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Accelerating India's Transition to an Automotive Circular Economy

Policy Imperatives, Industry Action, and Pathways for Systemic Change

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Executive Summary

India's automotive sector is approaching a structural inflection point where circularity must be treated as an industrial system challenge rather than a downstream waste-management activity. Rising vehicle volumes[10], increasing material complexity[17], and tighter policy expectations[12, 13] are collectively exposing the limits of the traditional linear model. In this environment, circularity becomes central to managing material risk, maintaining supply resilience, and preserving long-term competitiveness[13].

This paper frames automotive circularity through a Reduce-Reuse-Recycle (3R) hierarchy, emphasizing value retention over end-of-life disposal[4]. Global experience demonstrates that high circularity outcomes emerge only when interventions are sequenced deliberately: material reduction is embedded at the design stage[4], reuse is enabled through disciplined end-of-life capture and OEM-backed systems[7, 8], and recycling is engineered for quality recovery rather than volume alone[9]. Benchmarks from Germany, Japan, and the Netherlands illustrate how each lever performs when supported by coherent policy, infrastructure, and industry alignment[5, 7, 9].

India enters this transition with a unique profile. Material recovery occurs at significant scale[16], supported by deep repair and reuse markets, but remains largely informal and uneven in quality, safety, and traceability[12]. Over the past few years, India has built an increasingly comprehensive circularity policy stack combining vehicle scrappage rules[12], Registered Vehicle Scrapping Facilities (RVSFs)[12], and multiple Extended Producer Responsibility (EPR) regimes covering batteries[14], tires[15], plastics[16], oils[16], and residues[16]. The challenge has shifted from policy formulation to system delivery.

Infrastructure development marks this critical transition phase. Formal dismantling capacity is expanding[12], and OEM participation is rising[13], but end-of-life vehicle flows remain dominated by informal channels[12]. Automated Testing Stations (ATS), designed to act as the trigger for formal ELV capture[12], are unevenly distributed and currently convert very few vehicles into scrappage[11]. As a result, formal facilities remain underutilized, reuse remains inconsistent, and outcomes beyond bulk metals continue to lag in quality compared to global best practice[9].

India's constraint is not intent or scale, but system discipline across the value chain. Measuring success by value retained per vehicle, through better design[4], organized reuse[7], quality recycling[9], and traceability[15] can transform fragmented recovery into a circular manufacturing advantage.

Introduction

Circularity has become a familiar term in automotive policy and industry discussions, often framed around recycling rates, waste management, or compliance with environmental regulations[5 12]. While these dimensions are important, they capture only a fraction of what is now at stake. For a sector as material-intensive and system-dependent as automotive, circularity increasingly determines exposure to material price volatility, supply concentration, regulatory risk, and long-term manufacturing viability[13].

The objective of this context paper is to reframe automotive circularity for India as a system-level transition[4], rather than a collection of isolated end-of-life interventions. It seeks to move the discussion away from a narrow focus on scrappage and recycling[12], and toward a lifecycle perspective that connects design, manufacturing, use-phase value retention, and end-of-life recovery into a single, integrated system[4].

Specifically, the paper aims to:

- Establish a practical organizing framework for automotive circularity using the Reduce-Reuse-Recycle hierarchy[4], clarifying why upstream and mid-life decisions matter more than downstream recovery alone.
- Draw targeted global lessons by examining how leading markets have progressed on individual circularity levers[5 7 9], rather than presenting generic international comparisons.
- Assess India's current position by analyzing its policy architecture[12 13 14 15 16], infrastructure build-out[12] , and ecosystem readiness, while recognizing the role and limitations of existing informal recovery systems[12].
- Identify the binding constraints that prevent policy intent and infrastructure investment from translating into consistent circularity outcomes on the ground[12 13].
- Outline a forward pathway focused on value retention[4], system discipline[7 9], and measurable performance, rather than aspirational targets alone.

It aims to provide a shared perspective for industry, policymakers, and ecosystem participants on where India's automotive circular economy stands today[12], how existing policy frameworks and infrastructure are translating into outcomes on the ground[12 13], and the factors that continue to constrain progress. By examining the system across design, use, and end-of-life stages[4 9], it highlights the areas that merit focused attention as India's circular economy framework continues to evolve[16].

1 Why Circularity Now: The Strategic Imperatives for India's Automotive Sector

For most of the automotive industry's modern history, growth was understood in straightforward terms. We built more vehicles, mobility expanded, supply chains scaled, and economic activity followed. Scale for this sector meant production numbers, sales volumes, or market penetration.

What was discussed far less was what sat beneath that growth: materials.

Automotive Recycling Materials

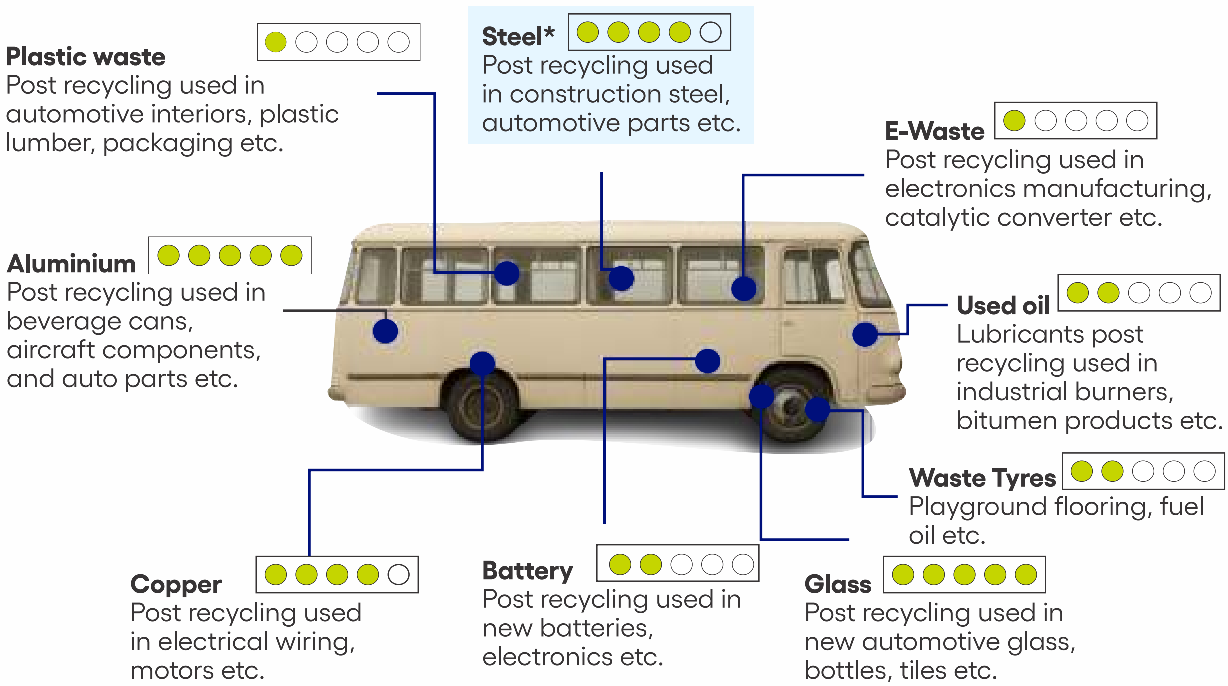


Figure 1: ELVs as Material Value Pools: Key Recyclable Streams & Reuse Pathways

"ELVs contain multiple recyclable streams-metals, plastics, tyres, oils, glass and batteries, each enabling downstream reuse across industrial and automotive value chains."

With the expansion of mobility, steel, aluminium, plastics, rubber, electronics, fluids and today battery minerals, multiplied[17]. Yet this growth did not shape strategy in the way cost, technology, or regulation did.

That has changed.

A useful question to ask today is this: when we scale mobility, what exactly are we scaling? It is not the number of vehicles and infrastructure alone[10], but also the volume of materials entering, circulating within, and eventually exiting the automotive system[13]. The United Nations Environment Program reports that resource extraction has more than tripled since the 1970s and is projected to continue rising significantly by mid-century if current consumption patterns persist[1].

Rising material demand brings exposure to price volatility, supply concentration, environmental constraints, and policy intervention. Circularity, in this context, is no longer a peripheral sustainability theme. It is increasingly about managing system-level risk.

1.1 The Benefits of Circularity: Why It Matters Beyond Compliance

Before examining why circularity has become urgent for India's automotive sector, it is important to clarify what circularity delivers in practical terms. Circularity is often discussed narrowly as a waste or recycling issue,[5 12] but its benefits extend well beyond end-of-life management. When applied across the vehicle lifecycle, circularity generates environmental, climate, and resource efficiency gains[4], while also aligning closely with India's broader national sustainability ambitions[16].

Environmental benefits arise primarily from reducing the volume of waste generated across the automotive system[5]. More efficient material use, structured dismantling[12], and higher-quality recycling[9] reduce landfill dependence, uncontrolled disposal, and leakage of hazardous substances[16]. In parallel, circular practices lower local pollution and emissions associated with informal processing and inefficient material recovery[12].

