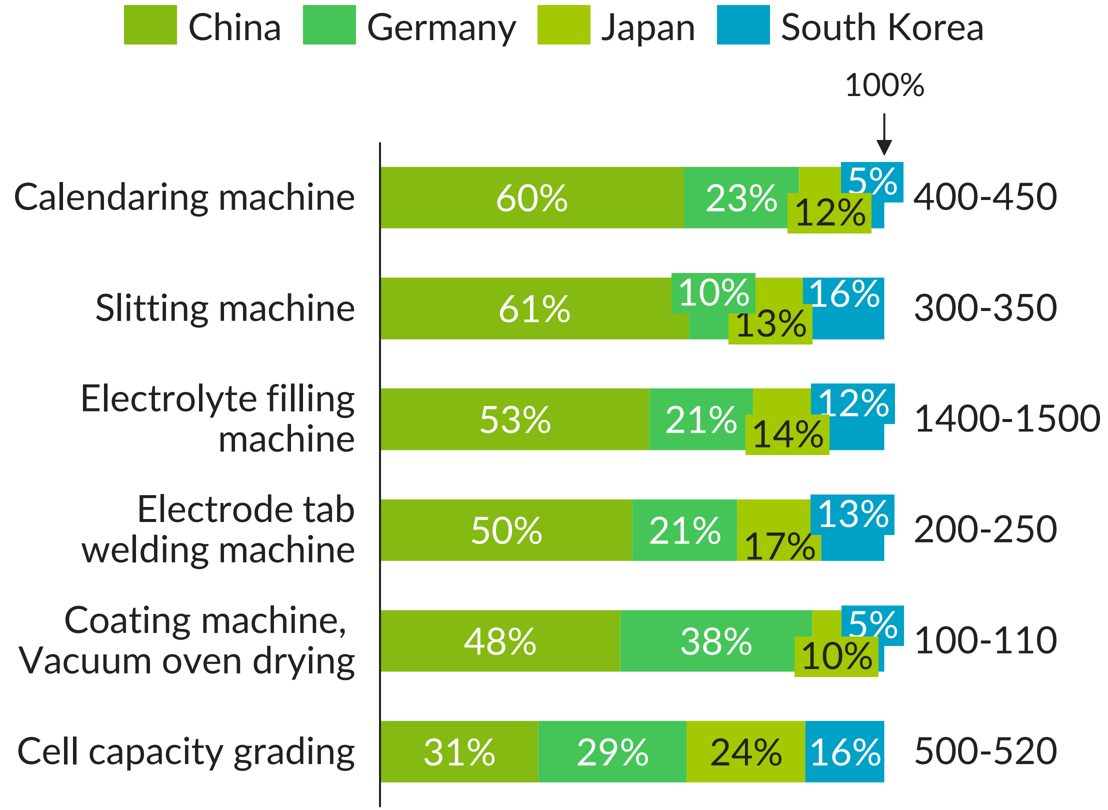
India landscape:

- Battery manufacturing equipment imported from **China, Japan, Korea and** high precision equipment from **Germany**
- **Domestic** production and installation for **clean rooms** across all requirement levels (~5% of Capex cost)
- Most **battery recycling** equipment manufactured **domestically**
- Some **testing equipment assembled** locally (e.g. by Ador Digatron)

Headwinds and challenges for continued import dependence

- **Changing Geopolitical dynamics** could impact capital equipment sourcing and supply timelines, after-sales service
- **High technical expertise** required for select equipment manufacturing

India’s battery capital equipment import, USD Mn, 2024



*Current incentives do not focus much on capital equipment sourcing - addressing current risks **requires a fresh strategy** (detailed ahead)*

Sources: PIB report; IISD: Unlocking Supply Chains for Localising Electric Vehicle Battery Production in India, UN Comtrade Database, 2024

India could reduce its battery capital equipment import dependence by up to 60% across cell formation, module assembly, and CAM Processing (80%) manufacturing by building select equipment domestically (1/2)

Domestic capacity for capital equipment manufacturing could be built for equipment with cross-sector synergies and economies of scale potential, low tech expertise needs, along with high efficiency and cost effectiveness

Potential pathways for catalyzing India's capital equipment manufacturing:

