BATTERY360

# SCOPE FOR BATTERY AADHAAR IN INDIA

## Identification of priority use-cases and data attributes

The document insights were developed by the Battery360 Working Group on Battery Aadhaar, anchored by WRI India.

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# Contents

# Executive Summary

## About This Report

This report, published by Battery360 with support from WRI India, presents the findings of a structured multi-stakeholder consultation process to define the scope and design of Battery Aadhaar—a proposed national digital framework to uniquely identify and track batteries across their lifecycle in India. It covers: an articulation of the priority use-cases that Battery Aadhaar should enable (Section 3); the data attributes required to support those use-cases, mapped to their owners across the value chain (Section 4); the key implementation challenges and recommended responses (Section 5); and a forward agenda for governance design and next steps (Section 6). The findings are intended to inform the development of a national Battery Aadhaar framework and support alignment between industry, regulators, and policymakers.

## Why Battery Aadhaar Matters

India's shift to electric mobility will generate a large and growing stock of used batteries over the coming decade, with annual retiring volume of Lithium-ion Batteries (LIBs) crossing 80 Gigawatt-hour (GWh) by 2030 as per National Institution for Transforming India (NITI) Aayog. The central challenge is not the absence of battery data, but its fragmentation across actors and lifecycle stages—making it unavailable to those who need it for decisions on reuse, recycling, compliance, financing, and safety. The Office of the Principal Scientific Adviser (PSA) has identified Battery Aadhaar as a priority in India's e-Mobility R&D Roadmap, and Ministry of Road Transport and Highways (MoRTH) has issued draft guidelines signaling formal policy intent. A well-designed Battery Aadhaar system would link each battery to a secure, interoperable lifecycle record—enabling it to be treated as a traceable, accountable, and financeable asset.

### At a Glance

| 5 | 12 | 34 | 30+ |
|---|---|---|---|
| Thematic Use-Case Areas | Priority Use-Cases Identified | Key Data Attributes | Stakeholders Consulted |

## Identified Priority Use-Cases

The use-cases were identified through structured consultations by Battery Aadhaar Working Group under Battery360 and anchored by WRI India and synthesised into five thematic areas, each representing a distinct system-level challenge. This classification highlights common root causes across seemingly distinct issues raised by different parts of the battery value chain.

**Table 1**

| Thematic Area | Priority Use-Case | Core Question it Answers |
|---|---|---|
| **AREA 01**<br>**Traceability & Governance**<br><br>*Impact: Supports Battery Waste Management Rules (BWMR) 2022; strengthens Central Pollution Control Board (CPCB)/State Pollution Control Boards (SPCBs) enforcement* | **Extended Producer Responsibility (EPR) Compliance & Informal Battery Flows** | *Can the movement and ownership of batteries be reliably tracked across the system to support EPR compliance and reduce leakage into informal channels?* |
| **AREA 02**<br>**Circular Economy & Resource Efficiency**<br><br>*Impact: Aligns with Battery Waste Management Rules (BWMR), 2022, Production Linked Incentive (PLI) Scheme for ACC Battery Storage, and Critical Minerals Mission* | **Reuse vs Recycling Decision-Making** | *Can stakeholders reliably determine whether a battery should be reused, repurposed or recycled, based on its actual condition and history?* |
| | **Enabling Second-Life & Refurbishment** | *Can batteries be safely refurbished and redeployed for second-life applications using credible lifecycle data?* |

| Thematic Area | Priority Use-Case | Core Question it Answers |
|---|---|---|
| | **Recycling Efficiency & Material Recovery** | *Can recycling processes be made safer and more efficient through better information on battery chemistry and composition?* |
| **AREA 03**<br>**Market Creation & Financial Enablement**<br><br>*Impact: Supports EV adoption, green finance, and reduced total cost of ownership* | **Enabling Electric Vehicle (EV) & Battery Resale Markets** | *Can buyers and sellers reliably assess the condition and value of a battery in resale transactions?* |
| | **Battery Leasing & Battery-as-a-Service (BaaS)** | *Can batteries be separated from vehicles and offered as leased or service-based assets with reliable performance and risk profiles?* |
| | **Financing, Insurance & Risk Assessment** | *Can financiers and insurers assess battery-related risks using credible lifecycle data?* |
| **AREA 04**<br>**Risk, Safety & Consumer Protection**<br><br>*Impact: Reduces warranty disputes, enables proactive import screening, and strengthens consumer confidence* | **Warranty & Liability Transparency** | *Can availability of and accessibility to transparent and verifiable information on the battery lifecycle lead to an improvement in fairness, efficiency and accountability in warranty and liability determination?* |
| | **Safety/Quality Certification & Compliance Verification** | *Can battery safety and quality compliance be supported through verifiable lifecycle information rather than relying solely on periodic physical audits?* |

| Thematic Area | Priority Use-Case | Core Question it Answers |
|---|---|---|
| | **Strengthening Import Verification & Quality Assurance** | *Can imported battery cells and packs be verified for quality, safety and compliance prior to their entry into the domestic supply chain?* |
| **AREA 05**<br>**Climate, Environmental, Social and Governance (ESG) & Global Integration** | **Lifecycle Emissions Reporting & ESG Enablement** | *Can structured battery lifecycle information support credible emissions accounting and ESG reporting?* |
| *Impact: Supports access to green finance, carbon markets, and export competitiveness* | **Harmonization with International Battery Passport Systems** | *Can India's Battery Aadhaar framework align with the emerging global battery passport standards to enable interoperability and reduce duplicative reporting?* |

Taken together, the identified use-cases show that Battery Aadhaar can help move the battery ecosystem from today's dispersed and partly manual processes towards a more traceable, digital and decision-ready system. Where the current state is marked by limited visibility over battery movement, condition and ownership, Battery Aadhaar can enable verified lifecycle records that support stronger compliance, more efficient reuse and recycling, improved market confidence, better risk assessment, and more credible sustainability reporting.

## Identified Priority Data Attributes

The effectiveness of Battery Aadhaar depends on a clearly defined, implementable dataset. Thirty-four data attributes were identified through structured stakeholder consultations, mapped against the priority use-cases to ensure functional relevance.

## Complete List of Priority Data Attributes

Please refer to section 4.3 for mapping of these data attributes to the identified use-cases.

### Table 2

Current data owner represents the stakeholder who currently holds the data attribute or has exclusive access to it.

| Data Attribute | Description | Current Data Owner |
|---|---|---|
| Change of state | Current lifecycle phase (first-life, second-life, retired, recycled) | *Original Equipment Manufacturer (OEM)/ Refurbisher/Recycler* |
| % of recycled content | % by weight of recycled metals in active materials | *Battery OEM* |
| Battery carbon footprint (BCF) | Total Greenhouse Gas (GHG) emissions across lifecycle (kilogram (kg) Carbon Dioxide Equivalent (CO2e)/Kilowatt-hour (kWh) | *Battery OEM/ Importer* |
| Battery chemistry | Electrochemical composition—cathode and anode materials (e.g. Lithium Ferro Phosphate (LFP), Nickel Manganese Cobalt (NMC) | *Battery OEM* |
| Current State of Health (SoH) | Real-time battery condition as % of original rated capacity | *Vehicle OEM* |
| Cycle count (first life) | Total complete charge–discharge cycles in first-life deployment | *Vehicle OEM* |
| Date of manufacture (battery) | Date of pack assembly | *Battery OEM* |
| Date of manufacture (cell) | Date of cell manufacturing | *Battery OEM* |

| Data Attribute | Description | Current Data Owner |
|---|---|---|
| Date of retail use | Date first placed in service by end user | *Vehicle OEM* |
| Date of retirement | Date battery was formally removed from its application | *Last Holder/Fleet/ OEM* |
| Dismantling information | Safe disassembly instructions for end-of-life processing | *Battery OEM* |
| Distance travelled (first life) | Total cumulative kilometre (km) covered by the vehicle | *Vehicle OEM/Fleet Operator* |
| Mass balance of the pack | Total weight of battery pack including cells, modules, casing | *Vehicle OEM/Battery OEM* |
| No. of deep discharges | Count of discharges significantly below recommended State of Charge (SoC) threshold | *Vehicle OEM* |
| Ownership history | Chronological log of all legal owners/custodians from manufacture | *Economic Operator (registry)* |
| Pending lifecycle (est. remaining cycles) | Estimated remaining charge–discharge cycles before capacity threshold | *Vehicle OEM/ Analytics Provider* |
| Qty. recycling material extracted | kg of each recoverable material (Li, Co, Ni, Cu, Al) extracted | *Recycler* |
| Safety test certificates | Formal documentation of testing against applicable safety standards | *Battery OEM/Vehicle OEM* |
| Temperature anomalies (first life) | Instances of operating temperature exceeding safe thresholds | *Vehicle OEM* |
| Type of vehicle deployed in | Vehicle model and category (2W, passenger EV, commercial EV) | *Vehicle OEM* |

| Data Attribute | Description | Current Data Owner |
|---|---|---|
| Usage capacity profile (pack) | Capacity fade over time relative to original rated capacity | *Vehicle OEM/Fleet Operator* |
| Usage capacity profile (cell) | Cell-level capacity fade over time | *Vehicle OEM* |
| Warranty repairs | Record of maintenance/ repair activities under warranty | *Vehicle OEM* |
| Warranty status | Active or expired warranty indicator | *Vehicle OEM* |
| SoC | Current energy level as % of total capacity | *Vehicle OEM* |
| Charge/discharge events | Log of individual charging and discharging event counts | *Vehicle OEM* |
| Firmware/Battery Management System (BMS) version | Software version running on BMS | *Vehicle OEM* |
| Change of passport ownership | Record of digital passport custodianship transfer | *Vehicle OEM/ Refurbisher* |
| Country of origin of raw materials & ESG certifications | Geographic origin of critical raw materials and ESG certifications | *Battery OEM* |
| Presence of hazardous materials | % by weight of hazardous substances in the battery | *Battery OEM* |
| Symbols, labels & conformity documentation | Compliance markings and declarations (e.g. Bureau of Indian Standards (BIS) certification) | *Battery OEM* |
| Material composition (w/w) | % by weight of each primary material (cathode, anode, electrolyte, structure) | *Battery OEM* |

| Data Attribute | Description | Current Data Owner |
|---|---|---|
| Details of suppliers, audit reports, certifications | Identity and due diligence compliance of upstream material suppliers | *Battery OEM* |
| Change of structure | Record of physical modifications (cell replacement, reconfiguration) during refurbishment | *Refurbisher* |

## Key Implementation Challenges and Recommendations

Stakeholder consultations indicate strong alignment on the need for Battery Aadhaar. Five operational and governance constraints must be addressed for effective implementation at scale.

1. **Absence of Standardised Data Export Protocols:** Battery performance data such as SoH, cycle count and temperature history is generated in different formats across OEM systems, limiting interoperability. A minimum mandatory dataset with standardised formats and calculation methodologies will be needed to enable consistency across manufacturers.

