Pathways to Circular Economy in Indian Electronics Sector

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सत्यमेव जयते

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भारत सरकार
Ministry of Electronics &
Information Technology (MeitY)
Government of India

Foreword

'***Circular Economy***' is the new 'Mantra' for future development and growth. Hon'ble Prime Minister has emphasized for *'Taking forward the Mission Circular Economy in full earnest'* during his address to the nation on Independence Day 2021, since it minimizes the wastage at each life-cycle stage and promotes 4Rs (i.e. reuse, repair, recover, re-manufacture) and also ensures regeneration of products and materials. Circular economy approach is thus imperative to fulfill the need of resources for the growing economy, like India.

India is the third largest consumer of raw materials produced globally. If current economic trends persist, then India's material consumption would reach nearly 15 billion tonnes by 2030 and above 25 billion tonnes by 2050. In order to fulfill the resources need, it is imperative to follow circular economy approach rather than the current linear economy principle of take-make-dispose.

Ministry of Electronics and Information Technology is implementing the '*Action Plan on Circular Economy in Electronics and Electrical Sector*' under the guidance of NITI Aayog.

This joint study on circular economy by ICEA and Accenture ensures an India-centric approach to understand the preparedness of circular economy business models, identify gaps and opportunities, as also to formulate evidence-based policy recommendations.

I compliment ICEA and Accenture for this comprehensive well-researched white paper on circular economy.

Best Wishes,

(Alkesh Kumar Sharma)

Place: New Delhi
Dated: 26th June, 2023

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Foreword - Pankaj Mohindroo

Report on Circular Economy

A combination of technological advancements, supportive policies, and pan-India consumption trends have bolstered the expansion of the Indian electronics sector, which is all set to be a global manufacturing hub in the near future. In FY22-23, India manufactured USD 103 billion worth of electronic goods and is on track to create a USD 300 billion electronics manufacturing ecosystem by FY25-26. However, while this growth is promising, the sector remains highly resource-intensive, with significant environmental impacts and social risks. Therefore, there is a need for the sector to present a united front in tackling these challenges by transforming linear value chains into closed-loop ones.

In response to these challenges and realizing the benefits of the circular economy, Indian electronics manufacturers are adopting leading circular economy practices such as, the use of secondary materials in manufacturing, designing for recyclability, and so on. However, increasing global chip shortages, short product lifecycles due to changing consumer demands, and electronics frauds stemming from their high value, etc. are generating operational challenges for the Indian electronics sector.

In this context, relevant policy support is essential to promote the growth of the different circular business models without inhibiting the ease of doing business in the sector. As the representative of the Indian electronics sector, ICEA has already assisted the Ministry of Electronics and Information Technology (MeitY), Government of India in the formulation of landmark schemes such as Production Linked Incentives (PLI) for Large Scale Manufacturing Electronics Manufacturing, PLI 2.0 for IT Hardware, Scheme for Promotion of Manufacturing of Electronic Components and Semi-conductors (SPECS) and Modified Electronics Manufacturing Clusters Scheme (EMC 2.0), among others, for the growth of the Electronics Industry in India. These policies facilitated the transformative growth of electronics manufacturing in India.

We are pleased to present the white paper on 'Pathways to Circular Economy in the Indian Electronics Sector', which is the result of our efforts to understand the current maturity of the circular economy in the Indian electronics sector and identify pragmatic circular policy recommendations. The data-modeling powering this study estimates an incremental ~$20 Bn in economic benefits, the generation of ~132,000 jobs, and reduction of ~0.6 Mn metric tons of waste and ~2.2 Mn metric tons to emissions reduction by 2035.

We take this opportunity to thank Accenture for jointly developing this report with ICEA. We also thank all the other organizations and practitioners that have contributed to this critical study. We hope this study will guide Indian policymakers and industry players through this essential circular economy transformation.

Pankaj Mohindroo

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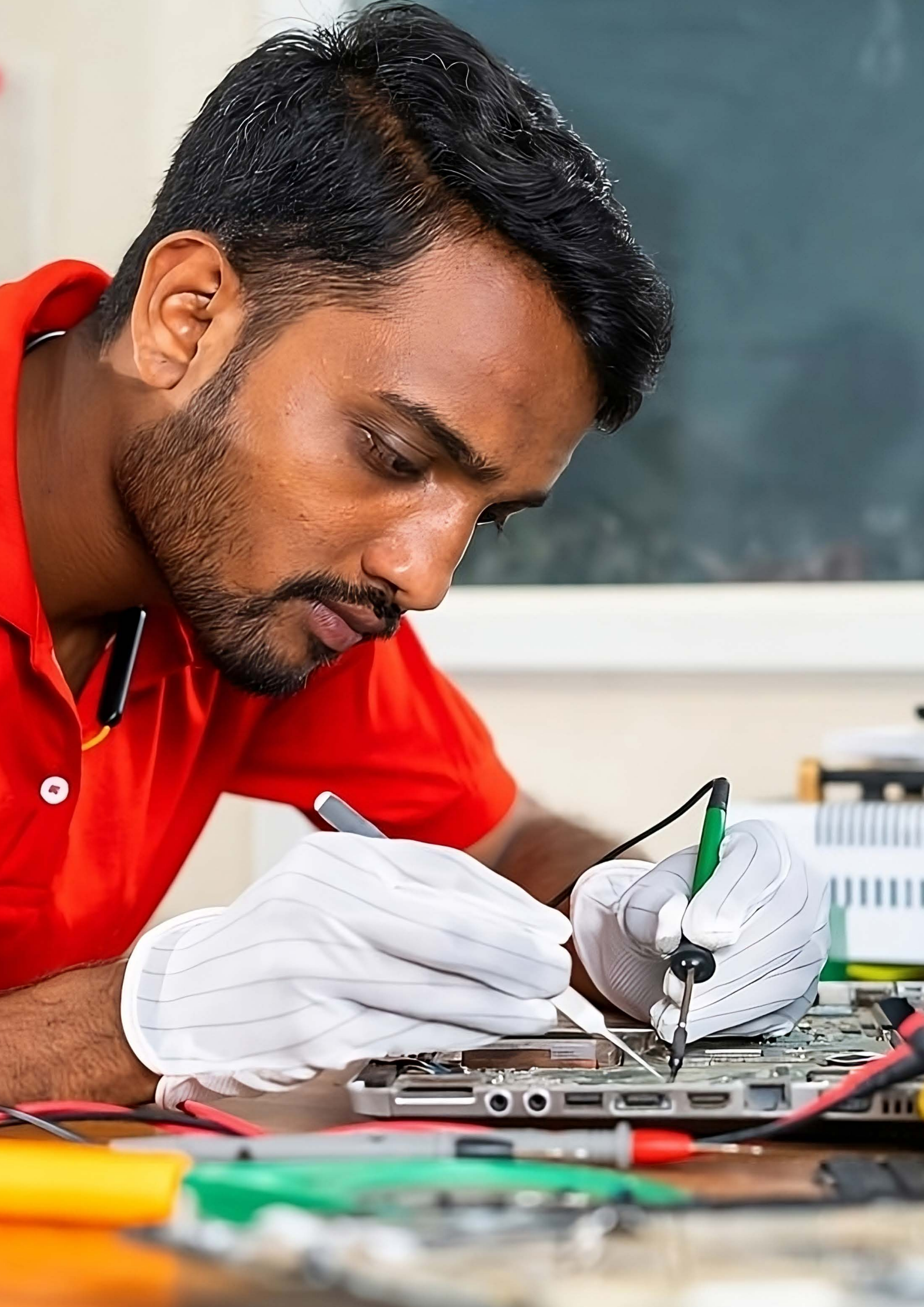

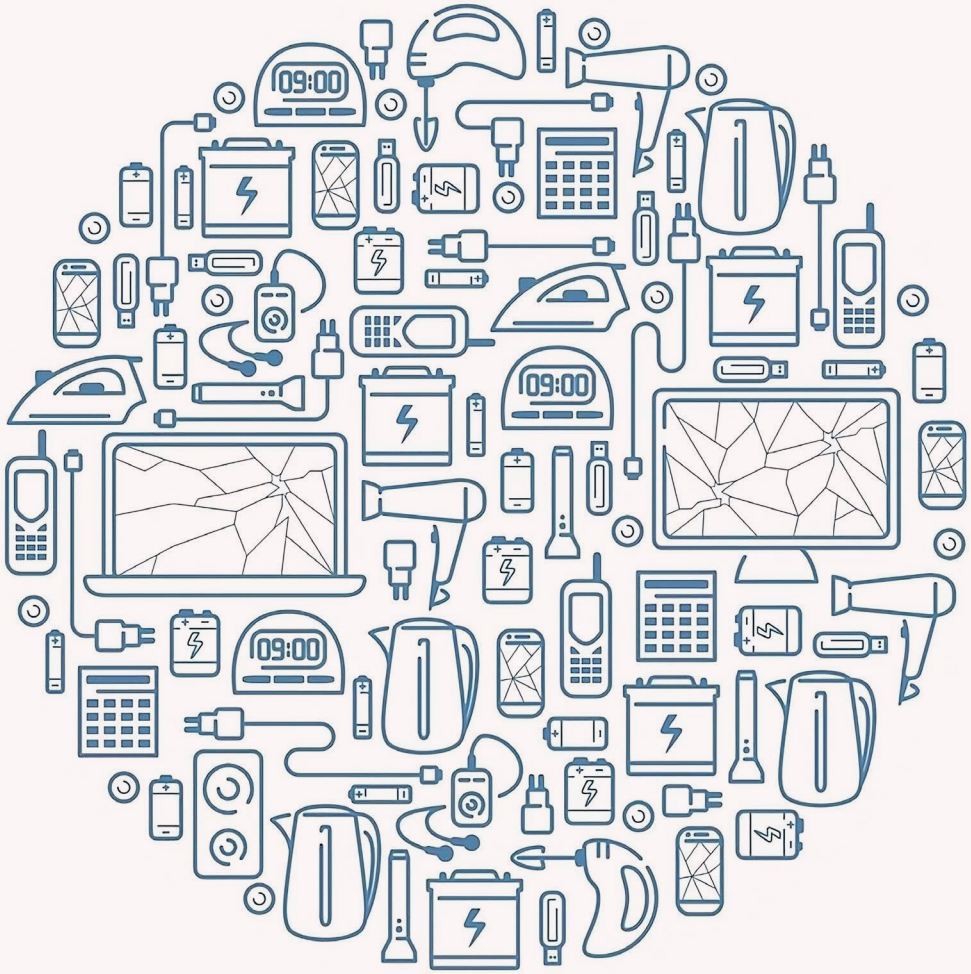

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Executive Summary

Circularity in electronics is more than e-waste management; it's a source of resilience, resource efficiency and economic growth. Besides that, it offers co-benefits for climate, health, and livelihoods. India's circular electronics policy framework has evolved in the last decade with E-Waste Management (EWM) Rules 2016 and subsequent amendments, NITI Aayog's prioritization of e-waste as one of the 11 focus areas, circular electronics policy paper by the Ministry of Electronics & IT (MEITY) and inclusion of e-waste recycling in Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS), etc. The Government of India has also embarked on a consultative process on topics such as the right to repair and eco-design standards.

Overall, the policy framework continues to expand its envelope. But considering India's unique local context and an ambition to emerge as a global manufacturing hub, there is an enormous potential for a pivot. To make the most out of the country's distinctive advantage, there is a need to step-back and establish a fact-based consultation on the economic, social, and environmental impact of various policy interventions. With that objective, this report provides insights into the effectiveness of different solutions, and their attractiveness to consumers, businesses, and government. Finally, the report recommends game-changing policy interventions and charts a roadmap to accelerate the circular transformation.

Our research and stakeholder consultations identify six critical findings:

Finding 1: Circular electronics business models offer an untapped revenue potential of $7bn in India in 2035

Figure 1 Market size of circular electronics opportunities in India in 2035

Scenario	Business as-usual	Total economic potential
Market size of circular business models in 2035	$13 bn	$20 bn

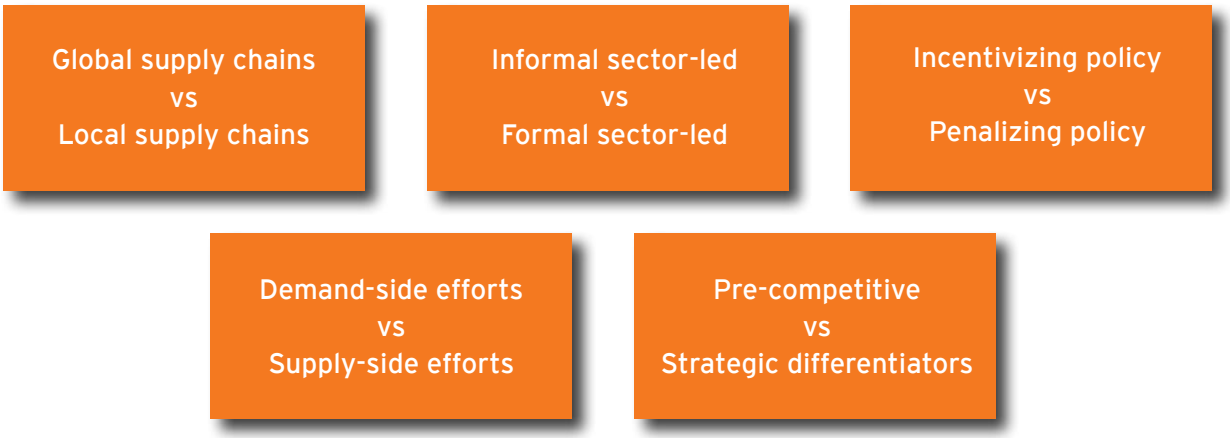
Note: The detailed approach used to estimate the above numbers can be found in Appendix 3

There are six circular business models in the electronics sector, namely, Circular Design, Product-as-a-Service, Repair, Resell, Refurbishment and Recycle. The projected market size of these six in business-as-usual scenario (based on existing commitments and targets) in 2035 stands at $13bn whereas the total addressable market, if right public and private sector actions were to be undertaken, is as high as $20bn. Therefore, approximately 35% of the revenue potential could remain untapped, including not just wasted embedded value but also wasted capacities and lifecycles. In terms of margins, it is estimated that 1-3% of electronics industry's EBITDA is at stake if the circular transition is not made.

Finding 2: To fully unlock this potential, India needs to carve out its own path which balances five key trade-offs

India is unique and so is its potential: aspiring cost-conscious consumers, informal sector dominance, overseas-led design decisions, and nascent domestic manufacturing sector. To unleash the full potential, it needs to pursue a holistic circular electronics policy framework. India faces trade-offs that are decidedly different from the EU and other mature economies, therefore, there is a need for an India-centric approach. Like China, it needs to balance these trade-offs in novel ways:

Figure 2 Five key trade-offs for India's circular electronics vision



- **Trade-off 1**: Reset the policy vision given the global nature of electronics supply chain and India's potential to emerge as a global repair and refurbishment hub.
- **Trade-off 2**: Prioritize formalizing the informal sector without losing its capabilities and net new formal sector-led collection infrastructure creation.
- **Trade-off 3**: Favor ease of doing business (incentivizing infrastructures) over penalizing policies (regulating design through command-and-control approaches).
- **Trade-off 4:** Balance strengthening supply-side of circular business models vis-à-vis tapping into consumer-led demand shift.
- **Trade-off 5**: Encourage pre-competitive collaboration for capital intensive WEEE management infrastructure but allow competitive design-led product innovation to thrive.

Finding 3: Circularity is already functioning at scale in India largely driven by informal sector presence, but with significant negative environmental and social externalities

Of the six business models, three (Repair, Resell and Recycling) are already prevalent at scale, largely dominated by the informal sector presence.

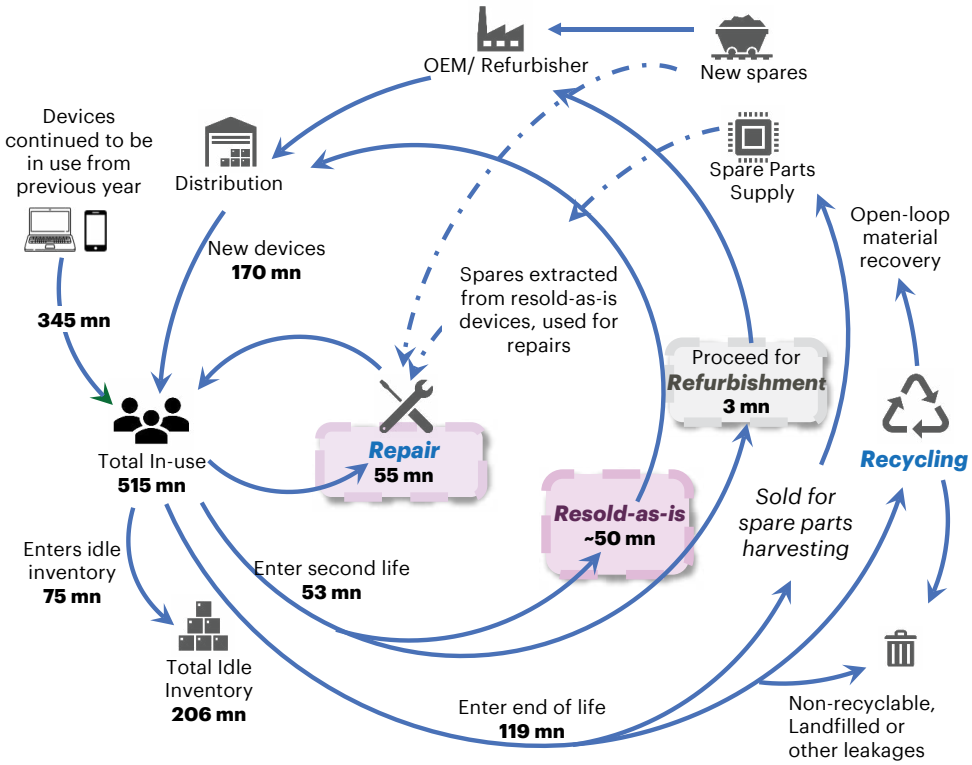
Recovery and recycling. Roughly 90% of collection and 70% of the recycling are managed by a very competitive informal sector. Only 22% of collected WEEE is recycled by the formal sector, which is characterized by small-scale fragmented capacities and lacking technical know-how for difficult-to-recycle fractions. And the secondary materials recovered, lack quality and quantity both. In fact, improper behavior through collusion between the formal recyclers and informal

collectors are also reported. The remaining 8% of WEEE is mismanaged, such as leaked into nature or landfilled. Idle inventory is another key bottleneck, as over 200 mn unused devices are stored in the Indian households at a given time.

Repair, refurbish and resell. Roughly 60% of the devices needing repair are serviced by a cost-effective and accessible informal sector, especially for out-of-warranty devices. Consumers conscious of service quality choose the formal sector repairs which form 18% of total, and that mostly pertains to in-warranty repair demand. The remaining 22% of the consumers who need repair, continue using their devices as-is. Venture capital investments into multi-brand startups are supporting rapid growth to overcome the currently limited footprint of the formal repair and refurbishment business.

Circular design and as-a-service models. India imports a significant share of electronics products, and the local value addition is still low. Even after domestic manufacturing ramps up and design-linked incentives are enabled, harmonization with global supply chain is the key. Product as a Service (PaaS) grew by 65% last year but remains nascent, gaining traction in the B2B segment particularly for laptops.

Figure 3 Circular material flow of smartphones and laptops in India



Note: The detailed approach used to estimate the above numbers can be found in Appendix 3

The existing scale of the informal sector-led recovery and recycling comes with negative environmental and social externalities. The current dominance of the unregulated informal sector has resulted in the leakage of toxic substances into nature. Crude methods such as acid leaching, open-air cable burning, etc. potentially result in contamination of soil and water, and emission of harmful gases in the air. Social issues, on the other hand, include negligence of waste workers' safety and health, child labor and meagre wages. Given the quantum of volumes and number of workers employed, these issues magnify into urgent environmental and human rights risks.

Finding 4: Nine bold policy interventions across three distinct pathways can produce game changing results

The study evaluated more than 50 policy interventions based on a comprehensive and data-led approach. Nine bold policy interventions have been shortlisted across three pathways.

Downstream pathway:

EPR's initial momentum is likely to slow down if the gaps are not plugged soon. In parallel, conditions that make formal sector WEEE recycling competitive must be created to attract big ticket capital infusion

Game changers	Required policy interventions
Urgently improve the quality and fairness in E-waste collection and recycling ▸ Improper practices are widespread and due to existing intermediate players in the downstream, e-waste is being sold at significantly lower price than it should be (with a difference of ~30-50%[1]) ▸ If not recalibrated soon, India will miss the opportunity to create a powerful foundation on which more value-adding activities such as smelting, and refining can be performed. ▸ Standards, which are auditable by independent accredited auditors and widely accepted, have proven impactful. Regulatory authorities such as CPCB and SPCB have limited bandwidth but legitimizing a WEEE management certification could be a quick win.	**1. Launch 3rd party auditable standards and material flow database for collectors, dismantlers, and recyclers**
At collection and dismantling stage, liquidate idle inventory and minimize negative externalities associated with informal sector operations ▸ On an average, each Indian household is hoarding at least one device, despite last-mile presence of informal sector collection. ▸ Material recovery activities in the informal sector must be highly regulated and potentially limited to aggregation and dismantling. ▸ In mid-long term, there is a need for net new formal sector collection infrastructure creation for which actions are needed today in public-private partnership mode	**2. Explore public-private mechanisms for formal consumer take-back of devices** **3. Develop government-led aggregation and dismantling zones in targeted geographies**

Game changers	Required policy interventions
At recycling stage, enhance competence of existing players and attract investment from new players to manage difficult-to-recycle fractions ▸ Current recycling capacities are fragmented (~60% of recyclers have less than 1000 tons per annum of capacity and represent approximately 15% of the installed capacity). Small, decentralized recycling capacities usually have poor cost economics, low yields are difficult to monitor. ▸ Only select fractions (~80% by weight) have a mature downstream ecosystem. Existing players lack the capital and technical know-how to manage difficult-to-recycle fractions (~20% by weight), and there is a need for fresh capital infusion and technology partnerships. ▸ It could be a lucrative commercial opportunity: urban mining of gold alone from waste PCBs in India can be a $1.5bn business.	**4. Incentivize high-capacity high yield advanced recycling facilities**

Use-phase pathway:

Emergence of multi-brand service providers could be the silver bullet, but demand and supply-side efforts are needed to improve the affordability, accessibility and availability of high-quality refurbished products and after-sales services.