🟢 High 🟡 Medium 🔴 Low

Pathway criteria	**1** Domestic manufacturing for *select battery equipment with existing industry synergies*	**2** Import *highly specialized, advanced battery capital equipment with no industry synergy*
Synergies with other sectors	🟢 Existing synergies with adjacent industries (similar machine/ components/ processes like solar)	🔴 No existing synergies
Tech expertise	🟢 Need marginal improvements/ tweaks to existing machines	🔴 Germany, Korea lead in technical expertise besides China; India could face very long lead time to build comparable domestic know-how
Efficiency and costs	🟡 Potential to attain global competitiveness in tech and cost efficiencies	🔴 Highly tech and cost-efficient imported capital equipment
% Capex contribution	**50-60%** across CAM to final pack assembly (Up to 80 % for CAM processing; Up to 100% for pack assembly and cell formation) ***Examples:*** Calcination Furnace, Aging Chamber, Clean room	**40-50%** across CAM to final pack assembly (Up to 80% for AAM processing and electrode formation: up to 100% for Cell Assembly) ***Examples:*** Carbon Coating Furnace, Electrolyte Filling Machine

Sources: Money Control; BHEL, Renewables Solar, 2025; Business Standard, "L&T's first electrolyser factory to start commercial operations soon", 2024; Bharat Forge, Power Business; SolarPower Europe, Solar Production Equipment – Key players in the EU's industrial ecosystem for solar PV, 2025 ; SaurEnergy; Industry experts

India could reduce its capital equipment import dependence by up to 60% across cell formation, module assembly, and CAM Processing (80%) manufacturing by building select equipment domestically (2/2)

Domestic capacity for capital equipment manufacturing could be built for equipment with cross-sector synergies and economies of scale potential, low tech expertise needs, along with high efficiency and cost effectiveness

Potential pathways for catalyzing India's capital equipment manufacturing:

1 **Domestic manufacturing** for ***select battery equipment with existing industry synergies***

2 **Import** ***highly specialized, advanced battery capital equipment with no industry synergy***

Key Benefits

1:
- Potential to repurpose and build on **existing capacity**
- Reap benefits of **economies of scale and long term market opportunity**
- Initiate building resilience against foreign supply shocks

2:
- **Leverage existing foreign capabilities** to procure at effective costs and diversify supplier base
- **Quick access** to capital equipment supports rapid production ramp up

Pathway unlocks

1:

Identify equipment synergies for battery equipment with other sectors

Synergies with other industries, e.g.,
- Calcination furnace with ceramic industry
- Grinding mill & drying oven with pharma industry
- Ball mill with mining industry
- Coating machine with paper industry
- Laser welding machine with aerospace industry

2:

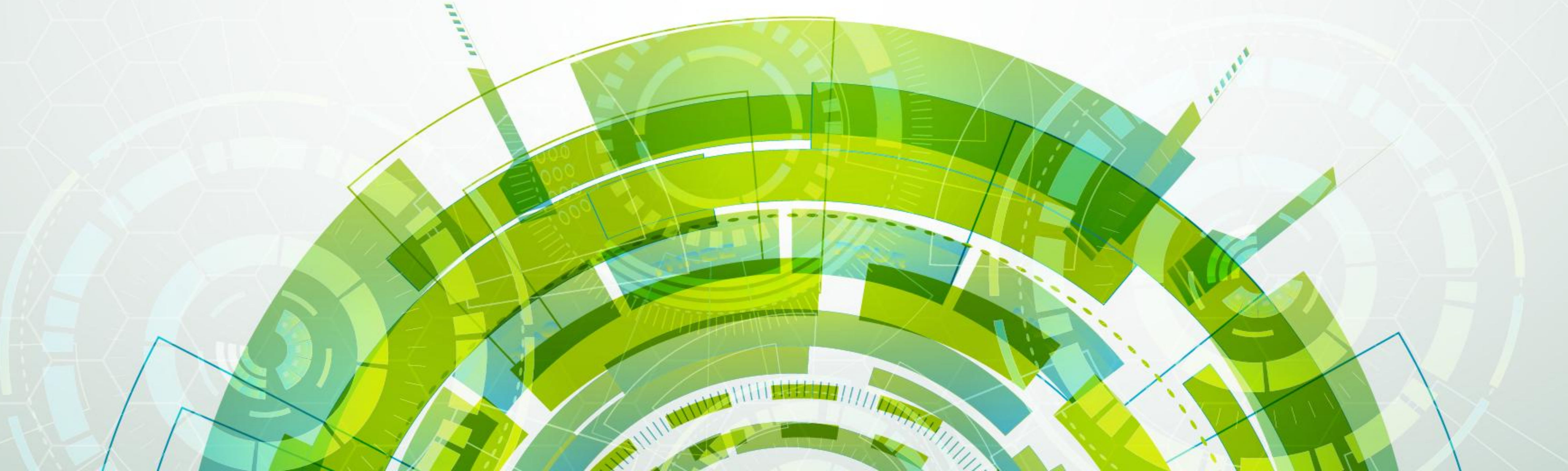
Potential to deepen current, and explore new partnerships for capital equipment sourcing across battery value chain