2. **Data Ownership, Consent and Controlled Access:** Several lifecycle data fields are commercially sensitive or subject to privacy regulations, making unrestricted sharing impractical. A national consent architecture with role-based access can enable secure data exchange while protecting confidentiality and limiting disclosure to what is necessary.

3. **Digital Infrastructure Constraints in Collection Networks:** End-of-life batteries often move through informal collectors and aggregators that have limited connectivity and no scanning infrastructure, creating breaks in traceability. A hybrid online–offline Battery-ID system, supported by low-cost tools and incentives for collection actors, can help maintain continuity.

4. **Legacy Batteries and Incomplete Historical Data:** A large stock of EV batteries already in circulation predates Battery Aadhaar and may not have retrievable lifecycle records. A transition protocol for legacy batteries,

including rules for estimated versus verified data, will be needed to bring these batteries into the system.

5. **Limited Access to Upstream Data from Foreign Cell Suppliers:** Some use-cases, especially import verification and emissions reporting, depend on upstream data that is often unavailable from foreign suppliers in structured digital form. Early implementation may therefore need to focus on domestically accessible data, while upstream disclosure requirements are phased in over time.

## Next Steps Towards a National Framework

The consultations undertaken under the Battery360 have enabled identification of priority use-cases and the data attributes required to support them. Translating these into an operational and scalable system will require further work across six fronts:

- **Technical Standardisation and Governance Refinement:** Assess commercial sensitivity of specific data fields, determine mandatory vs voluntary attributes, harmonise units of measurement, and standardise calculation methodologies.
- **Governance Architecture Design:** Define roles, responsibilities, data custodianship, and coordination mechanisms across OEMs, fleet operators, recyclers, and regulators to ensure accountability and long-term scalability.
- **Digital Public Infrastructure (DPI) Blueprint:** Develop a DPI-aligned digital architecture enabling secure, consent-based, role-based data exchange—interoperable with existing regulatory and industry systems, accommodating varying levels of digital readiness.
- **Expansion to Industrial and Stationary Batteries:** Continue stakeholder engagement with industrial battery ecosystem actors (stationary energy developers, utilities, financiers) to identify use-cases and data attributes specific to that value chain.
- **Pilot Implementation:** Convert identified use-cases and data requirements into a governance and digital architecture pilot that is practical, scalable, and aligned with India's regulatory and sustainability objectives.

India's rapid expansion of electric mobility and energy storage presents both opportunity and responsibility. As batteries become central to the country's energy transition, their governance, traceability, and lifecycle management will increasingly determine outcomes related to safety, circularity, compliance, and economic value creation.

A well-designed Battery Aadhaar system can address the information asymmetry by linking batteries to secure, role-based, and interoperable lifecycle records. In doing so, it can strengthen governance, reduce uncertainty, and enable batteries to be treated as traceable and accountable assets across their lifecycle.

# 1 Introduction

India's journey towards achieving net-zero emissions by 2070 depends on the rapid electrification of transport and large-scale deployment of renewable energy. As battery demand grows, the battery value chain is becoming increasingly resource-intensive, spanning multiple geographies, actors and lifecycle stages. Given batteries' reliance on critical minerals, there is a growing need to manage them responsibly across their lifecycle to reduce emissions intensity, mitigate environmental risks and unlock economic opportunities linked to recovery, reuse and efficient end-of-life management.

At the global level, governments are responding to this critical issue through the adoption of the digital battery passport framework. While the European Union (EU) has mandated battery passports under Regulation (EU) 2023/1542, similar initiatives are underway in the United States of America, Japan, South Korea and China. The systems will enable batteries to be digitally identified, monitored and verified throughout the lifecycle.

In India, the Office of the PSA has identified Battery Aadhaar as a priority in the Research and Development Roadmap for Electric Mobility. More recently, the MoRTH has issued draft guidelines for Battery Aadhaar, signalling a formal policy intent to establish a national battery identification and traceability framework. This report aims to inform the development of this national framework by providing stakeholder insights on what Battery Aadhaar should enable, whom it should serve and what data it must capture.

## 1.1. Need for a National Battery Data Management Framework

As outlined in the introduction, India's rapid scale-up of electric mobility and energy storage is expected to lead to a massive expansion of batteries circulating across the economy. These batteries will move through multiple stages, including manufacturing, use, ownership transfer, second-life deployment and end-of-life processing. However, while batteries move physically across this value chain, the data required to manage them does not. Information on battery design, chemistry, performance, ownership and safety remains fragmented across manufacturers, operators, service providers and recyclers.

This lack of an integrated battery data system results in significant risks and inefficiencies across the battery value chain. Fleet operators and end users face challenges in managing battery performance, warranties and safety, while second-life and recycling companies struggle to assess SoH, remaining useful life (RUL) and material composition, limiting reuse and safe material recovery. The lack of reliable, transparent performance history and condition of the battery assets they are underwriting leaves financiers and insurers to deal with increased exposure to credit and residual value risks. Regulators, in turn, are unable to reliably verify compliance with EPR obligations under the BWMR, 2022. Consequently, in most cases, batteries that could have retained substantial economic value through reuse or high-quality recycling end up being mishandled and underutilised or are lost to informal channels.

These challenges are further compounded by India's heavy dependence on imported battery cells. In the absence of systematic data and traceability, cells of varying quality are often imported without adequate supplier and product-level due diligence, creating downstream risks related to performance degradation, safety failures and premature end-of-life. Given that batteries are to be the cornerstone of India's energy security and its net-zero transition, ensuring their quality, performance and efficient lifecycle management is a matter of strategic importance. It is essential to establish a digital, data-backed system that enables the continuous monitoring of battery flows, supports evidence-based policymaking and strengthens governance in one of the most critical clean energy assets of the country.

Developing such a framework requires close collaboration with multiple stakeholders across the battery value chain, including OEMs, pack assemblers, fleet operators, recyclers and refurbishers. These stakeholders can provide critical insights into operational bottlenecks, information gaps and data requirements to help design a system that is both technically robust and practically deployable at scale.

## 1.2 Scope of the Document

This document defines the scope and value proposition of the Battery Aadhaar framework in the Indian context. It draws on the deliberations of the Battery360 Working Group on Battery Aadhaar through convenings and focused group discussions (FGDs) conducted by WRI India to identify and prioritise key use-cases and the corresponding data attributes required to enable these.

It is important to note that the priority use-cases and data attributes identified in this report are more closely aligned with the EV battery ecosystem. This reflects the composition of the stakeholders engaged in the first phase of consultations and the immediate regulatory and market drivers currently shaping India's battery landscape.

However, Battery Aadhaar is envisaged as a broader national framework applicable across battery segments, including industrial and stationary energy storage systems (ESS). In recognition of this, the Working Group will continue to expand engagement with the stakeholders across the industrial battery ecosystem and identify use-cases and data attributes specific to that value chain. The insights that have emerged from these consultations will be presented in subsequent reports released by the Working Group.

Specifically, this report covers:

| | | |
|---|---|---|
| The identification and prioritisation of use-cases across manufacturing, first-life use, second-life applications and end-of-life management of EV batteries | Identification of key static and dynamic data attributes needed to support these use-cases | The articulation of key challenges and gaps that must be addressed in designing a national Battery Aadhaar framework |

The findings presented here are intended to inform the subsequent phases of the development of Battery Aadhaar, including the digital architecture and governance structure of the battery data framework. Together, these form an evidence-based foundation for building a scalable, interoperable and India-specific Battery Aadhaar system.

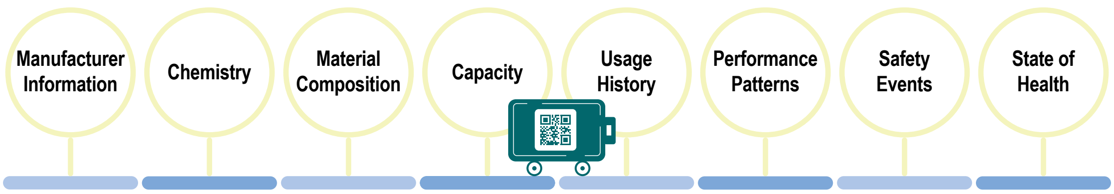
2

# Introduction to the Concept of Battery Aadhaar

Battery Aadhaar is envisioned as a national digital framework for uniquely identifying and tracking batteries throughout their lifecycle. Each battery will be assigned a secure and unique digital identity that can link key information generated at different stages of its life—from manufacturing and deployment to reuse, recycling and final disposal. This digital identity will enable batteries to remain traceable with access to their data as they move across different owners, applications, and geographical locations.

In practical terms, Battery Aadhaar is expected to function as a digital record that travels with the battery. It aims to consolidate essential static information, such as manufacturer, chemistry, capacity and material composition, along with dynamic information, such as usage history, performance patterns, safety events and SoH. To ensure practical and secure access, this information will be made available through systems such as Quick Response (QR)-based battery identifiers, supported by role-based access controls. This will ensure that only authorised stakeholders are able to access the data.

The primary objective of launching a Battery Aadhaar is to address the information asymmetry that currently characterises India's battery ecosystem. Batteries often change hands multiple times, particularly as they move from first-life EV use to second-life applications or to recycling. However, the data required to assess their condition, value and safety rarely travels with them. Battery Aadhaar aims to bridge this gap by creating a trusted digital backbone that links physical batteries to their lifecycle data, enabling more informed decisions on warranty management, resale, repurposing and end-of-life processing.



# 3

# Use-cases Identified for Battery Aadhaar

The use cases, or the applications where Battery Aadhaar can bring value to the ecosystem, identified during stakeholder consultations hosted by the Battery360 span multiple stages of the battery lifecycle and reflect a wide range of regulatory, operational and market challenges. The challenges were articulated by the stakeholders using different lenses, such as compliance, circularity, safety, financing and sustainability, which were often shaped by their specific role in the battery value chain.

To present these inputs in a structured and policy-relevant manner, the Working Group categorised the use cases into a set of **thematic areas**, each representing a distinct system-level challenge. These thematic areas are:

- **Traceability & Governance**
- **Circular Economy & Resource Efficiency**
- **Market Creation & Financial Enablement**
- **Risk, Safety & Consumer Protection**
- **Climate, Environment, Social and Governance & Global Integration**

This classification reflects a synthesis of the discussions amongst the Working Group rather than a categorisation proposed by individual stakeholders and is intended to highlight common challenges across seemingly distinct issues.

Each thematic area is presented through a set of priority use cases, articulated in terms of the core question it addresses, the current scenario and its key challenges as described by the stakeholders and their relevance in the Indian context.