Climate benefits follow directly from reduced reliance on virgin material extraction and energy-intensive primary processing[13]. Reusing components and recycling materials at higher quality levels significantly lowers lifecycle carbon intensity[4], particularly for metals, plastics, and batteries[17]. As circular systems scale, they contribute to meaningful reductions in greenhouse gas emissions across the automotive value chain[1].

Sustainability and resource-efficiency benefits emerge through better utilization of vehicles and materials already in circulation[4]. Improved ELV efficiency[12], higher component reuse[7], and material savings reduce pressure on finite resources[1 3] and increase resilience against supply volatility[1 3]. Importantly, circularity also encourages smarter material usage, linking design choices, material selection, and dismantling efficiency to long-term value retention rather than short-term cost optimization[4].

Beyond these system-level gains, automotive circularity is increasingly linked to India's national development and sustainability frameworks[16]. Circularity outcomes directly support the Sustainable Development Goals (SDG 2030), particularly those related to responsible consumption and production[1], while also advancing India's broader circular economy objectives by improving material efficiency and closing resource loops across industrial value chains[16]. They contribute to India's Net Zero 2070 commitment by lowering embodied and operational emissions[1 3] and align with the principles of Mission LiFE (2022) by promoting resource efficiency, waste reduction, and sustainable consumption patterns[16].

Seen through this lens, circularity is not only an environmental or regulatory agenda. It is a strategic lever that connects industrial efficiency, climate action, and national priorities setting the foundation for why its urgency has sharply increased for India's automotive sector[1 3]..

1.2 The world is discussing circularity but becoming less circular

While circular economy concepts are now widely discussed[4], the global economy has become less circular in practice. The Circularity Gap Report shows that the share of secondary materials used globally declined from 9.1% in 2018 to 7.2% in 2023, a 21% drop in just five years[2].

For the automotive sector, this matters directly. When secondary material use fails to scale, industries with large and complex material flows experience pressure first through costs, compliance requirements, and supply risks [1 3].

1.3 End-of-life vehicles treated as material value pools

The second trend relates to end-of-life vehicles (ELVs). Globally, ELVs are no longer viewed simply as waste[5]. In the European Union alone, over six million vehicles reach end-of-life every year (2023), representing a significant reservoir of recoverable material value[6]. Policy discussions in mature markets increasingly frame unmanaged ELVs as an economic loss, not merely an environmental issue[5].

1.4 India's scale makes circularity unavoidable

When this global lens is applied to India, the urgency becomes sharper.

According to the National Register of Motor Vehicles (VAHAN 4.0), India had over 41 crore (385.1 million) registered motor vehicles as of early 2025[10]. This places India among the largest vehicle populations globally.

A fleet of this magnitude creates a flow. More vehicles on the road today mean more vehicles reaching end-of-life in the years ahead along with tyres, plastics, oils, fluids, batteries, and other residues[12 14]. India-focused studies estimate that around [20–21] million vehicles could reach end-of-life by the middle of this decade[11] .

Historically, much of this activity has been handled through informal or semi-formal systems[12]. These systems have enabled recovery and supported livelihoods, but have also been characterized by uneven safety standards, limited environmental controls, and weak traceability[12]. As vehicle technologies evolve with higher electronics content and the growing presence of electric vehicles[17], these limitations become more visible v.

Policy has begun responding in a structured manner. India's vehicles scrappage framework under the Voluntary Vehicle-Fleet Modernization Program introduces fitness testing and registered scrapping facilities, signaling a shift toward formal, trackable end-of-life pathways[12]. In parallel, Extended Producer Responsibility (EPR) has emerged as a central instrument of India's circularity architecture[14 15 16].

Batteries illustrate this shift clearly. The Battery Waste Management Rules mandate EPR-based collection, recycling and refurbishment obligations[14], and official statements introduce minimum recycled-content requirements in new batteries from FY 2027-28 onwards[14]. As electric vehicle adoption grows[17], battery circularity becomes a matter of resource security and compliance, not just environmental performance.

Taken together, these developments lead to a clear conclusion. Circularity matters now because the traditional linear model is under pressure[1 3], rising material demand[1 3], visible end-of-life volumes[11 12] , and tightening policy expectations[12 13 14].

For India's automotive sector, circularity is no longer only a recycling task. It is a system transition linking design, manufacturing, use-phase value retention and end-of-life recovery[4].

The question is no longer whether this transition will happen. It is how deliberately and how effectively it will be managed.

2 Circular Economy Framework: Applying Reduce-Reuse-Recycle Across the Automotive Lifecycle

Once circularity is treated as a system transition[4], the next question becomes practical: how should circularity be organized into decisions that industry and policy can act on? In India's case, this question matters because the ecosystem is not starting from a blank slate design teams, suppliers, recyclers, and regulators are already making fragmented decisions that quietly determine what materials enter vehicles, how long components remain in circulation, and how much value survives at end-of-life[12 13]. What is often missing is a shared logic that connects these decisions into one lifecycle view[4]. A simple framework helps convert circularity from a broad ambition into a set of choices that can be prioritized, measured, and scaled[4].

The Reduce-Reuse-Recycle (3R) framework offers a clear organizing lens for circularity in automotive systems[4]. Importantly, the three are not equal actions; they form a hierarchy[4].

2.1 Why the 3Rs are a hierarchy

Reduce delivers the highest impact because material avoided at the design stage never needs extraction, transport, or end-of-life processing[1 4]. Reuse comes next because it retains product and economic value preserving embedded material and energy[4 7]. Recycle is essential but usually delivers the lowest retained value because material recovery often involves degradation, separation losses, and downcycling[9].

This hierarchy prevents circularity from being reduced to end-of-life recycling alone[4]. It forces attention upstream[4].

2.2 Applying Reduce, Reuse and Recycle in the lifecycle

Reduce operates mainly upstream and is shaped by design and manufacturing decisions: material selection, architecture, lightweighting, standardisation and modularity. A consistent insight from lifecycle work is that a large portion of material intensity and environmental footprint is locked in at the design stage[10].

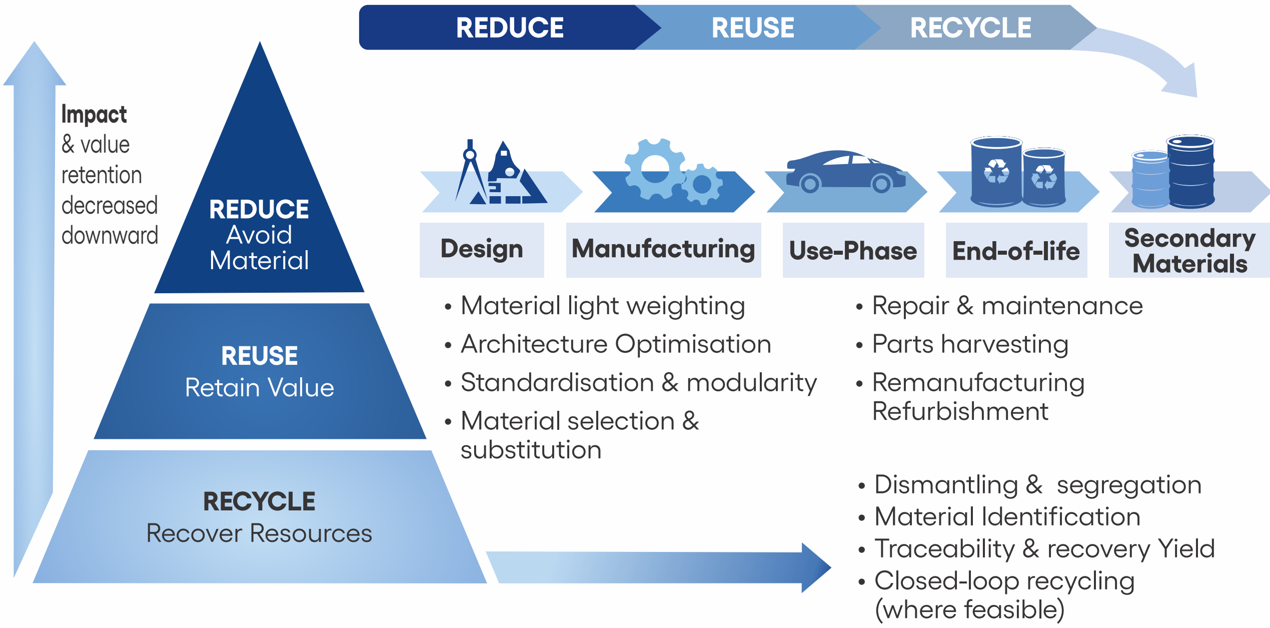


Figure 2: 3R Framework Across the Automotive Lifecycle

"The 3R framework organizes automotive circularity as a hierarchy: reduce material use at design, reuse components to retain value, recycle responsibly at end-of-life"

Reuse operates during and after the use phase. It focuses on extending component life through refurbishment, remanufacturing, and parts reuse[7]. Compared to recycling, reuse preserves both material and embedded energy and retains higher economic value[4 7].

Recycle becomes essential when components can no longer be reused. ELV recycling enables recovery of metals, plastics and other materials[5 6], but it is inherently a value-loss process[9]. This is why dismantling practices, material identification and traceability become critical for improving recycling quality and closing loops[9 12 15].