Game changers	Required policy interventions
Support growth of multi-brand services in formal sector as a force of change ▸ OEMs can leverage growing multi-brand formal players (currently forming 3% of repairs) to expand their presence while retaining control over intellectual property and service quality. ▸ Such partnerships can also help co-opt recognized informal sector repair service providers and MSME refurbishment capacities. ▸ Maintaining a high inventory of spare parts comes with additional costs, supply chain complexities and obsolescence risks for OEMs. To help strengthen spare parts supply chain, two options can be evaluated. Firstly, ramping-up domestic production of original spare parts with long-term supply contracts and favorable terms. Secondly, reducing the friction in the import of non-original spare parts ▸ Capital support and GST & custom duty rationalization on input materials should be provided to improve viability. ▸ In addition, the strategic advantage of facilitating smooth import of pre-owned devices specifically for export purposes needs to be reviewed. India can aim to emerge as a global repair and refurbishment hub with guardrails in place to minimize any risk of leakage in the local market	**5. Scale-up multi-brand formal services through strengthened spare parts supply chain, market linkages and incentives**

Game changers	Required policy interventions
Spur consumer demand of refurbished products ▸ Consumers are concerned about the quality of refurbishment and there is no uniform way of defining the tier of refurbishment quality. ▸ Quality concerns and global benchmarks (1 year OEM warranty globally as opposed to India's prevalent 6-month warranty offerings) make a case for additional mechanisms such as extending warranty period or protection plans to help address the consumer trust issues further.	**6. Define BIS and industry-led refurbishment standards and mandate aftersales protection options**
Ease movement of inventory across ecosystem actors, including consumers ▸ Multi-brand formal players which source devices for refurbishment and resell often face friction related to lack of provenance (e.g., handling cases of stolen devices). ▸ Consumers buying pre-owned devices desire to know the chain of custody, based on which they assess the health of the device they are going to purchase.	**7. Explore chain-of-custody mechanisms for validating legality of sourced devices**

Upstream pathway:

Design interventions must be harmonized and should be such that they do not compromise the ease of doing business. Instead, service models offer a lucrative business opportunity and must be catalyzed

Game changers	Required policy interventions
Reorient existing consultations on eco-design and sustainable product policy around domestic secondary materials market ▸ Electronics supply chain are global in nature, and creation of siloed India-specific standards compromises ease of doing business. Hence, there is a need to harmonize with globally established requirements. ▸ An on-pack sustainability label may not yield significant results given low levels of consumer awareness, and rather the focus should be on leveraging eco-design to enhance manufacturing incentives. ▸ Similarly, the policy should aim to promote robust local availability of secondary materials to meet demand from the manufacturing sector.	**8. Prioritize development of secondary materials market and adopt ease of doing business lens in eco-design consultations**

Game changers	Required policy interventions
▸ Of 14 metals (including precious and rare earths) present in a device, India has a 100% dependency on imports for 8 of those, thereby highlighting the need to support India's self-sufficiency for strategic raw materials. In fact, China controls around 80% of the world's production of rare earth materials, and accounts for 98% of EU imports. ▸ There is also a need to prioritize and take a phased approach as several design interventions will not bear fruits given the absence of downstream collection and recycling infrastructure	
Create a nurturing ecosystem for service models by providing a catalyzing policy indication ▸ While subscription or leasing models are opportunities for the private sector, there is a need for ecosystem-level enablement. ▸ Telecom players (with their post-paid subscribers), financial services (for underwriting the risk and KYC), insurance companies (for device protection plans) and 3rd party service platforms (for management of the device lifecycle) are needed. ▸ In addition, public procurement of as-a-service products can create a critical mass of initial demand while B2B and B2C channels ramp-up.	**9. Develop a product as a service framework to enable development of an ecosystem**

Note: The approach and policies referred to arrive at above policy interventions are explained in Appendix 2.

Finding 5: Cumulatively, these policies have the potential to add $1.7bn of economic value (net of costs) and divert 0.5mn tons of WEEE, just from two categories (smartphones and laptops) until 2035

Benefits of these policies are expected to outweigh the costs. In addition to economic value and waste avoidance, combined impact of these policies could lead to the creation of 110,000 high-quality formal sector green jobs and avoidance of 1.6 mn tons of GHG emissions, from just two categories (smartphones and laptops which are the focus areas of this report) until 2035. The impact would be several times higher if other electronics categories were also considered. Implementation of most of these policies will result in net positive impact, even if the capital and operational expenditure are high in the initial years. However, to make the implementation economically viable, much higher infusion and major redirection of capital investment is required. The key would be to create a win-win situation wherein the costs and risks are fairly shared across the stakeholders such as the OEMs, government, and consumers.

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Figure 4 Impact potential of recommended policy interventions across 2022 - 2035

	Required policy Interventions across three pathways	Economic Impact *($ Mn)*	Social Impact *(000' jobs created)*	Waste Avoided *(000' Metric Tons)*	Emissions Impact *(000' Metric Tons of CO_2e)*
Downstream pathway	Explore mechanisms for formal consumer take-back	61	30	230	331
	Launch 3rd party auditable standards and material flow database	9	0.4	33	47
	Develop aggregation and dismantling zones in targeted geographies	25	1	94	136
	Incentivize high-capacity high yield advanced recycling facilities	46	2	115	166
Use-phase pathway	Explore chain-of-custody and provenance mechanisms	271	3	1	176
	Set-up refurbishment standards and mandate provision of insurance/ warranty options	357	19	2	209
	Scale-up multi-brand formal aftersales services through strengthened spare parts supply chain, market linkages and incentives	504	30	1	34
Upstream pathway	Prioritize and harmonize eco-design imperatives and develop secondary recycle materials market	*Net Cost activity in short term with potential to recover costs in long term*	1	39	284
	Develop a Product as a Service policy framework	372	28	2	229

Note: The detailed approach used to estimate the above numbers is covered in Appendix 3

Finding 6: System change pathway balances these trade-offs and unlocks synergistic benefits, boosting the economic value (net of costs) potential to $2.5bn and WEEE diversion potential to 0.6mn tons

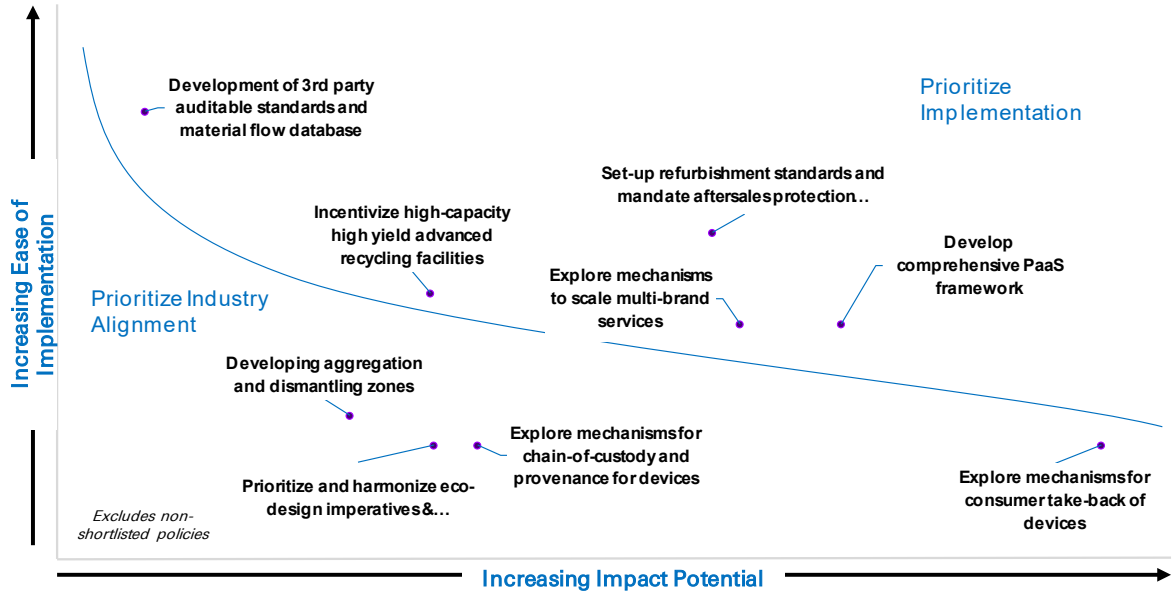
Choosing one pathway over another comes with two risks a) lack of balance in trade-offs in terms of economic, social, and environmental value b) untapped synergistic effects due to interconnectedness. For example, increasing the downstream collection would increase the spare parts harvesting volume and thereby supports the service industry in the use-phase stage. WEEE averted from informal sector could be increased especially in the downstream stage, due to further increase in demand of high-quality recycled raw materials from the manufacturers, because of policies in upstream pathway. Therefore, there is a need to adopt a system change approach, wherein simultaneous implementation of policy interventions across the value chain is undertaken, albeit with a graded ambition level. System change approach has the potential to increase industry gross profits by $0.8bn, showing a ~30% increase from the cumulative impact of individual pathways. Positive synergistic effects can result ininto an incremental impact on job potential, waste diversion and GHG emissions reduction potential to the tune of 15%, 10% and 25% respectively. The cost for offsetting the associated GHG emissions, roughly 2.2 mn tons of CO2eq, could go as high as ~$32mn (assuming a carbon price of $15 per ton).

Five key imperatives for government and industry to initiate a concerted action

The value of circular economy transition is undisputed, and it is achievable with joint public-private action and a well-articulated and stable long-term vision. There are five key imperatives for public and private sectors, as we begin firming-up India's circular electronics roadmap.

Layout a circular electronics roadmap which prioritizes big bets, in contrast to an all-encompassing thrust. NITI Aayog and MEITY have already started the process. The nine interventions proposed above must be prioritized. Of these, five can be taken up for implementation in the near term (Figure 5).

Figure 5 Prioritization of required policy interventions



Build a shared understanding among the public and private sector players and avoid unilateral decisions. The nodal agency responsible is already empowered and motivated, however, a new governance structure must be evolved to enable deeper consultations.

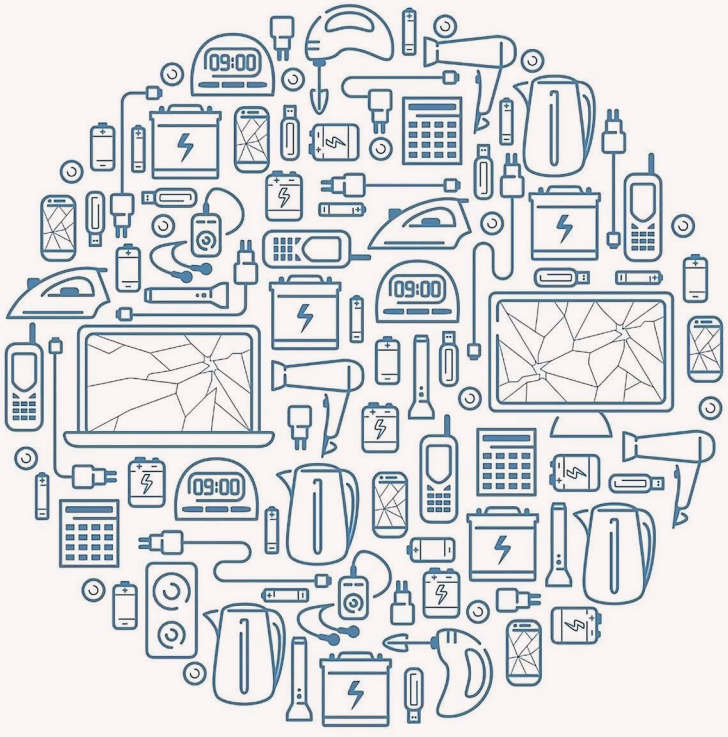
Undertake unprecedented ambitious actions such as overhauling of e-waste collection & recycling or attracting multi-billion-dollar investments in smelting and refining which needs a fresh techno-commercial thinking and calibrated use of regulatory bandwidth.

Form a coalition of willing industry players to change the regulatory risk-avoidance mindset of industry at large. Motivated private sector players should aim for stretched goals and, in the process, set a high benchmark for the rest of the industry and generate proof points to inform policymaking.

Embrace data-driven policymaking, given the contentions and complexities in the landscape. A national waste survey and cost-benefit analyses are crucial for objective decision making, and the required technical competence and funding must be organized by the nodal agency.

In conclusion, this decade is going to be a pivotal one to establish the foundation on which India's successful circular transition could be built upon. It requires a systematic and well-thought implementation roadmap – one that can only be designed and implemented through collaboration across diverse stakeholders. While the study zoomed in on two categories (smartphones and laptops), most of the recommendations are applicable to other categories as well. It is our hope that this document, rooted in data and research, will serve as a policy playbook for all those looking to be part of a systemic solution.

CIRCULAR ELECTRONICS IN INDIA: POLICY'S OPPORTUNITY TO DELIVER



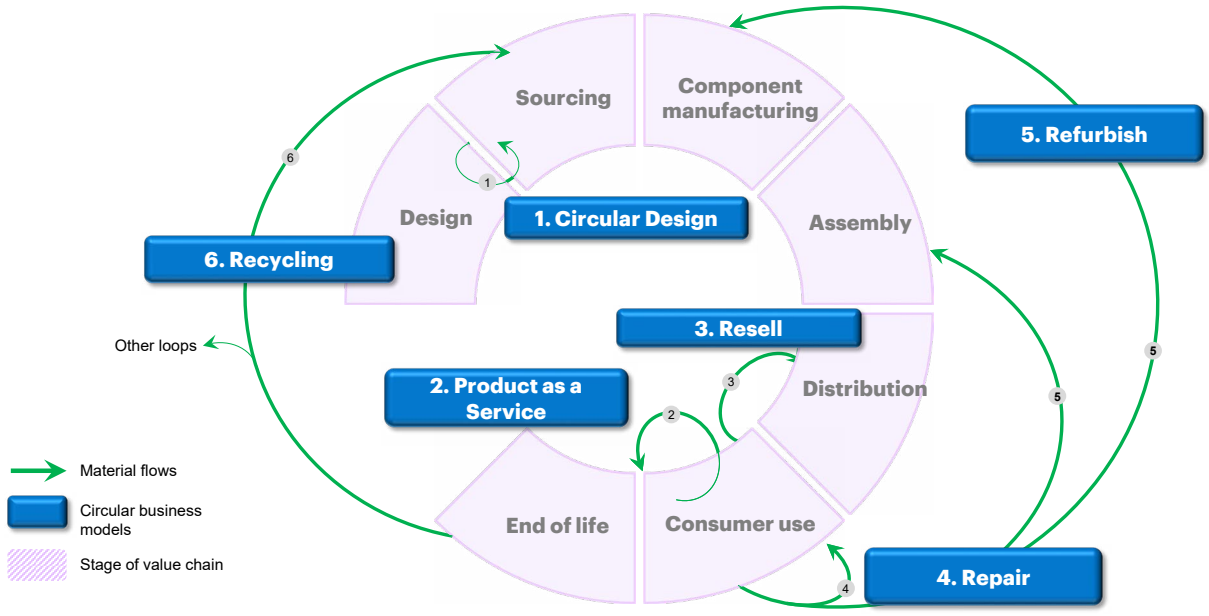
CIRCULAR ELECTRONICS IN INDIA: POLICY'S OPPORTUNITY TO DELIVER

Circularity in electronics is more than e-waste management; it's a source of resilience, resource and cost efficiency and economic growth

The electronics consumption is strongly correlated to economic development and is an indicator of living standard in developing countries like ours. On average, India consumes 0.47 mn tons of electronics products per year. After its use, the electronics products are disposed of, generating e-waste, or Waste Electrical and Electronic Equipment (WEEE). While managing WEEE is an urgent priority, the concept of circular economy goes beyond conventional waste mindset of the linear value chains. It is an economic paradigm based on three principles, driven by design i.e., elimination of waste and pollution, circulation of products and materials (at highest value) and regeneration of value[2]. The global value at stake is immensely high: $4.5tn across sectors and $20-50bn (1-3% of industry EBITDA) specifically for information and communications technology sector by 2030. This value is manifested in the form of cost savings, topline growth, and resilient supply chains.

Three of the six circular economy business models are already prevalent at scale in India

Figure 6 Six circular business models for electronics industry



These six business models are Circular Design, Product-as-a-Service, Repair, Resell, Refurbishment and Recycle. While the technical definitions of these business models are still not well defined in India (refer to Appendix), a complex network of actors are already implementing three of them at scale. Our modelling shows that the informal and formal sector together managed recycling of ~119 mn devices in FY21. Similarly, almost 55 mn devices got repaired, whereas ~50 mn devices got resold as-is. The remaining three business models – Refurbishment, Product-as-a-Service (PaaS) and Circular Design are still in the early stages. In the use phase, refurbishment and service models are key opportunities which the private sector hasn't fully explored yet. In fact, only ~3 mn devices were refurbished in FY21 despite the addressable market being sizeable enough. In upstream phase, circular design is an emerging theme globally, and global electronics players are already acting on it.

However, there is a need to minimize negative externalities and exploit full value potential

The existing scale comes with negative externalities in two forms, environmental and social. The current dominance of the unregulated informal sector has resulted in the leakage of toxic substances such as lead, mercury, biphenyls, barium etc. in nature. Crude methods such as acid leaching, open-air cable burning, etc. result in contamination of soil and water, as well as emission of harmful gases into the air. Social issues, however, include human rights risk such as negligence of waste worker safety and health, child labor and unfair wages. Given the quantum of volumes and number of workers employed, these issues magnify into urgent and colossal environmental and human rights risks. The existing scale is also not the most efficient in terms of maximizing economic potential, both in terms of increasing volume (high yield) as well as value (high quality). Unlocking this potential would be a function of two factors: 1) increase in volume (e.g., through enhanced liquidation of idle inventory) and 2) increase in value (e.g., diversion to more optimal routes such as resell, refurbish and repair instead of recycling).

KEY TRADE-OFFS FOR FRAMING INDIA'S CIRCULAR ELECTRONICS VISION

The time to pivot for transformation is here and now. Now just India is one of the largest markets globally, it is also unique in many ways. Most notably, a) presence of newly born domestic manufacturing sector b) highly cost-conscious consumers, c) dominance of informal sector led circular business models and d) limited regulatory enforceability. Therefore, in this study an India centric approach has been taken, where existing strengths are being leveraged (e.g., informal sector skillsets) while working on the weaknesses (e.g., underdeveloped formal infrastructure). To capitalize on the nine opportunities mapped based on the analysis of the as-is situation, the study has identified five key considerations that need deeper consultation as mentioned in Figure 2 (Five key trade-offs for India's circular electronics vision).

Trade-off 1: Environmental benefits of risk avoidance versus opportunity cost of not integrating boldly with global supply chains

Electronics supply chains are global in nature as the geography of production is not always the same as that of consumption. There are two immediate implications, firstly, the need for harmonization of standards & rules with globally accepted norms, and secondly, the need to promote India as a global repair and refurbishment hub more proactively. Players can import pre-owned devices to repair and refurbish in bonded zones, with the purpose of exporting them back, which needs to be categorically distinguished from importing for local consumption. A key condition for the success of such models is a short total turnaround time of 5-10 days, which is currently not possible. To reduce the friction, custom clearances need technology-enabled streamlining and with the right mechanisms in place, the risk of leakage in the local market can be minimized.

Trade-off 2: High financial cost of just transition versus high environmental and social cost of business-as-usual

So far, EPR implementation in India has largely benefitted from established informal sector collections with high efficiencies and low-cost structures. However, there is a need to focus on formalization of the entire supply chain, without which the goal of minimizing negative environmental externalities may not be difficult to achieve. At collection stage, the optimal way to formalize would be to co-opt informal sector players either as employees or microentrepreneurs. Public (ULB or state level) and private players could split the CAPEX, but a proven model is yet to emerge. At recycling stage, experience shows that the co-option of the informal sector is demanding, but better standards, audits and social inclusion programs may help.

Trade-off 3: Potential benefits from command and control versus ease of doing business

Policy can either be incentivization-based or penalization-based. Given India's key ambition to emerge as a global manufacturing hub, command-and-control legislations reduce the ease of doing business and therefore, are best leveraged to address the urgent challenges related to negative downstream externalities. In fact, overregulation of WEEE dismantling and recycling in the initial years will help steer away from unsound business practices. To influence device design and strengthen use-phase business models such as repair and refurbish, incentivization-based policies that take advantage of market mechanisms would be more impactful. Excessive regulation runs the risk of stalling the fledging domestic manufacturing industry. So far, the Indian policy framework has followed a similar approach but needs reinforcement.

Trade-off 4: Bolstering the supply-side infrastructure of circular products and services versus creating consumer demand.

Circularity in electronics comes at a cost, be it a longer warranty period or OEM-led last-mile take-back of devices. So far, the consumers have enjoyed a wide-spread availability of informal sector services, albeit at an environmental cost. In the Indian market, where the average sales prices are still one of the lowest in the world, consumer propensity to pay the green premiums is limited. Therefore, in the new paradigm, consumer awareness creation and demand generation are important. Based on the experience of EU countries, markets with a mobilized consumer base are usually able to push for circularity much easier.

Trade-off 5: Benefits of pre-competitive cooperation versus that of competitive innovations

In the downstream, large-scale collaborative solutions with shared costs among players are better than multitude of small-scale projects led by individual players. This is particularly important for those WEEE collection, dismantling and recycling activities which are still underserved. Successful examples can be seen in plastic waste management landscape, wherein, FMCG companies, packaging manufacturers and recyclers are coming together to set-up ambitious alliances and joint ventures. However, in the upstream, High-Tech business thrives on strategic differentiation, enabled by the protection of intellectual property, eventually to improve the experience for consumers and market-specific features.

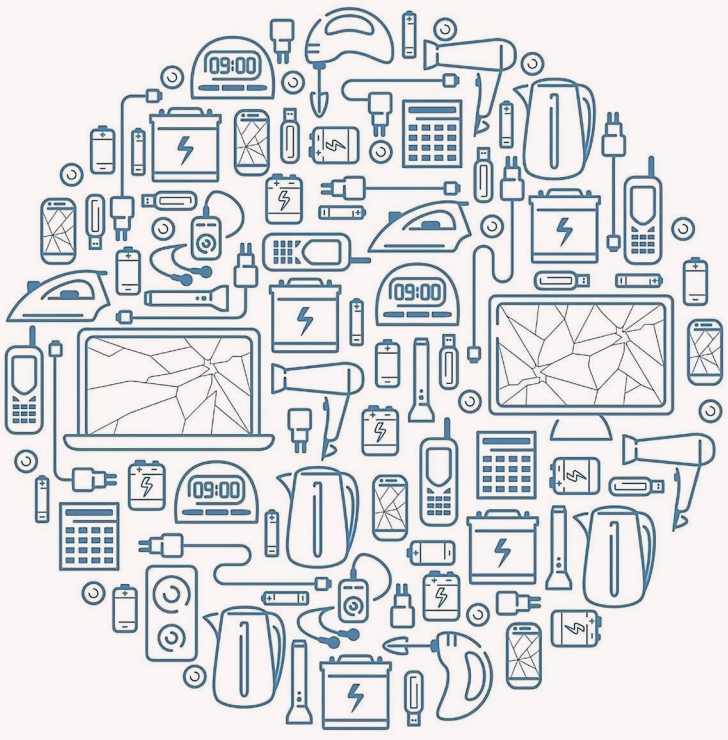
THREE PATHWAYS FOR CIRCULAR ELECTRONICS TRANSITION

Conducted a study (detailed out in next chapter) to assess the progress made so far across the six business models and maps key challenges and opportunities, and finally provides data-backed policy recommendations, by quantifying the economic, environmental, and social impact. These recommendations can be classified across three pathways based on the stage of the value chain.