### Fig 1. Identified use-cases mapped under 5 thematic areas

| Themes | Traceability & Governance | Circular Economy & Resource Efficiency | Market Creation & Financial Enablement | Risk, Safety & Consumer Protection | Climate, ESG & Global Integration |
|---|---|---|---|---|---|
| Use-cases | • EPR Compliance and Informal Battery Flows | • Reuse vs Recycling Decision-Making<br>• Enabling Second-Life and Refurbishment<br>• Recycling Efficiency and Material Recovery | • Enabling EV and Battery Resale Markets<br>• Battery Leasing and BaaS<br>• Financing, Insurance, and Risk Assessment | • Warranty & Liability Transparency<br>• Facilitating Safety/Quality Certification and Compliance Verification<br>• Strengthening Import Verification and Quality Assurance | • Lifecycle Emissions Reporting/ Carbon Credit & ESG Reporting Enablement<br>• Harmonisation with International Battery Passport Systems |

## 3.1. Thematic Area: Traceability & Governance

### Context and Relevance

A key concern that was repeatedly raised by the stakeholders was that of the absence of a reliable mechanism to track batteries as they move across different stages of the lifecycle. The stakeholders pointed out that once batteries leave the manufacturer or OEM network, they often move through multiple intermediaries, with limited or no documentation. This makes it difficult to know the location and ownership of the batteries.

This challenge was most frequently discussed in the context of compliance with the BWMR, 2022, and the dominance of informal collection and trading channels. The stakeholders emphasised that a large share of end-of-life batteries bypass authorised systems and enter informal markets, which undermines regulatory oversight and weakens accountability.

The use cases in this thematic area focus on enabling basic traceability of battery movement, ownership and custody, particularly in relation to informal flows and EPR compliance.

## 3.1.1. Use case: EPR Compliance and Informal Battery Flows

**Core Question**

*Can the movement and ownership of batteries be reliably tracked across the system to support EPR compliance and reduce leakage into informal channels?*

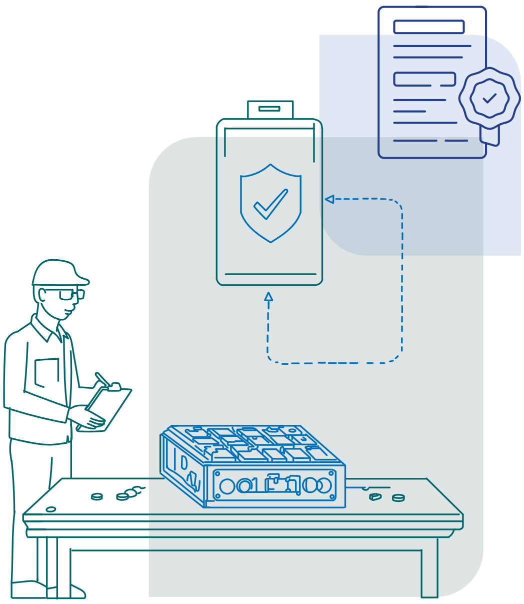
**Current Scenario and its Key Challenges**

The stakeholders reported on this challenge by raising concerns related to non-compliance with the BWMR, 2022, and the widespread role of informal collection and resale. The data provided by them indicated that a significant share of end-of-life batteries bypass authorised recyclers and are traded through informal routes, often without any documentation or reporting.

Recyclers pointed out that batteries frequently arrive with incomplete or unreliable paperwork, while producers voiced the difficulty they face in demonstrating that their EPR obligations have been met through legitimate channels. For regulators, the challenge lies in tracking the course of the batteries after these exit the formal supply chains, making enforcement dependent on self-reporting and periodic audits.

The stakeholders also pointed out that users often sell old batteries through alternate routes, with no standard legal or digital record of change of ownership or disposal. The difficulty in separating the battery asset from the vehicle owing to missing ownership mapping and absence of consistent identifiers was another issue that was highlighted.

As a result of this, it was expressed that neither producers nor regulators are able to reliably track the origin of batteries, the then-owner or the eventual end-of-life management route these batteries take.



**Why This Matters for India**

It is difficult to enforce EPR in practice without reliable traceability of battery flows and ownership, as this leads to continued leakage into informal and unsafe processing routes, weakens regulatory oversight and creates ambiguity in shouldering the responsibility of safe handling and end-of-life management.

The dominance of informal channels also undermines the effectiveness of national efforts to govern battery waste systematically, as a large share of material remains outside formal compliance and reporting systems.

**Stakeholders Impacted**

- Producers (vehicle OEMs and battery manufacturers)
- Producer Responsibility Organisations (PROs)
- Authorised recyclers and refurbishers
- CPCB and SPCBs
- Fleet operators and large battery owners
- Collection and aggregation networks, including informal sector participants

### 3.1.2. How Battery Aadhaar Can Enable Traceability & Governance

Battery Aadhaar can enable tracebility as each battery would be assigned a unique digital identity that can be used to record basic lifecycle events, such as sale, transfer, servicing, aggregation and recycling. This directly responds to stakeholder calls for a “digital trail” or a record of how the battery moves across different actors.

By linking this identity to custody and ownership records, Battery Aadhaar can enable producers, recyclers and regulators to access consistent information of the origin of batteries, the owners at any point in time, and the eventual end-of-life route the battery takes. This can result in an increased degree of reliability in compliance reporting and reduced dependence on manual documentation and self-reporting.

**Table 3: Current Scenario Versus Scenario With Battery Aadhaar**

| Current Scenario | Scenario With Battery Aadhaar |
|---|---|
| Batteries move through informal channels, with limited documentation. | Battery ownership can be digitally recorded. |
| Recyclers receive batteries with incomplete paperwork. | Custody history can be accessed through digital IDs. |
| Ownership transfers are undocumented. | Transfers can be logged digitally. |
| EPR is reliant on self-reporting. | Compliance can be supported by traceability records. |
| Regulators have a limited system visibility. | Regulators can monitor battery and material flows at the national level. |

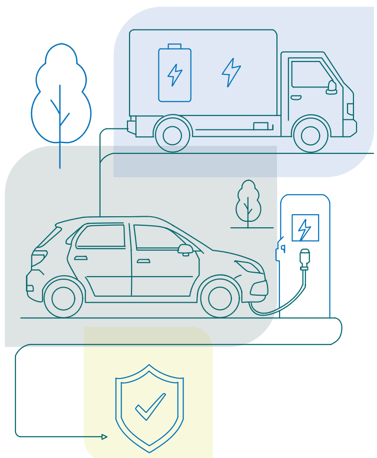
### Policy Linkages

The traceability and governance use cases falling in this thematic area directly support the implementation of the BWMR, 2022, and strengthen the enforcement capabilities of CPCB and SPCBs. These also align with the broader national objectives related to circular economy governance, resource efficiency and environmental protection.

## 3.2. Thematic Area: Circular Economy & Resource Efficiency

### Context and Relevance

A major concern recurring in stakeholder inputs was that batteries were not being utilised to their full technical or economic potential before being dismantled or recycled. It was emphasised that in the absence of reliable information on the condition, chemistry and usage history of a battery, the decisions related to reuse, repurposing or recycling are often made in an ad-hoc manner.



These issues were discussed most frequently in the context of premature recycling, low confidence in second-life applications, unsafe dismantling practices and material losses in informal recycling systems. The use cases presented in this thematic area focus on enabling better lifecycle decision-making and improving resource efficiency across reuse, repurposing and recycling pathways.

### 3.2.1. Use case: Reuse versus Recycling Decision-making

**Core Question**

*Can stakeholders reliably determine whether a battery should be reused, repurposed or recycled, based on its actual condition and history?*

**Current Scenario and its Key Challenges**

The stakeholders primarily described this challenge through concerns related to lack of information on battery SoH, RUL, chemistry and degradation. Multiple inputs indicated that recyclers frequently dismantle or shred battery packs that may be retaining usable capacity, simply because there is no standardised way to assess their condition.

Second-life operators voiced that in the absence of verified performance data, they faced a high degree of uncertainty regarding safety and reliability. As a result, reuse decisions are often disconnected from recycling processes and many batteries that could potentially be refurbished or repurposed are instead routed directly to recycling.

**Why This Matters for India**

Premature recycling leads to loss of usable value and reduces the economic and environmental benefits that could be achieved through extended battery lifecycles. In the absence of systematic reuse decision-making, India is unable to fully leverage batteries for applications such as stationary energy storage and backup power and remains dependent on fresh battery production.

**Stakeholders Impacted**

- Recyclers
- Vehicle OEMs (where routing decisions occur within authorised networks)
- Refurbishers and second-life integrators
- Fleet operators and large battery owners at retirement stage

## 3.2.2. Use-case: Enabling Second Life and Refurbishment

**Core Question**

*Can batteries be safely refurbished and redeployed for second-life applications using credible lifecycle data?*

### Current Scenario and its Key Challenges

This challenge was presented by the stakeholders in the form of concerns related to latent defects, the lack of repair and servicing records and the absence of standardised performance benchmarks. Second-life integrators highlighted that without access to battery history, it is difficult to detect micro-damage, prior misuse and degradation patterns.

Several inputs were made which pointed to the issue that many batteries that could technically be reused were instead being scrapped because refurbishers and buyers were unable to reliably assess their safety or remaining lifespan. This results in limiting the scale of second-life applications and discourages investment in refurbishment infrastructure.

### Why This Matters for India

Second-life batteries can have important applications, such as in distributed energy storage, renewable integration and backup systems. However, without reliable refurbishment pathways, these opportunities remain underutilised and battery value is lost prematurely.

### Stakeholders Impacted

The following stakeholders are directly involved in refurbishing, certifying, deploying or financing second-life battery systems:

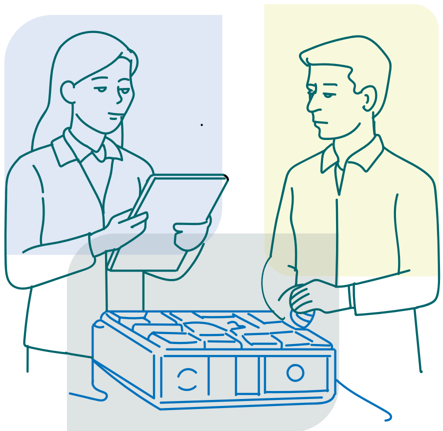
- Refurbishers and second-life integrators
- ESS developers
- Utilities and microgrid operators
- Financiers and insurers
- Commercial and institutional buyers of second-life battery systems

## 3.2.3. Use-case: Recycling Efficiency and Material Recovery

**Core Question**

*Can recycling processes be made safer and more efficient by access to comprehensive information on battery chemistry and composition of batteries?*

**Current Scenario and its Key Challenges**



According to the concerns raised by the stakeholders, they faced challenges related to unsafe dismantling, frequent fires in informal recycling units and low material recovery rates. It was pointed out that a large share of end-of-life batteries in India are handled by the informal sector, often without proper equipment, adherence to safety standards or knowledge of battery chemistry.

Recyclers also shared that batteries often arrive without labels or documentation, forcing them to rely on manual inspection or conservative processing methods. This increases environmental and safety risks and results in significant material loss.

**Why This Matters for India**

Inefficient recycling leads to loss of valuable materials and increases environmental and occupational hazards. Without improvements in recycling efficiency and safety, India remains dependent on imported raw materials and continues to face the risks associated with informal processing.

