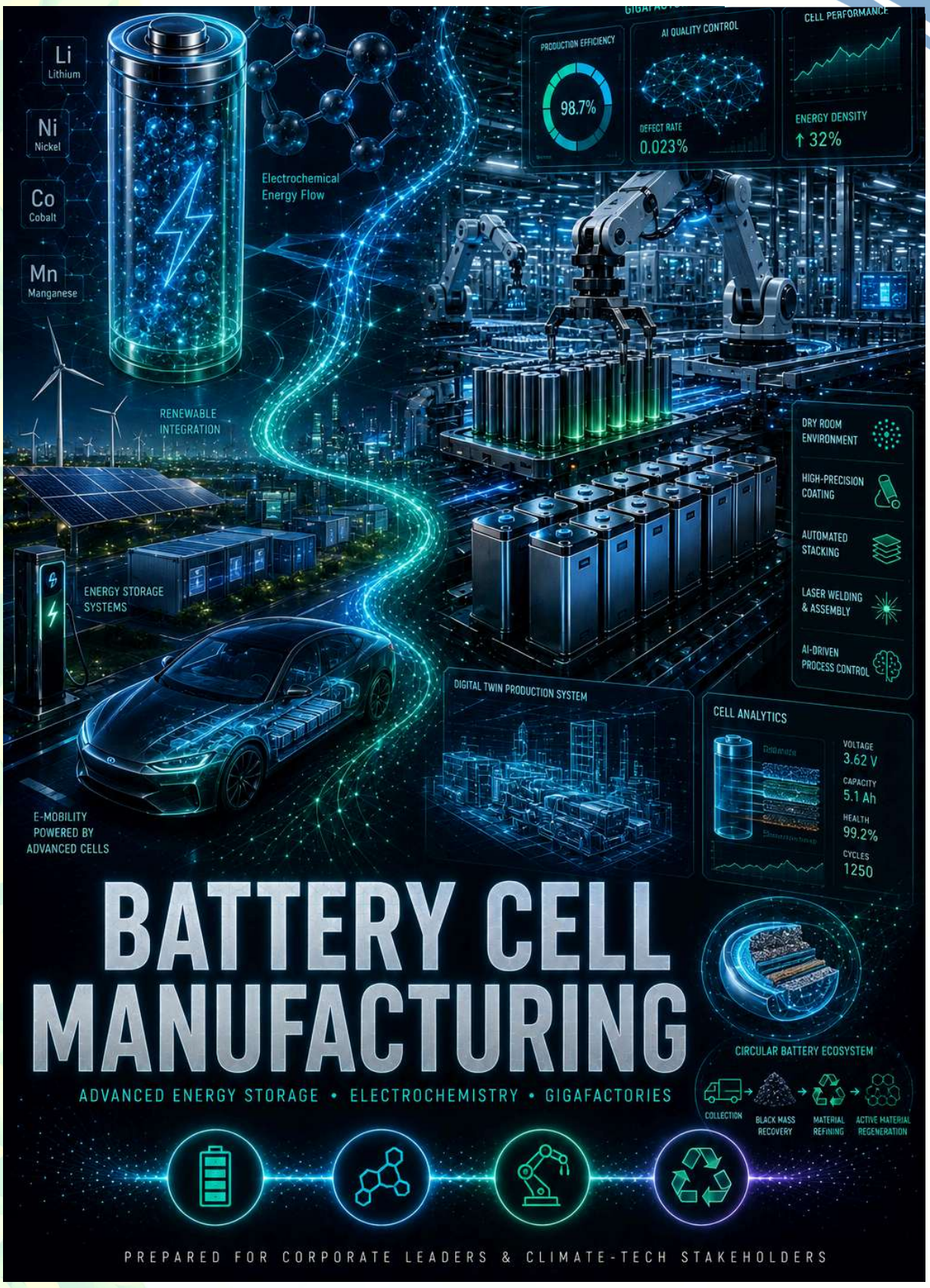
Li
Lithium
Ni
Nickel
Co
Cobalt
Mn
Manganese
Electrochemical
Energy Flow
PRODUCTION EFFICIENCY
98.7%
AI QUALITY CONTROL
DEFECT RATE
0.023%
CELL PERFORMANCE
ENERGY DENSITY
↑ 32%
RENEWABLE
INTEGRATION
ENERGY STORAGE
SYSTEMS
DRY ROOM
ENVIRONMENT
HIGH-PRECISION
COATING
AUTOMATED
STACKING
LASER WELDING
& ASSEMBLY
AI-DRIVEN
PROCESS CONTROL
DIGITAL TWIN PRODUCTION SYSTEM
CELL ANALYTICS
VOLTAGE
3.62 V
CAPACITY
5.1 Ah
HEALTH
99.2%
CYCLES
1250
E-MOBILITY
POWERED BY
ADVANCED CELLS
BATTERY CELL
MANUFACTURING
ADVANCED ENERGY STORAGE • ELECTROCHEMISTRY • GIGAFACTORIES
CIRCULAR BATTERY ECOSYSTEM
COLLECTION
BLACK MASS
RECOVERY
MATERIAL
REFINING
ACTIVE MATERIAL
REGENERATION
PREPARED FOR CORPORATE LEADERS & CLIMATE-TECH STAKEHOLDERS