Together, Reduce-Reuse-Recycle shows that automotive circularity is not a single intervention. It is a connected sequence of decisions spanning design, use and end-of-life recovery[4].

3 Global Experience: Best Practices by Circularity Lever

With a framework established, a natural question follows: what does success look like in practice?

Global experience shows that circularity has not advanced uniformly. Different markets have moved faster on different levers making benchmarking most useful when anchored to Reduce, Reuse and Recycle.

3.1 Reduce benchmark: Germany (design discipline and upstream mandates)

Germany's approach to Reduce starts with design and material discipline[5]. Germany had 49.3 million passenger cars registered as of 1 January 2025[6]. In a system of this size, downstream measures cannot keep pace[5].

Under the EU's December 2025 political agreement, each new vehicle type must include at least 15% recycled plastic within six years of the regulation entering into force, rising to 25% within ten years, with 20% of that requirement sourced from closed-loop plastics recovered from end-of-life vehicles or removed parts[5] This pushes circularity upstream into sourcing materials and documentation.

OEM practice supports this. BMW's Recycling and Dismantling Centre (RDC) uses dismantling insights to improve design for recyclability and recovery[4]. Similar upstream circular design practices are visible across German OEMs: Mercedes-Benz has been scaling recycled materials and circularity-focused design initiatives through its circular economy programs; Volkswagen Group has been working on closed-loop material concepts and recycled plastics integration across vehicle platforms; and Audi has advanced use of secondary materials and recycled content pilots in vehicle components[5]. Together, these OEM efforts reinforce Germany's core advantage: circularity is treated not as a downstream compliance task, but as an engineering-led and procurement-led strategy embedded into vehicle development[5].

3.2 Reuse benchmark: Japan (disciplined ELV capture and dismantling)

Reuse works only when end-of-life vehicles are captured early, intact, and through formal channels[7]. Japan's system is built around this discipline, with ELV volumes of around ~4 million vehicles per year (or ~5 million including exports).[7]

What makes Japan different is that OEMs are directly part of the end-of-life system, not outside it. Under Japan's Automobile Recycling Law, manufacturers and importers have defined responsibility for key ELV waste streams such as airbags, fluorocarbons (vehicle AC gases), and automobile shredder residue (ASR), managed through an upfront recycling-fee model and coordinated nationally through JARC.[7] [8] This keeps ELVs inside a controlled chain and allows dismantling to happen in a structured way so parts can be recovered early and safely[7].

Japan also supports reuse through OEM-linked programs that make reused parts reliable and acceptable in the formal market. For example, Nissan's "Green Parts" program supplies certified reused/rebuilt parts through formal service channels, helping build trust and demand[7] Similar, remanufactured and reused parts initiatives have also been scaled by major OEMs such as Toyota, especially through aftersales supply chains.[7]

The outcome is not only high recycling, but also high value retained before recycling. Under the ELV Recycling Law, 99% of ELVs are effectively utilized, with 86% through material recycling and 13% through thermal recovery.[7] In short, Japan leads on reuse because it combines disciplined ELV capture with OEM-backed programs that make parts reuse organized, trusted, and scalable[7].

3.3 Recycle benchmark: Netherlands (coordinated chain + post-shredder separation)

The Netherlands is a strong global benchmark for automotive recycling because it has built a system where end-of-life vehicles are not handled randomly they move through a controlled national recycling chain[9]. This system is run through an Extended Producer Responsibility (EPR) model led by Auto Recycling Nederland (ARN), which tracks results and ensures that vehicles are processed through registered dismantlers and recyclers[9]. ARN reports 98.7% total recovery in 2023 and 98.8% in 2024 well above the EU's 95% ELV recovery target[5].

What explains this high performance is not just policy it is the infrastructure and process discipline[9]. Vehicles are first dismantled and depolluted properly, where reusable parts and key materials are removed[9]. After shredding, the Netherlands goes further than most countries by using post-shredder separation technology to recover additional plastics, metals and other materials from shredder residue[9]. ARN's reporting shows that this "post-shredder" stage plays a major role in achieving consistently high recovery, supported by PST-enabled separation systems.[9] In short, the Netherlands succeeds because it treats ELV recycling as an engineered industrial chain with measurable performance not a disposal activity[9].

3.4 What global benchmarks collectively reveal

These benchmarks make one point clear: circularity does not happen automatically[2, 4]. It succeeds when systems are designed to retain value early (through design and reuse)[4, 7] and recover materials predictably (through organized recycling chains)[9]. Germany shows how "Reduce" is driven upstream through material and design discipline[5]; Japan shows how "Reuse" depends on formal ELV capture and OEM-backed reuse[7, 8]; and the Netherlands shows how "Recycle" performs when the full recovery chain is engineered and measured[9]. With these global reference points in view, the discussion now shifts to India-its current policy landscape[12, 13, 14, 15, 16], ecosystem readiness[12], and the gaps that must be addressed to scale circularity outcomes.

International Comparison of Automotive Circularity Systems					
	India	**EU**	**Japan**	**China**	**USA**
Circularity system maturity	Large-scale recovery, but fragmented and informal; system discipline still evolving	Mature, regulation-driven system with clear lifecycle accountability	Highly disciplined, OEM- integrated circularity system	Rapidly formalizing, scale-driven, quality still uneven	Market-led system, focused primarily on metals
ELV capture & routing	Predominantly informal capture; formal scrappage still not the default route	~88.3% reuse & recycling of end-of-life vehicles in formal systems	Over ~95% overall recovery/ recycling of materials from ELVs (formal system)	increasing formal capture, regional variation remains	Strong capture, limited traceability
EPR Regime	Emerging EPR through scrappage, batteries, tyres; vehicle-level ELV EPR still evolving	Mandatory ELV EPR under EU Directive with lifecycle responsibility on producers	Comprehensive OEM-led ELV EPR with upfront fees and national coordination	Policy-driven EPR expanding for ELV, implementation veries significantly by province	No unified ELV EPR; recycling largely market-driven under general environmental regulation
Reuse & remanufacturing	High reuse activity, low Standardisationand trust	Moderate ruse, regulated markets	Strong, certified reuse and remanufacturing	Expanding reuse, mixed quality	Established remanufacturing in select components
Recycling focus & quality	High metal recovery; plastics and residues underdeveloped	Quality-focused recycling with growing post-processing	Balanced recycling with controlled dismantling	Volume-driven recycling, quality improving	Metal-centric recycling, limited material diversification

4 Policy Frameworks, Regulations, and Ecosystem Readiness

4.1 India's circularity ecosystem

India's automotive circularity ecosystem has always had one strong feature: materials do not go entirely to waste[16]. End-of-life vehicles (ELVs) have historically been dismantled, parts have been reused, and metals have been recycled often at impressive speed[12 16]. But the system has also had a structural limitation: recovery has largely been driven by informal or semi-formal channels[12] , where value extraction is high, but environmental safeguards, quality control, and documentation are uneven[12 16]. As vehicles become more electronics-rich and EVs grow in share[17], these gaps start to matter much more for both safety and material quality[14 17].

This is why India's starting point is best described in one sentence: recovery is happening, but circularity is not yet organized as an industrial system[12]. Circularity at scale needs predictability-how ELVs enter formal channels[12], how materials get segregated, and [12 15]whether recycled output is good enough to return into high-quality manufacturing loops[5 9]. That is still evolving.[12]

4.2 India's Innovative Regulatory Stack

Unlike many countries, India's approach to automotive circularity is not built around a single ELV law[5]. It is emerging as a policy stack-a set of rules that together cover ELVs[12 13] and key material streams used in vehicles[14 15 16]. This makes sense because a vehicle is not one product: it is a system of steel, aluminum, plastics, rubber, electronics, oils/fluids, and batteries[1 17].

At the center there are two related shifts

- formal ELV captures through scrappage,[12 13] and
- stream-wise EPR systems, where responsibility is pushed back to producers[14 15 16]

(a) End-of-Life Vehicles: scrappage (2025) and RVSF rules (2021)

The scrappage framework under the Voluntary Vehicle-Fleet Modernization Programme (2021) forms the backbone of India's automotive circularity architecture because it addresses the first and most fundamental requirement: capture[12]. A circular economy cannot function if ELVs do not enter a structured, traceable chain[4]. The framework links vehicle fitness testing, formal scrapping, and deregistration into a single pathway[12], creating a system mechanism to identify ageing or unfit vehicles and route them away from informal dismantling into regulated processing channels[12].

This architecture was operationalized through G.S.R. 653(E), 2021, which notified detailed rules for RVSFs[12]. These rules prescribe minimum standards for digital processing, depollution and dismantling protocols, hazardous material handling, record-keeping, and the issuance of a Certificate of Deposit (CoD)[12]. Together, they establish the conditions for safer dismantling, documented recovery of reusable parts[12], and the generation of cleaner, higher-quality scrap streams capable of supporting organized reuse and downstream recycling[9 12].