**Stakeholders Impacted**

The following stakeholders are directly involved in material recovery processes or depend on the quality and safety of recycling operations:

- Authorised recyclers and dismantlers
- Battery manufacturers (where recycled materials re-enter production)

- Vehicle OEMs (in relation to recycled content obligations)
- CPCB and SPCBs

## 3.2.4. How Battery Aadhaar Can Enable Circular Economy & Resource Efficiency

Battery Aadhaar can enable improved circular decision-making by creating a digital record of the condition, chemistry and usage history of a battery throughout its lifecycle. This directly responds to stakeholder concerns regarding the absence of reliable data to guide decisions related to reuse, refurbishment and recycling.

By linking battery identity with performance and handling records, Battery Aadhaar can enable stakeholders to determine whether a battery is suitable for second-life use or should be routed to recycling. For recyclers, access to information on chemistry, composition and hazardous materials can support safer processing and reduce reliance on manual inspection.

By expanding the availability of information across the lifecycle, Battery Aadhaar can help ensure that batteries are utilised to their maximum potential before final material recovery.

**Table 4: Current Scenario Versus Scenario With Battery Aadhaar**

| Current Scenario | Scenario With Battery Aadhaar |
|---|---|
| Reuse decisions are ad-hoc | Decisions can be based on lifecycle data |
| Second-life safety is uncertain | Refurbishment can use performance history |
| Batteries are scrapped prematurely | RUL can be more reliably measured, and usable batteries can be redeployed |
| Recycling is often unsafe | Data on chemistry and hazardous material can improve safety |
| Material recovery is inefficient | Detailed information on chemistry and composition can improve process efficiency |

**Policy Linkages**

The use-cases of circular economy and resource efficiency illustrated in this thematic area align closely with India's evolving policy framework on mineral security, advanced battery manufacturing and waste governance.

Improving recycling efficiency and material recovery directly supports the objectives of the BWMR, 2022, which mandate recycling targets and the use of recycled content. By enabling improved lifecycle visibility and structured tracking of battery flows, Battery Aadhaar can strengthen compliance, improve scientific recycling practices and reduce material leakage into informal channels.

These use-cases also complement the PLI Scheme for Advanced Chemistry Cell (ACC) Battery Storage, which aims to build domestic cell manufacturing capacity. As ACC production scales, reliable access to materials for cathode and anode manufacturing and improved traceability across the value chain will become increasingly important. Battery Aadhaar can support this linkage between end-of-life recovery systems and upstream manufacturing ecosystems, reinforcing domestic value addition.

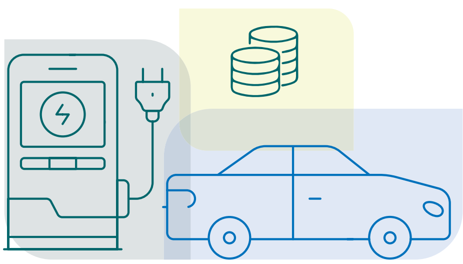
Further, in strengthening recovery and refining pathways for strategic materials, these use-cases align with India's priorities under the Critical Minerals Mission. This Mission seeks to enhance domestic availability and reduce import dependence on key battery minerals. Structured lifecycle tracking and improved recycling efficiency contribute directly to the objectives of this mission.

Together, these linkages position Battery Aadhaar as a digital governance infrastructure that supports the implementation of the BWMR, 2022, strengthens the outcomes under the ACC PLI Scheme and advances the objectives of the Critical Minerals Mission within the broader circular economy framework.

## 3.3. Thematic Area: Market Creation & Financial Enablement

### Context and Relevance

A recurring concern among the inputs provided by the stakeholders was that despite the fact that batteries are emerging as high value components in vehicles and energy systems, the ability to consider these as independent economic assets is limited. The lack of reliable information on battery condition, performance and ownership creates uncertainties for buyers, sellers and financiers, as reported by the stakeholders.



These challenges were discussed primarily in the context of EV resale markets, vehicle financing, battery leasing models and insurance and warranty disputes. The use-cases presented in this thematic area focus on enabling transparency and information availability so that batteries can be valued, transferred and financed more reliably.

## 3.3.1. Use-case: Enabling EV and Battery Resale Markets

**Core Question**

*Can buyers and sellers reliably assess the condition and value of a battery in resale transactions?*

### Current Scenario and its Key Challenges

With regard to this challenge, the stakeholders voiced concerns related to the absence of organised resale markets for EVs and the inability of brokers and platforms to access reliable information on battery quality. A key feedback was that currently, resale transactions depend on visual inspection or informal checks, with no standard mechanism to verify battery health or remaining life.

The stakeholders also pointed out that buyers face a high degree of uncertainty regarding battery performance and sellers are unable to demonstrate asset quality in a credible manner. These issues limit the development of structured resale platforms and make price discovery difficult.

### Why This Matters for India

Without credible resale mechanisms, the total cost of ownership for EVs remains high and consumers remain hesitant to adopt battery-based mobility. Weak resale markets also reduce confidence among fleet operators and financiers, slowing the transition to electric mobility from a broad perspective.

### Stakeholders Impacted

The following stakeholders are directly involved in pricing, transacting and financing used EVs and battery assets:

- Individual EV owners and fleet operators
- Used EV dealers and resale marketplace platforms
- Vehicle OEMs
- Banks and Non-Banking Financial Companies (NBFCs) involved in vehicle financing
- Insurance and financing providers (where residual value affects underwriting or business economics)

## 3.3.2. Use-case: Battery Leasing and Battery-as-a-Service

**Core Question**

*Can batteries be separated from vehicles and offered as leased or service-based assets with reliable performance and risk profiles?*

**Current Scenario and its Key Challenges**

With regard to this challenge, the stakeholders voiced their concerns related to financing constraints, residual value uncertainty, EV resale difficulties and insurance and warranty disputes. However, the discussions of the Working Group unveiled a broader underlying opportunity for service-based and asset-light models, such as battery leasing and BaaS.

In all the consultations, it was stated that although batteries are increasingly high-value assets, these lack an independent identity, reliable performance records and clear ownership mapping. This creates difficulty for financiers and service providers in assessing the long-term asset condition, usage patterns and the residual value.

The synthesis of the discussions of the Working Group indicates that these limitations constrain the viability and scalability of such service-based models. The stakeholders did not explicitly propose leasing or BaaS as policy instruments.

**Why This Matters for India**

Battery leasing and service-based models have the potential to reduce upfront costs for consumers and enable innovative mobility and energy services. However, without the trusted asset identity and performance records, these models cannot be operationalised in a reliable and scalable manner.

**Stakeholders Impacted**

The following stakeholders are directly involved in owning, leasing, financing and operating batteries as independent assets:

- Battery leasing and BaaS providers
- Vehicle OEMs offering service-based battery models
- Battery manufacturers participating in asset-based structures
- Fleet operators and commercial vehicle users
- Financial institutions and investors supporting leased battery assets

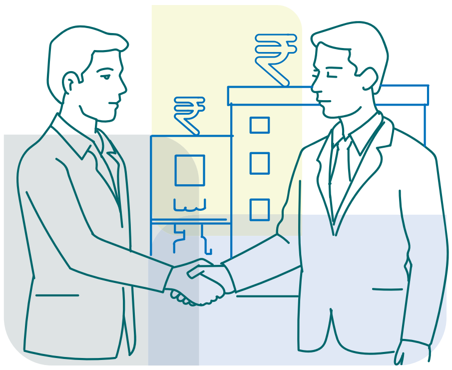
## 3.3.3. Use-case: Financing, Insurance and Risk Assessment

**Core Question**

*Can financiers and insurers assess battery-related risks using credible lifecycle data?*

### Current Scenario and its Key Challenges

Concerns related to vehicle financing, insurance disputes and warranty claims were put forth by the stakeholders while attempting to place the spotlight on this issue. It was pointed out that owing to lack of confidence in battery performance and residual value, financiers are not keen to finance EVs from new manufacturers.



The insurance and warranty providers too placed on record the difficulty they faced in resolving disputes owing to the absence of reliable records for distinguishing between manufacturing defects and improper usage. Without credible asset-level data, risk assessment remains uncertain and largely subjective.

### Why This Matters for India

Limited access to financing and insurance places constraints on the adoption of EVs and battery-based systems. In the absence of transparent information on battery history and condition, financial institutions remain cautious and consumers face higher uncertainty and risk.

### Stakeholders Impacted

The following stakeholders are directly involved in financing, underwriting and bearing risks related to battery assets:

- Banks and NBFCs
- Insurance providers
- Vehicle OEMs (in relation to warranty and product liability exposure)
- Fleet operators and commercial borrowers
- Consumers financing their EVs

### 3.3.4. How Battery Aadhaar can Enable Market Creation & Financial Enablement

Battery Aadhaar can enable market creation by providing each battery with a persistent digital identity and maintaining records of ownership, usage and performance. This directly responds to stakeholder concerns related to the lack of battery-level identification and the absence of trustworthy performance information.

By making verified lifecycle data available, Battery Aadhaar can support increased transparency in resale transactions, enable the separation of battery assets for leasing models and instil greater confidence among financiers and insurers. It can also reduce the information gap faced by market participants and allow batteries to be treated as more reliable economic assets.

**Table 5: Current Scenario Versus Scenario With Battery Aadhaar**

| Current Scenario | Scenario With Battery Aadhaar |
|---|---|
| Battery quality is difficult to verify | Lifecycle data can support evaluation |
| Resale relies on informal checks | Transactions can use digital records for basing resale values |
| Leasing faces high uncertainty | Access to asset usage and performance data can support service models |
| Financing is hesitant | Risk assessment can use performance data |
| Warranty disputes are common | Usage records can support resolution |

**Policy Linkages**

The use-cases on market creation and financial enablement align with the national priorities on EV adoption, the development of green finance and financial inclusion. These also support the broader objectives of reducing the total cost of ownership, encouraging private capital participation and strengthening the economic viability of battery-based mobility and energy systems.

## 3.4. Thematic Area: Risk, Safety & Consumer Protection

### Context and Relevance

Some of the recurring themes that emerged in the discussions and consultations with the stakeholders were those of warranty disputes, insurance risk assessment and safety compliance. Batteries are high-value and safety-sensitive components whose failure can result in financial loss, operational disruption and reputational risk.

It was pointed out by the stakeholders that in the absence of reliable lifecycle information, it is often difficult to determine battery condition, degradation patterns, and usage history. This creates ambiguity in warranty decisions, increases insurance risk perception and weakens consumer confidence.

In addition, currently, safety and quality compliance processes rely heavily on periodic inspections and documentation review, with limited integration of verifiable lifecycle performance data.

The use-cases in this thematic area focus on improving transparency, accountability and safety verification through structured information on battery lifecycle.