- **Extending useful life of devices and components:** Extending useful life of devices by promoting scale of repair and refurbishment operations
- **Extracting maximum value of end-of-life devices:** Taking measures to liquidate consumer idle inventory, developing recycling infrastructure and standardization of process to extract maximum value from end-of-life devices.
- **Leveraging design and service models to close the loop:** Developing long-term policy strategies to develop design and service models in India.

While EEE includes large devices such as TVs, washing machines, etc., this study has focused on small IT equipment, particularly smartphones and laptops. This has helped ensure sharpness in analysis and to cover for category's uniqueness such as high emotional value, high embedded value and comparatively short-use-cycles with a significant potential of second and third life. However, it is not to encourage de-prioritization of low value and high-volume fractions e.g., mercury containing lamps or low-grade PCBs which are often found to be economically less attractive but have an extremely high negative externality associated.

DOWNSTREAM: EXTRACTING MAXIMUM VALUE AT END-OF-LIFE

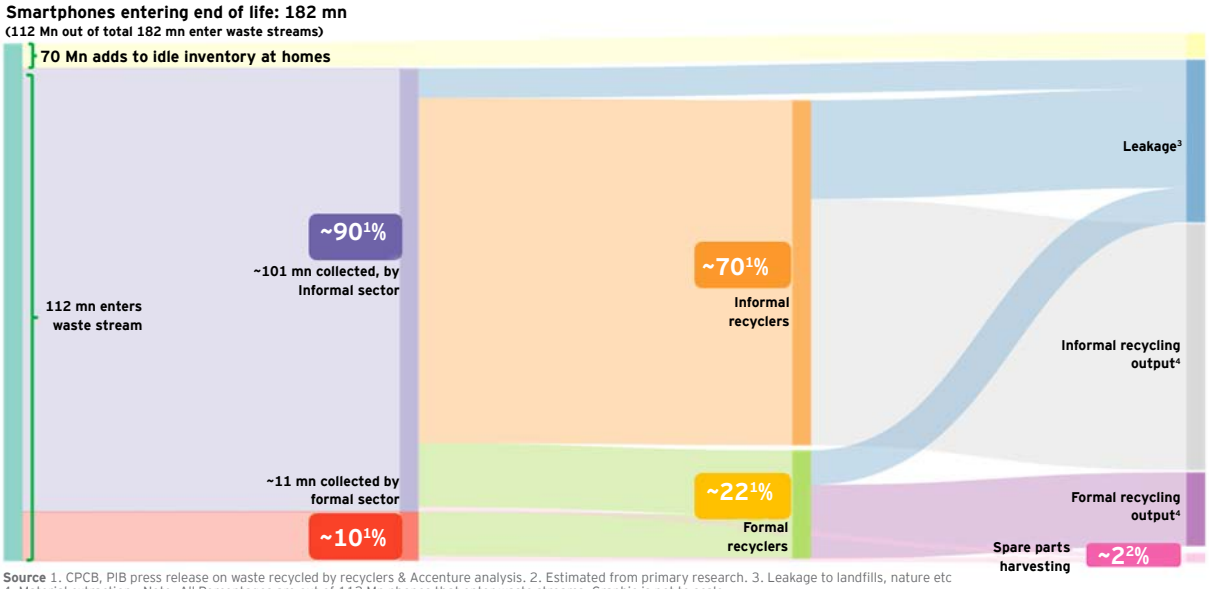


DOWNSTREAM: EXTRACTING MAXIMUM VALUE AT END-OF-LIFE

PROGRESS SO FAR: RECYCLING

Over 90% of the collection volume and 70% of the recycling volume is managed by informal sector

Figure 7 Recycling material flow shows high WEEE leakage and informal sector dominance



Source 1. CPCB, PIB press release on waste recycled by recyclers & Accenture analysis. 2. Estimated from primary research. 3. Leakage to landfills, nature etc 4. Material extraction - Note- All Percentages are out of 112 Mn phones that enter waste streams. Graphic is not to scale

WEEE collection occurs largely through two channels, from end consumers by informal scrap dealers and from bulk generators by formal players as part of the Extended Producer Responsibility (EPR) mandate. Other channels such as drop-off boxes and collection drives are useful but not institutional enough yet to be able to attract substantial volumes. The key drivers of collection rates are convenience and value that waste generator gets. Overall, ~90% of the collection volumes are managed by a highly competitive informal sector, with a last-mile presence and ability to pay more. A major share is sold to the informal sector recyclers, an attractive channel which can offer relatively higher prices to the informal aggregators as compared to the formal recyclers. Underlying reason for this competitiveness is the informal sector's favorable cost structure, which does not include the cost of compliance such as GST or cost of adopting EHS (Environment, Health and Safety) practices. In addition, roughly 2% of devices are used for spare part harvesting but there is anecdotal evidence of this being a much more extensive practice.

40% of our survey respondents agree to hoarding four or more unused devices in their homes, despite the massive last-mile informal sector presence. Our estimates show that 210 mn

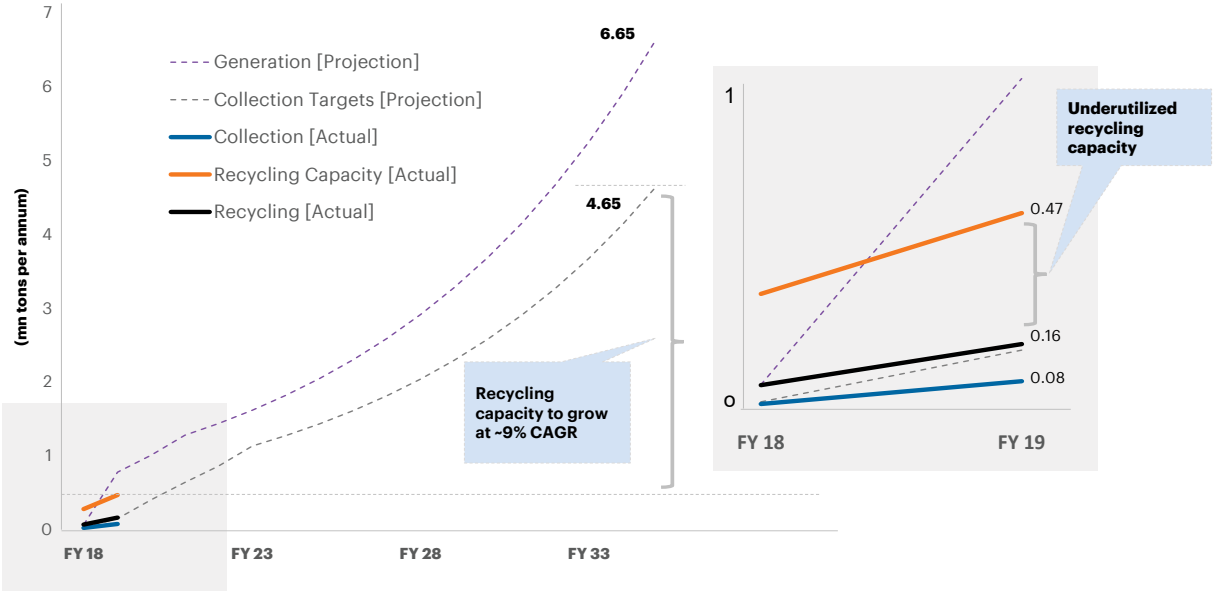
devices lie as idle inventory in Indian households, and even Kabadiwalas and scrap dealers are not able to liquidate it. There are three underlying factors a) right economic incentivization b) high personal attachment as consumers find it difficult to part with their devices due to the personal data that device holds, necessitating the need for an industry action on easy and trusted data sanitization options and c) lack of awareness as indicated by the fact that 2 in 5 consumers do not give up devices for recycling due to lack of awareness of options.

EPR has provided a strong initial momentum, resulting into emergence of a new formal ecosystem

EPR is India's anchor policy framework to manage WEEE and it has resulted in increased collection and recycling rates in the first few years of its implementation. In FY19, the collection target was 0.14 mn tons against WEEE generation of 0.78 mn tons (based on CPCB data). Approximately 50% of this target was met, demonstrating the success which needs to be built-upon in future. With involvement of stakeholders such as Producer Responsibility Organizations (PROs) and dismantlers, a strong ecosystem flourished. PROs and dismantlers were majorly involved in procuring WEEE inventory from informal sector aggregators and supplied it to formal sector recyclers. As shown in Figure 7, roughly 50% of the total volumes handled by the formal sector recycling can be attributed to informal collection. The formal recycling sector has barely gone up, increasing from 0.16 mn tons in FY19 to 0.20 mn tons in FY20 (Figure 8). If compared with the total capacity of 1.44 mn tons, this depicts a huge capacity underutilization but not for too long. Ambitious collection targets, 60% onwards and going as high as 80% of WEEE generated from 2023 onwards, mean a collection target of roughly 4.65 mn tons in FY35. In the short term, growth in EPR-led collection volume will continue to be absorbed by existing excess capacity but the capacity needs to grow at 9% every year in 2022-2035 period.

Figure 8 Forecast of WEEE collection targets and required recycling capacity

Recycling capacity needs to grow at ~9% CAGR until 2035 to meet the demand



Note: Consumer electronics market size expected to grow by ~13%; EPR collection target taken from CPCB, after 2023 the target is considered as ~70%

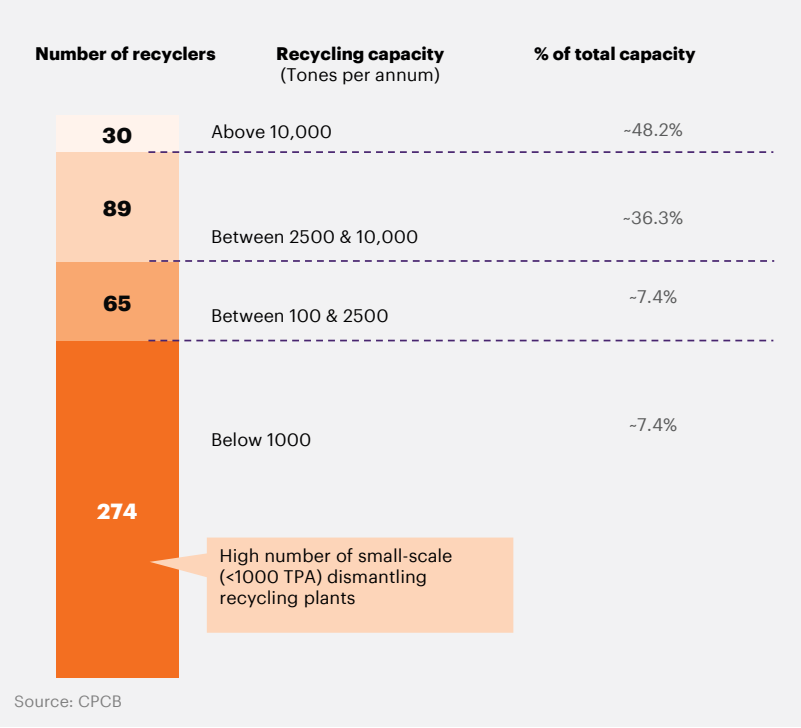
However, excessive competition among PROs and unfair disadvantage has driven down EPR costs and thereby, effectiveness

In essence, EPR is about collective responsibility, which was usually undertaken by PROs (procurement operations) as representatives of several OEMs, that led to better coordination among OEMs & recyclers, overall low implementation cost and ease of monitoring by regulators. But as the number of PROs in India increased significantly over the last few years, many of them being recyclers themselves, the Indian PRO market was characterized by excessive competition. Of these, 10 to 15 large PROs competed aggressively on securing collection contracts from OEMs and undercut each other on the prices. The cost pressure further aggravated due to lack of level playing field with cost-competitive informal sector and aggressiveness of EPR targets. For instance, PROs used to charge 30-45 per kg for smartphones and 15-20 for laptops to the OEMs[1]. However, the cost of EPR, which is a fair cost at which environmental and social externalities are minimized and new infrastructure creation happens, would be two to five times higher than the prevailing rate. Thus, it can be concluded that WEEE management was underfinanced, despite EPR's existence for many years now. And with the introduction of E-Waste (Management) Rules 2022 the responsibility of e-waste collection & recycling has been shifted to authorized recyclers & manufacturers, and a new system of procurement of recycling certificates through the CPCB managed EPR portal has been introduced.

This provides OEMs & producers with an opportunity to work with EPR authorized partners where scope of net new infrastructure creation or additionality can be further explored

Relying on informal sector aggregators for collection is cost-effective and even socially inclusive, but it comes with trade-offs. Most importantly, it results in leakage of inventory to informal material extraction units, the cornerstone of negative environmental and social externalities. A formal collection, on the other hand, would provide more control over the supply chain activities, thereby reducing any possibility of leakage into non-optimal routes. EPR implementation in India so far has not pushed for formal collection aggressively. It would include designated drop-off centers in physical

Figure 9 Recycling capacity is currently fragmented



Source: CPCB

retail stores, pick-up from home by e-commerce players, door-to-door collection by trade-ins or buy-backs by OEMs. Some options have emerged in Tier 1 and Tier 2 cities, but most of them are either inconvenient or do not offer enough incentives to consumers. The CAPEX and OPEX associated with scaling-up these options are immense, and there is no clarity on who should fund this transformation. With the revised E-Waste regulations coming into effect, the CPCB has been assigned the task of integrating all registered stakeholders into one digital system. Further exploration of the digital system can be carried out to ensure the visibility of funding and e-waste material flows.

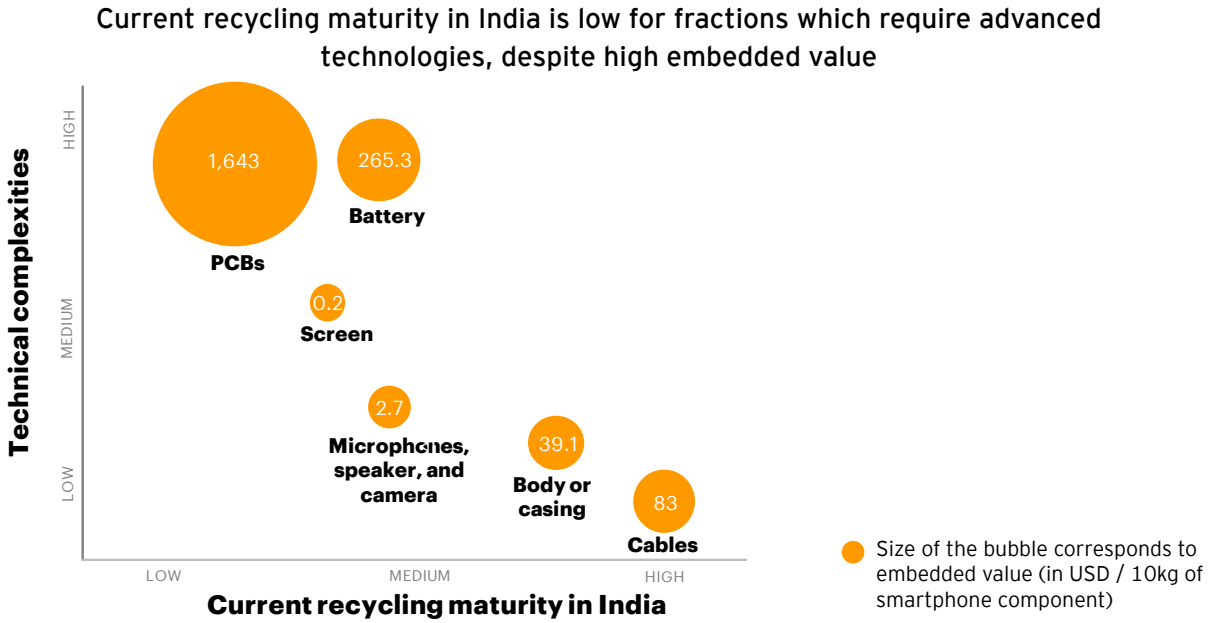
At recycling stage, share of formal sector has grown, albeit in a fragmented manner and with inadequate technologies

EPR has led to formal recycling expansion, but it is characterized by two challenges.

Fragmented capacity: The number of registered recyclers has gone up from 80 to more than 450 between FY15 - FY20 period. Roughly 60% of recyclers have less than 1000 tons per annum of capacity and represent approximately 15% of the installed capacity (Figure 9). While it indicates the private sector's interest, the evolution has been fragmented. As a result, not only are the economies of scale in these facilities low, but it has also become difficult for regulators to monitor and audit them. There is anecdotal evidence of improper behavior, including allowing the formally collected inventory to leak into the informal sector. Paper transaction or unethical rotation of the inventory to bump-up the collection numbers for reporting purpose is also alarming. These formal sector units could be indirectly compromising the quality of EPR implementation which goes unnoticed due to lack of enforcement bandwidth. Therefore, consolidation is needed to improve the dynamics, and to help Indian EPR achieve its true potential.

Difficult-to-manage fractions: WEEE consists of 60+ fractions, from which valuable materials, metallic and non-metallic, can be extracted. For non-hazardous fractions, amounting to roughly 80% of weight, there is a well-developed downstream material recovery industry in India. However, for the remaining 20% difficult-to-manage fractions, Indian recyclers do not have an adequate technology solution yet. Components such as printed circuit boards (PCBs), display, plastics with flame retardant coating, thin cables, cartridges etc. fall under this category. Priority should be to ensure recycling of the fractions for which a proven route to environmentally sound recycling and treatment exists globally. It could be a lucrative commercial opportunity, for instance, Accenture study shows that urban mining of gold alone from PCBs in India can be a $1.5bn opportunity.[3]

Figure 10 As-is assessment at fraction-level and deep-dive on Waste Printed Circular Boards (WPCBs) recycling



Comparison of solutions for metal extraction of Waste Printed Circular Boards

		Global state-of-art	Indigenous technologies	Informal extraction	
	Illustrative technology	Pyrometallurgy, hydrometallurgy, electrometallurgy	Wide range of technologies (yet to be validated)	Acid bath, open burning	
Operational	THROUGHPUT AND YIELD	High	Low to Medium	Low	Global yield is high at >95%, whereas for indigenous it is low as it is not commercialised
Operational	QUALITY OF METALS RECOVERED	High	Medium	Low	Global recovery is high at >99% and quality is proven while Informal sector recovery is at ~60% for key metals like gold, silver, etc. and yet to be validated at commercial score
Operational	CLOSED-LOOP RECYCLING VALIDATED	High	Low to Medium	Very low	While secondary material market is present, they are largely supplied to other industries like tin to solder industries, gold & silver to jewellers
Financial	MINIMUM ECONOMIC MODEL SIZE	Very high	Low	Very low	Global capacity requirement is relatively high i.e. ~10,000 tons, whereas indigenous & informal operates in between 20 to 100 tons
Financial	CAPEX & OPEX REQUIREMENT	High	Medium to high	Low	Global players have profit margins around 30 to 40%, with CAPEX requirement ~3000 crores; whereas indigenous profit margins lies in between 10 to 25% with CAPEX requirement ~200 crores. In informal, CAPEX & OPEX is relatively low leading to significant profit margins i.e., ~20 to 25%
Financial	GROSS MARGINS	Medium	Low	Medium to Low	

Source: Expert interviews, Site visits, Global players like Umicore, Glencore, etc.

Very high — Very low

While it may sound technically feasible, Indian players have struggled to succeed so far. Existing WEEE recyclers do not have the ability to make high CAPEX requirement usually associated with these state-of-art technologies or do not have the appetite to compete with informal sector recyclers on feedstock costs. Even if a few Indian players claim to have an indigenous cost-effective technology, it is commercially not viable at scale, and other recyclers have shown minimal interest in licensing the solution. Thus, there is need to make existing players financially and technologically more competitive. Entry of new promoters, such as metals and mining PSUs or private sector leaders, could be a game changer and will set the

ball rolling for transformation. Government's primary focus should be on facilitating such high-level discussions in addition to continuing the development of technology solutions for demonstration purposes.

To address the key challenges above, the game changers to focus on are as follows:

#1 Mobilizing consumers to liquidate inventory via formal channels

#2 Minimize negative environmental externalities of informal sector led WEEE management

#3 Ensure fairness and high quality in E-waste collection and recycling

#4 Enhance technical competence and investment attractiveness of WEEE recycling sector

FOUR POLICY INTERVENTIONS ARE NEEDED TO ACCELERATE THE DOWNSTREAM PATHWAY

POLICY INTERVENTION #1:
EXPLORE PUBLIC-PRIVATE MECHANISMS FOR FORMAL CONSUMER TAKE-BACK OF DEVICES

Call to action:

Policymakers can unblock operational complexities of formal collection, and help reduce the funding gap for new infrastructure creation

Infrastructure: While establishing reverse supply chains is CAPEX-heavy, funding the operational cost of last-mile collection weighs heavily on the OPEX.

Value to consumers: While it is not recommended that policy determines a residual value, there is a need to encourage a consumer incentivization mechanism. In the long term, the cost of take-back could cascade into consumer prices.

Data protection: Regulators can motivate industry to develop innovative solutions such as data sanitization applications for convenient data swipes, thus giving the consumer the desired comfort.

Consumer awareness: Government's existing awareness creation and behavior change platforms could be used. Key messaging should discourage consumers from selling WEEE and batteries to Kabadiwalas (unlike solid waste such as plastics or metals) and should amplify information on formal take-back channels.

Policy design principles:

A. Providing consumer incentives and last-mile collection infrastructure for end-of-life device take-back

There are multiple options that can be explored:

Scale-up assured buy-back program mandates: Assured buy-back and trade-up programs are common business practices and a proven formal collection channel. Consumers sell their old device back to OEMs and receive a cash voucher, which can also be used to purchase a new device. Policy framework can standardize and incentivize this model, particularly for small IT equipment, and make it a mandate for OEMs and retailers.