Existing capacities present in

Sources: Money Control; BHEL, Renewables Solar, 2025; Business Standard, "L&T's first electrolyser factory to start commercial operations soon", 2024; Bharat Forge, Power Business; SolarPower Europe, Solar Production Equipment – Key players in the EU's industrial ecosystem for solar PV, 2025 ; SaurEnergy; Industry experts

SUB-SECTION FIVE

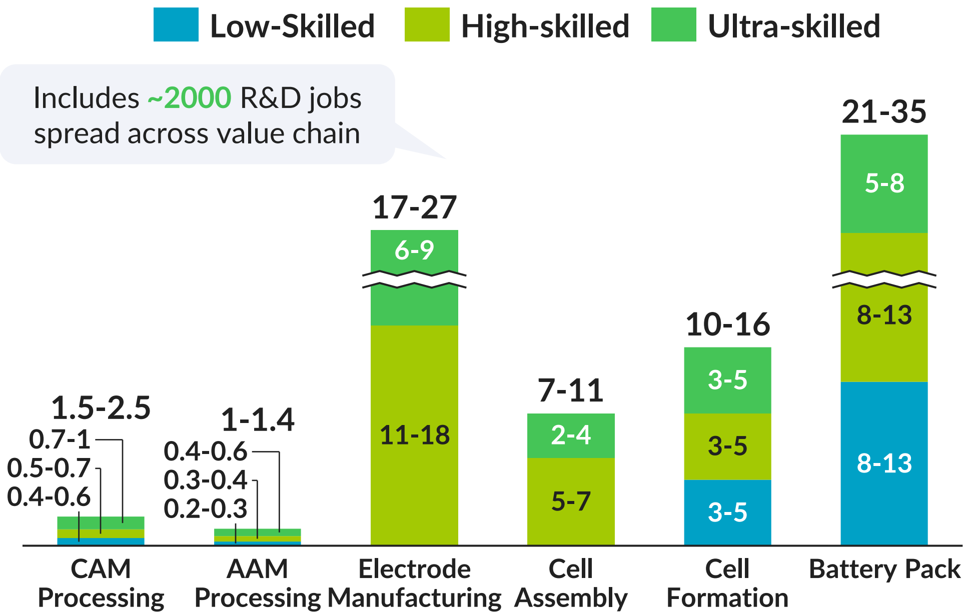
TALENT & WORKFORCE



India would require 58,000-91,000 additional ultra, high, and low-skilled workers across battery manufacturing value chain by 2030; low skilled workers could be trained with <1% of ITI upgradation budget

Training of Ultra and High-Skilled workforce critical for developing battery manufacturing ecosystem in India; lower-skill workforce primarily needed in pack manufacturing, which could also be hired from adjacent industries[1]

Projected (2030) additional workforce requirement for battery manufacturing value chain, in '000



Includes ~2000 R&D jobs spread across value chain

Skill levels and sources of talent for battery manufacturing

Focus

Ultra-skilled	**R&D & Innovation Experts** *Research labs, PhD/Post-graduate programs, Tier-1 engineering institutes*
High-skilled	**Engineers & Technical Specialists** *Tier-1 and Tier-2 engineering colleges*
Low-Skilled	**Production line workers** *ITIs, vocational training programs*

Industry insights

Battery Pack:

- Potential to hire from adjacent industries like **automotive and electronics** industries

Battery Cells:

- **No adjacent industries,** requirement for **high skilled workers** who meet clean room, process discipline for manufacturing

CAM/AAM Processing:

- Potential to hire from adjacent industries like **chemicals** industry

Total training cost[1]		Total demo facility investment[2]		Total budget
INR 1000-2000 Cr	+	INR 3000-5500 Cr	=	INR 4000-7500 Cr