Building on this foundation, India's scrappage framework has been significantly strengthened in 2025 through the notification of the Environment Protection (End-of-Life Vehicles) Rules, 2025, effective 1 April 2025, by the Ministry of Environment, Forest and Climate Change. These rules introduce a stronger environmental and lifecycle lens to vehicle retirement by explicitly linking ELV management to extended producer responsibility (EPR)[13]. Manufacturers are required to ensure the scrapping of a defined proportion of vehicles reaching end of life, reinforcing circular material flows and shifting accountability upstream[13].

The 2025 rules also tighten operational triggers for scrappage. Vehicles that fail mandatory inspections at Automated Testing Stations (ATS) are deemed unfit and must be scrapped through registered facilities[12 13]. Coverage includes transport vehicles older than 15 years and private vehicles older than 20 years[12], with specific regional enforcement measures strengthening implementation[13].

Taken together, the 2021 RVSF rules and the 2025 ELV regulations mark a shift from pilot-scale scrappage toward a more enforceable, producer-linked, and environmentally grounded ELV management system[12 13]. The effectiveness of this transition, however, will ultimately depend on consistent enforcement, ATS utilization, and the ability of formal scrappage infrastructure to attract vehicles early and at scale[12].

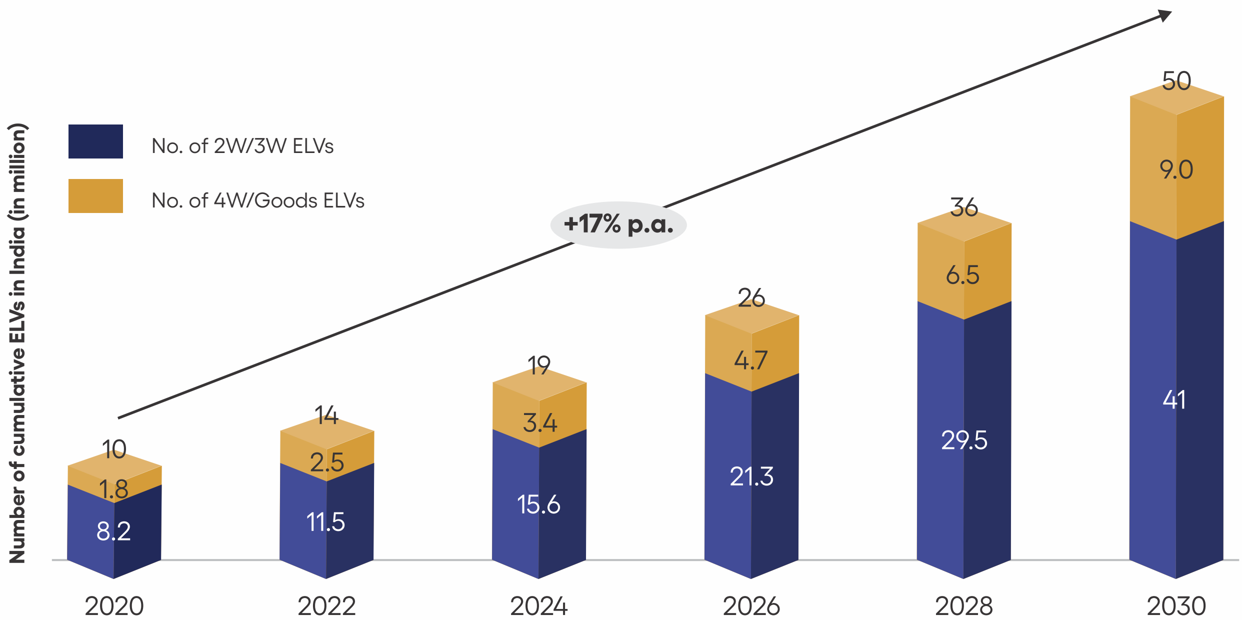


Figure xx: Projected ELV stock in India (Source: NITI Aayog)

(b) Battery circularity: the most mature EPR in India today

Battery circularity is where India is moving fastest because EV growth creates urgency[17]. The Battery Waste Management Rules, 2022 establish EPR-based collection, recycling and refurbishment obligations.[14]

The stronger part is what comes next: official government statements highlight that producers will be required to ensure minimum use of domestically recycled materials in the manufacture of new batteries from FY 2027-28 onwards.[14] This matters beyond compliance. It creates demand pull for battery recycling, improves project economics for formal recyclers, and pushes the system toward closed-loop circularity-closer to what mature markets are doing in critical materials[5 17].

(c) Tyres: EPR formalisation through digital tracking

Tyres are one of the biggest leakage streams in India, historically handled through informal trade routes[12]. India's response has been to push tyres into a digital EPR compliance model. The Waste Tyre EPR regime (under Hazardous and Other Wastes amendments) is now operationalised through the CPCB Waste Tyre EPR portal, where producers, recyclers and retreaders must register, and EPR obligations are tracked digitally.[15 16]

This is important for automotive circularity because tyre recycling is not only a waste issue-it affects circular use of recovered carbon black, rubber, and energy recovery[15]. The biggest gap remains enforcement and leakage reduction[12].

(d) Plastics: automotive relevance is indirect, but strategically important

Plastics circularity in India is governed through Plastic Waste Management Rules and EPR guidelines[16], largely anchored to packaging rather than vehicles. But the relevance to automotive is strategic. Europe is moving toward vehicle-level recycled plastics requirements. If India wants to benchmark toward Germany/EU reduce strategies, it will need reliable supply of high-quality recycled plastics, which in turn depends on strong EPR systems[16]. CPCB's centralised EPR systems for plastic packaging are an early foundation for scaling recycling networks and compliance infrastructure[16].

In simple terms: plastic EPR may not be automotive-specific today, but it builds the material ecosystem required for future recycled-content mandates in vehicles[5].

(e) Used oils and residues: hazard rules now moving into EPR

Circularity is not only about solid materials. Vehicles generate oils, lubricants, and residues that can become environmental hazards[16]. India's Hazardous and Other Wastes (Management and Transboundary Movement) framework governs these streams[16]. Notably, India has introduced EPR for used oil through the Hazardous and Other Wastes Second Amendment Rules, 2023, operational from April 2024, with CPCB portal-based compliance[16].

This is an important step toward lifecycle accountability for automotive fluids-an area where informal handling has been a persistent risk[12 16].

(f) Metal EPR Rules

India has notified stringent EPR rules for metals including aluminium, copper, zinc, and lead, under the Hazardous and Other Wastes (Amendment) Rules, 2025, effective 1 April 2026[16]. The framework mandates registration of producers, importers, and recyclers on the CPCB portal[16], introduces graduated recycling targets starting at 10% in FY 2026-27 and scaling to 75% by FY 2032-33, and requires minimum recycled-content usage[16]. Importers of scrap face 100% EPR obligations, while non-compliance attracts environmental compensation, marking a decisive shift toward regulated, traceable circularity for non-ferrous metals[16].

The introduction of metal EPR marks a significant broadening of India's circular economy governance beyond waste handling toward material lifecycle accountability[16]. By linking recycling targets, recycled-content requirements, and digital compliance, the framework is expected to strengthen demand for quality secondary aluminium, copper, zinc, and lead[16]. Over time, this creates incentives for improved segregation, traceability, and ELV-linked recovery,[12 16] integrating non-ferrous circularity more directly into industrial supply chains.

4.3 How roles align in India's circularity structure

India's circularity architecture is fundamentally a coordination problem. Each actor controls one part of the chain.

- **Central Government** sets the national direction: notifications, standards, registration frameworks, and digital compliance systems (CPCB portals for EPR, MoRTH rules for scrappage/ATS/RVSFs)[12 13 15 16]. It shapes incentives and creates the legal backbone.
- **State Governments, State Pollution Control Boards (SPCBs)** and local bodies determine implementation reality: licensing facilities, monitoring compliance, enabling land/clearances, and enforcement[12 16]. Since ELV flows are local, state execution strongly influences outcomes[12].
- **OEMs / Producers** carry increasing responsibility under EPR logic[14 15 16]. They influence upstream circularity through design choices, supplier material requirements, and compliance funding[4]. Over time, they will become the strongest lever for aligning India with Germany-style reduce mandates[5].
- **Recyclers and RVSFs** are the operational heart[12]. They determine depollution quality, dismantling discipline, and material output quality[12 9]. Whether India produces "scrap" or "secondary raw material" depends on these nodes[9].
- **Aggregators** and **informal collection networks** are still powerful[12]. They control ELV and scrap flows[12]. India's transition will not succeed by ignoring them. It succeeds by integrating or formalising flows, making capture efficient but documented[12 13].

4.4 Where India stands against global best practice

Global benchmarks show that circularity improves when each lever is strengthened deliberately[4 5 7 9]: Reduce starts at design and material strategy[4 5]; Reuse depends on disciplined capture and organised dismantling[7]; and Recycle improves only when recovery chains are engineered and measured[9]. India has movement on all three levers, but not at the same maturity level[12 13 16].