Test-out public-private or retailer-led approaches: The urban local bodies can give concessionaire contracts to authorized entities for WEEE collection. Model could be particularly more effective for white goods. Authorities in Noida and Ghaziabad have engaged two organizations with a rate card of residual value that consumers can claim. The rates go from 120 per smartphone to 2400 for a 1.5-ton scrap air conditioner1. Consumers can call a toll-free number to schedule a doorstep pick-up, just like how a Kabadiwala would do. If successful, this model could be replicated across municipalities in public-private partnership approach.

In addition, policymakers can also mandate electronics retail chains in organized sector to act as a collection arm. A threshold could be defined in terms of floor area (m2) and paperwork should be limited. OEMs and retailers can agree on the buy-back prices, and digital payment solutions can be used to pay-out consumers.

Support price discovery of end-of-life devices: Given the criticality of consumer incentivization, price discovery of end-of-life devices becomes important. In trade-in flows, OEMs and supply chain partners need to agree upon a simple formula which can be used to process the payments. A ring-fenced portion of EPR funds can be used to make payments to only legitimate end-consumers with verified identities.

B. Developing a data sanitization standards and applications

Policymakers can develop a data sanitization protocol that service providers can follow, while buying back pre-owned or end-of-life devices. This protocol could be like the one developed by National Institute of Standards and Technology, US Department of Commerce for sanitization of media for various types of mobile phones and electronic devices[4]. OEMs can build their respective applications based on this uniform protocol.

C. Creating awareness for mid to long-term impact

Mandates to make take-back options known to consumers at point of sale can be explored. While the target group of this initiative is limited, it will at least force OEMs to beef-up their take-back infrastructure. Once a nation-wide formal collection infrastructure gets established, policymakers can leverage campaigns such as Swachh Bharat Mission or PM Lifestyle for the Environment (LiFE) Movement as a vehicle to popularize them.

Conditions for success:

Informal sector inclusion: Formal collection systems can integrate informal sector workers through direct or indirect employment. Other informal-formal partnership approaches, such as the already-prevalent microentrepreneur model, can also be explored to ensure just transition.

Cost-effective approach: Innovative digital-enabled solutions can be explored, instead of replicating the approaches followed by European countries. In addition, pre-competitive efforts or well-designed public-private partnerships can bring the cost down.

Buy-in from OEMs and recyclers: Extensive consultations must be conducted with end-users to understand their needs and to assess the cost of adopting the tool.

POLICY INTERVENTION #2:
LAUNCH 3RD PARTY AUDITABLE STANDARDS AND MATERIAL FLOW DATABASE FOR COLLECTORS, DISMANTLERS, AND RECYCLERS

Call to action:

3rd party auditable standards and a material flow database will improve the quality of WEEE management through EPR without increasing the enforcement burden on regulatory authorities

Standards, which are auditable by independent accredited auditors and are widely accepted have proven to be impactful. Regulatory authorities such as CPCB and SPCB have limited bandwidth but legitimizing a WEEE management certification could be a quick win. Standards can codify the requirements with respect to the collection, logistics, recycling, and disposal of all kinds of WEEE. Conformity with these standards can be verified through audits, post

which the process can be confirmed to be certified. In addition, there is a need to develop a digital platform for reporting of material flows at fraction-level. It can be used by dismantlers, recyclers, smelters etc. to enter granular details. The benefits are twofold a) transparency-led improper behaviour minimization and b) data analytics to inform policy decisions.

Simplified versions of two key solutions - CENELAC 50625 and WF-Rep tool - can be adapted to Indian context

There is no need to start from scratch as the existing standards and tools can be adapted to the local context. While the Indian context differs greatly from that of Europe, the underlying principles remain relevant. Their implementation can bridge the gap between as-is and should-be EPR costs. For 3rd party auditable standards, CENELEC 50625 (earlier WEEELABEX) and Responsible Recycling (R2) Standard provide a good reference. By detailing technical requirements for the safe and environmentally sound collection and treatment as prescribed by the EU's WEEE Directive, the standards set the bar high. Countries such as Belgium, France, Netherlands and Czech Republic have introduced legal obligation to adopt these standards. The WEEE Forum reporting tool, known as WF-RepTool, can be used to track and monitor WEEE flows, at the level of individual components (fractions). The tool captures the data across dismantling, shredding & separation, separation of fractions, application of final fractions in final treatment technologies, resulting in creation of material flows, and calculation of standardized indicators.

Policy design:

A. Develop and enforce use of 3rd party auditable standards

The policymakers and private sector can follow a two-step process.

Development of standards: Consultations can adopt a simplified version of CENELEC 50625 standards, limiting to minimum requirements in the initial years. However, local customization might be needed to make it work for Indian players. Technical specifications, such as compliance with best practices, data management and informal sector integration, should lead to improvement in the EPR implementation quality.

Integration of requirements in EPR: Either policymakers can make these standards part of the EPR regulation or OEMs can place a mandate on their EPR contractors to get certified by accredited auditors. The cost of EPR implementation is expected to go up, but the long term environmental and social benefits will far outweigh the short-term incremental financial burden.

B. Develop and enforce use of a mass flow reporting digital platform

An IT service provider can be contracted to define the business requirements in consultation with local Indian players and build a digital platform, which is harmonized with WF-Rep tool. The digital platform should ensure fraction-level granular reporting, alignment with E-Waste Management Rules and must consider local challenges such as small-scale operations, informal sector activities, lack of advanced technologies etc. Karo Sambhav, a waste management service provider, has already developed a solution which is locally relevant and yet harmonized with the international reporting system.

Conditions for success:

Identification of a lead agency: Regulator needs to identify a lead agency, such as a multi-lateral organization, which can coordinate the development of these standards and define the processes.

Creation of auditing ecosystem: A local network of auditors needs to be created which can be accredited by the National Accreditation Board for Certification Bodies (NABCB).

Buy-in from OEMs and recyclers: Extensive consultations must be conducted with end-users to understand their needs and to assess the cost of adopting the tool.

POLICY INTERVENTION #3
DEVELOP GOVERNMENT-LED AGGREGATION AND DISMANTLING ZONES IN TARGETED GEOGRAPHIES

Call to action:

Majority of informal sector led WEEE activities in India are largely geographically concentrated

Over the years, certain neighbourhoods across large cities have emerged as a hub for informal dismantling and material recovery. For instance, Delhi is reported to have 15 geographically identifiable areas such as Gaffar market and Seelampur, where more than 150,000 workers across more than 3,400 units manage a large collection catchment area. On an average, a waste worker earns 500-1,000 per day, with women and children being paid lesser than the men. Once the reusable components are removed, inventory is transported to Moradabad, wherein additional 1.5 to 2 lakh workers are engaged. In fact, it is estimated that Moradabad handles roughly 50% of all the waste PCBs generated in India. Despite the negative environmental and social externalities, strong operational efficiency and almost zero cost of compliance, continues to provide the tailwinds that has allowed these informal sector hubs to flourish.

Given the operational complexity and execution risks, Indian policymakers and non-profits can learn from similar existing programs

China's problem with informal sector WEEE recycling and material extraction is very similar to that of India. Guiyu, a city in China considered to be the largest e-waste hub in the world, housed 5,000 informal sector units. In 2013, the state government approved a plan to set up Guiyu Recycling Economy Industrial Park at the cost of $233mn. Built in 2015, the park drove merger of 1,200 informal sector units to form around 500 formal workshops, under 29 big recycling operations housed within the park. Local officials followed a mix of carrot and stick approach. They offered around $300 subsidy to each household that agreed to dismantle their makeshift chimneys, whereas banning those which did not. After a stipulated deadline, a crack-down was conducted resulting in closure of more than 2,500 units over the years. In the park, rudimentary metal extraction methods were restricted, and only mechanical disassembly with simple tools was allowed. The park authority regulated the working hours, adherence to PPE mandates and standard operating procedures. Several central facilities such as a trading hub, smelting complex and water treatment plant were established to create a complete ecosystem. Smelting plants procured the dismantled inventory and extracted precious metals physically or chemically to produce gold and copper ingots. A trading center facilitates these transactions

and maintains a material flow registry. As of now, the park is reported to be managing 0.3-0.4 mn tons of WEEE and has resulted in a significant improvement in local air and water quality improvement.

Targeted interventions in select geographies can help co-opt the informal sector actors, while minimizing the negative externalities in and around these geographies

India is yet to figure out a "fit for purpose" operating model to implement a formal collection network. It would be prudent to continue to leverage informal collection network while slowly transitioning towards formalization. Right interventions in these geographies can help reduce social and environmental externalities by encouraging operational best practices and socially inclusion schemes. Like the China model, key activities performed by the micro-entrepreneurs should be limited to aggregation and dismantling, post which they can supply the inventory to registered formal recyclers for material recovery. Spare parts harvested doing the process can be sold to formal multi-brand repair and refurbishment players. In India, Ecowork is piloting a similar model. The organization supports informal sector units (as tenants) with a legal set-up and a physical working space. Tenant informal sector units will be able to rent space and services under a pay-per-use scheme and gain access to the required tools and machinery.

Policy design:

A. Develop operating model of aggregation and dismantling zones

Policymakers need to define the operating model across multiple dimensions.

- **Legal structure:** Special purpose vehicles or corporations can own the land and become the manager of the zone. The role of the government should be limited to mobilizing the initial set-up. Existing platforms such as the Common Facility Centre scheme of the Ministry of Micro, Small and Medium Enterprises (MSME) should be leveraged.
- **Standard operating guidelines:** Existing informal sector units are offered tenancy in the zones and are asked to comply with required rules and regulations, such as GST and environmental compliance. The workers are provided with PPEs (Personal Protective Equipment), identity cards and other social inclusion services (e.g., opening of a bank account, health insurance). Open incineration-based activities are banned.
- **Benefits available:** Through the tenancy contracts, the zones can extend multiple benefits such as designated workshop area, access to utility, tools and equipment, and legalization. In return, tenants are mandated to supply the dismantled inventory to recyclers, pre-approved by the zone.
- **Co-located sampling and material extraction facilities:** Sampling facilities should be set up to grade the quality of the logic boards for fair compensation. Small-scale material extraction facilities can be promoted either within or in proximity to the zone. Stable flow of feedstock and reduced logistics cost could uplift the profitability of these facilities.

B. Prepare roadmap for on-ground mobilization

Local administration and the inhabitants must be notified in advance. Like the Chinese model, a lucrative financial assistance should be provided to the entities opting-in. One or more private sector players or multilaterals can be onboarded to ensure effective functioning on day-to-day basis.

Conditions for success:

- **Buy-in from local authorities:** District and state level administration must be involved in the execution to avoid any law-and-order problems. The administration should extend support to community leaders and non-government organizations responsible for supporting the inclusion process.
- **Retention approach:** Making the operating model waste worker-centric is important. The earning potential of the microentrepreneurs post formalization is expected to fall, thereby necessitating strong retention policies. Alternative approaches such as green premiums for ethical supply chain practices can be explored to boost the earnings.

POLICY INTERVENTION #4:
INCENTIVIZE HIGH-CAPACITY HIGH YIELD ADVANCED RECYCLING FACILITIES

Call to action:

There are three potential directions – usher global state-of-art technologies, validate commercial viability of indigenous technologies or continue with informal sector material recovery

Global players such as Umicore and Glencore have advanced smelting and refining technologies with high yield and throughput and adherence to environmental standards. Extracted metals have the purity required for reuse in electronics value chain. However, the CAPEX requirement is extremely high which discourages financially starved Indian recyclers. Intense competition with informal sector recycling is another concern. A few Indian players are reported to possess the technologies for most WEEE fractions, including patented technology for extraction of precious metals from PCBs. Others rely on overseas smelters and refiners for management of waste PCBs. MEITY and CMET have developed an indigenous technology, but limited uptake among Indian players is observed. The last resort is to continue with business as-usual, wherein informal sector continues to use acid bath to extract limited amount of visible gold, while losing a significant amount of non-visible gold and other precious metals.

There is a need to encourage large investments in advanced recycling technologies, for high capacity and high yield operations

MEITY has amended the Scheme for Promotion of manufacturing of Electronic Components and Semiconductors (SPECS) to reimburse 25% of capital expenditure in precious metal extraction units, with a minimum investment threshold of 2 Cr. This is an incredibly positive move and will support small to medium-size recycling facilities to expand further. However, the sector needs to undergo a transformation: adoption of advanced technologies to improve the yield and higher capacity to improve the viability. Only a few existing recyclers can deliver this ambition and therefore, entry of new players can be a game charger. These large players will have the appetite as well as the ability to make high CAPEX investments. Smelting and refining of precious metals from waste PCBs is a complex technology with proprietary processes mastered over the decades. Large players can enter technology licensing partnership with global players holding the intellectual property. In long run, there will be multiple cascading effects: strengthening of upstream collection and improvement of downstream secondary material quality and quantity.

Policy design:

A. Provide science-based guidance on 'fit-for-purpose' technologies for various sub-streams

Government should commission an independent study to evaluate the list of potential WEEE recycling technologies, their pros, and cons in Indian context, and map the suppliers of these technologies. Particularly for difficult-to-recycle fractions, government must provide a guidance on acceptable route of treatment. A science-based definition of recycling, with specific quantitative output metrics, will be needed to avoid improper behaviour and to raise the bar. Definition of recycling in Battery Waste Management Rules 2022 demonstrates a step in right direction, however, over-simplification (e.g., same requirements for different battery chemistries) should be avoided.

B. Incentivize set-up of high capacity high-yield advanced material extraction facilities

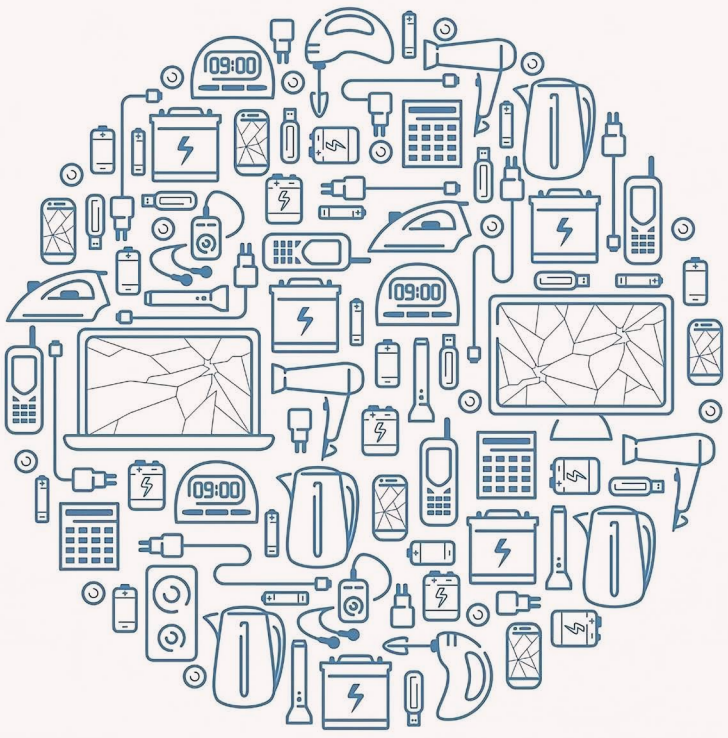
Projected recycling targets are not in line with the business-as-usual recycling capacity. Besides, domestically available secondary material is limited, both in quality and quantity. In this light, ambition of existing government incentivization schemes such as SPECS needs to be raised.

- **Improve investment attractiveness:** Investments supported should be such that high-capacity smelting and refining capacities are encouraged. Single-window facilitation should be provided to large domestic and international players. Public sector units (e.g., Hindustan Copper, MMTC-PAMP) and private copper and precious metal players should be encouraged to partner with state-of-art technology providers such as Umicore, Glencore, Aurubis and Boliden for technology licensing and joint venture. Urban mining needs to be promoted through programs such as Invest India and requires a much more aggressive investment promotion approach.
- **Specify technical requirements:** In case of waste PCBs, the scheme can define the technical specification of outputs, in terms of yield and quality. Also, solutions with the ability to manage other components such as connectors, wires, plastic with flame-retardant coating should be promoted.

Conditions for success:

- **Small start followed by comprehensive coverage:** A focused effort on high-value fractions e.g., WPCBs (Waste Printed Circuit Board) can play a catalysing role, however, end goal should be to set-up a cluster wherein all fractions can be managed. Usually, one single player does not have the technology for managing all the metal fractions (for instance, Aurubis specializes in copper recovery whereas Umicore is more focused on precious metals). Therefore, an ecosystem of players, including sampling players, is needed.
- **Synergies with automotive sector:** India has an already existing automotive scrapping policy. Therefore, automotive spent catalytic converters which are well-established source of secondary Platinum, Palladium and Rhodium should be explored as an additional feedstock by prospective WEEE recyclers.
- **Competitiveness against informal sector recyclers:** Supplies to informal sector should be gradually reduced to create a level playing field for formal players. If the WEEE inventory just from bulk generators, if not end consumers, inflows into formal channels, a substantial feedstock security can be achieved for newly set-up formal recycling units.

USE PHASE: EXTENDING PRODUCT LIFE

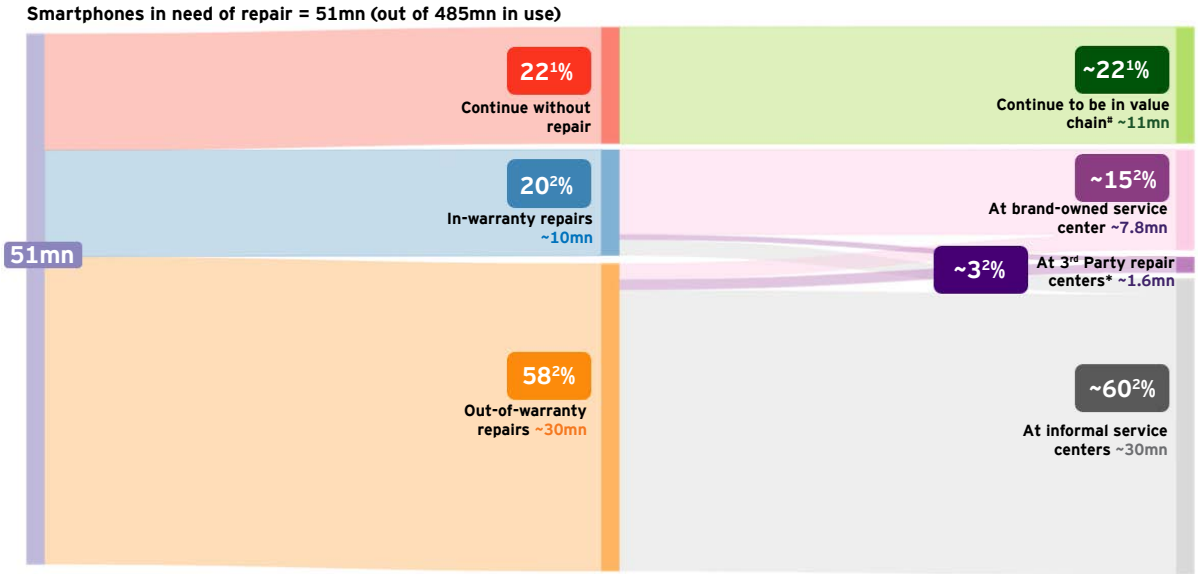


USE PHASE: EXTENDING PRODUCT LIFE

PROGRESS SO FAR: REPAIR, RESELL AND REFURBISHMENT

Formal sector dominates in-warranty repairs, whereas informal sector ecosystem dominates out-of-warranty repairs

Figure 11 Repair material flow show informal sector dominance for out-of-warranty repairs



Notes: 1. Press media Consumer Survey 2 Accenture Research & Analysis 3. 3rd party service centers refer to non-brand-owned formal sector repair service providers e.g., Cashify. Yantra etc. 4. Continue in value chain as in-use inventory

Quality repair services are provided by formal players i.e., OEMs and their extended network, multi-brand start-ups and MSMEs. These account for 18% of total repair demand, with a noticeable strength in the in-warranty repair market. Highly accessible and affordable informal sector services 60% of the total repair demand, mostly in out-of-warranty cases. The technical competency of our informal sector professionals is high and needs to be leveraged. They rely on practical experience to enable quality repairs, without needing any manuals. They are also able to push firmware updates, wherever freely downloadable or open-sourced. The remaining 22% of the damaged devices continue to be used by their owners without any repairs.

Formal and informal sector players have been serving different ends of the spectrum well enough for decades, but there are opportunities to meet shifting consumer demand

Our survey shows that while one-third of consumers find the service provided by local repair shops to be satisfactory, another one-third strongly prefers brand repair centers for quality and

trust. So, different players are meeting the needs of different consumer bases seamlessly, but there are opportunities to improve.

Price sensitivity: Our survey shows 2 in 5 consumers find the cost of repairs a key consideration. Informal sector service is usually 40-60% cheaper than formal sector service for out-of-warranty repairs. Key reasons (Figure 11) are the low cost of compliance, lack of quality control and low cost of spare parts (that are low in quality, stolen or harvested).

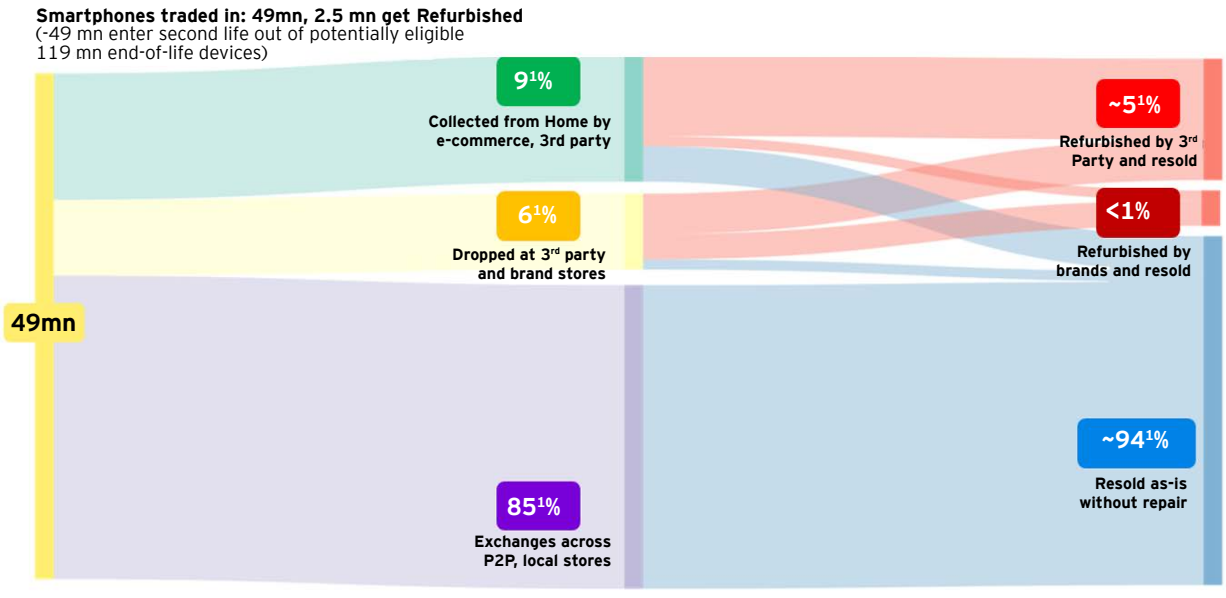
Security and trust: Our survey indicates 1 in 5 consumers are concerned about personal data breaches during repairs. Players such as Samsung have built a 'repair-mode' feature that offers data protection during repairs and can be made available to the Indian market. Similarly, Apple ensures data protection through a secure enclave authorization and serialization.