## *Energy Storage*

# *Battery Cell Manufacturing*

*This section provides key inputs on Indian Battery Cell Manufacturing Opportunities for corporate leaders.*

## Highlights

- Structural demand growth across EVs and grid storage driven by electrification, renewable integration, and long-duration storage needs
- Strategic supply-chain importance as cell manufacturing determines cost, energy density, safety, and bankability across downstream EV/BESS markets
- Rapid technology evolution (LFP, NMC/NCA, emerging sodium-ion & solid-state) creating leapfrogging opportunities for new capacity
- Strong localization and policy tailwinds through PLI incentives, import substitution, and OEM demand for domestic, secure supply

## Key recommendations for corporate leaders include:

- Anchor investments in chemistry choices aligned to target markets (LFP for mass EVs & BESS; high-nickel for premium EVs; sodium-ion for cost-sensitive storage)
- Secure upstream materials and OEM offtake early through long-term contracts, JVs, or strategic equity to stabilize margins and utilization
- Build digital, high-yield manufacturing platforms with automation, inline QA/QC, and process analytics to compete on consistency and cost, not just scale
- Design plants for technology migration with modular lines and upgrade paths to avoid stranded assets as chemistries evolve

# Opportunity Snapshot: Battery Cell Manufacturing

Produces core battery cells that store and supply electrical energy.

## Market Signals

- EV & BESS demand driving massive need for domestic cell capacity
- Strong policy push via PLI for ACC batteries (~50 GWh approved capacity)
- Annual Market size by 2030: ₹ 1,50,000 - 1,75,000 Cr

## What Makes or Breaks It?

- Technology selection between LFP , NMC and next-gen chemistries
- Scale (GWh-level giga factories) for cost competitiveness
- Access to raw materials (lithium, cobalt,nickel) and supply chain integration

## Why It Matters NOW?

- Energy security due to reducing dependence on cell imports
- EV adoption and renewable storage is scaling up rapidly
- Strategic nudge to build domestic giga factories

## Well Aligned Opportunity for

- Large industrial conglomerates (deep capital + long-term play)
- Auto OEMs (backward integration for EV supply security)
- Global battery players entering India via JVs

## Key Challenges

- Extremely high capex: ₹6,000–8,000 Cr/ 10 GWh
- Technology complexity and rapid evolution (risk of obsolescence)

## Business Models

- Greenfield giga-factories leveraging PLI incentives
- Joint ventures with global technology providers
- Vertical integration via cell to pack to EV / storage ecosystem

Explore this opportunity further with EAI
consult@eai.in / Call Muthukrishnan - +91 9952910083

## Introduction and Business Case

Battery cells are the foundation of the new energy economy, powering electric vehicles, renewable integration and next-generation consumer technologies. Beyond powering EVs and stabilizing the grid, battery cells enhance energy independence, fuel the digital economy through devices and IoT systems and anchor national self-reliance in critical technology, making this one of the a compelling and strategically vital investment opportunity.