Includes INR 100-200 Cr for Low-skilled workers (<1% of ITI upgradation budget)

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(1) Training cost for additional workers required across skill levels; (2) R&D and demonstration facilities across ITIs and top 100 engineering institutes
Source: Industry experts (industry associations, key manufacturing players), Dalberg analysis

Action would be required across four critical levers to successfully build this workforce: reducing foreign trainer dependency, standardizing course design, improving employability and securing financing

Applicability: 🟢 Ultra-skilled 🟡 High-skilled 🔵 Low-skilled

LEVERS	CURRENT STATUS	APPLICABILITY	RECOMMENDATIONS
Trainers	Dependent on foreign trainers for capital machinery set up	🟢🟡🔵	• **Launch a 'Train the Trainer' program** for professors and academicians at Tier-1 engineering colleges, with overseas immersion in advanced battery manufacturing hubs like EU, Korea, Japan, China
Course Design	Varied training approaches and modules across different industry players	🟢🟡	• **Develop dedicated Masters programs** and **Certification and Specialization** courses for ultra and high-skilled workers respectively
		🔵	• **Standardise qualification packs, courses and training modules** through collaboration with industry, academia for low skill workers
Employability	Employability impacted due to limited manufacturing job-ready skills for graduates from ITIs, engineering colleges	🟢🟡	• **Setting up R&D infrastructure, live demo plants** and access to industry R&D facilities for engineering students
		🟢🟡	• **Live internships** and **on-the-job training** through jointly funded industry-government partnerships
		🔵	• **Apprenticeships** at manufacturing facilities for low-skill workers
Finance	Disaggregated investment in manufacturing skills – either directly at ITI level or manufacturer-led on-the-job training	🟢🟡🔵	• Invest INR 4000-7500 Cr for training programs and demonstration facilities and R&D labs across skill levels through **innovative financing instruments** (e.g., skill bonds)
		🟢🟡🔵	• Catalyze private sector investments in skilling, **CSR and private foundation** funding for ultra-skilled talent development and ITI investments

(1) As per recommendations for R&D infrastructure upgrade in R&D section, leveraging the upgraded infrastructure for training is imperative

Source: Industry experts (industry associations, key manufacturing players)

Skilling efforts for battery manufacturing across skill levels could focus on strengthening industry linkages and global partnerships, along with offering specialized courses in engineering colleges and ITIs

Skill level	Recommendations	Responsible Ministry/Agency
Ultra-Skilled	• **Develop 'Train the Trainer'[1] program** to train 200–300 trainers/academicians from top 100 engineering colleges with help of 25 leading global trainers via government-to-government (G2G) partnerships with academia, industry in EU, Korea, Japan, China, others	Ministry of Education, Ministry of Skill Development and Entrepreneurship (MSDE), Directorate General of Training (DGT)
	• **Attract battery/cleantech experts** from the EU, Korea, Japan, China to **train academicians and professors** at Tier 1 Engineering colleges (top 25-30)	MSDE, Ministry of Education
	• **Launch dedicated master's programs** on battery technology in tier 1 Engineering colleges along with setting up R&D Labs	Ministry of Education
	• Develop jointly funded **industry-government on-the-job training initiatives** with global exposure to retain talent in India	Ministry of Education, DGT
High-Skilled	• **Introduce 6-month certification courses** or **1-year specialization courses** for battery manufacturing for Top 100 engineering colleges with setting up of R&D Labs	Ministry of Education
	• **Strengthen industry-academia** by co-delivery of cleantech manufacturing modules, and internships at manufacturing plants for engineering students	Ministry of Education
Low-skilled	• **Develop standardized qualification packs and courses** that reflect a superset of competency requirements defined by private sector manufacturers	National Council for Vocational Education and Training, DGT, Skill Council for Green Jobs, Electronics Sector Skills Council of India
	• **Repurpose <1% of the ITI upgradation scheme** to promote public-private skilling partnerships (apprenticeship programs using NAPS, joint trainings by ITIs and manufacturers) between battery manufacturers and ITIs (total 40-50 ITIs)	MSDE, DGT, ITIs
	• **Develop modules for retraining** workers from adjacent industries like automobile, electronics (for pack) or chemicals (for CAM/AAM)	NCVET, DGT, SCGJ, ESSCI, ITIs