Last-mile accessibility: OEM-owned repair centers have a limited presence, mostly in Tier 1 and Tier 2 cities. OEMs can explore opening more brand-owned or authorized repair centers, thereby improving their penetration, or partner with formal multi-brand start-ups & MSMEs and informal sector to expand their extended repair network.

Formal sector multi-brand startups offer an alternative which brings the best of both the ends of spectrum and may be a silver bullet

Initial success of venture capital-funded startups such as Cashify and Servify has validated the need for a new approach to the aftersales solution, in both B2B and B2C contexts. Models such as Cashify solve for price, trust and accessibility, all at once for consumers. B2B players like Servify partner with OEMs to deliver services such as assured buy-back, device subscription, upgrade programs and liquating device inventory to OEMs. As the formal multi-brand service providers grow their market penetration, OEMs will themselves be motivated to enter large-scale service partnerships with them instead of solely relying on OEM-led repair centers.

Figure 12 Resell and Refurbishment material flow shows low refurbishment despite demand



Note: 1. ICEA-IDC report 2. Unorganized Sector includes local mobile stores: e-commerce includes Flipkart, Amazon etc. 3. 3rd Party includes Cashify, Yeantra etc. 4. Brands Includes OEMs (graphic is not to scale)

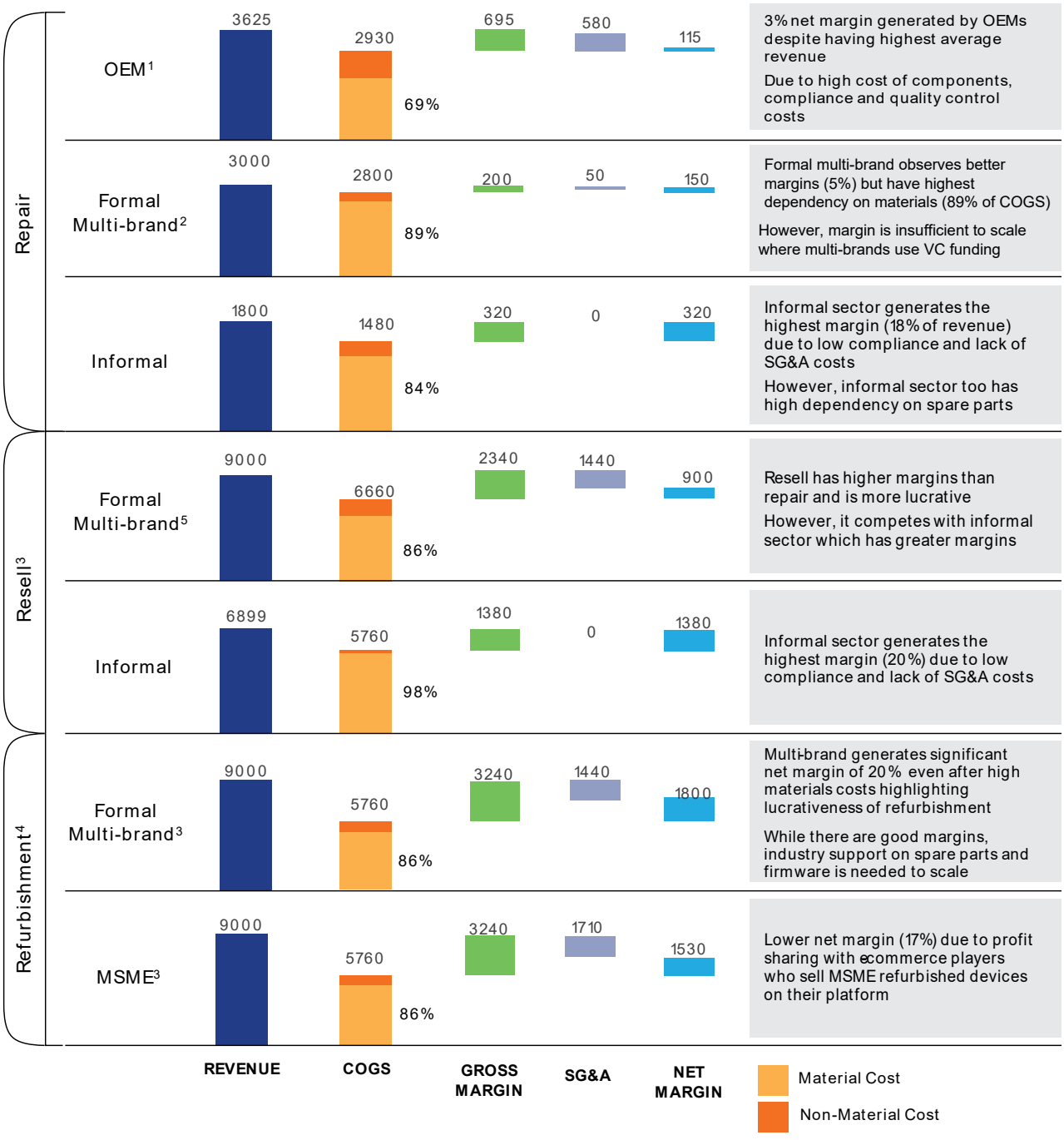
The strategy will help OEMs minimize their costs and risks associated with establishing and maintaining a large repair network, while also being able to provide the same quality of aftersales services to consumers. However, their presence is still limited to select urban clusters across cities, and it remains unclear if these models will be equally successful in rural areas. These startups could also be the vehicle to co-opt informal sector through innovative models, such as that of Urban Company. The government has also tied up with Urban Company to facilitate upskilling and placement of young technicians

Refurbishment market is nascent, and is a key business opportunity for OEMs as well as multi-brand startups

Indian policy framework doesn't make a good distinction between repair and refurbishment. However, that has not stopped the market from evolving. Programs such as Amazon Renewed and Flipkart Refreshed as well as the multi-brand startups have proven the viability and desirability of refurbishment business model, particularly for premium models. Refurbished devices are 40-60% cheaper as compared to new devices, with refurbishers still making 20% gross margins (Figure 13). This has manifested a mushrooming demand: more than 500% and 340% year-on-year growth in rural and urban areas, respectively. However, the market demand is grossly under-served with only 2.5 mn refurbished devices sold in 2021 (5% of total trade). While OEMs notably do not refurbish in India yet, non-OEM players follow different approaches and variation in the quality of available refurbished devices is a challenge. Our survey indicates that 3 in 5 consumers see quality as a key deciding factor for their choice between refurbished vis-vis new devices. Driven by quality concerns, consumers expect extended warranty and insurance options.

Another notable feature of the Indian landscape is a huge presence of C2C or C2B trade in the grey market, mostly without any upgradation. In C2C trade, consumers sell their devices either to local electronics shops or to other consumers via platforms like Olx, Quikr. A key consumer need is the ability to assess the true condition of the pre-owned device as highlighted by 2 in 5 consumers who responded to our survey. In C2B trade, resellers aggregate the pre-owned devices in Tier 1 and 2 cities and redistribute them to retailers in Tier 3 cities and rural towns, with 500 to 1000 pieces in each lot. Multi-brand startups have tried to intercept this trade and have diverted this inventory of pre-owned devices into their supply chain.

Figure 13 Comparative view of unit economics of repair, resell and refurbishment business models



Source: Economics view developed basis interviews with leading repair service providers and refurbishers;
Note: [1]OEM Economics are basis out-of-warranty repairs. [2]Formal multi-brand numbers are basis high-level economics of Cashify and Instacash. [3]Informal refurbishment is absent is India hence not depicted in the above graph. Both resell and refurbishment are not enabled by OEMs. [4]Formal and MSME refurbishment assumed to have same average selling price with differences is cost as MSME. [5]Material cost of resell in multi-brands are assumed to be similar to refurbishment

Scaling-up formal sector multi-brand startups is dependent on two limiting factors

A. Complexities in pre-owned device supply chain

- **High cost of liquidating idle inventory in households:** From a service delivery perspective, leading formal multi-brands highlighted the high cost associated with creating consumer awareness (~2-3% of their COGS) but they believe that a national-level campaign could precipitate a gradual consumer behavior shift.
- **Provenance and chain-of-custody of devices:** Formal refurbishers and resell service providers find provenance to be a key challenge. There is a risk of stolen devices entering their inventory, creating a law-and-order situation, and avoiding such transactions in the first place will enhance the ease of doing business. The government has built a centralized database known as Central Equipment Identity Register[8], which facilitates verification of details like brand name, model name, manufacturer name and device type based on IMEI number, however, the uptake is not seen on the ground.

B. Complexities in spare parts supply chain and firmware updates

- **Need to strengthen original spare parts supply chain:** High cost of out-of-warranty repairs in the formal sector is mainly attributed to the cost of spare parts arising from the cost of quality materials, compliance costs and marketing & selling overheads. Non-original spare parts are 50% - 70% cheaper than original ones. In addition to cost, the availability is also limited. Indian OEMs can try strengthening this supply chain but there are operational and financial barriers: Spare parts category is a low volume and high mix category, and currently most of it is imported. OEMs face four types of challenges namely, a) the cost of maintaining a high inventory b) the risk of obsolescence due to innovations and c) unpredictable downstream demand from repair and refurbishment services and d) high custom duties and complex paperwork limiting the import of refurbished original spare parts, which could have otherwise unblocked the supply constraints. Capping spare parts cost is an option but it is unrealistic given the associated implementation complexities.
- **Need to review frictions in non-original spare parts supply chain:** A vibrant grey market of non-original spare parts exists, largely supported by informal sector activities, and the margins are very high. The quality of non-original spare parts is questionable, and their packaging often infringes intellectual property or trademark rules. Therefore, their imports are strictly scrutinized by the custom departments. It leaves formal players such as multi-brand startups disadvantaged and at risk of liability and customer dissatisfaction. Multi-brand startups would prefer to rely on either original or higher quality of non-original spare parts, and currently both these channels are constrained. Long-term partnerships between OEMs and non-OEM formal repair and refurbish service providers for stable supply could be game changers.

Intentions behind consumer-led initiatives such as recent right-to-repair conversations are appreciated but implementation needs to be rooted in the contextual realities of India

Government has set up a committee to develop a right to repair framework for India, and the initial consultations seem to be inspired by the EU's Right to Repair plan. However, there is a need to contextualize the same to the Indian context. While there are some good observations such as the need for harmonization of trade between OEMs and third-party buyers and sellers, there are some specific clauses that need further consultation. For instance, uncontrolled dissemination of repair manuals, software updates and diagnostic tools for repair self-sufficiency should be checked. In the EU, labor cost is high, therefore, consumers tend to perform certain activities themselves instead of outsourcing them. However, Indian consumers always have the option to depend on the vibrant presence of low-cost aftersales service. So, the openness might be grossly misused (OEM intellectual property, consumer data etc.) given the lack of contract enforcement. The study has found that expanding the multi-brand formal players, which co-opt informal sector, would rather be a much more impactful way forward as compared to consumer empowerment-led change.

To address the key challenges above, the game changers to focus on are as follows:

#5 **Support growth of multi-brand services in formal sector**

#6 **Increase demand for refurbished devices**

#7 **Ease device inventory movement across ecosystem actors**

THERE ARE THREE POLICY INTERVENTION THAT FORMS THE USE PHASE PATHWAY

POLICY INTERVENTION #5:
SCALE-UP MULTI-BRAND FORMAL SERVICES THROUGH STRENGTHENED SPARE PARTS SUPPLY CHAIN, MARKET LINKAGES AND INCENTIVES

Call to action:

While formal multi-brand players have shown significant progress, policy support is necessary to unlock their hypergrowth

- **Spare parts supply chain:** Formal multi-brand players currently facing difficulties in custom process to obtain non-original spare parts, are unable to secure original spare parts and face challenges due to lack of GST harmonization of spare parts. Adding to this is the pressure to compete with the lucrative and accessible informal sector. Policymakers can ease these operational challenges.
- **Market linkages:** By co-opting informal sector and MSMEs, OEMs and multi-brand startups not only grow their last-mile presence but also capitalize their talent pool, instead of competing with them. To that end, government schemes like Pradhan Mantri Kaushal Vikas Yojana can identify and train such entities and connect them with formal players for partnerships.

Policy design:

A. Strengthen spare parts supply chain

Given the complexities OEMs face with strengthening the supply chain of spare parts, there could be two options a) boost availability of original spare parts, and thereby, bear a higher inventory cost and risks b) ease the import of high-quality non-original spare parts in the short-medium term. In the long term, an increased competition with high-quality non-original spare parts and a domestic production would force OEMs to address the prevailing shortage and pricing issues.

- **Support period mandates:** Stakeholder consultation should be conducted to explore support period mandates (a set number of years after the launch of the model) during which OEMs make spare parts available. During this period, aftersales service providers which have been vetted by the OEMs can get the access.
- **Long-term supply contracts:** To address unpredictable demand and risk of high inventory cost of original spare parts, formal repairers and refurbishers can enter a long-term supply contract with OEMs, to give them an assured offtake at a preferential price. While it's a private sector driven action, the role of policymakers should be to encourage such partnerships.

B. Support market linkages among OEMs and aftersales actors

Informal sector is already competent; however, Indian policymakers can develop a program to formalize and recognize high-quality repair service providers to enable market linkages. To grant access to repair tools, information and spare parts, OEMs can set forth a list of requirements that these recognized entities must meet as a pre-requisite. Additionally, OEMs can explore utilizing their CSR funds to adopt these entities to support inclusion.

C. Incentivize repair and refurbishment capacity

- **Review of materials tax:** There is a need to simplify and standardize GST brackets on various spare parts categories. For instance, device LCDs are at 18%, power-related parts are at 12%, loose components are at 22% and so on. Similarly, customs duty on many spare parts stands at 20% and could be rationalized.
- **Capital support:** Policymakers can support non-OEM players to set up centralized large-scale L3 (Level 3) (complex repairs) and above-level repair and refurbishment warehouses in a hub-and-spoke model. To improve the viability of these warehouses, a capital support scheme can be created.

Conditions for success:

- **OEM buy-in:** OEMs need to take a business decision to ramp up supply and therefore OEM buy-in is critical for success. Lack of the same will limit growth in multi-brand start-ups and MSME-led repair and refurbishment.

POLICY INTERVENTION #6:
DEFINE BIS AND INDUSTRY-LED REFURBISHMENT STANDARDS AND MANDATE AFTERSALES PROTECTION OPTIONS

Call to action:

Our modelling shows that the market size of refurbishment of smartphones and laptops alone is more than $4bn by 2035 in India. Despite the attractiveness of the business opportunity, supply side remains constrained. On the demand side, there is a need to standardize refurbishment quality standards and an aftersales protection option in the form of insurance and warranty options.

Uniform refurbishment standards will address the issue of variance in quality and would streamline partnerships among multi-brand start-ups, MSMEs and OEMs

Service providers define the quality of refurbished devices based on three parameters a) Cosmetic criteria: Number of scratches on the screen, dents on the body of the device, etc. b) Functionality criteria: Functional camera, display, updated software, etc. c) First-life criteria: warranty remaining, years of first life of device, etc. In the absence of any standards, quality varies, and lack of transparency creates mistrust among consumers. So, unified quality standards developed in collaboration with the industry will promote consumer trust and provide validity to refurbishment operations, which are at times misconstrued as illegal. The common language these standards introduce will also enable smooth partnerships among OEMs, refurbishment startups and MSMEs.

Similarly, while leading multi-brand start-ups and MSMEs have been providing insurance and warranty options, a level playing field would be needed as the market grows exponentially in coming years

Our survey indicated that 1 in 4 consumers opt for extended warranty or a protection plan while buying a new device, to minimize the out-of-pocket service cost. The concern is exacerbated further for pre-owned devices. There are two ways to address this concern – a warranty period or a protection plan. Current warranty periods for new devices are already on par with global

norms. However, for refurbished devices, quality concerns and global benchmarks (1 year OEM warranty globally as opposed to India's 6-month warranty offerings) make a case for extending the warranty period. It is not expected to change the cost equation significantly as warranty support is usually 2-5% of the device cost and the majority of claims anyway are reported to come within the first 6 months. Protection plans, such as those enabled by Servify, have also emerged as a lucrative option for both consumers and OEMs. Usually, these plans safeguard consumers against accidental damages and mechanical failures through unlimited repairs at a nominal fee borne by the consumers. Protection plans, when combined with assured buybacks, address the take-back challenge as well.

Policy design:

A. Developing BIS-led refurbishment standards

A committee should be set up with participants from BIS, OEMs, refurbishment start-ups such as Cashify, InstaCash, Servify etc., MSMEs and leading circular economy experts. The committee can develop an overarching framework to define grades based on cosmetic, functional, and first-life information. In the short term, while the startups and online retailers align their labeling and claims with these standards, in the long run, it can be expected that OEMs will adopt them as well as enter this market more aggressively.

B. Explore developing mandates on the provision of warranty and insurance options by refurbishers

Indian policymakers can explore mandates for refurbishers to provide both insurance and a minimum warranty period to consumers as a minimum requirement. These requirements can be based on the refurbishment standards, for instance, a longer warranty period or a higher scope of insurance coverage for a device that didn't go through advanced refurbishment.

Conditions for success:

- **Buy-in from refurbishers:** While policymakers can provide the guiding principles, the specifics of the standards should be defined by the industry. Standards should be such that they create a level playing field for all players and improve average refurbishment quality. Additionally, they should not be too strict that they hamper refurbishers' ability to conduct business.
- **Development of a new aftersales ecosystem:** Formal multi-brand start-ups such as Servify, which enable protection plans, need to grow. They can manage the end-to-end program of underwriting, distribution, claims administration and fulfilment with the support of insurers, logistics service providers, and service partners.

POLICY INTERVENTION #7:
EXPLORE CHAIN-OF-CUSTODY MECHANISMS FOR VALIDATING LEGALITY OF SOURCED DEVICES

Call to action:

Developing provenance mechanisms addresses the opportunity of easing device inventory movement across ecosystem actors

A chain-of-custody or provenance can solve multiple problems. It legitimizes the physical transaction between two actors, even if the financial transaction is in cash. Thus, it gives formal repair and refurbishment service providers an opportunity to verify if the device is stolen or not and thereby improves the ease of doing business. For consumers, a mechanism like this can ease-out the payment when they sell their devices. It could be a solution hosted by the government, and interfaces can be provided for authorized actors to use. Multiple sectors and their respective government ministries and departments will have to come together to orchestrate the solutioning and implementation. Given the need for cross-sectoral orchestration, the role of policymakers is critical. Policymakers and industry will also have to agree on mechanisms to protect sensitive consumer and OEM data.

Policy design:

Explore the creation of a technical solution for chain-of-custody and provenance

Policymakers need to set up a committee of experts to identify relevant product data to be sourced and develop mandates for industry players to provide data. And authorized users should be allowed to update the ledger and access any information from it in a controlled way.

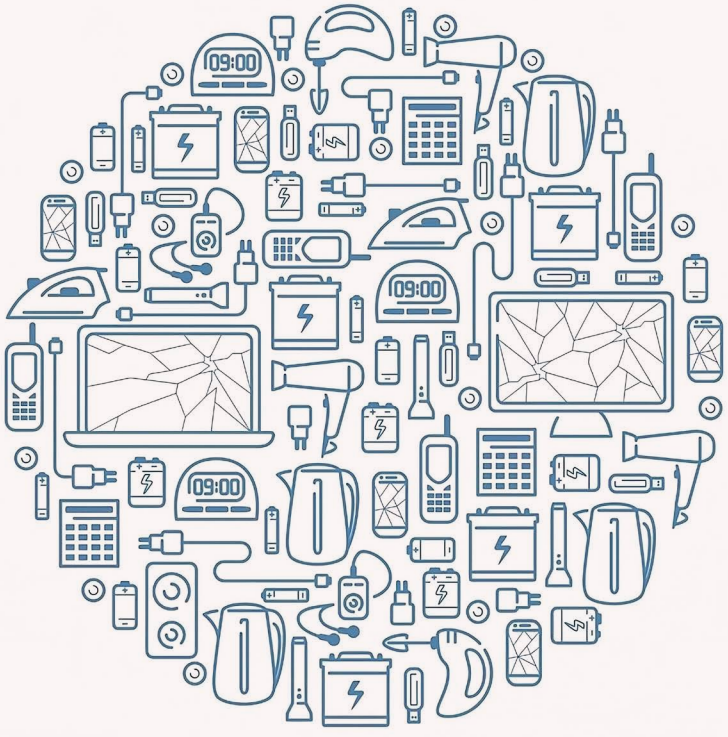
Table 1 Potential sources of data to power the provenance database

Actor	Potential data capture
OEMs	IMEI number, invoice, warranty
Telecom players	Activation details
Financial services	Creditworthiness of the owner, insurance claims made in the protection plan
After sales service providers	Ownership transfer
Law enforcement	FIR data for stolen devices

Conditions for success:

- **Data privacy norms:** Protecting consumer data and intellectual property of OEMs is the key. The scope of violations could hinder sharing of data from different players.
- **Alignment with industry players:** Lack of alignment will create data gaps in chain-of-custody information and ineffectiveness in identifying false transactions.

UPSTREAM: LEVERAGING DESIGN AND SERVICE MODELS TO CLOSE THE LOOP



UPSTREAM: LEVERAGING DESIGN AND SERVICE MODELS TO CLOSE THE LOOP

PROGRESS SO FAR: ECO-DESIGN

Global OEMs have started the eco-design journey, in response to their own sustainability commitments and regulatory requirements in the EU (European Union).

Studying EU's eco-design directive is important as most of the global players would be complying with these requirements across all their markets, as OEMs do not tend to design and produce for just one market alone. The directive sets a framework for performance criteria that manufacturers must meet in order to legally bring their product to the market. In late 2022, an agreement was found on smartphone and tablet eco-design requirements. There are two key pillars, namely, new labelling requirements and wider eco-design issues.