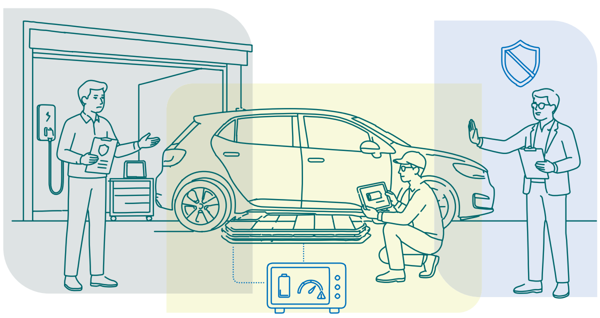
### 3.4.1. Use-case: Warranty & Liability Transparency

**Core Question**

*Can availability of and accessibility to transparent and verifiable information on the battery lifecycle lead to an improvement in fairness, efficiency and accountability in warranty and liability determination?*

### Current Scenario and its Key Challenges

This challenge was presented by the stakeholders primarily in the context of warranty claims, insurance disputes, and risk assessment. When battery failures occur, it is often difficult to determine whether the cause is related to manufacturing defects, normal degradation or usage-related factors.



In many cases, battery condition and usage history are not readily accessible in a consolidated and verifiable format. This may result in the following conditions:

- Warranty claims may involve prolonged dispute resolution.
- Liability attribution can become subjective.
- Insurance underwriting remains cautious.
- Risk perception remains high, particularly for new OEMs and second-life batteries.

The refurbishers also noted that the absence of reliable lifecycle records places limitations on their ability to offer graded or tiered warranty products for reused batteries.

### Why This Matters for India

As EV adoption expands, it is essential to have transparent systems for warranty and liability in place with the objectives of protecting the consumer and instilling confidence in the market.

Without credible and accessible battery history records:

- Consumers face uncertainty regarding coverage.
- OEMs face elevated dispute risk.
- Insurers face difficulty in pricing risk.
- Second-life markets face trust barriers.

Improved transparency in warranty can help reduce disputes, strengthen accountability and support structured resale and reuse markets.

### Stakeholders Impacted

The following stakeholders are directly involved in warranty provision, claim adjudication and liability determination:

- Vehicle OEMs and battery manufacturers
- Insurance providers
- Fleet operators
- Refurbishers offering second-life warranties
- Consumers filing warranty claims

## 3.4.2. Use-case: Facilitate Safety/Quality Certification and Compliance Verification

**Core Question**

*Instead of relying solely on periodic physical audits, can the verification of battery safety and quality compliance be supported through verifiable lifecycle information?*

### Current Scenario and its Key Challenges

The stakeholders pointed out that the safety and quality compliance of batteries were largely verified through periodic audits and documentation review. However, operational patterns and performance history are not systematically integrated into certification and compliance processes. In addition, fragmented data structures and limited standardisation make it difficult for authorised assessors to access consistent lifecycle information. This makes verification of compliance a time-consuming process and partially dependent on manual checks.

### Why This Matters for India

With the rapid expansion of battery deployment across mobility and stationary applications, it is critical to ensure seamless compliance to safety.

Data-backed certification mechanisms can improve regulator confidence, reduce audit costs and enable faster verification cycles while strengthening overall consumer protection.

### Stakeholders Impacted

The following stakeholders are directly involved in safety certification, compliance verification and regulated quality assurance processes:

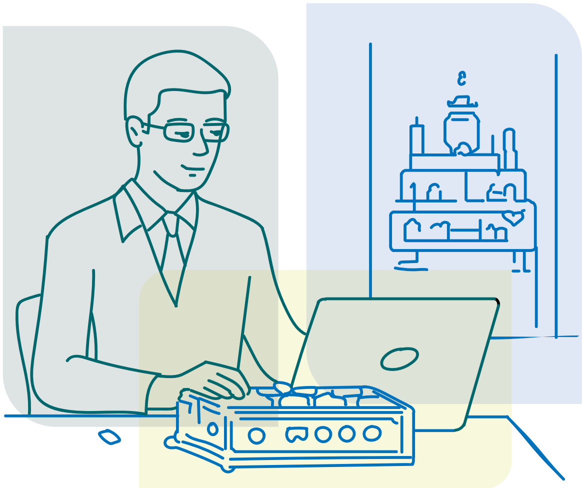
- Certification bodies and authorised testing agencies
- Vehicle OEMs and battery manufacturers
- Refurbishers and second-life integrators
- Relevant regulatory authorities overseeing safety standards
- Commercial and institutional buyers requiring certified systems

## 3.4.3. Use-case: Strengthening Import Verification and Quality Assurance

**Core Question**

*Can imported battery cells and packs be verified for quality, safety and compliance prior to their entry into the domestic supply chain?*

### Current Scenario and its Key Challenges



A key concern raised by the stakeholders was that importers often struggled with a lack of visibility into supplier performance and product quality at source. This, in turn, hindered proactive quality management and risk mitigation. Importers typically rely on documentation provided by overseas suppliers. There is no structured digital mechanism to independently verify conformity certifications, sourcing disclosures or product-level information prior to shipment.

Variations in international standards and documentation practices further complicate assessment processes. In the absence of harmonised identification and verification systems, quality assurance remains reactive, with unsuitable or non-compliant batches being identified only after arrival at times. This increases the risk of performance variability, raises safety concerns and generates avoidable logistics costs associated with transporting defective inventory.

### Why This Matters for India

India remains significantly dependent on imported battery cells and upstream materials. Weak verification mechanisms at the point of entry can introduce systemic risks into the domestic battery ecosystem, affecting OEM reliability, consumer safety and lifecycle performance outcomes.

Strengthening import quality assurance is, therefore, critical for supply chain resilience, industrial competitiveness and effective downstream lifecycle management.

### Stakeholders Impacted

The following stakeholders are directly involved in importing, verifying and relying on the quality of battery cells and packs entering the domestic market:

- Battery OEMs and pack assemblers importing cells
- Importers and authorised distributors
- Vehicle OEMs dependent on imported battery components
- Customs authorities and relevant standards enforcement agencies

## 3.4.4. How Battery Aadhaar Can Enable Risk, Safety & Consumer Protection

Battery Aadhaar can strengthen risk management and consumer protection by linking each battery to verifiable lifecycle information that remains accessible across ownership and application transitions.

The stakeholders raised concerns that fragmented or inaccessible information on battery history often leads to warranty disputes, hesitation in insurance and ambiguity in liability. By enabling role-based access to relevant static and dynamic lifecycle information, Battery Aadhaar can support a more objective assessment of the battery condition, degradation patterns and usage history. This can also help reduce the time taken for dispute resolution and lead to fairness in decision-making on warranty and liability.

In the context of insurance and financing, improved visibility into the history of battery performance can help reduce information asymmetry and support more informed risk assessment.

In safety certification and compliance verification, lifecycle traceability can complement periodic audits by providing evidence of operational patterns over time, thereby strengthening accountability and regulatory oversight.

By mandating that international suppliers provide digitally verifiable information prior to shipping, importers and OEMs can conduct remote quality checks and screen batches before dispatch. This would enable a virtual inspection of relevant product records—including available performance logs or last recorded battery condition—and allow unsuitable or non-compliant consignments to be rejected at source. Such proactive screening will help reduce downstream risks and avoid unnecessary shipping costs associated with an unusable inventory.

By putting in place consent-based and role-based access architecture, Battery Aadhaar can help strengthen transparency while preserving data governance safeguards, thereby reinforcing trust across the battery ecosystem.

**Table 6: Current Scenario Versus Scenario With Battery Aadhaar**

| Current Scenario | Scenario With Battery Aadhaar |
|---|---|
| Warranty and liability disputes rely on fragmented or manual records | Verifiable lifecycle information supports objective claim assessment |
| Insurance underwriting is cautious due to limited visibility into battery condition | Role-based access to performance history supports informed risk pricing |
| Liability attribution can be subjective | Usage and degradation records improve accountability |
| Safety compliance depends largely on periodic audits | Lifecycle traceability complements audits with evidence over time |
| Consumer confidence is affected by uncertainty | Transparency in battery history strengthens trust |
| Supplier information is verified through documentation only | Digitally verifiable disclosures by the supplier are made prior to shipment |

## 3.5. Thematic Area: Climate, ESG & Global Integration

### Context and Relevance

Stakeholder consultations highlighted the issue of increasing regulatory and market expectations around lifecycle emissions reporting, responsible sourcing and supply chain transparency. As battery deployment expands across mobility and stationary applications, questions related to carbon footprint, material origin and ESG compliance are becoming more prominent.

The stakeholders noted that battery-related environmental disclosures are currently fragmented across the supply chain. A consolidated mechanism to link emissions data, sourcing disclosures and compliance documentation to individual battery units across their lifecycle does not exist.

The lack of harmonised standards also complicates the process of alignment with emerging international battery passport frameworks and global sustainability reporting requirements.

The use-cases in this thematic area focus on enabling structured lifecycle emissions reporting and harmonisation with international battery passport systems.

### 3.5.1. Use-case: Lifecycle Emissions Reporting to Regulators/Carbon Credit and ESG Reporting Enablement

**Core Question**

*Can structured battery lifecycle information support credible emissions accounting and ESG reporting?*

**Current Scenario and its Key Challenges**

The stakeholders pointed out that lifecycle emissions data—comprising information on manufacturing emissions, sourcing disclosures and end-of-life processing—is not systematically consolidated at the battery level.

Environmental reporting often depends on aggregated corporate disclosures rather than asset-level traceability. This limits the ability of regulators, investors and financial institutions to verify the claims related to carbon footprint, recycled content or responsible sourcing.

In addition:

- Supply chain due diligence reporting is not uniformly structured.
- Upstream sourcing disclosures may not be consistently accessible.
- Reporting formats vary across actors and jurisdictions.

As a result, ESG reporting remains fragmented and difficult to verify at the battery lifecycle level.

**Why This Matters for India**

As India expands EV deployment and battery manufacturing capacity, credible lifecycle emissions reporting will be critical to ensure the following:

- Regulatory oversight
- Access to green finance
- Participation in carbon markets
- International trade alignment

Without structured lifecycle data, sustainability claims may face verification challenges, potentially affecting investor confidence and global competitiveness.

### Stakeholders Impacted

The following stakeholders are directly involved in lifecycle emissions disclosure, ESG reporting and sustainability-linked financing:

- Battery manufacturers
- Vehicle OEMs
- Relevant regulatory authorities overseeing environmental reporting
- Financial institutions and ESG-focused investors
- Export-oriented manufacturers subject to international disclosure requirements

## 3.5.2. Use-case: Harmonisation With International Battery Passport Systems

**Core Question**

*Can India's Battery Aadhaar framework align with the emerging global battery passport standards to enable interoperability and reduce duplicative reporting?*

**Current Scenario and its Key Challenges**

During discussions of the Working Group on Battery Aadhaar, the stakeholders pointed out that the absence of harmonised standards would create complexity for companies operating across jurisdictions. International markets are increasingly moving towards digital battery passport systems that require structured disclosure of lifecycle and sustainability information. Without alignment in identification formats, reporting templates and data schemas, Indian manufacturers may face the burden of duplicative reporting or compliance mismatch when exporting batteries or EVs.