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(1) The “Train and Trainer” program is applicable to the high-skilled workforce as well

SUB-SECTION SIX

FINANCING & TAXATION

Financing | INR 2.6-3.7 Lakh Cr would be required during 2025-30 to achieve 45% cost-competitive indigenisation across the battery value chain, build a cohesive R&D ecosystem and train the required workforce

Government funding of INR 64.8-92.2 Lakh Cr would be required across demand acceleration, R&D, workforce skilling and subsidies on electricity, capex and interest by 2030 to achieve these goals

Theme	Total Funding Required (INR Cr)	Government Funding Required (INR Cr)	Key Activities	Potential outcomes
Demand & Market Architecture	4,500-6,500	4,500-6,500	Introduction of Approved List of Pack and Cell Manufacturers, DVA requirements for EV and BESS supported by VGF for domestic e4W	Increased demand for domestically produced battery cells
R&D & Product Innovation	1,800-3,600	900-1,800	12-16 R&D development and testing labs for battery technology, battery recycling R&D; INR 600-1,200 funding for project grants	Indigenous development of battery technologies; accelerated adoption of early-stage innovative global technologies
Upstream Raw Materials & Critical Inputs	143,000-146,600[1]	29,400-30,400	Input subsidies on capex for refining, refurbishment and recycling capacity; investment in collection facilities and mineral storage facility	Reduce import dependency on refined raw materials; meet mineral demand through recycled materials and use 21 GWh refurbished batteries
Capital Equipment & Infrastructure ①	76,000-158,000[2]	Detailed in cost competitiveness below	Support timely deployment of announced capacities through incentives; Indigenous production of up to 55% of capital equipment	Reduce import dependence for capital equipment where feasible; Ensure accelerated capacity expansion to meet 45% indigenisation target
Talent & Workforce	4,000-7,500	3,000-5,500	Training additional 58,000-91,000 ultra, high, and low skilled workers across the value chain and setting up demo training and R&D facilities	Ensuring a stable supply of workers, reducing attrition and lowering training costs for manufacturers
Cost Competitiveness ②	27,000-48,000[3]	27,000 – 48,000[3]	Input subsidies on electricity, capex and interest subvention till 2030; import duty exemption[4] and increased BCD on imported cells leading to INR 800-3000 Cr potential net tax revenue increase	Increased cost competitiveness of domestic battery cells – potentially bringing within 23% of Chinese landed costs
TOTAL	256,200-370,200	64,800-92,200		