India's heavy investments in domestic gigafactories are reducing import dependence and positioning the country as a global hub at a time when demand is expected to grow more than 50-fold by 2040. That would be some growth!

## Market Potential for Battery Cell Manufacturing in India

| Year | Demand (GWh) | Market Size (₹ Cr) | Drivers |
|---|---|---|---|
| **2025** | 25-30 | 20,000-25,000 | EV 2W/3W surge; early 4W and storage packs |
| **2030** | 250-300 | 1,50,000-1,75,000 | 2W/3W dominance + 4W mass adoption; grid & C&I storage |
| **2040** | 250-300 | 2,00,000-2,25,000 | Deep electrification of transport + large-scale stationary storage |

## Market Segments and Applications

| Segment | Applications | Business Model | Key Drivers |
|---|---|---|---|
| Mass-market EV lithium-ion cells | Passenger EVs, two-wheelers | High-volume OEM supply contracts | Rapid global EV adoption |
| Premium / high-energy EV cells | Long-range & performance EVs | Customization-led OEM partnerships | Demand for higher energy density |
| LFP battery cells | Entry EVs, buses, ESS | Cost-optimized, scale manufacturing | Safety, longevity & raw-material security |
| Nickel-rich battery cells | Long-range EVs | Advanced chemistry production | Range anxiety & charging speed |
| Cylindrical cell manufacturing | EVs, power tools, ESS | Standardized cell platforms | Manufacturing automation & yield |

| | | | |
|---|---|---|---|
| | | | gains |
| Prismatic / pouch cell production | EVs, ESS | OEM-specific form-factor supply | Vehicle platform optimization |
| Grid-scale ESS cells | Utility & commercial storage | Project-based supply + service | Renewable energy integration |
| Regionalized cell manufacturing | Local EV & ESS markets | Localized gigafactory model | Supply-chain resilience & localization policy |
| Low-carbon / sustainable cells | EVs, ESS | Green-premium supply contracts | OEM Scope-3 emission targets |
| Next-generation battery cells | EVs, ESS (future) | R&D-led scale-up partnerships | Performance limits of current Li-ion |

## Typical Project Capacities & Investments Required in India

| Facility Type | Throughput | Indicative Capex (₹ Cr) | Automation Level |
|---|---|---|---|
| Pilot / Proto Line | 0.3-0.5 GWh/yr | 60-100 | Manual + semi-auto |
| Commercial Line - Tier-2 | 1-2 GWh/yr | 150-250 | Semi-auto |
| Multi-Line Plant - Tier-1 | 4-5 GWh/yr | 350-600 | High semi-auto |
| Large-scale Plant | 8-10 GWh/yr | 700-1,000 | Highly automated |
| ESS-dedicated Line | 1-2 GWh/yr | 120-180 | Semi-auto |

## Underlying Technologies & Processes

| Chemistry | Key Traits |
|---|---|
| Lithium Iron Phosphate (LFP) | High thermal stability, long cycle life, low cost, lower energy density |
| Nickel Manganese Cobalt (NMC) | High energy density, longer range, good performance, higher cost |
| Lithium Titanate Oxide (LTO) | Ultra-fast charging, excellent cycle life, low energy density |
| Solid-State Batteries | High energy density, solid electrolyte, improved safety, still emerging |
| Sodium-Ion Batteries | Lower cost, no lithium dependency, moderate performance |