Reduce: policy is moving, but upstream design discipline is still limited

India is beginning to build the foundation[16], but "Reduce" is still weak because most interventions remain downstream[12]. The current focus is largely on waste rules and end-of-life handling[12 16], instead of stronger upstream pressure through design standards and material reduction requirements.[4 5]

This challenge becomes even more important in India because the scale is massive. With around 38.5 crore registered vehicles[10], even small reductions in material use per vehicle can translate into huge long-term savings[1 3]. However, India still does not have strong vehicle-level requirements like the EU, such as mandatory recycled-content obligations for plastics[5].

Plastic EPR systems can help improve recycling capacity[16], but they do not yet create large-scale demand for automotive-grade recycled plastics[5]. Because of this, the upstream push remains limited. Overall, India has the biggest potential to gain from "Reduce" due to its sheer scale[10], but it will need stronger signals upfront-clear design standards[4], recycled-content readiness[5], and stronger material discipline to start matching Germany/EU leadership[5].

Reuse: strong market activity, but weak standardisation and capture discipline

India actually has a strong starting point. Reuse already happens at a large scale because the repair culture is deep, the parts market is huge, and extending the life of components is common across vehicle categories[12].

However, the challenge is that much of this system is still informal[12]. ELVs often reach dismantlers through untracked routes, which creates two major issues: first, parts recovery becomes inconsistent and quality varies widely; second, traceability remains weak, which makes it difficult to scale reuse in a certified and trusted manner[12].

This is where the scrappage framework and RVSFs become important[12 13]. Reuse becomes a real and scalable circularity lever only when the ELV capture and dismantling chain is organised and predictable[12 7]. Overall, India has very high reuse potential because the repair ecosystem is already strong[12], but to match Japan's leadership it needs stronger system discipline better ELV capture[12], clear quality standards[7], and formal reuse channels that build trust in reused parts[7].

Recycle: high volumes, but recovery quality and chain performance are uneven

India also recycles at a large scale, especially metals like steel and aluminium[16]. But recycling quality is not uniform across all materials, and the system still performs unevenly across different waste streams[12 16].

The main challenge in India is not the intent to recycle, but the quality and completeness of recycling[9]. Metals recover well, but plastics, electronics, fluids, and shredder residue often do not achieve high-value recovery[12 9]. In many cases, these materials are still treated as low-grade "scrap" instead of being recovered as quality secondary raw materials that can re-enter manufacturing[9].

RVSFs can improve depollution and bring more structure to the system[12], but high-quality recycling also needs investment in better segregation, stronger shredding standards, and post-processing infrastructure[9]. This is where the Netherlands performs strongly-it has built a performance-driven recycling chain that focuses on material separation and measurable recovery outcomes[9]. Overall, India is already recycling large volumes[16], but to reach Netherlands-level results it needs stronger chain engineering-better material separation[9], higher post-processing capacity, and reliable measurement of recovery across the system.[9]

Looking across all three levers, India's overall direction is clear. The policy framework is steadily expanding[12 13 14 15 16] , and the ecosystem is gradually shifting from informal recovery practices toward a more formal and structured circular economy[12]. This momentum is real, and the foundation is being created.

However, benchmarking with global leaders makes one thing equally clear: the next phase is not only about doing more, it is about doing better[4 9]. For Reduce, India needs stronger action upstream, especially through design discipline and material-reduction signals[4 5], not only downstream waste rules[12]. For Reuse, the missing piece is system discipline predictable ELV capture[12], better traceability[12 15], and clear quality assurance so reuse can scale in a trusted way[7]. And for Recycle, India needs stronger chain engineering advanced material separation[9], post-processing capability[9], and performance measurement that ensures recovery is not just high-volume, but high-quality[9].

These are the critical system upgrades India must build if it wants circularity outcomes comparable to global leaders[4 5 7 9]. The goal is not only higher recovery rates, but higher quality recovery and ultimately, greater value retention across the vehicle lifecycle[4].

5 Turning Policy into Practice: Infrastructure Build-out and the Constraints Still Holding It Back

India's circularity transition is now moving into its most decisive phase[12 13]. Until recently, the debate was dominated by policy intent: rules, obligations, and frameworks aimed at shifting the automotive sector from linear consumption to circular value retention[12 14 16]. But the last section established a more practical truth: **circularity outcomes depend not only on what the policy says, but on what the system can physically deliver[4 9].** India's gaps across Reduce-Reuse-Recycle are clear: upstream material discipline remains limited[4 5], reuse remains large but uneven and informal[12], and recycling is high-volume but still inconsistent in recovery quality beyond bulk metals[9 16] .

The next question is therefore operational: what is changing on the ground to close these gaps?

This is where enabling infrastructure becomes central. In India, three infrastructure layers matter most: **Automated Testing Stations (ATS)** as the trigger for end-of-life capture[12], **Registered Vehicle Scrapping Facilities (RVSFs)** as the formal dismantling and depollution engine[12], and **collection/aggregation networks** that determine whether vehicles and material streams enter compliant channels[12].

At the same time, infrastructure is not a guaranteed circularity. India is building capacity rapidly[12], but the system still faces structural constraints like fragmentation, leakage into informal routes[12], uneven utilisation[12], technology gaps in high-value streams[9], and inconsistent measurement[12]. This section therefore makes one argument: **India is building the physical infrastructure needed for circularity, but system-level frictions still prevent it from consistently delivering outcomes.**[12 9]

5.1 Formalisation has begun but the system has not yet reversed

India's ELV recycling has historically operated at scale but largely through informal channels, with limited formal processing[12]. Since the notification of the vehicle scrappage framework[12], formal ELV recycling has begun to scale from a very low base. Cumulative scrappage through Registered Vehicle Scrapping Facilities increased from pilot-scale levels in 2022-23 to over one lakh vehicles by mid-2024 and crossed approximately four lakh vehicles by early 2026[12 13]. While the formal share of ELV recycling remains low, the trajectory indicates steady growth, with improving processing quality and traceability[12].

What is new now is that **India is actively constructing a formal capture-and-processing system,** instead of relying on fragmented market-driven dismantling[12]. The scrappage framework and associated rules are not merely regulatory; they are meant to create physical pathways through ATS and RVSFs[12 13].

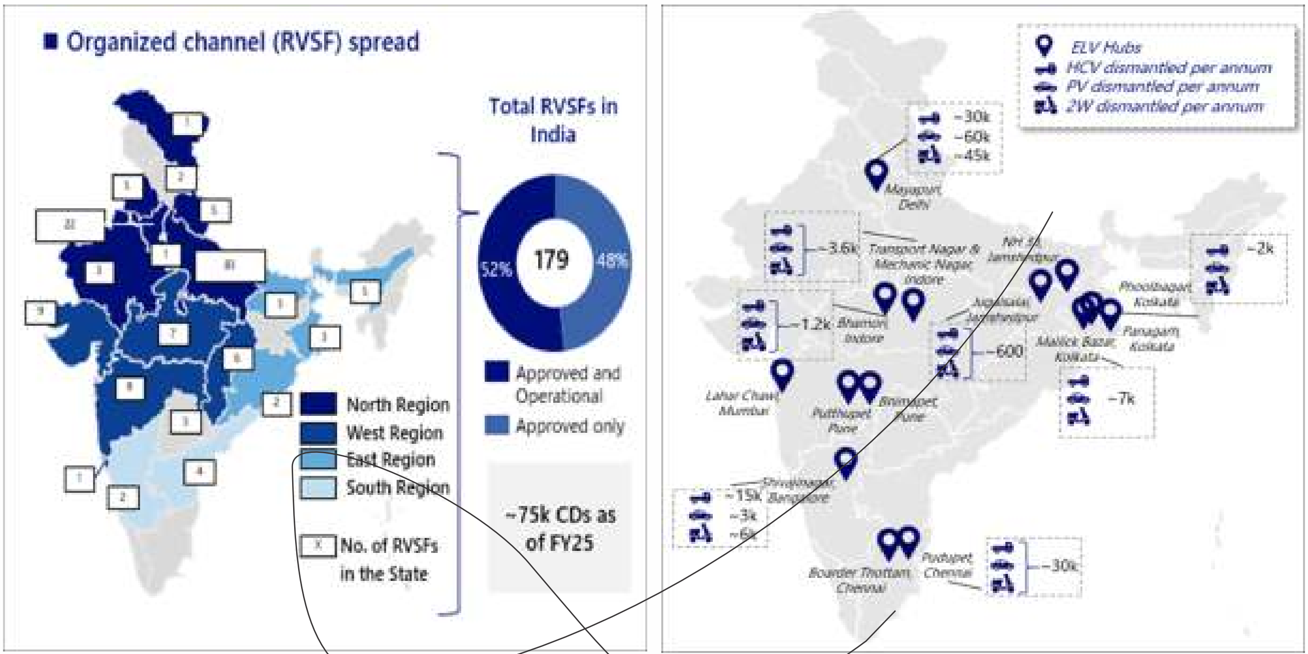


Figure 3 : ELV market landscape: organized vs unorganised share + CoDs + RVSFs + dismantling volumes