ⓧ ***Detailed ahead***

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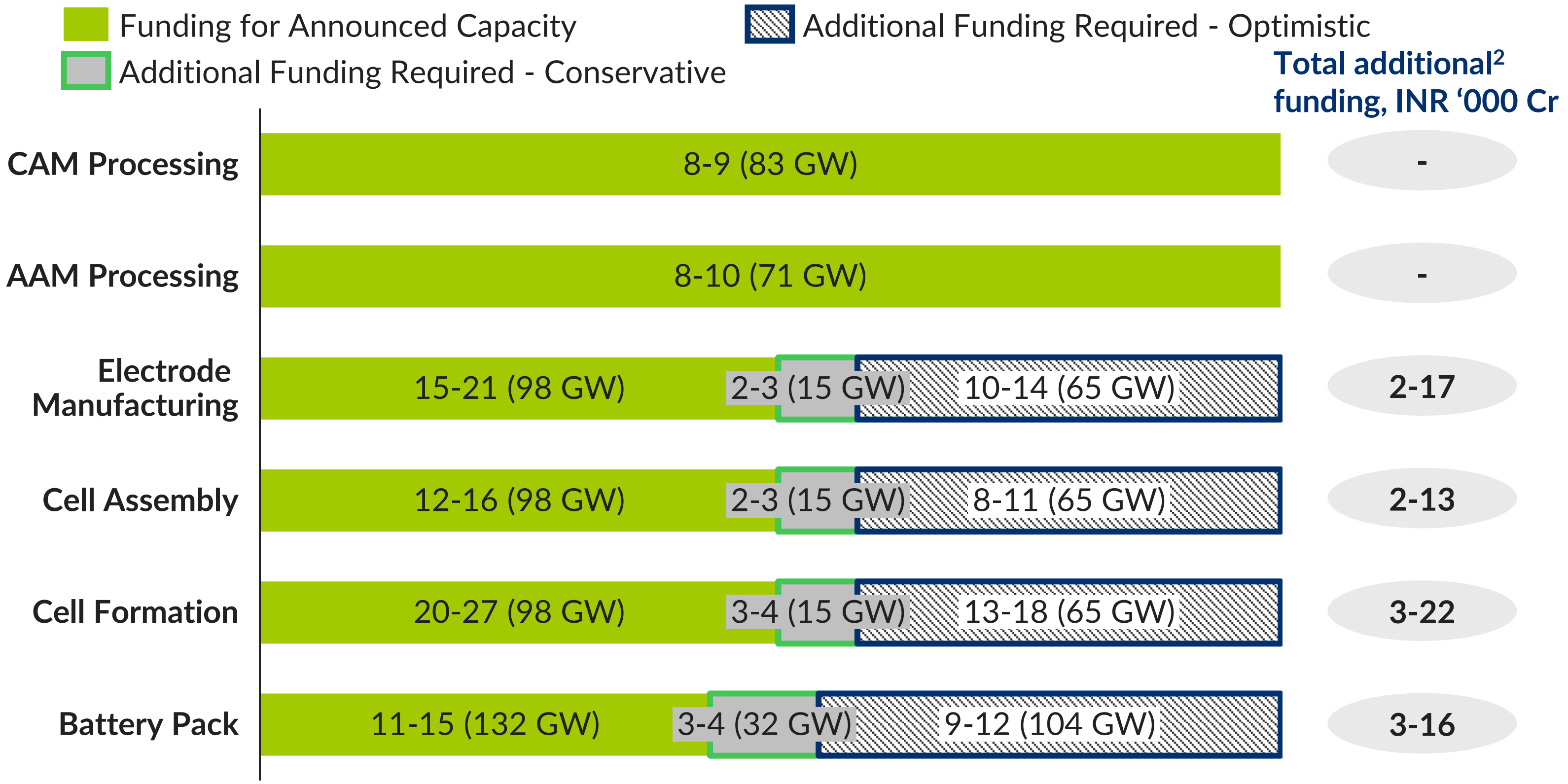
(1) Refers to investments required for domestic refining, circularity and stockpiling (2) Capex for CAM, AAM, Cell and Pack Manufacturing for announced and additional capacities required (3) Includes Input side electricity, capex subsidy and interest subvention till 2030; (4) On select raw materials – PVDF Binder and Electrolytes

1 **Capital Equipment & Infrastructure** | Beyond announced capacity additions of INR 90,000 Cr, additional capital investment of up to INR 68,000 Cr would be required to achieve 45% indigenisation across battery value chain

Critical to ensure that announced capacities are set up within timelines, including key upstream areas like Cathode and Anode active material production

Cumulative capital investment required till 2030[1], INR '000 Cr (Capacity in GWh)



Key insights

- Several capacity additions due in 2024, 2025 delayed potentially due to current global market dynamics
- Need to address potential risk of announced capacities facing similar delays (capital investment of INR 90,000 Cr)
- Policy support like modified PLI with longer timelines required to drive investment in incremental integrated capacity from electrode to pack
- Incentives for Cathode, Anode Active material production required to secure supply chains

Incremental capex investment required (beyond announced capacity), 2026-30

Conservative Scenario:

INR 10,000-14,000 Cr

Optimistic Scenario:

INR 49,000-68,000 Cr

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(1) CAM and AAM refer to Cathode Active Material and Anode Active Material respectively

(2) Assumed that announced capacities have already been funded and that cell capacity announcements refer to 'cell to pack' manufacturing

(3) Assumed 2-3-year delay in commissioning of announced capacities across value chain due to global market conditions

Source: Company announcements, Industry experts (industry associations, key manufacturing players), Dalberg Analysis

2 **Cost Competitiveness** | INR 27,000-48,000 Cr of targeted electricity, capex subsidies, and low-cost financing could narrow cost competitiveness gap for indigenous battery cells to 13% of potential Chinese landed cost

Mix of input subsidies, import duty waivers, tariff barriers and establishing global partnerships on technology and raw material sourcing could lead to long term cost-competitiveness for domestic manufacturers