- New label: focus on displaying energy efficiency, EU-wide repairability ratings and reliability related information (e.g., battery lifespan, performance when exposed to dust, submerged in water, or accidentally dropped)
- Wider eco-design issues: focus on better access to spare parts, product design that facilitates repairs, and the availability of repair manuals as part of the right to repair push.

Removable batteries, minimum battery life and mechanism to check battery health are some of the proposed battery-related requirements. The draft requires OEMs to ensure that operating system and security updates are made available for a minimum of three and five years respectively, from the date the model is placed on the market. Manufacturers will also be required to ensure that updates do not mean a drop in the performance of older devices.

Among voluntary initiatives by the private sector, Apple's efforts on recycled content integration are noteworthy where the company has made a commitment to use only recycled and renewable materials across its product portfolio. In 2022, 20% of the materials shipped in Apple products came from recycled or renewable sources. In 2021 iPhone 13 was the first Apple product to use certified recycled gold, in 2022 the company reported 4% use of recycled gold across all product lines - up from 1% in 2021. Apple has most recently committed to use 100% recycled cobalt, tin, gold & rare earth elements in select components by 2025. The company is also making progress on its goal to eliminate all plastics from its packaging by 2025. In 2022, only 4% percent of Apple's packaging footprint was from plastic, and 66% percent came from recycled fiber.[11] Samsung has also committed to incorporating recycled material, eliminating plastic packaging, and reducing the standby power consumption of all chargers to <0.005W in their smartphones by 2025[12]. While the global players are making progress, smaller players with relatively minimal presence in European markets are not as aggressive.

OEMs find it complex to design and manufacture country-specific SKUs (stock keeping units) which meet the local regulations. In that light, the need for local eco-design requirements must be revisited. In either case, ease of doing business, and goal of making India an export hub should not be compromised

Currently, the scope of manufacturing in India is narrow but the government's aggressive focus (schemes such as PLI, PMP EMC 2.0) and interest demonstrated by private sector has precipitated into on-ground action. In coming years, India is expected to become a manufacturing hub, for local as well as export markets. In most cases, there will be no India-specific models and it's the same inventory for domestic and overseas markets. In that light, the proliferation of local ecolabels and eco-design requirements will not accelerate circular transition as such and in the absence of harmonization with global frameworks, would even compromise the ease of doing business, and India's ambition to emerge as an electronics exporter. Similarly, to standardize reporting and benchmarking, several frameworks already exist. At the organization level, Circular Transition Indicator and Circulytics, and at the product level, C2C Certification could be studied. There are three possible approaches a) adopt the global frameworks as they are b) adapt the global frameworks to the Indian context, such as simplification while adding new India-specific indicators or c) build a new India-specific approach. Indian policymakers must evaluate these strategic directions before finalizing an eco-design policy framework for India.

In the absence of strong downstream infrastructure and systemic challenges, any design change improvements may anyway not necessarily yield the intended outcomes

Upstream choices impact the downstream recyclability, component reusability, repairability and refurbishability. However, the effectiveness of some of the dimensions of eco-design depends on India's ecosystem readiness. For instance, design for recyclability would not lead to actual recycling on the ground unless there is a sound recycling infrastructure.

Table 2 Eco-design's scope in India will be limited by the lack of ecosystem readiness

Dimensions	Illustrative indicators	Limiting factors in India
Materials	▸ Recycled materials as % of total	▸ Low domestic availability and quality of secondary materials
Design	▸ On-product or on-pack labelling	▸ Consumers' limited understanding of and interest in eco-labels
Production and distribution	▸ Renewable energy-based production ▸ Logistics decarbonization	▸ Emission-intensive transportation modes ▸ High share of traditional trade as compared to modern trade
Lifecycle and use	▸ Availability of repair services ▸ Guaranteed availability of spare parts ▸ Secure data deletion	▸ Competition with informal sector service providers and non-genuine parts ▸ Underdeveloped refurbishment and subscription models
Collection	▸ Formal take-back programs ▸ EPR targets achieved in a fair manner	▸ Challenges in existing EPR implementation ▸ Lack of joint public-private effort
Recycling and material extraction	▸ Information on bill of materials for disposal or recycling	▸ Lack of downstream WEEE recycling infrastructure

Therefore, policymakers and OEMs need to balance the trade-off between full-blown eco-design implementation vis-à-vis prioritizing downstream modernization and reforms.

Focus should rather be on ramping-up the domestic secondary materials market which will make local manufacturing resilient to the supply security shocks and make India self-sufficient for critical raw materials

As per a report, China controls around 80% of the world's production of rare earth materials[13], and accounts for 98% of EU imports. EU's demand for rare earth elements is projected to increase fivefold by 2030 and the bloc has already mapped strategic dependencies and capacities to identify 30 critical raw materials[14] for which resilience strategies are being built. In addition, secondary metals use up to 85% less energy[15], resulting in up to 60% reduction in CO_2 emissions[16]. So, this would have a decarbonizing potential as well, considering India's net zero target by 2070.

Table 3 India's opportunity to enhance self-sufficiency for key strategic raw materials

Material present in a smartphone	% by weight in a smartphone[2]	Global recycling rates	India's dependency on imports[3]
Metals			
Aluminum	2.35	High	53%
Cobalt	5	High	100%
Copper	9.94	High	68%
Indium	0.00006	Low	100%
Lead	0.004	High	81%
Lithium	0.35	Low	100%
Nickel	1.6	High	100%
Steel	9.74	High	48%
Tantalum	0.018	Low	100%
Precious metals			
Gold	0.02	High	38%
Silver	0.24	High	26%
Palladium	0.008	Low	100%
Rare earths metals[1]	**0.05**	**Low**	**100%**

Note: 1. Constitute two rare earth metals, Praseodymium and Neodymium 2. The weightage values are an approximate average taken from different smartphones available worldwide (excludes non-metals such as glass and plastic) 3. Defined by DST-CEEW report titled Critical Non-Fuel Mineral Resources for India's Manufacturing Sector: A Vision for 2030

OEMs would require a domestic supply of secondary materials instead of continuing to rely on supply-contained virgin metals or on imports which are often marred by regulatory bottlenecks related to waste shipments. India's current secondary materials supply chain lacks both quantity and quality. Responsible sourcing of recycled metals and plastic either in a closed-loop fashion (e.g., precious metals extracted from PCBs) or from other loops (e.g., recycled plastic from packaging or automotive) would be preferred. However, currently it is almost impossible given

the non-availability of technology and investments. Developing a local secondary materials market also supports the development of advanced secondary smelting and refining capacities, thereby creating a demand for recyclables. The domestic landscape, however, is still very nascent as far as producing an electronics-grade purity is concerned.

MEITY's eco-design draft consultation is a good start, but there is a need to step back, review priorities and harmonize with globally established requirements

Infusing circularity at the design stage requires a two-pronged strategy. Firstly, it entails reduced use of virgin raw materials and promotion of the use of secondary raw materials. Secondly, designing devices to be repairable, refurbishable and recyclable. As a result, this approach has a cascading impact on all other circular business models. To that end, the draft consultation document on a sustainable product policy is a good start. However, trying to cover a very diverse set of aspects, the document has diluted the focus. The document also does not attempt to synchronize with globally emerging standards. So, prioritization followed by detailing out of 3-4 critical elements, and harmonization are the next steps. Anchoring it around strategic raw material self-sufficiency through urban mining and linking it with manufacturing incentives could be a game changer. As of 2021, a global OEM's responsible materials sourcing program has mapped ~150 suppliers (of virgin and recycled cobalt, lithium, tungsten, tin, tantalum, and gold), of which only four are from India. Among these four, only two are believed to be supplying electronics-grade recycled content.

PROGRESS SO FAR: PRODUCT-AS-A-SERVICE

Service models are garnering interest among small and medium B2B customers but still nascent

Product as a Service (PaaS) model has the potential to extend the device's useful life, not only through design interventions but through assured takebacks. Once the final subscription cycle is over, returned devices can be given a new life through reselling, refurbishing or sending for formal sector recycling. The business model has registered a good growth (roughly 65% in last one year), particularly driven by adoption among small and medium enterprises (SMEs).[17] Organizations find it attractive for reasons such as cost savings on maintenance costs and ease of ramp-up or down. Most of this B2B demand is fulfilled by OEMs or 3rd party PaaS providers in select categories such as laptops. The model is also attractive for end consumers desiring to rotate models frequently. Startups such as RentoMojo and Furlenco offer B2C services, with monthly smartphone rentals starting from ₹2,099 up to ₹9,299, depending on model and contract duration[1]. However, the scale is still low.

Need to create an enabling ecosystem which allows players to launch and grow this model

PaaS is a business opportunity and market mechanisms will help it grow, however, there is an ecosystem enablement role that policy can play. In India, key players in the PaaS ecosystem are OEMs, 3rd party PaaS providers, retailers, telecom companies and financial service providers. Mature players in each of these sectors can collaborate to bring innovative products to the

market. For instance, financial services companies can help OEMs with the creditworthiness check of the consumers, a major issue in markets like India. Similarly, carriers can provide devices on rent to their post-paid subscribers, like in the US market. There are some additional issues such as writing off the assets which will stay on the balance sheets of the service providers. A framework that provides a policy indication, lays out the role that each player needs to play and provides demand side impetus will go a long way to support scale-up. A notable front runner is Dell which has established a subsidiary, Dell Financial Services (DFS), which not only provides financing solutions but also offers leasing options to customers who want to acquire Dell products but don't want to commit to a long-term purchase.

To address the key challenges above, the game changers to focus on are as follows:

#8 **Reorient existing consultations on eco-design requirements to the Indian context**

#9 **Create a nurturing ecosystem for service models in India**

THERE ARE TWO POLICY INTERVENTIONS NEEDED TO UNLOCK THE GAME CHANGERS ABOVE

POLICY INTERVENTION #8:
PRIORITIZE AND HARMONIZE ECO-DESIGN IMPERATIVES, AND DEVELOP SECONDARY MATERIALS MARKET

Call to action:

Components proposed in MEITY's draft eco-design policy paper can be classified into three clusters

- **Cluster 1**: Good-to-have features but need to be globally harmonized for ease of doing business e.g., 3rd party assured eco-label.
- **Cluster 2:** Good-to-have features but need consultations on details and scope e.g., quantifiable circularity measurement approach.
- **Cluster 3:** Non-design related features which do not have a direct relationship with device design: e.g., knowledge bank, green skill development, extended warranty, etc.

Table 4 Clustering of components in the proposed eco-design policy paper draft

#	Component	India	EU	Classification	Remarks
1	Eco-label	Yes	Yes	Cluster 1	▸ Assess harmonization with existing global standards e.g., Electronic Product Environmental Assessment Tool (EPEAT), EU labelling requirements once firmed-up
2	Hazardous substances compliant	Yes	Yes	Cluster 1	▸ India is already a signatory
3	Eco-design parameters	Yes	Yes	Cluster 1	▸ Enlist key requirements and mechanism to ensure conformity without compromising ease of doing business
4	Product-level Sustainability Index	Yes	Yes	Cluster 2	▸ EU does not define an index, but there are examples such as CTI and C2C Certification ▸ Mechanism to quantify needs to be defined
5	Company-led Sustainability Index	Yes	No	Cluster 3	▸ Not linked with design of device ▸ Already measured via ESG ratings
6	Lifecycle assessment	Yes	No	Cluster 2	▸ Neither LCA nor product carbon footprint results necessarily enable brand comparisons in a standardized manner
7	Targeted subsidies linked to embedding sustainability	Yes	No	Cluster 2	▸ Mechanism to qualify for subsidies is missing
8.	Secondary raw materials standard	Yes	No	Cluster 2	▸ Harmonize with existing global standards or work closely with brands to understand existing best practices
9	Green public procurement based on eco-labeling	Yes	No	Cluster 2	▸ Lack of clarity on implementation
10	Knowledge bank industry academia	Yes	Yes	Cluster 3	▸ Not linked with design of device
11	Design for repair, recycle and refurbish	No	Yes	Cluster 2	▸ Need to be globally harmonized
12	Management system for assessing conformity	No	Yes	Cluster 2	▸ Lay down procedure for OEMs without impacting ease of doing business
13	Extended warranty	Yes	No	Cluster 3	▸ Extended warranty is related with aftersales instead of design
14	Green skill development program	Yes	No	Cluster 3	▸ Not linked with design of device
15	Explore circular business model	Yes	No	Cluster 3	▸ Not linked with design of device

Eco-design policy can also catalyze creation of a local secondary materials market

Development of a robust secondary materials market in the medium to long term should be one of the anchors of eco-design policy. The first step in this direction would be identification of strategic raw materials for the electronics industry and testing the viability of a local closed-loop recycled metal integration model.

Policy design principles:

A. Clustering of existing eco-design policy to optimize efforts

Policymakers can prioritize Clusters 1 and 2 as they are more relevant to eco-design. Given the global nature of the electronics supply chain, harmonization to the highest degree will help OEMs maximize the synergies in the finished goods shipped across the world. The use of harmonized standards would help provide a presumption of conformity and would reduce the varying requirements OEMs need to comply with across different geographies.

B. Linking Sustainability Index with manufacturing incentive programs

Well-harmonized product-level or company-level sustainability index can be used as one of metrics for the evaluation of applications for manufacturing incentive programs. It can help determine the extent, quantum, and duration of incentives. However, mandates requiring on-pack labels based on such an index should be avoided. The utility of such a label is limited by the low level of consumer awareness and besides, it might be counter-productive for ease of doing business and India's ambition of emerging as a global manufacturing hub.

C. Developing a domestic secondary materials market in India

Defining priority secondary materials: EU has defined a list of critical raw materials, consisting of many metals used in electronics manufacturing. Indian policymakers should do so based on the following criteria:

- **Global ease of availability:** based on the limit and concentration of global production and reserves, recycling rates, availability of alternatives in case of supply restrictions, and political stability in source countries.
- **Domestic supply robustness:** based on domestic secondary smelting and refining capabilities, ore concentration and extraction, production capacity and export dependence.
- **Domestic ESG impact:** based on material's carbon and water intensity, biodiversity impact, hazardous uses or release during production, recyclability when used in consumer electronics and human rights risk.

Proof-of-concept pilot of local circular supply chain: Pilots should be conducted with the support of OEMs, CMET and local refiners to validate the quality of domestically produced recycled content as a replacement for virgin materials. As the secondary materials market scales up, policymakers can evaluate the adoption of existing global secondary material quality standards, instead of creating new ones.

Conditions for success:

- **Ease of doing business for OEMs:** The need for a local eco-design policy should be re-evaluated in consultation with OEMs, and if at all, a need is felt, any such policy should be aligned with global best practices. The definitions and scope must be water-tight, claims should be easy to verify and must enable OEMs to get additional manufacturing incentives with minimal red tape.

POLICY INTERVENTION #9:
DEVELOP A PRODUCT AS A SERVICE FRAMEWORK

Call to action:

Our modelling shows that market size of subscription model of smartphones and laptops alone in India will be more than $2bn by 2035. While product as a service is a private sector initiative, policy indication can catalyze the creation of a nurturing ecosystem for service models.

Policy design:

Define a framework for Product as a Service (PaaS)

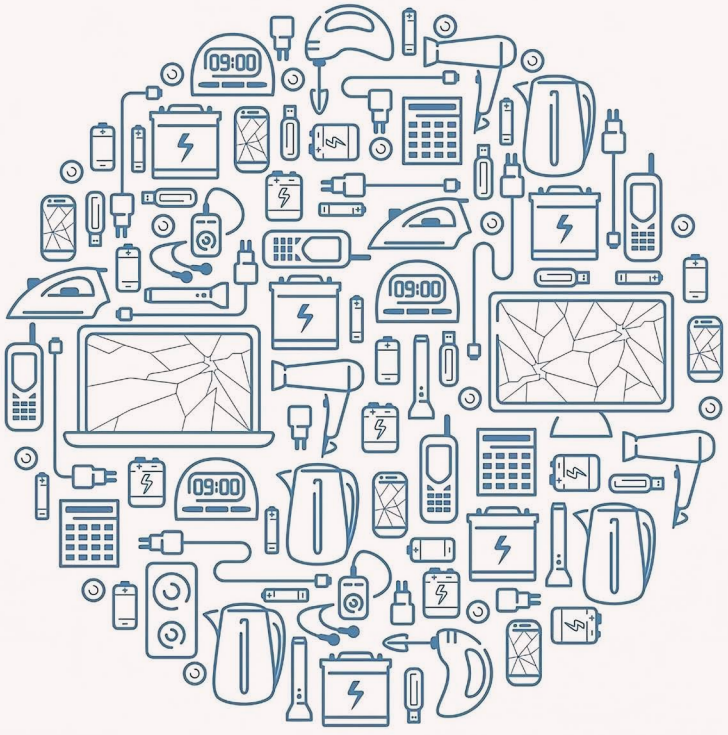
Firstly, there is a need to define product-as-a-service business models. Secondly, there is a need to assign roles to ecosystem players such as OEMs, 3rd party players such as start-ups, telecom, financial services companies, and reverse logistics providers to manage take-back. A minimum service level requirement can be bundled with contracts. This could include installation and configuration, on-site support and remote monitoring, anti-virus, data backup, break-fix warranty etc.

- **Solutions for B2C segment:** In a market like India, there is a need for service providers to evaluate consumer's creditworthiness through technology-enabled KYC and to provide insurance to the service providers, in case of theft or loss. For such services, a strong partnership with financiers and insurers is needed. Telecom players can also play a role by providing access to their post-paid consumer base.
- **Solutions for B2G and B2B segments:** To generate demand, green public procurement by government departments can be explored. Even the private sector can be incentivized for using PaaS models through rationalized GST structure such that the total cost of subscription remains lower than the total cost of ownership over the usage period.

Conditions for success:

- **Active participation of OEMs:** OEMs are best placed to understand consumer needs and have the working capital to scale up subscription models through attractive market offers.
- **Partnerships with non-electronics sectors:** OEMs or multi-brand startups alone cannot scale up PaaS model and there is a need to co-innovate with telecom and financial services players.

UNLOCKING FULL ECONOMIC, SOCIAL AND ENVIRONMENTAL POTENTIAL



UNLOCKING FULL ECONOMIC, SOCIAL AND ENVIRONMENTAL POTENTIAL

The value case of nine policy interventions identified in the previous chapter is a must to create a data analytics-based narrative for informed decision making. Policy framework can take three directions:

- **Continue with business as usual:** continue with existing policies such as EPR in their current shape and no new policy intervention is made, business practices remain the same.
- **Focus on a particular value chain stage:** policy framework decides to prioritize a specific stage of the value chain, namely, downstream, use-phase and upstream pathways. As a result, other pathways get deprioritized given the limited resources.
- **Efforts across the value chain:** simultaneous implementation of all policy interventions, albeit with a graded ambition level, across the value chain to capitalize on the synergies given the interconnectedness across pathways and balance the trade-offs. We are calling this scenario, which incorporates all three pathways, **a System Change approach**.

We have quantified the economic, social, and environmental impact of the policies across 5 pathways. The computations show the incremental impact of the implementation of a policy intervention between 2023 and 2035. We have chosen 2035 because the year marks the 20th anniversary of EPR introduction in India. Economic value is measured through incremental gross profits that the private sector (including non-OEM actors) can generate. Social value is indicated by the incremental number of jobs generated. Environmental value is based on WEEE diverted from informal sector recycling and GHG emissions avoided.

The results of quantitative impact modelling are directional in nature and an in-depth study would be required in the coming years, using high quality data and assumptions, to sharpen this further. Further details on the approach are explained in the Appendix.

Pathway 1: Business as usual

Market size of circular economy business models in the Indian electronics sector is projected to be ~ $13bn by 2035 in BAU scenario

The current policy framework is focused on plugging the downstream leakages by improving collection rates (going as high as 70% of total WEEE generated in EPR framework). However, the leakages into informal sector recycling, and issues such as overstated reporting will likely continue. There will be minimal consolidation in the WEEE recycling sector and any large-scale capital investment into advanced smelting and refining is not expected. Indian OEMs will have no choice but to depend on the import of secondary metals instead of domestic urban mining. In addition, use-phase product life extension and upstream design changes will not be encouraged yet. Formal and informal dynamics in the repair market will continue, with a large strain on the spare parts supply chain. The increasing refurbishment demand would likely be met by non-OEM players.

The choice in front of policymakers is to either continue with the status quo and let the market take its own course or actively intervene to create an enabling environment for change. Policymakers and the private sector have the choice to concentrate on a particular stage of the value chain, leading to three distinct pathways, each with their own trade-offs.

Pathway 2: Downstream focused

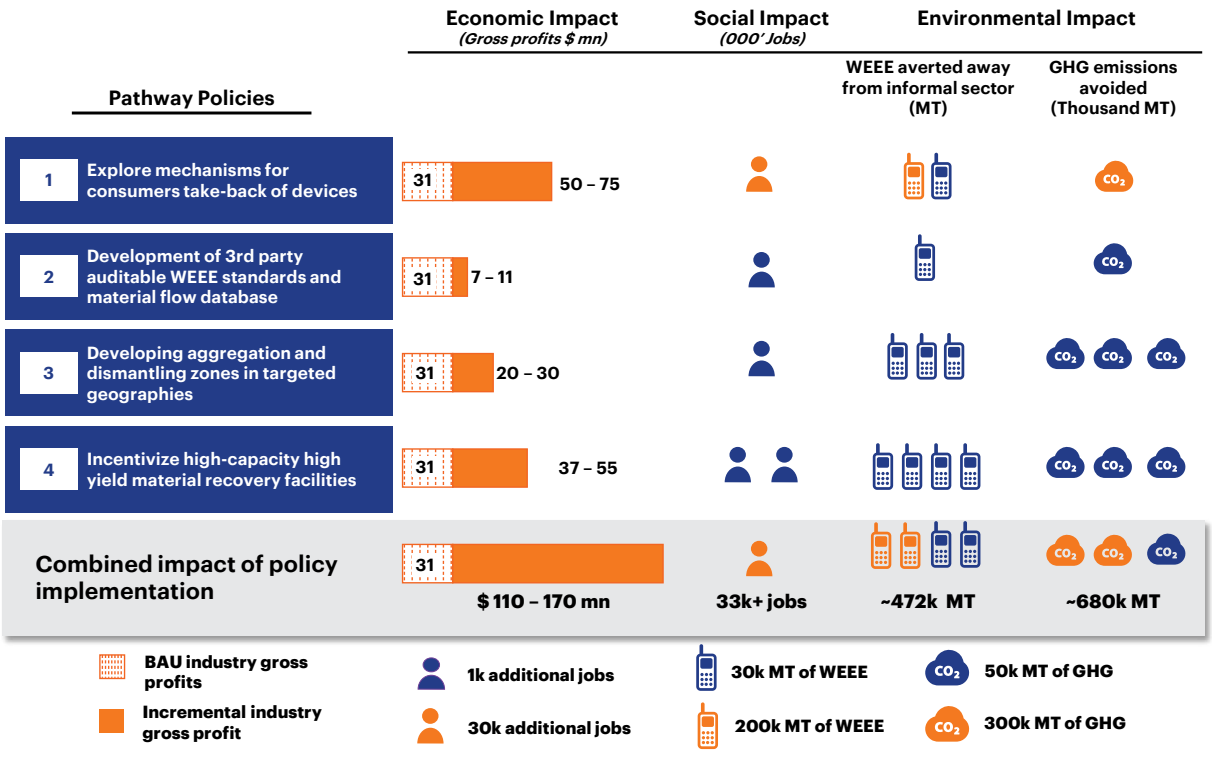
While the economic impact of the downstream pathway is relatively low, the large WEEE leakage reduction makes this pathway attractive. In the absence of proposed policies in the downstream pathway, ~70% of the WEEE will continue to be recycled in the informal sector, losing out on more than half of the embedded precious metals value

Economic Impact: Implementation of policies in this pathway will lead to higher formal recycling volumes as well as efficient material value extraction due to advanced recycling technologies, thereby having a positive effect on industry revenues. Effective audits and recycling standards might increase compliance costs, which could be offset by plugging leakages (due to reduced improper practices) and an increase in material recovery. As a result, incremental gross profits of $110-170mn can be realized by 2035.