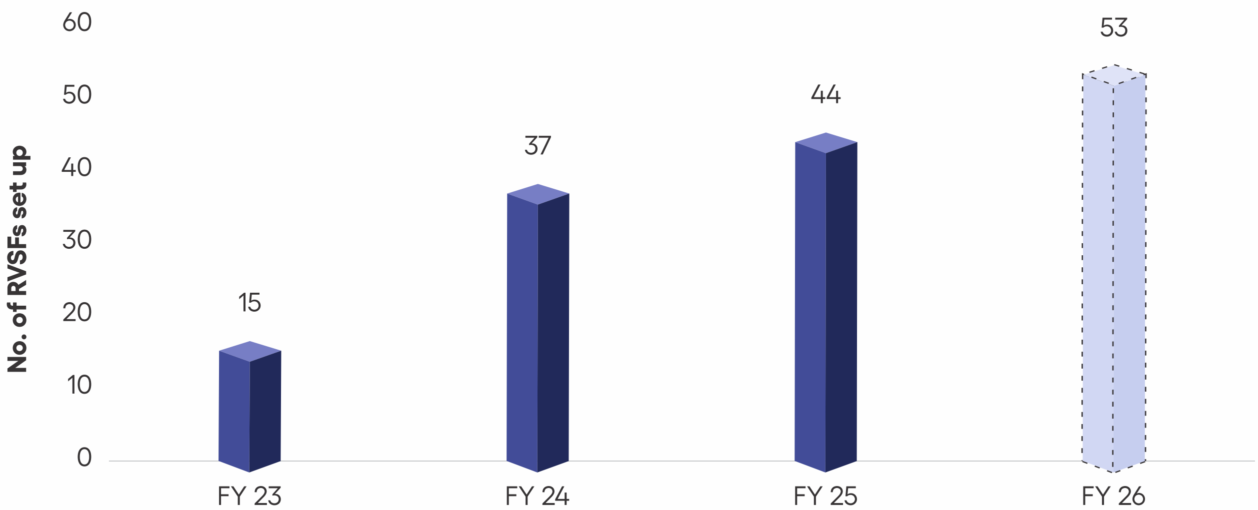


Figure xx: RVSF set up in each financial year (Source: NITI Aayog, MoRTH)

"Formal scrappage is emerging, but ELV flows still remain dominated by informal dismantling hubs-organised processing is rising, not yet the default."

Unorganized ELV hubs account for ~88%+ of the ELV business[12], operating under unsafe working conditions with space constraints and a lack of standardization[12] [16].

The picture from the current landscape is directionally encouraging but still transitional. Organised facilities are growing, Certificates of Deposit (CoDs) are being issued, and ELVs are being channelled through RVSFs[12]. Yet unorganised ELV hubs continue to dominate the flow[12]. This is a critical point: circularity cannot scale without capture discipline, and capture discipline [4] [7]depends on infrastructure being both available and attractive enough to become the default route[12].

5.2 RVSFs are scaling dismantling capacity especially through independents, with OEM participation rising

If circularity begins with capture, it becomes real at the dismantling stage[7,12]. This is where RVSFs play a unique role[12]. Unlike conventional scrap yards, RVSFs are meant to perform systematic depollution and dismantling under defined standards: fluids removal, hazardous material handling, dismantling discipline, and issuance of traceable documentation.[12] This is the difference between "recovering scrap" and producing "secondary raw material"[9,12].

The RVSF ecosystem has expanded rapidly, increasing from 60 operational facilities in July 2024 to 129 by February 2026[12,13]. Nationally, capacity additions are being driven largely by independent facility developers, but OEM participation is visibly rising[12]. This mix is important. Independents expand faster and cover more geographies. OEM-linked facilities, however, help strengthen quality assurance, process standards, and long-term closed-loop potential (especially for plastics and components)[4,5].

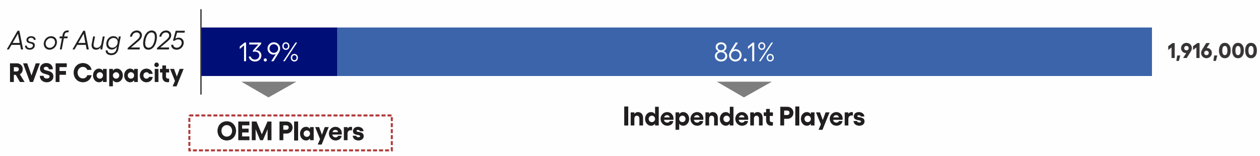


Figure 4: RVSF capacity and ownership split: OEM vs independent

"RVSF capacity is scaling rapidly, but most is still independent; OEM-linked capacity is smaller but strategically important for standardization and higher-quality recovery."

What the capacity picture also highlights is the emerging ecosystem strategy.[12] Several OEMs are building direct or partnership-linked formal dismantling networks.[12] These models matter because they start to connect the upstream and downstream sides of circularity: OEMs can influence dismantling outcomes[4,5], and dismantling insights can increasingly influence future design choices[4].

But here the system faces a crucial limitation: RVSFs can only process what they receive[12]. The true bottleneck is not only dismantling capacity but whether ELVs are routed into these facilities early and consistently[12]. That routing depends heavily on the next infrastructure layer: ATS[12,13].

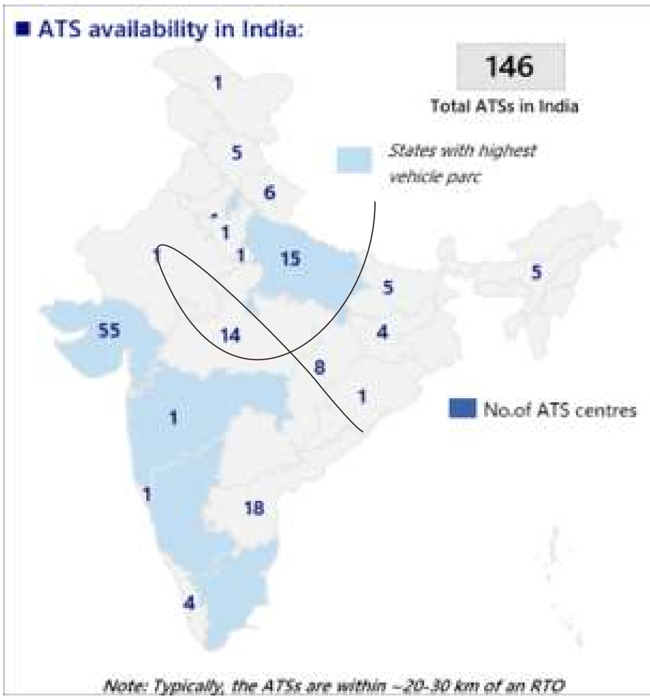
5.3 ATS is the missing trigger infrastructure-but conversion into ELVs remains weak

Circularity systems need a trigger point[4]. In Japan's benchmark reuse system, ELVs enter formal channels early[7]. In the Netherlands, the ELV recovery chain works because the system captures vehicles reliably[9]. India has historically lacked a comparable trigger[12]. ATS is meant to fill that gap[12,13].

The ATS logic is simple: fitness testing creates a system mechanism to identify vehicles that should be retired[12], pushing them away from uncontrolled informal channels and into structured scrappage[12]. It is not only a safety system; it is a circularity trigger[12].

ATS availability is expanding rapidly, but not evenly.

ATS availability is expanding rapidly[12], but not evenly[12].



ATS locations & ownership structure:

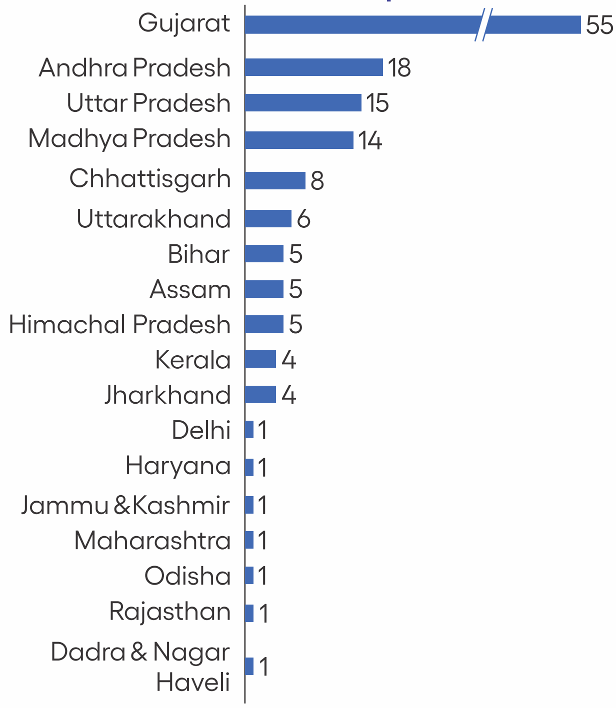


Figure 5: ATS distribution by state

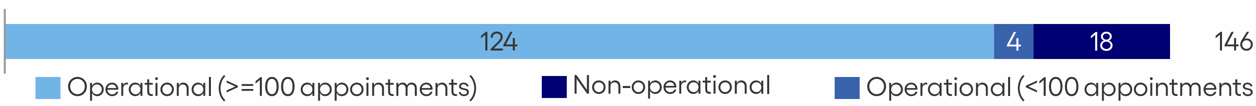
"ATS infrastructure is growing, but highly concentrated-some states are scaling much faster than the national average. India has much lower number of ATS, which are spread non-uniformly hence reliance on RTOs will continue for some time"