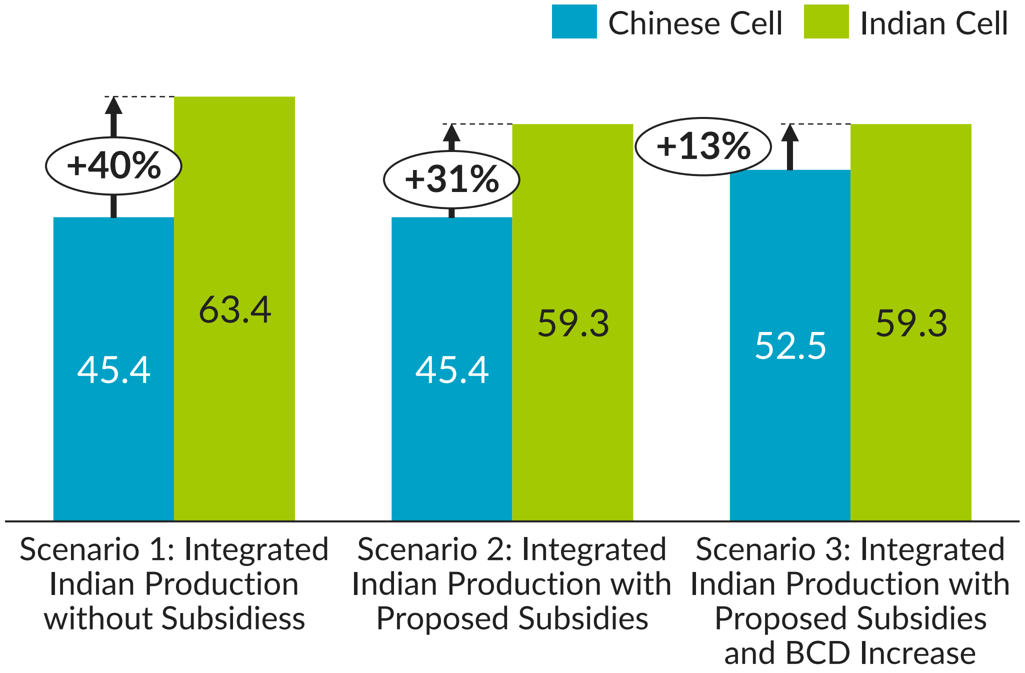
Current landscape indicates major challenges to cost competitiveness

- **Potential 40% cost–gap** between landed costs for Chinese LFP cells[1] and Indian cells from large scale integrated manufacturing facilities[3] potentially due to Chinese over capacity
- **Cost-competitiveness unlikely in short term** – need for tariff (e.g. raising BCD on cell imports) and non-tariff barriers (e.g. ALMM, DVA mandates)
- Limited impact of existing **State-level incentives** on capex, interest subsidies for large manufacturers due to **low ceilings**

Proposed interventions could limit potential LCOE impact of 45% battery indigenisation to 7-10%[4]:

Intervention type	Impact (INR Cr)
Electricity price subsidy of **20%** till 2030	**10,500-16,500**
Upfront capex subsidy of **15%**	**12,500-25,000**
Interest subvention of **15%** till 2030	**4000-6500**
Import duty exemption on key raw materials[5] till 2030	**1500-3000**
Increased BCD to **20%** on imported cells till 2030	**1000-3500**

Comparison of Chinese and Indian Battery Cell Landed Cost[1,2], USD kWh, ex-GST



Targeted subsidies on electricity, capex and interest subvention
INR 27,000-48,000 Cr till 2030

Detailed on next slide

(1) Landed costs for Cells for stationary applications potentially 5-7% lower, average cell price assumed; (2) Chinese cell landed cost assumed to remain consistent via interventions like BCD; (3) Cost estimates assume optimized integrated production at multi-GWh scale, costs for smaller plants could be 20-25% higher; (4) Refers to Solar LCOE; (5) On PVDF and Electrolytes; (6) Potential additional revenue

Source: Shanghai Metal Market, Industry experts (industry associations, key manufacturing players), Dalberg Analysis

2

Electricity, capex and financing costs, and key raw materials are key cost drivers targeted for subsidies and duty waivers to narrow the cost competitive gap with Chinese imports