The variation in import/export data requirements across jurisdictions will further complicate traceability and compliance processes.

### Why This Matters for India

Alignment with international battery passport systems can:

- Reduce reporting fragmentation
- Support export competitiveness
- Facilitate supply chain transparency
- Enable mutual recognition of compliance data

Ensuring interoperability from the outset can position India's Battery Aadhaar framework as compatible with evolving global standards.

**Stakeholders Impacted**

- Export-oriented OEMs and battery manufacturers
- Regulators
- International trade partners
- Investors and sustainability auditors

## 3.5.3. How Battery Aadhaar can Enable Climate, ESG & Global Integration

Battery Aadhaar can support the objectives of both climate and ESG by linking each battery to structured lifecycle information related to manufacturing, sourcing and end-of-life processing.

By enabling role-based access to relevant environmental and supply chain disclosures, Battery Aadhaar can improve the traceability of sustainability claims and support more credible reporting for regulators, investors and financial institutions.

At the system level, standardised digital identification and harmonised data structures can help reduce reporting fragmentation and facilitate interoperability with international battery passport frameworks.

Through consistent data schemas and lifecycle traceability, Battery Aadhaar can strengthen transparency across the battery value chain while supporting alignment with global sustainability and trade requirements.

**Table 7: Current Scenario Versus Scenario With Battery Aadhaar**

| Current Scenario | Scenario With Battery Aadhaar |
|---|---|
| Emissions and sourcing disclosures are fragmented | Emissions and sourcing disclosure schemas can be standardised |
| ESG reporting relies on aggregated corporate disclosures | Asset-level traceability supports verifiable reporting |
| Reporting formats vary across actors | Standardised data structures improve consistency |
| Requirement of international data framework alignment for export | Interoperability with global passport systems is facilitated |
| Sustainability claims are difficult to verify | Structured lifecycle records improve credibility |

Overall, the use-cases underline Battery Aadhaar's potential to move beyond data collection and create tangible improvements in how decisions are made across the battery value chain. By making lifecycle information traceable, verifiable and usable, it can improve efficiency, reduce uncertainty and enable more accountable action by stakeholders across the ecosystem.

4

# Priority Data Attributes Identified for Battery Aadhaar

## 4.1. Rationale for Identifying Priority Data Attributes

The effectiveness of the Battery Aadhaar framework depends not only on the articulation of use-cases but also on the identification of a clear and implementable set of data attributes required to enable these use-cases. During the stakeholder consultations, participants were requested to identify the specific data fields necessary to address the operational, regulatory, safety, circularity and market related use-cases described in Section 3.

The identification of data attributes followed a structured methodology. For each use-case, the stakeholders were asked to specify the following:

- The exact data attribute required
- The unit of measurement
- The current data owner

Importantly, the identification of current data owners was based on stakeholder submissions and reflects the current data custody realities across the battery value chain. This is critical from a policy design perspective. A national Battery Aadhaar framework must operate within a distributed data ecosystem in which:

**Vehicle OEMs** generate and control pack-level performance, warranty and manufacturing data.

**Battery OEMs** generate and control cell-level chemistry, sourcing and manufacturing data.

**Fleet operators and consumers** generate first-life usage and telemetry data.

**Recyclers** generate end-of-life processing and material recovery data.

**Refurbishers** generate reuse and lifecycle transition data.

Recognising current data ownership structures allows policymakers to design governance, consent architecture, interoperability standards and role-based access frameworks that are realistic and implementable.

### 4.1.1. List of Data Attributes Identified by Members of the Working Group on Battery Aadhaar

Table 8 lists the data attributes identified by the stakeholders during consultations, along with information on the unit and the respective current data owners.

**Table 8: Data Attributes, Units and Current Data Owners**

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 1 | Change of state | A recorded update to the battery's lifecycle status, indicating its current phase, such as first-life (active deployment), second-life (repurposed application), retired amd recycled | Text | Current economic operator (OEM/ refurbisher/recycler, depending on stage) |
| 2 | % of recycled content (metal-wise, w/w) | The percentage, by weight, of each metal (e.g., cobalt, lithium, nickel) in the battery's active materials sourced from recycled rather than virgin feedstocks | % w/w | Battery OEM |
| 3 | BCF | The total GHG emissions associated with the battery across its lifecycle, including raw material extraction, manufacturing, transport and end-of-life | kg $CO_2$e/ kWh | Battery OEM/importer |
| 4 | Battery chemistry | The electrochemical composition of the battery, specifying the active materials used in the cathode and anode (e.g., LFP, NMC, Lithium Cobalt Oxide (LCO)) | Text | Battery OEM |

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 5 | Change of structure | A record of any physical or configurational modification made to the battery pack, such as cell replacement, module reconfiguration and reassembly, during refurbishment | Text | Refurbisher |
| 6 | Current SoH | A real-time or periodically updated indicator of the battery's present condition, relative to its original rated capacity, expressed as a percentage; reflects cumulative degradation due to cycling and ageing | % | Vehicle OEM |
| 7 | Cycle count in first-life usage | The total number of complete charge–discharge cycles the battery has undergone during its first-life deployment; a primary indicator of electrochemical ageing used to assess residual capacity and RUL | Number of cycles | Vehicle OEM |
| 8 | Date of manufacture of the battery | The date on which the battery pack was assembled and completed at the manufacturing facility; used to determine battery age, assess warranty eligibility and support lifecycle traceability | Date | Battery OEM |
| 9 | Date of retail use of the battery | The date on which the battery was first placed into service by an end user or deployed in a vehicle; marks the commencement of the operational phase of the battery | Date | Vehicle OEM |

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 10 | Date of retirement of battery | The date on which the battery was formally removed from its application and designated as no longer suitable for its original use; initiates the transition to second-life assessment or end-of-life processing | Date | Last holder/fleet/OEM/recycler |
| 11 | Details of suppliers, audit reports, certifications, responsible sourcing declarations | Documentation establishing the identity and due diligence compliance of upstream material and component suppliers; includes audit reports, certifications and responsible sourcing declarations for critical raw materials | Document uploads | Battery OEM |
| 12 | Dismantling information | Structured documentation providing instructions and specifications for the safe and efficient disassembly of the battery pack at end-of-life; includes removal sequences, fastening methods and material separation guidance | Document uploads | Battery OEM |
| 13 | Distance travelled in first-life application | The total cumulative distance (in kilometres) covered by the vehicle in which the battery was deployed during its operational period | km | Vehicle OEM/fleet operator |
| 14 | Mass balance of the pack | The total weight of the battery pack, including cells, modules, casing, connectors and BMS | kg or % | Vehicle OEM/battery OEM |

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 15 | No. of deep discharges | The number of instances in which the battery was discharged to a very low SoC, significantly below its recommended operating threshold. Deep discharges accelerate electrochemical degradation and are used as an indicator of battery stress and RUL. | Number | Vehicle OEM |
| 16 | Ownership history | A chronological log of all legal owners or custodians of the battery, from manufacture to its current holder | Text log/ record | Economic operator updating registry |
| 17 | Pending lifecycle (estimated remaining cycles) | An estimate of the number of charge–discharge cycles the battery can complete before its capacity falls below an acceptable threshold, based on current SoH, usage profile and chemistry-specific degradation models | Estimated cycles | Vehicle OEM/Battery analytics provider |
| 18 | Quantity of recycling material extracted | The quantity (in kilograms) of each recoverable material—such as lithium, cobalt, nickel, copper, and aluminium—extracted from a battery during the recycling process | kg | Recycler |
| 19 | Safety test certificates | Formal documentation confirming that the battery has been tested and certified against applicable safety standards by an accredited testing body | Document uploads | Battery OEM/Vehicle OEM |

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 20 | Temperature anomalies during first-life deployment | A record of instances where the battery's operating temperature exceeded defined safe thresholds during first-life use, expressed as maximum deviation in degrees Celsius and the number of such events; usually associated with accelerated degradation and safety risks | Degree Celsius (°C) (max deviation and number of events) | Vehicle OEM |
| 21 | Type of vehicle deployed in | The model name and category of the vehicle (e.g., two-wheeler, passenger EV, commercial EV) in which the battery was deployed; provides context for usage intensity, duty cycle and degradation profile | Model name | Vehicle OEM |
| 22 | Usage capacity profile of battery (capacity fade/ degradation, % or Ah) | A record of the battery pack's capacity over time, capturing the rate of capacity fade relative to its original rated capacity; provides a longitudinal view of pack-level performance | % or Ah | Vehicle OEM/fleet operator |
| 23 | Usage capacity profile of cell (capacity fade/ degradation, % or Ah) | A record of individual cell-level capacity over time, capturing the rate of capacity fade from the original rated value | % or Ah | Vehicle OEM |
| 24 | Warranty repairs | A record of maintenance, repair or component replacement activities carried out under the battery's warranty; includes the number of interventions and relevant documentation | Number/ details/ document uploads | Vehicle OEM |

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 25 | Warranty status | An indicator of whether the battery is currently covered under a valid manufacturer or OEM warranty (Active) or whether the warranty period has lapsed (Expired) | Status: Active/ Expired | Vehicle OEM |
| 26 | SoC | The current level of electrical energy stored in the battery expressed as a percentage of its total capacity at a given moment, analogous to a fuel gauge reading | % | Vehicle OEM |
| 27 | Charge/ discharge events | A log of individual charging and discharging events, recording the number of such occurrences over the battery's operational lifetime; tracked alongside cycle count to provide detailed operational history and support degradation modelling | Number of events | Vehicle OEM |
| 28 | Firmware/BMS version | The version number or identifier of the software running on the BMS, which controls and monitors battery operation, safety, and data logging; relevant for assessing data reliability, diagnostics compatibility and accuracy of exported performance parameters | Version number/ text | Vehicle OEM |
| 29 | Change of passport ownership | A formal record of the transfer of digital passport custodianship from one economic operator to another (e.g., from a vehicle OEM to a refurbisher or recycler) | Text log/ record | Vehicle OEM/ refurbisher |

| S.No. | Data Attribute | Description | Unit | Current Data Owner |
|---|---|---|---|---|
| 30 | Date of manufacture of the cell | The date on which the individual battery cell(s) within the pack were manufactured | Date | Battery OEM |
| 31 | Country of origin of raw materials, sources of raw materials, ESG certifications | Documentation identifying the geographic origin of critical raw materials (e.g., lithium, cobalt, nickel) used in battery manufacturing, along with ESG certifications from upstream suppliers | Document uploads | Battery OEM |
| 32 | Presence of hazardous materials (% by weight) | The percentage, by weight, of hazardous substances, such as heavy metals, toxic electrolytes and restricted chemical compounds, present in the battery; required for safe handling, transportation and disposal | % by weight | Battery OEM |
| 33 | Symbols, labels and documentation of conformity | Standardised markings, labels and formal documentation confirming that the battery complies with applicable safety, performance and regulatory standards in its intended market (e.g., BIS certification marks in India; CE marking in the EU); includes declarations of conformity and relevant test documentation | Text/ Document uploads | Battery OEM |
| 34 | Material composition (w/w) | A declaration of the percentage, by weight, of each primary material or substance present in the battery, including cathode/ anode active materials, electrolyte components and structural materials | % w/w | Battery OEM |

While the data attributes listed in this section have been identified during structured consultations under the aegis of the Battery360, further technical work will be required before undertaking formal implementation. Specifically, standardised definitions, units of measurement, calculation methodologies (for parameters such as SoH and degradation metrics) and clearly specified documents and their formats for uploads (e.g., audit reports, certifications, sourcing disclosures) will need to be developed. In addition, alignment on reporting templates, exchange frequency and data schema harmonisation across OEMs, battery manufacturers, fleet operators, recyclers and regulators will be essential to ensure consistency and interoperability. The attributes presented in this report, therefore, represent a consolidated and prioritised functional dataset that will require subsequent technical standardisation and governance-level refinement prior to any operational rollout.