Environmental Impact: Advanced recycling facilities along with 3rd party auditable standards would ensure environmentally sound practices, improved recycling efficiency, and reduced virgin material dependency. The cumulative impact of the downstream pathway policies is diversion of ~472k tons of WEEE either from the informal sector or from idle inventory to the formal recycling sector by 2035. Our calculations also indicate roughly ~680k tons of GHG emissions savings, equivalent to taking 17 mn smartphones off the market, by 2035.

Social Impact: Not just the number of jobs, but the quality of jobs in dismantling and recycling will also improve with better health and safety measures in place. Self-employed formal microentrepreneurs will also emerge. Overall, ~33k new livelihood opportunities are expected to be generated by 2035, of which more than 70% will be generated at the dismantling stage.

Figure 14 Downstream pathway exhibits the largest WEEE diversion among all pathways



Pathway 3: Use-phase focused

Use phase focused pathway has the maximum potential in terms of economic (>70%), and social impact (~50%) out of total potential impact across five pathways. Approximately, more than $1bn in incremental gross profits and 51k livelihoods can be realized through this pathway by 2035.

This pathway covers policies impactinguse-phase models such as resell, refurbish,andrepair. Implementation of identified policy interventions will result inadditional in-flow of volumes, improvedcost and operational efficiency and increased consumer demand will drive the impact.

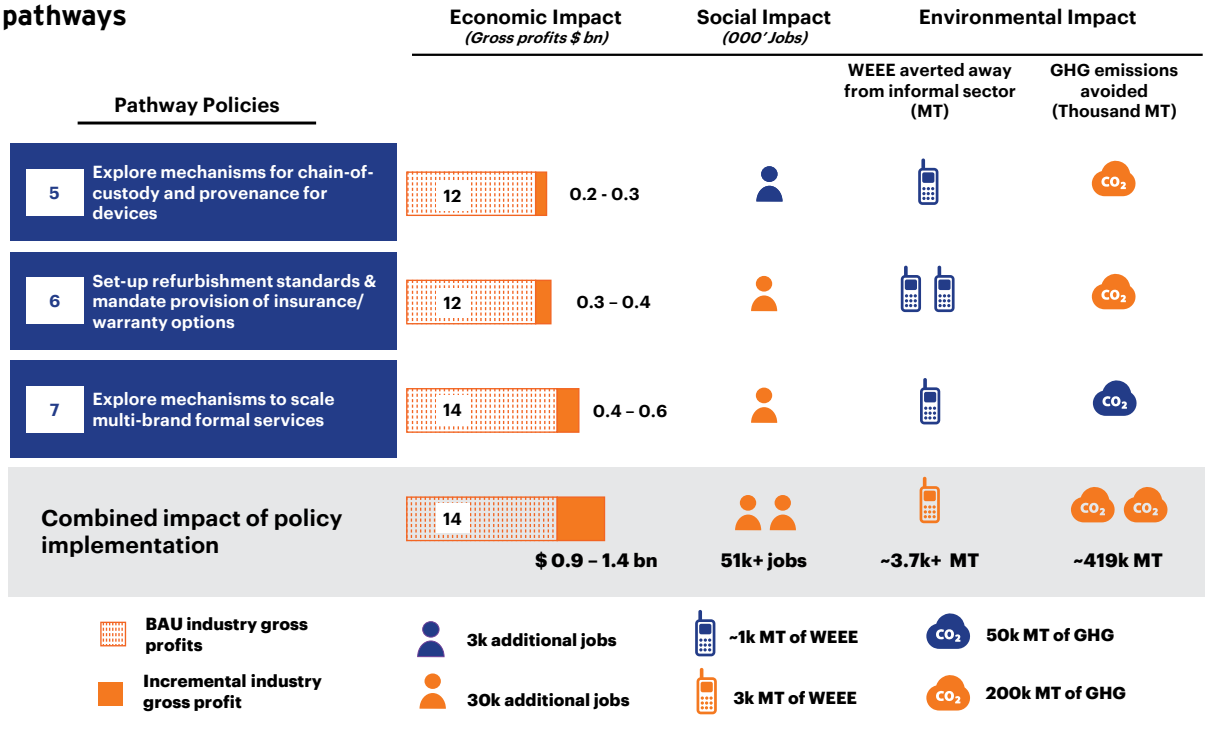
Economic impact: Additional devices (idle inventory liquidation or diversion of flows away from non-optimal routes) and more economic value per device (formal repair & refurbishment services) will lead to overall market expansion. The sale of refurbished devices, especially in the premium segment,may affect the sale of new devices in the mid & lower segments.

Social impact: Expansion of the refurbishment market would create demand for arelatively more skilled workforce as the technicalrequirement is higher. There will also be a proportional increase in blue-collar jobs to improve last mile collection infrastructure. As a result, ~51k additional skilled jobs could be created by 2035.

Environmental impact: Increased supply towards formal repair, resell and refurbishment wouldensure device longevity, thereby decreasing new devices sales and associated WEEE and GHG emission avoidance. This could result in averting ~3.7kMT of WEEE and 419kMTof GHG emissions by 2035.

Use-phase pathway shows the highest impact potential across the 3 pathways and would have uniform impact across economic, social & environmental metrics.

Figure 15 Use-phase pathway exhibits the largest economic and social impact among all pathways



Pathway 4: Upstream focused

Incorporating eco-design principles is a net cost activity for OEMs in the short-medium term with a potential cost parity in long term whereas the PaaS model has a significant economic potential

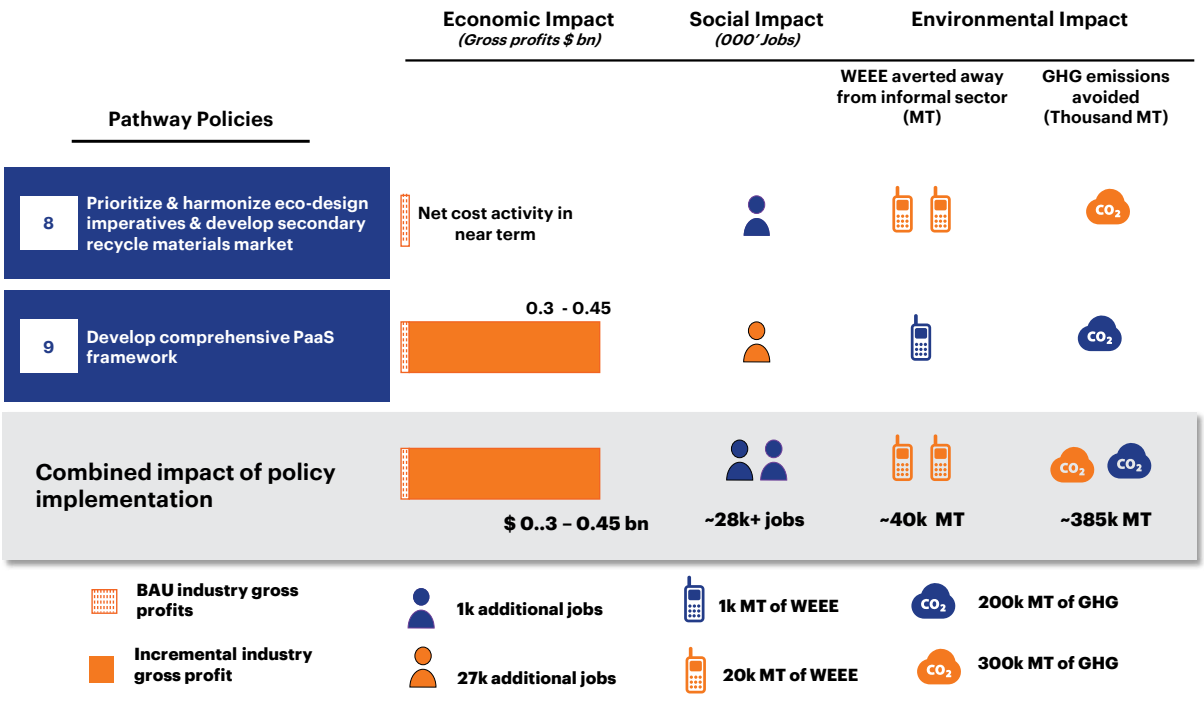
Implementing eco-design requirements is costly for OEMs, stemming from recycled raw material premiums, procurement of renewable electricity,cost of R&D and CAPEX needed for change in manufacturing lines. Valorizing eco-design with Indian consumers would be difficult given the price sensitivity. However, prioritizing upstreamfocus is important as it provides long-term benefits. On the other hand, PaaS not only is ahighly profitable business model, butit also enables other business models such as repair, resell, refurbishment and recycle. Therefore, the combined economic impact is very high.

Economic impact: PaaS framework would result in the creation of a new product category altogether, resulting in $ ~370mn as incremental gross profits. The eco design on the other hand will be a net cost activity in the short term with the possibility to achieve cost parity in the long run.

Social impact: The pathway will indirectly support employment in repair, refurbishment and recycling services, applicable throughout the PaaS lifecycle. As a result, the pathway could create ~28k new skilled jobs in OEMs and service sector by 2035.

Environmental impact: PaaS has the potential to cannibalize sales of low-end devices and to promote product longevity through multiple use cycles, leading to potential reduction in net new devices manufactured. At the same time, eco-design will boost the demand for high quality recycled raw materials, resulting in waste version to the formal sector and lesser use of carbon-intense virgin materials. Thus, the upstream pathway has the potential to avert ~40k tons of WEEE and reduce ~385k tons of GHG emissions by 2035.

Figure 16 Upstream pathway shows moderate overall impact



Pathway 5: System change pathway

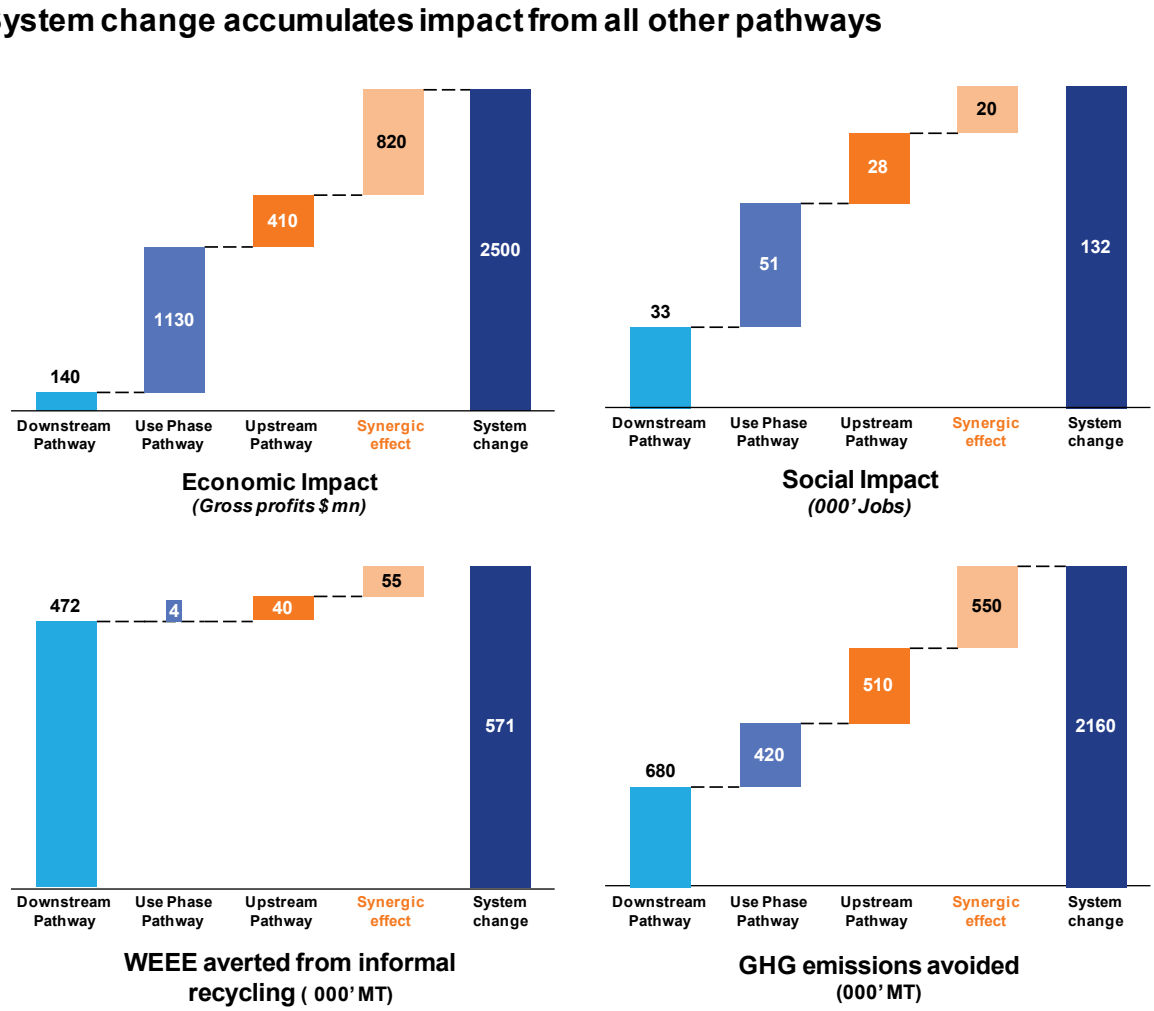
Any of the three pathways above is not a silver bullet and choosing one over another comes with two risks a) lack of balance in trade-offs in terms of economic, social, and environmental value b) untapped synergistic effects due to interconnectedness. Therefore, there is a need to adopt a system change approach

For instance, implementing downstream pathway policy interventions can have a significant impact on WEEE reduction but has a relatively lower impact on job creation and incremental industry profits. Similarly, the adoption of use-phase pathway policy recommendations will unlock significant economic and social impact but would not have a high environmental impact. A system change pathway, which acts across the value chain, optimizes these trade-offs. System change pathway also has the potential to unlock positive synergies among individual pathways. Some examples of these synergies are as follows:

- **Downstream - Use-phase synergies:** Interventions for improving consumer takeback of devices for recycling will have strong synergies with liquidation of idle inventory for repair and refurbishment. Our modelling shows that the combinatorial impact would roughly be 25% more than the combined impact of interventions, when modelled independent of each other.
- **Use-phase - Upstream synergies:** Higher the quality and reliability introduced by design, the lower would be the need for refurbishment and repair infrastructure. Similarly, scaling-up of product-as-a-service models necessitates development of a strong aftersales network, thereby improving the per unit economics.
- **Upstream - Downstream synergies:** Downstream and upstream policies will also benefit from each other. The use of recycled content as part of eco-design is dove-tailed with development of secondary materials market and creation of high-capacity high yield advanced recycling facilities.

The system change approach has the potential to increase industry gross profits by $0.8bn, showing a ~33% increase from the cumulative impact of individual pathways. In addition, an increase of ~20k jobs can be seen, which is ~18% more than the combined social impact of the 3 pathways. GHG emissions reductions of ~2.1 mn MT could be achieved, the cost for offsetting which could go as high as ~$32mn (assuming a carbon price of $15 per ton).

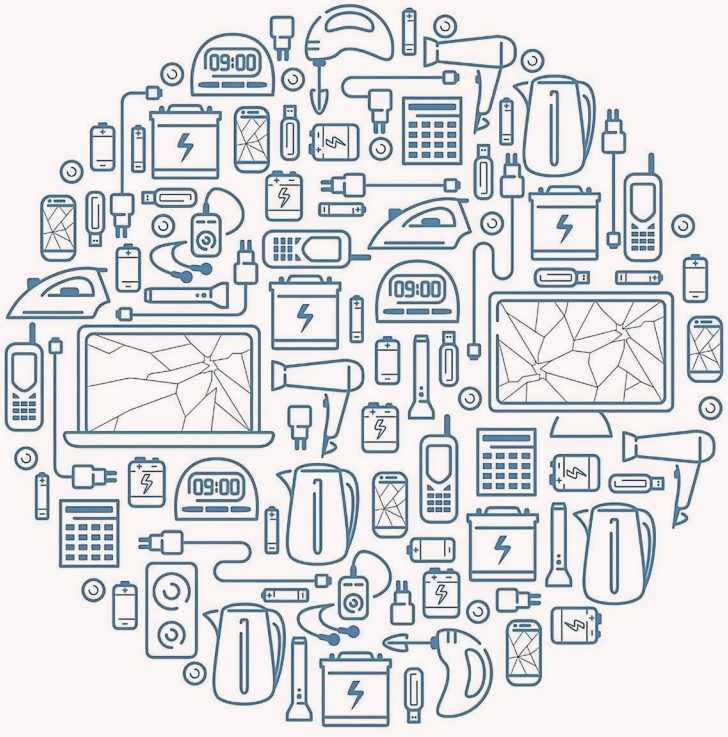
Figure 17 Strong economic, social, and environmental synergies observed in system change approach



A win-win for industry, consumers and environment would require a stakeholder-centric balanced approach

There are certain key considerations to shape the system change approach. Firstly, it must follow a graded approach to avoid burdening policymakers, OEMs, and other ecosystem players and to give them time to adapt. Secondly, transformation should be such that it remains economically viable for consumers, the government, and the private sector. While system change unlocks compounded benefits, it also calls for significant investments.India's domestic manufacturing stands at a cusp, and OEMs are focused on setting up an Indian supply chain.

MANAGING THE TRANSITION

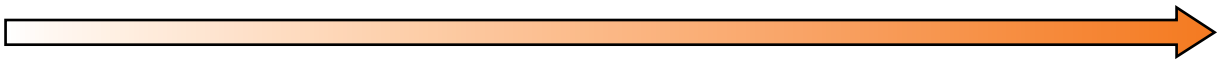


MANAGING THE TRANSITION

The value of circular economy transition is undisputed, and it is achievable with joint public-private action and a well-articulated long-term vision. The key question is where to start and what to prioritize. So, for each of the nine policy interventions identified, the study maps a pragmatic call to action in the short and medium terms, for the government and the industry.

Table 5 Recommended action plan for public and private sector

Horizon 1: Short-term imperatives (<2 yrs.) Horizon 2: Medium-term imperatives (2 - 5 yrs.)



EXTRACTING MAXIMUM VALUE AT END-OF-LIFE	
Policy Intervention #1: Explore mechanisms for formal consumer take-back of devices	
o Align with industry on last-mile formal collection approaches, costs involved and consumer incentives o Commission a national-levelwaste inventory mapping exercise	o Implement formal collection vision with mandates across supply chain e.g., collection mandates for retailers and ULBs o Leverage existing campaigns such as PM LIFE to create mass awareness
▸ Create an ecosystem of 3rd party reverse logistics and retailers to enable assured buybacks/trade-in ▸ Establish a minimum end-of-life residual valueto support price discovery	▸ Initiate industry consultations on data sanitization protocols ▸ Develop strategies to scale trade-in programs and use marketing budget to create consumer awareness
Policy Intervention #2: Launch 3rdparty auditable WEEE standards and material flow database	
o Work with multilateral organizations and certification agencies to develop 3rd party auditable standards o Launch a project to develop an IT tool for mass flow reporting and balancing under EPR framework o Create deterrence against improper behavior among the formal players through steep fines	o Evaluate should-be vs current costs of EPR on per ton basis o Develop an ecosystem of certification agencies
▸ Conduct intra-industry consultation to move from compliance to quality mindset in the EPR compliance	▸ Introduce mandates for EPR contractorsfor 3rd party auditable standards and reporting tool

Legend	o Public sector	▸ Private sector

Policy Intervention #3: Develop aggregation and dismantling zones in targeted geographies	
o Develop an operating model (e.g., legal structure, location, services offered, retention policy etc.) o Alignment with local administration and community leaders to confirm a mobilization plan	o Build cluster infrastructure in specific geographies under PPP mode o Invite metals and mining companies to set-up smelting units in proximity of the zones
▸ Deploy CSR funds to support inclusion programs in aggregation and dismantling zones	▸ Leverage EPR contracts to encourage recyclers to offtake materials dismantled in the zones
Policy Intervention #4: Incentivize high-capacity high-yield advanced recycling facilities	
o Define technical requirements (based on yields) to qualify recycling o Perform fraction-wise analysis to assess the technology requirements in India o Facilitate discussions between global and local technology providers and traditional metal and mining companies	o Amend SPECS to encourage more aggressive private sector capital infusion for setting-up large capacity sampling, smelting and refining facilities o Support local R&D commercially viable technologies by private sector
▸ Work with government to secure conditions for success e.g., viability gap funding in initial years	▸ Execute joint-ventures or technology licensing partnerships to set-up smelting and refining units locally
EXTENDING USEFUL LIFE OF DEVICES	
Policy Intervention #5: Explore mechanisms for chain-of-custody and provenance of devices	
o Initiate consultation of solution architecture, leveraging existing tech stacks with OEMs, telecom&financial services	o Kick-off development of the digital solution with aprofessional IT company
▸ Provide industry-led solutions while protecting consumers privacy and OEM IP	

Legend	o Public sector	▸ Private sector

Policy Intervention #6: Set-up refurbishment standards and mandate provision of insurance/ warranty options	
o Establish a committee comprising BIS, OEMs, multi-brand formal players etc. to validate need for refurbishment standards o Conduct market study and discussions with industry on warranty and insurance provision	o Introduce the BIS-led refurbishment standards or provide recognition to a voluntary industry-led approach
▸ Conduct cost-benefit analysis of extended insurance and warranty options	▸ Introduce provisions for both insurance and potentially extended warranty for refurbished devices
Policy Intervention #7: Explore mechanisms to scale multi-brand formal services through strengthened spare parts supply chain, market linkages and financial incentives	
o Initiate consultations on OEM support period, spart parts availability and harvesting o Assess potential harmonization of GST slabs for spare parts	o Explore support period requirements with mandates related to controlled access of spare parts o Conduct needs assessment to define capital support needed by multi-brand formal service providers
▸ Explore long-term supply contracts of sparewith multi-brand formal players ▸ Develop capacity building-led partnership programs by adopting qualified informal sector repair providers	▸ Explore strategies for spare parts cost optimization
LEVERAGING DESIGN & SERVICE MODELS TO CLOSE THE LOOP	
Policy Intervention #8: Prioritize and harmonize eco-design imperatives and develop secondary recycle materials market in mid-long term	
o Re-assess the eco-design draft, and engage with the industry to discuss need for harmonization o Initiate studies on metal prioritization basis current technology, supply chain constraints, etc.	o Amend PLI guidelines to offer additional incentives with voluntarysustainability index o Develop mechanism to explore eco-design requirements focused on easeofdoing-business and global harmonization o Onboard partners for closed-loop local secondary materials supply chain pilot and evaluate need for quality standards
▸ Support government in developing a holistic eco-design framework and ensuring global harmonization ▸ Undertake voluntary initiatives and commitments	▸ Strengthen recycling capacity to source secondary materials locally for domestic production

Legend	o Public sector	▸ Private sector

Policy Intervention #9: Develop comprehensive PaaS framework	
o Mobilize the ecosystem to unlock key challenges with other sectors such as OEMs, telecom, financial services	o Introduce green public procurement criteria and GST benefits for subscription models
▸ Explore 3rd party platforms to scale PaaS forB2B and B2G customers	▸ Invest in direct-to-consumer PaaS business models

Legend	o Public sector	▸ Private sector

Unless the WEEE value chain is transformed in coming years, the compounding risks will become unmanageable. While the study gives a broad direction, policymakers and industry need to engage more than ever to translate them into an action plan. Aligning on a uniform set of national priorities and areas of coordination is critical. In this new governance structure for policymaking, the government should ensure the voice of the industry is heard to test the pragmatism and applicability of proposals. At the same time, industry players should align among themselves and present a combined point of view much more proactively to the government. Competent stakeholders on both sides must have transparent and exhaustive consultations to align on a long-term circular electronics vision for India, thus, ensuring policy predictability which is crucial to ensure the success of ongoing efforts to make India an electronics manufacturing hub. We have eight years before the decade of action ends, 18 years before the 25th anniversary of EPR's introduction in India and almost half a decade to fulfil our net zero target by 2070.