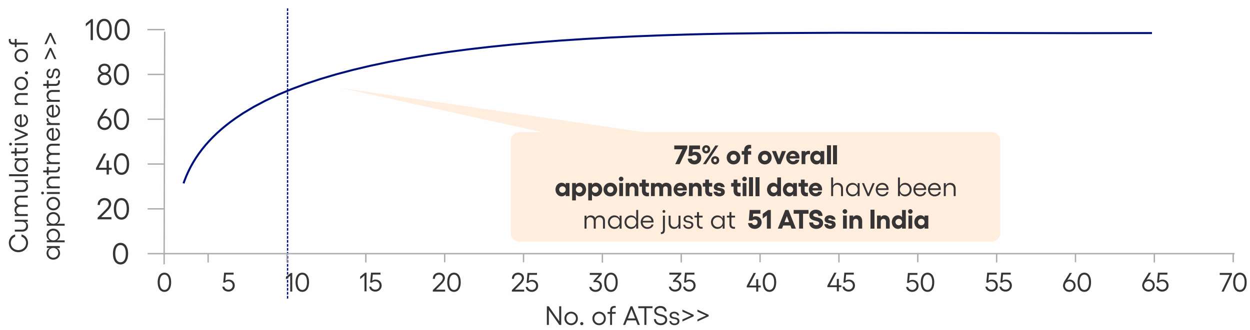
Only 18 states in India have ATS centres[12] with most no. of ATSs concentrated in Gujarat[12]. Majority of these ATSs are owned by MSMEs[12]: many of them were previously into auto-related businesses e.g. HSRP, RTO agents, Transport co., Auto-maintenance, etc[12].

The geographic concentration tells an important story. Where ATS coverage is dense, ELV capture discipline can grow faster[12]. Where ATS coverage remains thin, informal capture remains dominant[12]. This regional unevenness creates an unequal circularity map with leading states begin to develop the ecosystem faster, while others lag behind[12 13].

However, the most important issue is not just geography. It is utilization and conversion.

ATS Utilization:





Share of states in utilization of ATSs (No. of appointments till date)

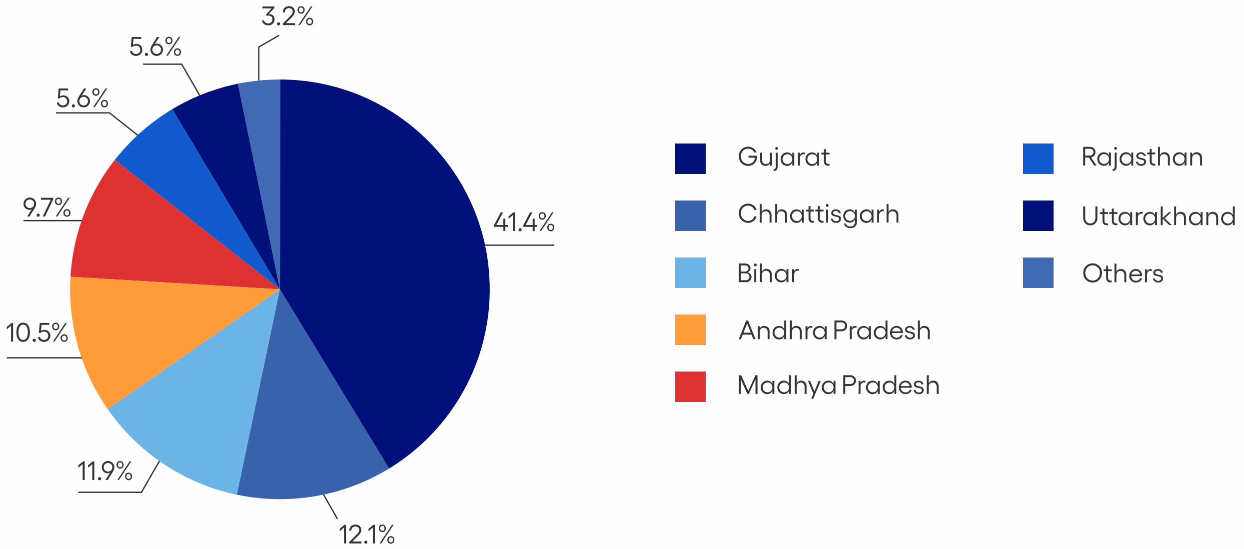


Figure 6: ATS utilisation split

"ATS utilisation is skewed and most tested vehicles receive 'fit'; ELV conversion remains negligible-ATS is not yet functioning as a scrappage trigger at scale."

Only 124 of the existing ATSs are fully operational with at least 100 appointments till date[12]. As 75% of the appointments till date have been booked at the top 51 ATSs with 33% at 1, there is a huge inequality in utilization of existing ATSs owing to a) Lack of mandatory testing & b) Geographical exclusivity[12,13]. The utilization of ATS is India is still skewed with only 5 states i.e., contributing to ~85% of the appointments to date[12].

This is the biggest operational finding in the infrastructure story. Even where ATS exists, it is not yet generating ELV capture at scale. A small subset of ATS accounts for most appointments[12]. Many stations are low-activity or non-operational. But most importantly, the "Fit vs Unfit" distribution shows that the vast majority of vehicles tested are certified fit[12]. This suggests that ATS is currently functioning more as a compliance or certification channel than as a retirement trigger[12,13].

Until ATS begins to convert meaningful numbers of vehicles into scrappage routing[12], RVSF capacity growth will remain under-fed, and informal dismantling hubs will continue to dominate[12]. This is the practical constraint holding the entire formal circularity chain back[12,9].

5.4 System-level constraints slowing the transition

Even as capacity increases, structural barriers continue to slow outcomes.

Fragmentation and informality: A large share of ELV collection and first-stage dismantling still happens through informal networks[12]. They are fast and commercially efficient, so formal channels struggle to attract vehicles early and intact[12]. This leakage weakens depollution, documentation, and traceability[12], making consistent reuse and high-quality recycling difficult to scale[7,9].

Bias toward bulk material recovery: The system naturally recovers what is easiest and pays quickest steel and basic metals[16]. That keeps volumes moving, but it sidelines harder streams like plastics, alloys, electronics, and shredder residue where real circular value sits[9]. Without stronger incentives and quality standards, recovery remains "scrap-led" rather than "material-grade" and closed-loop[5 9].

Technology gaps: RVSFs improve dismantling[12], but high-quality recycling needs downstream capability: sorting polymers, separating alloys, recovering electronics, and treating shredder residue[9]. Many facilities lack this equipment and know-how[12], so even formally processed ELVs can end up as mixed, lower-value outputs. Capability gaps directly limit recycling quality and circular use in manufacturing[9 5].

Economic constraints: High-value recovery often costs more-collection, segregation, compliance, and processing[12]-while recycled outputs can struggle against virgin materials on price and consistency[13]. Where economics reward volume over quality, actors optimise for bulk scrap[16]. Long-term circularity needs predictable financing and stable offtake demand for recycled materials, not only more capacity[5 9].

Data and traceability: Circularity is hard to manage without measurement[4]. Today, ELV and material flows are unevenly tracked across[12 15] states and actors, especially where aggregation is informal[12]. Weak traceability makes it difficult to verify compliance, measure recovery quality, or build trusted secondary material markets[12 9]. It also limits learning loops from dismantling back to design[4].

Enforcement and skill limitations: Standards exist[12 13], but on-ground application varies[12]. Depollution discipline, hazardous handling, and segregation quality depend on trained operators and consistent monitoring[12 16]-both uneven across regions. When enforcement is inconsistent, compliant facilities compete with lower-cost non-compliant routes[12], and overall system performance becomes patchy despite growing infrastructure[12].

6 The Path Forward: Accelerating India's Automotive Circular Economy Transition

India's automotive circularity transition is now in its delivery phase. The next few years will decide whether the ecosystem evolves into a high-performance industrial value chain, or remains a fragmented mix of compliance activity and uneven recovery. The required shift is simple to state: move from scrap recovery to value retention. That means designing vehicles so components and materials can be recovered cleanly, scaling reuse markets so value is retained before shredding, and upgrading recycling outputs into manufacturing-grade inputs.