From a policy perspective, this distribution confirms that battery-relevant data is inherently decentralised. Any national Battery Aadhaar architecture must, therefore, be interoperable, role-based and capable of integrating multiple custodians without requiring forced data centralisation.

### 4.1.2. Mapping Data Attributes to Priority Use-Cases

Following consolidation, the Working Group on Battery Aadhaar mapped the identified data attributes against the priority use-cases identified in this section. This step ensured that the proposed dataset is functionally anchored in clearly articulated system needs.

The mapping exercise served three purposes:

- **Minimum Dataset Identification** – It enabled identification of the smallest viable dataset required to unlock high-impact use-cases, such as EPR compliance, reuse decision-making and financing enablement.
- **Overlap and Synergy Assessment** – Several attributes (e.g., current SoH, cycle count, temperature anomalies) support multiple thematic areas, including circularity, risk assessment, resale markets and safety certification. This strengthens the case for their prioritisation.
- **Implementation Sequencing** – By linking attributes directly to use-cases, policymakers can prioritise phased rollout, based on regulatory urgency (e.g., EPR traceability) versus market enablement (e.g., resale and financing).

## 4.1.3. Thematic Mapping of Priority Data Attributes

Table 9 reproduces the structured thematic mapping of priority data attributes.

**Table 9: Priority Use Cases and Data Attributes for Battery Aadhaar**

| Thematic Area | Use-Case (Report) | Data Attribute |
|---|---|---|
| Traceability & Governance | **EPR Compliance and Informal Battery Flows** | Change of state |
| | | % of recycled content |
| | | Change of passport ownership |
| | | Change of structure |
| | | Date of retail use of the battery |
| | | Ownership history |
| | | Quantity of recycling material extracted |
| | | Country of origin of raw materials, sources of raw materials, ESG certifications |
| | | Symbols, labels and documentation of conformity |
| Circular Economy & Resource Efficiency | **Reuse vs Recycling Decisions** | Current SoH |
| | | Cycle count in first-life usage |
| | | Date of manufacture of the battery |
| | | Date of manufacture of the cell |
| | | Distance travelled in first-life application |
| | | Mass balance of the pack |
| | | Pending lifecycle |
| | | Temperature anomalies during first-life deployment |
| | | Type of vehicle deployed in |
| | | Usage capacity profile of cell/capacity fade |

| Thematic Area | Use-Case (Report) | Data Attribute |
|---|---|---|
| | **Enabling Second-life & Refurbishment** | Current SoH |
| | | Cycle count in first-life usage |
| | | Date of manufacture of the battery |
| | | Date of manufacture of the cell |
| | | Date of retirement of battery |
| | | Dismantling information |
| | | Distance travelled in first-life application |
| | | No. of deep discharges |
| | | Temperature anomalies during first-life deployment |
| | | Type of vehicle deployed in |
| | | Usage capacity profile of cell/capacity fade |
| | | Warranty repairs |
| | **Recycling Efficiency & Material Recovery** | Battery chemistry |
| | | Material composition |
| Market Creation & Financial Enablement | **Enabling EV and Battery Resale Markets** | Battery chemistry |
| | | Current SoH |
| | | Cycle count in first-life usage |
| | | Date of manufacture of the battery |
| | | Date of retirement of battery |
| | | Distance travelled in first-life application |
| | | No. of deep discharges |
| | | Ownership history |

| Thematic Area | Use-Case (Report) | Data Attribute |
|---|---|---|
| | | Safety test certificates |
| | | Temperature anomalies during first-life deployment |
| | | Type of vehicle deployed in |
| | | Usage capacity profile of battery/capacity fade |
| | | Warranty repairs |
| | | Warranty status |
| | **Battery Leasing and BaaS** | Ownership history |
| | | Cycle count in first-life usage |
| | | Distance travelled in first-life application |
| | | No. of deep discharges |
| | | Temperature anomalies during first-life deployment |
| | | Current SoH |
| | **Financing, Insurance & Risk Assessment** | Current SoH |
| | | Cycle count in first-life usage |
| | | Date of manufacture of the battery |
| | | Date of manufacture of the cell |
| | | Distance travelled in first-life application |
| | | Type of vehicle deployed in |
| | | Usage capacity profile of cell/capacity fade |

| Thematic Area | Use-Case (Report) | Data Attribute |
|---|---|---|
| Risk, Safety & Consumer Protection | **Warranty & Liability Transparency** | Current SoH |
| | | Cycle count in first-life usage |
| | | Date of manufacture of the battery |
| | | Date of manufacture of the cell |
| | | Distance travelled in first-life application |
| | | Type of vehicle deployed in |
| | | Usage capacity profile of cell/capacity fade |
| | **Facilitate Safety/ Quality Certification and Compliance Verification** | Relevant audit reports, testing and certification reports, responsible sourcing declarations |
| | **Strengthening Import Verification and Quality Assurance** | Details of the suppliers, audit reports, testing and certification reports |
| | | Date of manufacture of the battery |
| | | Date of manufacture of the cell |
| | | Date of import of cell/battery |
| Climate, ESG & Global Integration | **Lifecycle Emissions Reporting to Regulators/ Carbon Credit and ESG Reporting Enablement** | BCF |
| | **Harmonisation with international Battery Passport frameworks** | Details of the suppliers, audit reports, certifications, responsible sourcing declarations |

### 4.1.4. Policy Implications

The structured identification and mapping of data attributes highlight three key design considerations for a national Battery Aadhaar framework:

1. **Interoperability Over Centralisation**: Data ownership remains distributed; policy must enable secure, standardised exchange rather than full data transfer.
2. **Role-based Access and Consent Architecture**: Not all actors require full data visibility; differentiated access is necessary.
3. **Standardisation and Harmonisation**: Units, formats and reporting structures must be standardised to ensure consistency across OEMs, fleets, recyclers and regulators.

Together, the priority dataset identified through this exercise provides an evidence-based foundation for the next phase of development of Battery Aadhaar, including digital architecture design, governance frameworks and pilot implementation.

5

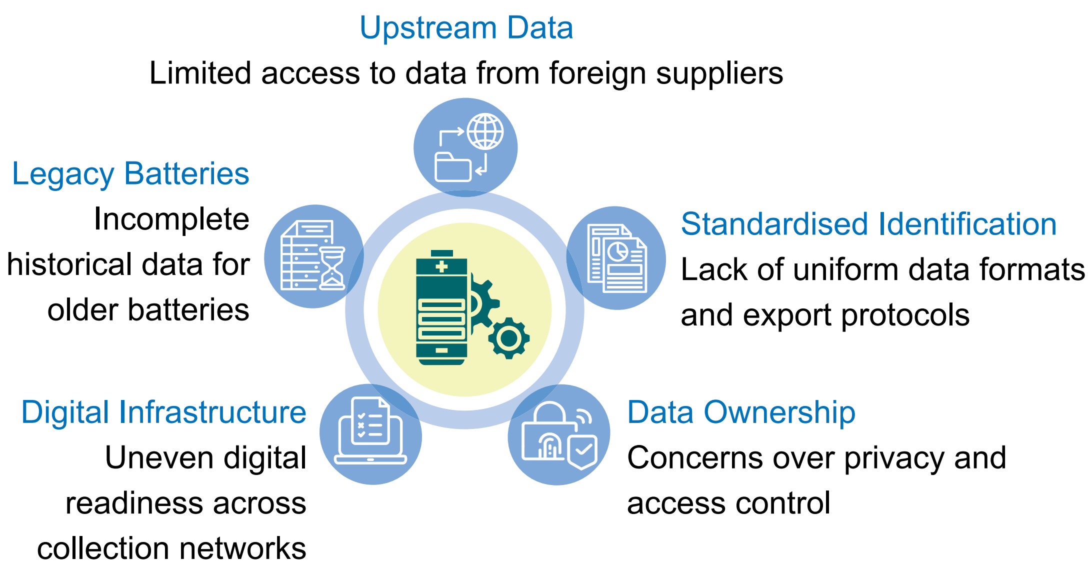
# Challenges and Recommendations

There was unanimity among the stakeholders on the need for Battery Aadhaar. Its implementation, however, will require addressing a set of operational and governance constraints that directly affect the design and deployment of the system.

The challenges presented in Section 5.1 relate specifically to the implementation of a national battery identity and lifecycle tracking system. The recommendations have been derived from the mitigation measures proposed by the stakeholders.

## 5.1. Challenges in Implementation of Battery Aadhaar

### Challenges in Battery Aadhaar Implementation



### 5.1.1. Absence of Standardised Identification and Data Export Protocols

Battery Aadhaar will require batteries to be digitally identified and key lifecycle data to be uploaded in a consistent and comparable format. However, during the stakeholder consultations, it was pointed out that battery data is currently being stored across different OEM and manufacturer systems in non-uniform formats.

Performance parameters, such as current SoH, cycle count, temperature history and usage profiles, are generated by OEMs but not exported using a common structure. Similarly, chemistry, recycled content and material composition data are held by battery manufacturers but are not always available in standardised, machine-readable templates.

As a result, even if Battery Aadhaar assigns a new unique identity in the future, integrating data from different actors into a single national system will require clearly defined standards on the following:

- The essential data fields that must be shared
- Methodologies for estimation of these data fields
- The format in which these will be uploaded

Without harmonised identification and export standards, implementation may face interoperability challenges and inconsistent data quality across participants.

**Recommendations**

- Define a minimum exportable dataset for priority use-cases (e.g., SoH, cycle count, temperature history, chemistry, recycled content).
- Create standardised formats for SoH and BMS log exports to ensure consistency across manufacturers.
- Establish clear definitions and calculation methodologies for commonly used performance parameters to improve comparability.

For standardised and interoperable ESG reporting, the stakeholders proposed the following steps:

- Develop a national dashboard with a standardised data schema for lifecycle emissions reporting.
- Mandate structured manufacturer uploads of relevant disclosures.
- Enable audited reporting and third-party verification mechanisms.
- Standardise reporting templates and data retention formats to ensure consistency.
- Encourage mutual recognition agreements to reduce duplicative reporting across jurisdictions.