## Key Challenges

| Challenge Area | Key Issues | Business Impact | India Specific | Strategic Implications |
|---|---|---|---|---|
| Raw Material & Supply Chain Dependence | Dependence on imported lithium, nickel, cobalt, graphite and precursor materials | Cost volatility and geopolitical supply risk | Limited domestic reserves; reliance on China and global markets | Secure long-term sourcing agreements and diversify supply chains |
| High Capital Intensity & Scale Economics | Gigafactory-scale investments required for cost competitiveness | Long payback periods and financing challenges | High initial capex; need for automation and cleanroom infrastructure | Strategic partnerships, phased capacity build-up, and government incentives critical |
| Technology Evolution & Obsolescence Risk | Rapid shifts in chemistries (LFP, NMC, sodium-ion, solid-state) | Risk of stranded assets or outdated production lines | Indian market still deciding dominant chemistry pathways | Flexible manufacturing design and technology partnerships essential |
| Energy Costs & Sustainability Requirements | Energy-intensive manufacturing processes affect operating costs and carbon footprint | Reduced competitiveness vs global players if energy costs high | Grid reliability and renewable sourcing vary by region | Co-locate with renewable energy or industrial clusters to reduce costs |
| Demand Forecasting & Offtaker Alignment | EV OEM demand growth still evolving; dependency on few large customers | Revenue volatility and capacity underutilization risk | Policy-driven EV adoption cycles; evolving domestic storage markets | Secure long-term OEM contracts and diversify into stationary storage markets |

## Prominent Players in the Indian Market

| Company / Entity | Focus Areas |
|---|---|
| Ola Electric Mobility Ltd. | 4680-format cylindrical cell production |
| Amara Raja Energy & Mobility | 16 GWh cell + 5 GWh pack capacity. First production lines by Q4 2026, full 16 GWh by FY 2029 |

| | |
|---|---|
| Exide Industries | 6 GWh cell. Commercialisation targeted end 2024-25 |
| Reliance Industries | 30 GWh battery systems → cells. Phase 1 systems/packs by H2 2026, later cell capacity |
| Tata Group (Agratas) | Lithium-ion cell factory. $1.5 bn, 2026 start; full integration by 2028 |

## Innovation Perspectives

| Innovation | Business Opportunity | For Senior Management |
|---|---|---|
| Chemistry portfolio strategy | Multi-chemistry gigafactories | Reduces technology and raw-material risk |
| Manufacturing scale & yield innovation | Ultra-scale, cost-leader cell platforms | Lowest cost per kWh wins volume markets |
| OEM-embedded cell co-development | Platform-level OEM partnerships | High switching costs, long contracts |
| Low-carbon cell manufacturing | Green-premium cell supply contracts | Meets OEM Scope-3 mandates |
| Standardized cell formats | Global standardized cell ecosystems | Faster scale, better margins |
| Next-gen chemistries (post-Li-ion) | Technology option value investments | Long-term performance or cost breakthroughs |
| Cell-to-system optimization | Joint cell-pack-ESS design platforms | Improves system-level economics |
| Regionalized gigafactory models | Replicable regional manufacturing hubs | Policy compliance, supply security |
| Data-driven quality & lifecycle tracking | Battery data & analytics services | Improves reliability, residual value |
| Closed-loop recycling integration | Circular battery ecosystems | Cost + sustainability moat |