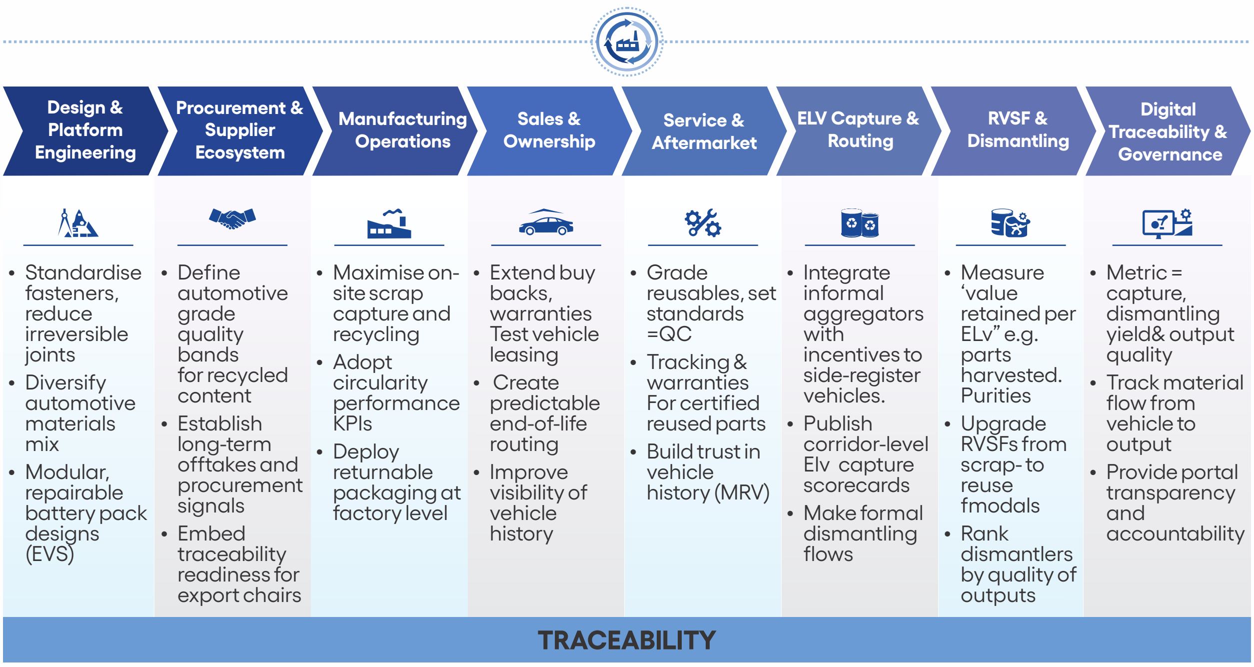


Figure 7: Path Forward: Circularity Levers Across the Automotive Value Chain

"Circularity is created or lost at each value-chain node-from design and procurement to service, ELV capture, dismantling and recycling. Strengthening every step shifts the system from scrap recovery to value retention."

A value-chain lens is the most practical approach. Circularity is created-or lost-at every node: design, procurement, manufacturing, ownership and service, capture and routing, dismantling, and post-processing. Weaknesses at one node breaks the chain. Strengthening each node compounds benefits.

1. Design and platform engineering: embed circularity as a product requirement (Reduce)

Circularity cannot be solved at the scrapyard. It begins in design[4 5]. The most practical "Reduce" move for India is to treat dismantling time and material separability as product requirements alongside safety and serviceability. Even modest improvements scale significantly when applied across mass platforms[10].

Two quantitative signals matter. First, material complexity is rising sharply, especially in polymers, trims, and mixed assemblies[1 3]. This increases the risk of downcycling unless design enables clean separation[9]. Second, India's aluminium intensity per vehicle remains far lower than developed markets-around **40 kg per vehicle in India versus ~140 kg in developed markets-**[16] implying that as lightweighting and EV platforms scale, India's material mix will diversify and demand stronger circular design readiness[5].

In practice, OEMs should standardise fasteners, reduce irreversible joints, improve modularity of interiors/electronics, and impose polymer discipline in high-volume parts[4 5]. For EVs, battery pack design becomes decisive: modular, repairable packs support refurbishment and second-life pathways[14 17]; sealed architectures push early recycling and raise compliance cost[14].

A pragmatic SIAM initiative would be a voluntary **Circular Design Index** at platform level (disassembly proxy, modularity score, polymer diversity and labelling compliance)[4 5]. Once measurement exists, procurement and policy can reinforce it[5 13].

2. Procurement and supplier ecosystem: create demand pull for secondary materials (Reduce + Recycle)

Recycling becomes circularity only when recycled outputs return into manufacturing[5 9]. Today, recycled polymers and alloys often remain stuck in low value uses because OEM specs and quality assurance pathways are weak[9]. The missing lever is demand pull through procurement[5].

Global direction is moving upstream. Under the EU's evolving ELV framework, agreed provisions include recycled plastics obligations in new vehicle types-**15% recycled plastic within six years** and **25% within ten years, with 20% sourced from closed-loop ELV plastics**[5]**.** India may not adopt identical mandates soon, but export-facing supply chains will increasingly need traceability and recycled-content readiness[5 15].

Practically, Indian OEMs can start by defining automotive-grade recycled quality bands for polymers and aluminium alloys[5 16], supporting supplier certification and testing[5]. Long-term offtake agreements are critical; without them, recyclers cannot justify investment in sorting, washing, compounding and contamination control[9]. A focused approach-beginning with a few high-volume non-safety plastic applications-can build confidence without risking quality[5 9].

3. Manufacturing operations: close internal loops where control is highest (Reduce)

Factories offer the fastest circular gains because streams are clean and controllable[4]. Closed-loop scrap recovery for stampings, castings, machining and plastics moulding can keep value inside certified loops instead of leaking into open scrap markets where quality and traceability degrade[5 9].

This aligns with competitiveness and jobs. The auto component sector recorded turnover of roughly **$73.1 billion in FY 2023-24** and supports about **1.5 million direct jobs**[10]**,** meaning circularity that reduces material loss also supports industrial productivity[13].

Returnable packaging across supplier interfaces and yield improvement (reducing rework) are practical measures with quick payback[4]. A SIAM-aligned "factory circularity KPI" framework-scrap rate, closed-loop share, packaging circularity-would help scale best practice[4 5].

4. Sales and ownership models: extend vehicle life and retain lifecycle visibility (Reuse)

Reuse is the highest value-retention lever[4 7], but it needs lifecycle visibility. and traceability[12 15]. In segments like fleets and commercial vehicles where standardisation is high, buyback programs, warranty extensions tied to preventive maintenance, and controlled retirement schemes can improve life extension and create predictable end-of-life routing[12 7]. Leasing/subscription models can be tested selectively in fleet-heavy corridors where data and compliance monitoring are feasible[12 15].

5. Service and aftermarket: industrialise reuse through trust and standardisation (Reuse)

India's reuse market is large but fragmented[12]. Without trust mechanisms, it remains informal and uneven[12]. Japan demonstrates what disciplined systems can achieve: under Japan's ELV framework, **99% of ELVs are effectively utilised, with 86% via material recycling and 13% via thermal recovery[7 8].**

India does not need to copy Japan's full institutional model, but it can adopt the trust mechanisms[7]. Certified reuse can start with a limited set of high-churn components (alternators, starters, steering assemblies, transmissions and selected electronics), supported by grading standards, basic testing, QR traceability and limited warranties[12 15]. Insurance acceptance of certified reused parts for older vehicles can be a rapid scale driver[7 12].

6. ELV capture and routing: make formal flows competitive, not only compliant (Reuse + Recycle enabler)

Formal facilities cannot perform without feedstock[12]. India's capture challenge is largely an incentive challenge because informal networks are embedded and commercially efficient[12]. The practical solution is integration: aggregator registration, predictable payment mechanisms, and verified routing incentives linked to deregistration benefits and scrappage incentives[12 13]. Publishing corridor-level capture scorecards would strengthen accountability and expose where formal routing is failing[12 15].

7. RVSFs and dismantling: shift from scrap extraction to value extraction (Reuse-first)

Dismantling is where value retention peaks[4 7]. If dismantling is rushed or depollution is weak, plastics and electronics degrade into residue, forcing downcycling[9 12]. RVSF performance should therefore be measured not only in tonnes processed but in "value retained per ELV"-parts harvested, depollution compliance and material purity outputs[12 9]. OEM-linked dismantling networks can accelerate standardisation[4 7] and provide formal channels for certified reused parts[12 7].

8. Recycling and post-processing: engineer quality recovery, not just recovery volume (Recycle)

India's biggest recycling gap lies beyond metals[16]. The Netherlands illustrates what engineered recovery looks like: ARN reports 98.7% useful application in 2023 and 98.8% in 2024[9], above EU targets[5], achieved through a controlled chain where shredding and post-shredder separation contribute the bulk of recovery[9].

India's practical path is to upgrade polymer sorting, alloy separation, electronics recovery and shredder-residue processing in high-volume clusters[9 12]. The metric must shift from tonnes recovered to manufacturing-grade outputs produced[5 9].

9. Digital traceability and governance: connect the chain through measurement (system enabler)

Circularity cannot be managed without data. India has a starting foundation through CPCB digitised EPR portals and waste-stream tracking systems. vii Extending this logic into ELVs-vehicle to dismantler to recycler output-requires an MRV framework (measurement, reporting and verification). State-wise scorecards tracking capture, dismantling quality and recovery output will drive transparency and competition.

Closing: defining success in the next phase

Success in India's automotive circular economy transition must be measured in one outcome: value retained per vehicle across its lifecycle. Reduce must become an engineering and procurement discipline, Reuse must become a trusted market, and Recycle must become a technology-driven quality recovery chain. If these levers are aligned and connected through traceability, India can move beyond fragmented recovery into a circular manufacturing advantage built on material security and industrial competitiveness.

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8 Table of Figures

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