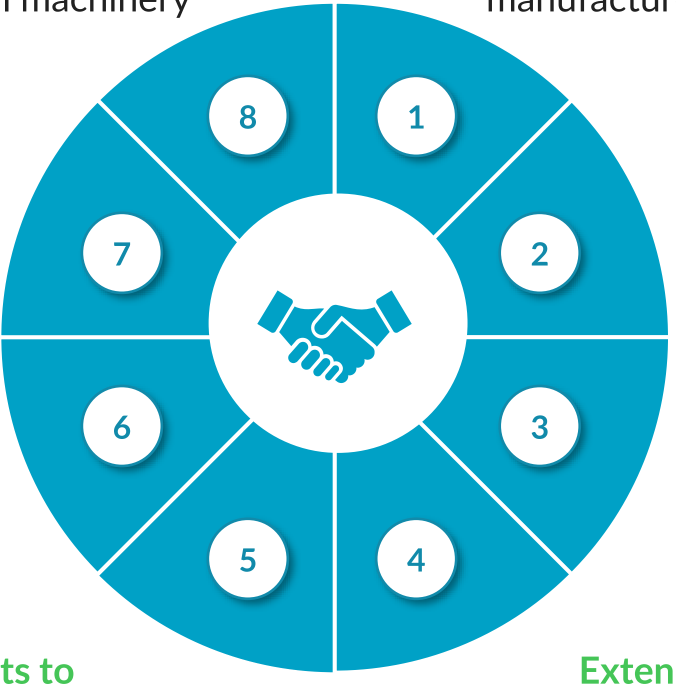
Category	Intervention type	Inputs and assumptions	Key recommendations	Total Impact, INR '000 Cr	
				Conservative	Optimistic
Input Subsidy	**Electricity Price Subsidy**	• Average electricity price of INR 9/Unit • Cost contribution of 16% of overall value chain	• **20% price subsidy** proposed • Effective electricity price INR 7.2/Unit • Covering entire value chain	10,500	16,500
	CAPEX Subsidy	• INR 76,000 – 158,000 Cr additional capex required[1] • 5-7% cost contribution of overall value chain	• **15% capex subsidy** proposed • Covering announced and incremental capacity required across manufacturing value chain	12,500-17,000	18,000-25,000
	Interest Rate Subsidy	• Interest rate assumed 11% • 7-9% cost contribution of overall value chain	• **15% interest subvention** proposed • Effective rate of 9.35% p.a. • Proposed for announced and additional capacity required	4,000	6.500
Tax Revenue Impact	**Import Duty Waiver** on PVDF Binder and Electrolytes	• ~10% of raw material cost for electrode, cell assembly • Current BCD 11% (PVDF) and 7.5% (Electrolytes)	• BCD, CVD, ACD waiver proposed at **8-digit HS Code level** • Covering Electrode and Cell Assembly stages	1,500	3,000
	Import Duty Increase on Battery Cells	• Current BCD has provision for reduction to 5% if for E-mobility, BESS	• Restoring 20% BCD • Will result in potential revenue increase	2,500	5,500

[1] Additional Capex refers to both announced and incremental capex

Source: Department of Revenue Notification; Industry experts (industry associations, key manufacturing players), Dalberg Analysis

2 Financing costs could also be lowered via concessional capital from DFIs, MDBs, bilateral funding, and lowering domestic borrowing costs through credit guarantees, concessional lines of credit, among others

An enabling environment could be created to facilitate tapping of domestic and international capital sources at concessional rates – targeted policies for battery and other cleantech manufacturers required



Easing access to equity capital by **relaxing exchange listing requirements** on profitability for battery manufacturers to reflect their longer path to profitability

Utilizing GIFT-IFSC's regulatory flexibility and lower transaction costs for green/transition bond listings and attracting foreign equity

Establishing **targeted Cleantech or Energy Transition Indices** to promote passive investment though mutual funds

Extending Priority Sector Lending and **concessional line of credit** to banks for battery manufacturing (similar to China's CERF program)

Structured guarantee instruments and **grants to reduce guarantee fees** to promote green bond issuances among first time issuers

Relaxing regulations to enable pension and insurance funds **invest up to specified limits in lower credit ratings**

Leveraging DFI, Multilateral concessional capital potentially backed by EU, bilateral guarantees, E.g. EU Global Gateway strategy, India-ETFA TEPA

Developing **structured bonds** with DFIs and MDBs **blending INR and foreign currency** denominated tranches to fund projects requiring significant imports of capital machinery

Source: Industry experts (industry associations, key manufacturing players), Dalberg Analysis

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