## Concentric & Satellite Opportunities

- Active Material (CAM/Anode) Manufacturing Integration - Concentric, co-located precursor (pCAM) and Cathode Active Material (CAM) or advanced anode production lines minimizing inter-plant logistics and ensuring a closed-loop supply of spec-locked materials to the giga-factory.
- Closed-Loop Solvent/Binder Recovery Systems - Concentric OEMs offering modular solvent (NMP/water) recovery and purification skids, directly integrated with the electrode coating/drying lines, to drastically cut material and energy costs.
- High-Throughput Continuous Mixing/Coating OEM - Concentric equipment providers specializing in continuous mixing (extrusion-based) and advanced dry-coating/electrode fabrication lines to increase throughput, reduce solvent use and improve electrode uniformity.
- Dry Room/Mini-Environment Energy Optimization - Concentric HVAC/clean-air providers offering mini-environment solutions around critical processes (cell assembly, electrolyte filling) to reduce the volume of ultra-dry air needed, cutting factory utility costs by up to 30%.
- In-Line Quality Control & AI-Powered Digital Twin - Concentric software platforms implementing real-time, non-destructive testing (NDT) with AI/ML to detect micro-defects during calendering, stacking and welding and a digital twin for predictive process optimization and virtual ramp-up.
- Raw Material Reverse-Logistics Networks - Digitized, compliant collection, storage and transport platforms for End-of-Life (EoL) batteries, feeding regional pre-processing hubs (discharge, dismantling, shredding) for black mass production.
- Advanced Black Mass Refining Hubs - Satellite hydrometallurgical or direct recycling facilities co-located near manufacturing clusters, recovering high-purity lithium, nickel, cobalt and manganese for direct re-introduction into pCAM/CAM production.
- Second-Life (2L) Battery Energy Storage Systems (BESS) - Satellite hubs for grading, re-packaging and thermal management integration of EoL EV battery packs into utility-scale or commercial/industrial BESS products, extending their useful life.
- Specialized Battery Component R&D/Supply - Satellite suppliers focused on next-generation components, such as solid-state electrolytes, high-capacity silicon-based anodes, or fluorine-free binders, to improve cell performance and sustainability.
- Digital Battery Passport & Compliance Platforms - Platforms enabling SKU-level traceability from mining to recycling, fulfilling upcoming regulatory requirements (e.g., EU Battery Regulation) by tracking material provenance, carbon footprint and state-of-health.

## Key Takeaway for Senior Management

| Takeaway | Details |
|---|---|
| Battery cell manufacturing is a chemistry and process-control business, not a scale race | • Long-term winners are defined by electrochemistry mastery, yield control, and consistency—not just GWh capacity<br>• ***Examples**:* LFP cathode morphology control, electrolyte formulation optimization, coating uniformity, formation cycling protocols<br>• **Competitive advantage:** higher yield and consistency translate directly into lower cost per kWh and stronger OEM trust |
| Chemistry choice defines market positioning and capital risk | • Different end markets require different chemistries, and misalignment leads to stranded assets<br>• ***Examples**:* LFP for mass EVs and BESS; high-nickel NMC/NCA for premium EVs; sodium-ion for cost-sensitive stationary storage<br>• **Innovation focus:** multi-chemistry, modular production lines<br>• **Competitive advantage:** flexibility to serve multiple demand segments and pivot as markets evolve |
| Upstream material security is a strategic moat | • Cathode materials, lithium salts, and anodes drive both cost and supply risk<br>• **Competitive advantage:** Strong upstream stability can drive stable margins and higher bankability with OEMs and investors |
| Yield, defect rates, and degradation performance drive lifetime IRR | • Small improvements in yield and cycle life have outsized financial impact<br>• **Suggestions for innovation:** digital manufacturing intelligence and predictive quality systems<br>• **Competitive advantage:** superior lifetime performance enables premium pricing and long-term contracts |
| Technology migration speed is becoming a core capability | • Battery technology cycles are shortening, increasing obsolescence risk<br>• ***Examples**:* transition readiness from LFP → LMFP → sodium-ion; solid-state pilot integration<br>• **Innovation focus:** modular equipment, rapid line reconfiguration, R&D partnerships<br>• **Competitive advantage:** future-proof plants that remain competitive across multiple technology cycles |

## Next Steps for Corporate Leaders

Battery cell manufacturing is scaling rapidly as global electrification expands across mobility, stationary storage, and industrial applications. Supply chains are maturing from cathode/anode materials to separators, electrolytes, and downstream integration with packs and BMS. Technology pathways (LFP, NMC, sodium-ion, solid-state) are evolving in parallel with localization policies, critical mineral strategies, recycling mandates, and geopolitical realignment of battery materials. As corporates seek to secure cost, supply, and lifecycle control, cell manufacturing is becoming a strategic chokepoint in the energy storage value chain.

This could be an attractive climate tech opportunity for industries and firms in specific sectors and industries keen on catering to this fast growing market.