### 5.1.2. Data Ownership, Consent and Controlled Access

Battery lifecycle information includes performance parameters (such as SoH and cycle count), manufacturing disclosures (such as chemistry and sourcing information), usage history and end-of-life records. Some of these data fields may be commercially sensitive, while others—particularly usage or location-linked information—may fall within the scope of privacy regulations, including India's Digital Personal Data Protection Act (DPDP Act), 2023.

This is a governance challenge in implementing Battery Aadhaar. The system cannot assume that all lifecycle data can be freely shared or made visible to all participants.

Battery Aadhaar will need to clearly define the following:

- Which data fields are mandatory for regulatory compliance
- Which data fields require user or owner consent before disclosure
- How role-based access controls restrict visibility to authorised stakeholders

Without a clearly defined consent and access framework, data sharing may lead to resistance or legal uncertainty, thereby affecting implementation.

The stakeholders at the workshop on Battery Aadhaar proposed the following measures:

- Build a national consent architecture, enabling secure data-sharing across stakeholders.
- Implement role-based access mechanisms to ensure that only authorised stakeholders can view specific data fields.
- Develop a standardised Application Programming Interface (API) framework for sharing battery data points that have been agreed upon.
- Formalise mutual data-sharing agreements between ecosystem participants, with clarity on data collection frequency and granularity.

These measures would enable lifecycle traceability while maintaining commercial safeguards and privacy compliance.

### 5.1.3. Digital Infrastructure Constraints Across Collection Networks

Battery Aadhaar relies on digital logging of lifecycle events such as sale, transfer, aggregation, refurbishment and recycling. However, digital readiness across battery collection and reverse-logistics networks is uneven. This was pointed out during the stakeholder consultations.

A significant share of end-of-life batteries move through small dealers, informal collectors and semi-urban or rural aggregation points. The stakeholders identified several challenges, including the following:

- Limited internet connectivity in certain regions
- Lack of QR scanning devices or digital tools among small collectors
- Damaged or missing labels disrupting traceability
- Inability to support real-time data updates

If custody transfers are not digitally recorded at each stage, the integrity of the Battery Aadhaar traceability chain may weaken.

Implementation will, therefore, require system design that accommodates varying levels of digital capacity, including mechanisms for offline data capture and, later, synchronisation.

The stakeholders proposed the following measures:

- Design a hybrid online–offline Battery ID system that allows transactions to be recorded offline and synchronised when connectivity is restored.
- Provide low-cost QR scanners, shared "community devices" or lightweight mobile applications to enable participation by small collectors.
- Introduce scan-based incentives or higher return fees for collection partners who reliably log battery transactions into the system.
- Establish structured battery collection centres, including government-supported intake points, where complete battery packs can be formally received, scanned and registered into the Battery Aadhaar system.

### 5.1.4. Legacy Batteries and Incomplete Historical Data

The introduction of Battery Aadhaar in set to take place in an ecosystem where a large number of batteries are already in circulation. Many of these legacy batteries do not have embedded digital identifiers or retrievable lifecycle records.

The stakeholders pointed out that the key data fields required for priority use-cases—such as SoH, cycle count, temperature history, and usage profiles—may not be consistently available for older batteries. Telemetry capability varies across platforms, and batteries arriving through informal channels may lack documentation.

As a result, the implementation of Battery Aadhaar cannot assume complete historical data availability.

**Recommendations**

- The system will need to define how legacy batteries are registered, how missing fields are handled and whether diagnostic estimation mechanisms are required when the original data is unavailable.
- Managing this transition from partial to structured data availability is a key consideration for implementation.

### 5.1.5. Limited Access to Upstream Data from Foreign Cell Suppliers

Several priority use-cases—including import verification, supply chain due diligence and lifecycle emissions reporting—require upstream data, such as cell manufacturing details, country of origin of raw materials, supplier certifications and carbon footprint disclosures.

During discussions, the stakeholders noted that such information is often generated outside India and may not be available in a standardised, digitally structured format. Importers typically rely on documentation provided by foreign suppliers, and reporting requirements vary across jurisdictions. This creates an implementation constraint. If Battery Aadhaar integrates upstream data fields, mechanisms will be required to define reporting templates, verification processes and alignment with international disclosure standards.

In the absence of harmonised international data frameworks, integrating foreign supplier data into a national digital registry may require phased implementation and coordinated engagement with trade and regulatory partners.

To address the constraints in obtaining upstream cell-level data from foreign suppliers, the stakeholders proposed collaboration on international agreements and standardisation of import/export data requirements.

In implementation terms, this implies:

- Prioritising domestically accessible data fields in early phases
- Gradually incorporating upstream supplier certifications and sourcing disclosures
- Encouraging mutual recognition agreements to reduce duplicative reporting burdens

A phased approach enables the gradual strengthening of supply chain transparency.

The challenges and measures outlined above reflect stakeholder-identified pathways for operationalising Battery Aadhaar. Implementation will require coordinated action across standardisation, consent architecture, digital inclusion, enforcement, upstream data integration, and certification ecosystems—all of which were directly proposed during consultations.

6

# Next Steps Towards a National Battery Aadhaar Framework

During the consultations undertaken under the Battery360, the priority use-cases and the data attributes required to support them were identified. This provides a structured foundation for the Battery Aadhaar framework. However, translating these functional requirements into an operational and scalable system will require further work.

While this report has identified a consolidated set of priority data attributes mapped to key use-cases, further scrutiny will be required before these are formally implemented. This includes assessing the commercial sensitivity of specific data fields, determining whether certain attributes should be mandatory or voluntary within the framework, harmonising units of measurement and reporting formats across actors and refining definitions, where needed, to ensure comparability. Such technical and governance-level refinement will be essential to ensure that the final Battery Aadhaar dataset is practical, proportionate and implementable at scale.

As the concept evolves from draft guidelines to formal policy and implementation, the Working Group will continue the discussions on the governance architecture required for smooth deployment. The scope identification work will continue to develop through FGDs with stationary energy developers, financiers, fleet operators and insurance agencies. Given that battery-related data is distributed across the value chain, ensuring clarity on roles, responsibilities, data custodianship and coordination mechanisms will be essential. A clearly defined governance structure will be critical to ensure accountability, interoperability and long-term scalability.

In parallel, further work will focus on developing a digital architecture blueprint aligned with a DPI approach. Such an architecture must enable secure, consent-based, and role-based data exchange, while accommodating varying levels of digital readiness across the battery ecosystem. Ensuring interoperability with existing regulatory and industry systems will be central to this effort.

It is equally important that the implementation challenges highlighted by the stakeholders—including issues related to standardisation, data ownership, infrastructure constraints, legacy batteries and upstream supplier data—are systematically addressed as the framework transitions from guidelines to policy. The Working Group will also continue to engage with and build upon the draft Battery Aadhaar guidelines issued by the MoRTH, providing evidence-based inputs to support a robust and implementable national framework.

Through continued multi-stakeholder engagement, the next phase of work will focus on converting the identified use-cases and data requirements into a governance and digital architecture that is practical, scalable and aligned with India's regulatory and sustainability objectives.

7

# Conclusion

India's rapid expansion of electric mobility and energy storage presents both opportunity and responsibility. As batteries become central to the country's energy transition, their governance, traceability and lifecycle management will increasingly determine the outcomes related to safety, circularity, compliance and economic value creation.

This report has presented a structured foundation for a national Battery Aadhaar framework, grounded in stakeholder consultations conducted under the Battery360. By identifying priority use-cases and mapping them to specific data attributes, the Working Group has outlined the functional requirements necessary to support regulatory compliance, reuse and recycling decisions, market development, risk management and sustainability reporting.

The findings underscore that the core challenge is not the absence of data, but its fragmentation across actors and lifecycle stages. A well-designed Battery Aadhaar system can address this information asymmetry by linking batteries to secure, role-based and interoperable lifecycle records. In doing so, it can strengthen governance, reduce uncertainty and enable batteries to be treated as traceable and accountable assets across their lifecycle.

As India moves towards formalising the Battery Aadhaar framework, continued collaboration between the industry, regulators and policymakers will be essential. A system that balances practicality with regulatory robustness can position India to build a transparent, circular and globally aligned battery ecosystem—one that supports national energy security, environmental objectives and long-term industrial competitiveness.

8

# Annexures

## 8.1. Battery 360

The Battery360 is India's multi-stakeholder platform to drive the country's transition towards a sustainable, circular and indigenous battery ecosystem through technological innovation, strategic collaboration and collective action. It brings together key actors across the battery value chain, including battery and vehicle manufacturers, pack assemblers, fleet operators, reuse and recycling companies, technology providers and policy and research institutions.

Within the context of Battery Aadhaar, Battery360 provides a neutral and structured forum for multi-stakeholder engagement. Through its working groups and consultations, it enables stakeholders to jointly identify priority use-cases, data gaps and operational requirements and to align on what information should be captured, shared and used across the battery lifecycle. This collaborative process ensures that the Battery Aadhaar framework is grounded in real-world needs while remaining aligned with the national policy objectives and international best practices.

## 8.2. List of Abbreviations

| | |
|---|---|
| BaaS | Battery-as-a-Service |
| BCF | Battery Carbon Footprint |
| BIS | Bureau of Indian Standards |
| BMS | Battery Management System |
| BWMR | Battery Waste Management Rules |
| °C | Degree Celsius |
| $CO_2e$ | Carbon Dioxide Equivalent |

| | |
|---|---|
| CPCB | Central Pollution Control Board |
| DPDP Act | Digital Personal Data Protection Act |
| DPI | Digital Public Infrastructure |
| EPR | Extended Producer Responsibility |
| ESG | Environmental, Social and Governance |
| ESS | Energy Storage System |
| EV | Electric Vehicle |
| FGD | Focused Group Discussion |
| GHG | Greenhouse Gas |
| GW | Gigawatt |
| GWh | Gigawatt-hour |
| kg | Kilogram |
| km | Kilometre |
| kWh | Kilowatt-hour |
| LCO | Lithium Cobalt Oxide |
| LFP | Lithium Ferro Phosphate |
| MoRTH | Ministry of Road Transport and Highways |
| NBFC | Non-Banking Financial Company |
| NITI Aayog | National Institution for Transforming India |
| NMC | Nickel Manganese Cobalt |
| OEM | Original Equipment Manufacturer |
| PLI | Production Linked Incentive |
| PSA | Principal Scientific Adviser |
| QR | Quick Response (Code) |
| SoC | State of Charge |
| SoH | State of Health |
| SPCB | State Pollution Control Board |
| UNEP | United Nations Environment Programme |

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Battery360 views this publication as part of an ongoing process of dialogue, evidence-building, and collective implementation. We hope it serves as a useful public resource for policymakers, industry leaders, researchers, innovators, investors, and civil society actors working to build a resilient and future-ready battery ecosystem for India.

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