APPENDIX 1: DEFINITIONS OF CIRCULAR ECONOMY (CE) BUSINESS MODELS

Table 6 Definitions of circular economy business models

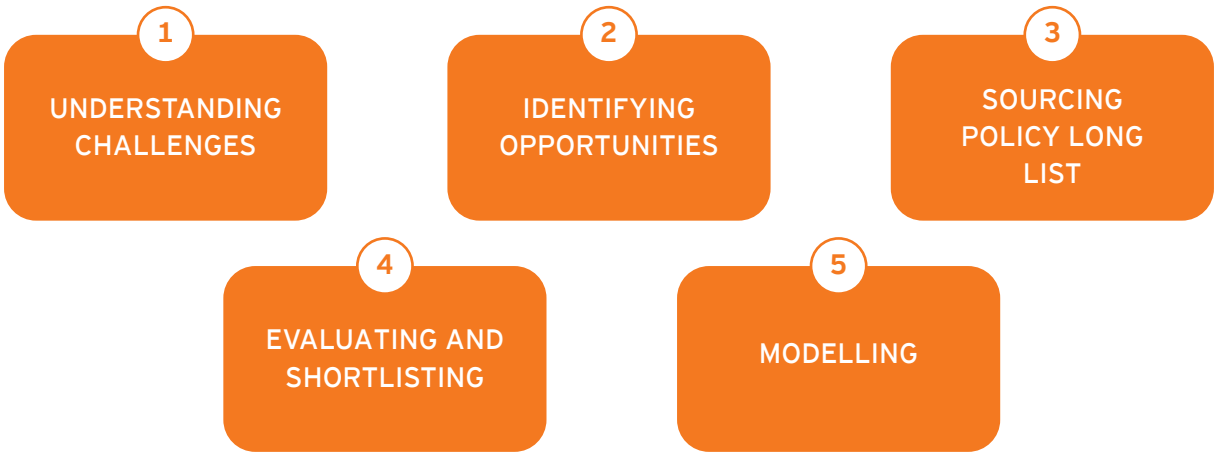
	Indian CE Model Definitions	Global CE Model Definitions
Circular Design	Products designed for durability, reuse, and safe recycling with substitutes of concern substituted out[17]	The integration of environmental aspects into the product development process, by balancing ecological and economic requirements. Eco-design considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product life cycle.[18]
Product-as-a-service	No definition articulated in existing policies	Effort is made to provide a user with access to the function of a product. The user no longer automatically becomes the owner of the product. Agreements are made concerning (1) the use of a product (access), (2) a certain performance level in terms of functionality (3)conditions including the quality of the performance and a predetermined fee[19]
Resell	No definition articulated in existing policies	Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived.[20]
Repair	Lack of clarity as no separate definition in EWM 2018 and draft 2022 amendment	Operation by which a faulty or broken product or component is returned back to a usable state to fulfil its intended use Actions to extend the duration of the product's service life through modifications of the equipment and generally refers to specialised repair of professional goods produced in the manufacturing sector with the aim of restoring machinery, equipment, and other products to working order[21]

	Indian CE Model Definitions	Global CE Model Definitions
Refurbish	'Refurbishment' means repairing of used electrical and electronic equipment (as listed in E-Waste Management Rules, 2016 schedule I) for extending its working life for its originally intended use and selling the same in the market or returning Refurbish means restoration of a used product for its intended use by performing minor alterations.[23]	Returning used product to at least its original state with a warranty that is equivalent to or better than that of a newly manufactured product. Performance after remanufacturing is expected to be at least to the original performance specifications. Refurbish: A process that may be used in B2B or B2C that renders the product available for re-use through part removal and upgrades/ replacements, and testing. Refurbished products do not necessarily perform better than a newly manufactured product and may include some small defects (such as a lower battery capacity), which do not have major impact on the use of the product[24]
Recycle	Recycler means any person who is engaged in recycling and reprocessing of WEEE or assemblies or their components and having facilities as elaborated in the guidelines of CPCB 'Recycle' means transformation of the good into raw material that can be reshaped into a new item[25]	Any recovery operation by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations

APPENDIX 2: METHODOLOGY FOR SHORTLISTING POLICY INTERVENTIONS

The purpose of this report is to lay down policy solutions to enhance circular economy integration into existing businesses. The approach taken to shortlist these policy solutions consists of the following stages:

Figure 18 Methodology for shortlisting policy interventions



STAGE 1: UNDERSTANDING CHALLENGES

The study began with an as-is assessment to understand the market context, players, business practices and relevant policies for the six-business models.

The following policies & best practices were referred to for this study across the phases listed below:

- **Downstream Phase**: E-waste (Management) Rules, 2016 (including amendments in 2018 and 2022), the Scheme for Promotion of Electronic Component and Semiconductors (SPECS), Extended Producer Responsibility mandate, government-run Awareness Programme on Electronic Waste's Environmental Hazards, etc. Further to that, some of the global initiatives were deep-dived to take inspirations such as E-Stewards recycling standard, CEN and CENELEC EU circular economy standards, WEEE directive, etc.
- **Use Phase**: Hazardous & Other Wastes Mgmt. Rules, 2016, Foreign Trade Policy, 2015-20, E-waste (Management) Rules, 2016 (including amendments in 2018 and 2022), etc. have been considered. Additionally, some of the global best practices were studied in detail to take inspiration such as Right to Repair, Repairability Index, Refurbishing Standard: Bsi KITEMARK, etc.

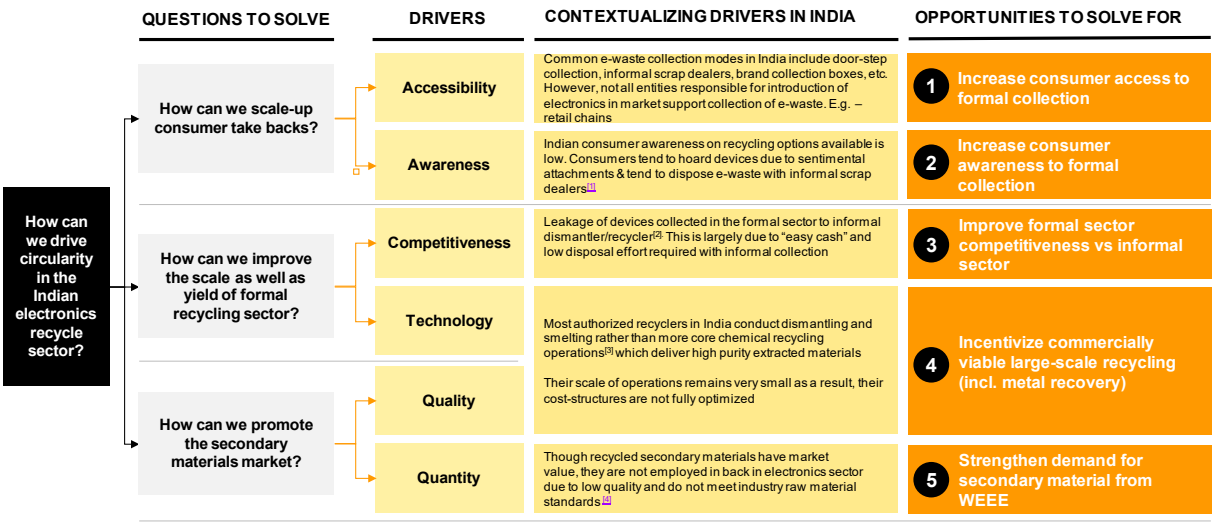
- **Upstream Phase**: Recent Eco-Design draft policy by NITI Aayog was referred that outline how India needs to focus on sustainability index, eco-labelling, and ROHS, consumer incentives, etc. Additionally, a deep-dive into the EU Eco-design directive was done to identify opportunities for Indian policy landscape.

The study also developed material flows for each of the business models for smartphone category, which demystified key leakages. Expert interviews and site visits were conducted across key stakeholder groups. Existing regulatory framework was also studied for gaps and opportunities. To bring the voice of consumer, a survey covering 25 questions across all the business models was administered to more than 200 consumers. The process led to the articulation of key challenges, or questions to solve for, for scaling up each of the business models.

STAGE 2: IDENTIFYING OPPORTUNITIES

For each of the key questions, we identified underlying consumer, financial, technical, regulatory and infrastructure related drivers. Each driver was contextualized to Indian context to map the potential opportunities.

Figure 19 Illustrative view of opportunities and drivers listed for recycling business model



STAGE 3: SOURCING POLICY LONG LIST

To unlock the opportunities identified in Stage 2, a long list of relevant policy solutions was compiled. The policy solutions listed have been derived from global best practices, advancing current Indian policies, and taking inspirations from other sector best practices in circular economy:

- **First-principles thinking** to address the grass root challenges highlighted by stakeholders with an India-centric approach.
- **Experiences from other countries** to get inspirated by policy framework in developed and emerging economies.

- **Past experiences in India** to guard against foreseen challenges given the unique local context. A total of ~50 policy solutions were identified and mapped to identified opportunities across business models.

A total of ~50 policy solutions were identified and mapped to identified opportunities across business models.

STAGE 4: EVALUATION AND SHORTLISTING

Not all the policy solutions identified are realistic to implement as they vary on ease of implementation by ecosystem and level of impact. To identify the most relevant and impactful policy solutions among the long list of 65, a high-level evaluation framework was developed which is as follows

Table 7 Evaluation framework for shortlisting of policy interventions

Evaluation Criteria		Sub-criteria	Description	Weightageof sub-criteria
Ease of Implementation		Consumer buy-in	▸ Consumer adoption of business model via the policy solution	0.3
		Local applicability	▸ Ease of enforcement in ecosystem ▸ Perceived fairness of the stakeholders	0.4
		System level implementation cost	▸ Financial viability in the long run ▸ Cost of implementation at system level	0.3
Impact	Environment	GHG emissions reductions	▸ Change in GHG emissions generated due to policy enablement	0.33
		Material efficiency and waste	▸ Amount of WEEE redirected from informal recycling	
	Social	High quality livelihoods creation	▸ High value jobs creation	0.33
	Economic	Revenue and profitability	▸ Increase in market share ▸ Change in cost per unit served	0.33

The maturity levels of high, medium and lowwere defined for each sub-criterion. For instance, a high for local applicability sub-criteria would mean easily enforceable, aligned with existing policies and high perceived fairness by stakeholders, whereas as a low would mean complexity in implementation and enforceability and contradictions with existing policies. The ease of implementation was defined qualitatively across the sub-criteria whereas impact was quantified

with data modelling covering cumulative impacts from 2023 - 2035 and an assumed impact potential of policy implementation.

STAGE 5: PRIORITIZATION

All 50 policy solutions were evaluated for ease of implementation and impact to shortlist the nine final policy solutions and composite scores for each were developed basis weightage defined in Table 6. The study then proceeded to prioritize policies basis the samewith ease of implementation and impact on each axis and policies presented in the form of a scatter plot. The intent was to identify policies that are quick wins i.e., high on ease of implementation and impact potential and policies that need to be viewed in the lens of long-term strategy i.e., relatively lower on ease of implementation and impact.

The above four stages thus provided a complete picture of methodology adopted to reach to the list of nine prioritized policy solutions.

APPENDIX 3: QUANTITATIVE MODELLING APPROACH AND ASSUMPTIONS

The aim of the modelling was to develop a data-based assessment to understand ecosystem impacts of recommended policy solutions and clarify underlying synergies and trade-offs across implementation pathways. The modelling followed a five-step approach as described below.

STEP 1: MAPPING BAU MATERIAL FLOWS

To understand the supply chain dynamics in the Indian electronics sectors, material flow map of smartphones and laptops were developed as depicted in the Figure 3. The estimates in figure 3 are a result of primary & secondary research, using FY21 numbers, as below:

- Consumer survey (detailed in Step 4 below) done helped to arrive at varied consumer preferences in treating damaged or outdated devices for repair, resell models and the ones stored as idle inventory
- For end-of-life treatment of devices, site visits to recyclers and dismantlers were conducted to determine how many devices get actually recycled, sold for spare part harvesting, or not recycled at all
- Secondary sources such as industry reports were also considered for finalizing the numbers

STEP 2: DEVELOPING IMPACT MODELLING METHODOLOGY ACROSS ECONOMIC, SOCIAL & ENVIRONMENTAL DIMENTIONS

The quantitative impacts of the nine proposed policy interventions and the pathways are modelled for the period 2023 to 2035 as year 2035 marks the completion of 20 years of EPR implementation in WEEE in India. The scope of the modelling is only smartphones and laptops. The proposed policy interventions impact is studied on previously defined six business models i.e., Circular Design, Product-as-a-Service, Repair, Resell, Refurbishment and Recycle. The impact calculation figures are incremental in nature i.e., they represent the incremental change in economic, social, and environmental metrics as a result of proposed policy implementation.

- **Economic Impact:** Industry-widerevenuesandcosts including loss of salesdue to cannibalizationof new devices sales by refurbished devices are calculated for all formal industry playersfor all six business models. The economic impact is thenshown as the incremental gross profits for the industry, due to proposed policy implementation.
- **Social Impact:** The social impact i.e., overall employment generation potential of the industry is considered and includes both skilled as well as unskilled direct jobs that could be created. With an increase in the formal footprint of businesses due to policy implementation there will be a requirement for skilled technicians which will boost the

employment generation. To calculate the employment generation potential, we have developed a standardized indicator for how many jobs can be generated in a particular business model.

- **Environmental Impact:** In Environmental aspect, the impact is calculated in terms of WEEE and GHG.

    - **Impact on WEEE:** Waste figures represent how much incremental WEEE can be prevented from going into informal recycling sector. For the use-phase pathway and PaaS business model these figures represent WEEE which can be averted from informal sector recycling due to reduction in manufacturing of new devices and due to increase in device longevity. For downstream pathway it is synonymous to how much of WEEE can be directed towards formal recycling sector which would have otherwise been recycled by the informal sector or will not be recycled at all.

    - **Impact on GHG emissions:** For the GHG emissions the impact is shown in terms of GHG avoided, which means, on account of policy implementation the quantum of GHG emissions that are prevented from being produced as compared to a BAU scenario. GHG emissions are derived from LCA (Life Cycle Assessment) of a device and includes scope 1, 2 and 3 emissions that can be avoided. This also includes avoided GHG emissions from producing recycled raw materials, reducing use and dependence on virgin materials while manufacturing new devices.

STEP 3: DETERMINING VOLUMETRIC SHIFTS DUE TO POLICY INTERVENTION

Because of policy implementation, volumetric shifts in the material flows are calculated or assumed via benchmarking effect of similar policies in other sectors or regionsand consumer survey outputs. The causesidentified for volumetric shifts are described below, and the same were mapped with each of the nine policy interventions.

- **New demand/supply generation:** Used devices in working conditions, which at present make their way into idle inventory, could be added back to the supply chain which become a part of refurbish and resell business models. With the expansion of formal repair infrastructure and accessibility, unserved demand of consumers for formal repair services could be addressed. PaaS business model development will create an entirely new demand of rental and leasing business services.

- **Shift in BAU demand:** Due to policy implementation there can be demand shift from low to high revenue generating business models, for example from resell as-is to refurbish and then resell. There will be a demand shift in repair business model from informal to formal sector. The demand for recycled raw materials will increase, replacing demand for virgin materials.

- **Shift in BAU supply:** With the improvement of infrastructure of formal collection and recycling there will be a shift in demand from informal recycling to formal recycling.

- **Leakage reduction:** Leakage of EOL (end of life) or used devices into the informal collection channels can be reduced when there is infrastructure developed for formal collection. Leakage of WEEE into informal recycling will reduce with the development of 3rd part auditable WEEE standards/certification, formalization of collection channels and advanced recycling facilities.

STEP 4: CALCULATE INCREMENTAL IMPACT

Apart from volumetric analysis, the incremental impact calculation of economic, social, and environmental aspects also requires data for value added per unit change in volume. The data inputs required to calculate value addition includes but not limited to average sale price (ASP) and cost to manufacturer or reseller of new, used, or refurbished devices, average costs to repair service providers and their gross profits, no. of jobs created per mn increase in repairs or per thousand tons of WEEE formally recycled, average weight of the devices, LCA footprint of devices and GHG emissions caused or avoided by repair or recycling activities.

The data inputs used for the modelling are sourced from primary and secondary sources as well as consumer survey which are explained in detail below:

- **Primary Sources:** Includes interviews with industry experts in repair, refurbishment and recycling, multi-brand start-ups who refurbish and resell devices, and site visits to formal and informal repair and recycling hubs like Gaffar market and Seelampur in Delhi, Moradabad in Uttar Pradesh, Cashify stores in Bengaluru and Delhi etc.
- **Consumer survey:** A consumer survey was also floated to understand consumer behavior vis-a-vis repair services, their considerations while purchasing a used device, giving back, or selling their old devices and acceptance towards PaaS business model.
- **Secondary sources:** Includes CPCB and PIB press releases and reports submitted to the NGT by CPCB, industry white papers from ICEA, Cashify etc. and other reports from the print media.

Combining volumetric analysis with the value addition data incremental impact for economic, social, and environmental dimensions is calculated as follows:

- Economic impact=Volumetric change × change in value($) per unit volume
- Social impact=Volumetric change× incremental jobs required per unit volume
- WEEE impact=Volumetric change ×average weight per unit volume
- GHG impact=Volumetric change ×Net GHG emissions avoided per unit volume

Outcome of this assessment has been presented in Figure 4 in terms of impact figures, where phase wise results have been captured in Figure 14, 15 and 16.

STEP 5: ANALYSING SYNERGIES ACROSS PATHWAYS

In Step 5, we analyzed the combinatorial impact after understanding the positive synergies between them. The approach for calculating the synergic impact can is explained as per the steps below.

1. Identify which of the proposed policy interventions have an effect on a particular business model.
2. The combined effect of volumetric shifts due to relevant proposed policy interventions is calculated for each business model. Any overlapping or common effects of different policies are identified and subtracted from the mathematical summation of the combined effect.

3. The data inputs required for value addition calculation remain the same.

4. The combined volumetric shifts are then multiplied with respective value changes per unit volume to get the synergic effect of the proposed policy interventions for a particular business model.

5. The synergic effect of proposed policy interventions on economic, social, and environmental impacts of all the business models is then added to get the overall synergic effect.

The above-detailed approach has been used to calculate the size of the circular electronics market in India in 2035 in figure 1

BUSINESS MODEL SPECIFIC APPROACH & ASSUMPTIONS

Table 8 Data assumptions across business models

#	Assumption description	Assumed value		
		Smartphone	Laptop	Units
	Environment			
1	Cradle to grave GHG emissions	40	331	Kg
2	GHG emissions per unit repair	4	7	Kg
3	GHG emissions avoided per ton of WEEE recycling	1.4		Kg
4	Average weight per device	150	2000	Gram
	Social			
5	Jobs required per year per mn increase in device repairs/refurbishment in formal sector	3355	6670	#
6	Jobs required per year per thousand-ton increase in WEEE recycling	245		#
	Economic			
6	Average selling price of a new device	15,680	61,030	
7	Average industry gross profit margins on a new device	50%	52%	%
8	Average selling price of a resold as-is device	6,899	22,000	
9	Average gross profit margins on resold as-is device	10%	22%	%
10	Average selling price of a refurbished device	8,603	26,000	
11	Average gross profit margins on refurbished device	20%	40%	%
12	Average revenue per ton of WEEE recycled (BAU)	53,000		
13	Gross profit margins of WEEE recyclers	40%		%

Repair business model

For the repair business model, the industry demand is calculated for 3 players namely Brand-owned repair centers (15%), multi-brand start-up and MSME repair service providers (3%), the informal sector (60%). While 22% of consumers who need repair continue using their devices without repair. There will be demand shifts among the players as well as new demand generation. With the increase in accessibility of formal multi-brand players it is assumed that 10% of demand served by informal sector will shift to multi-brand players and 25% of consumers who continue using their devices without repair, are assumed to shift to multi-brand formal repair service providers. For the social impact the impact is calculated in terms of employment generation potential of skilled technicians required for repair/refurbishment of devices. It is assumed that timely repairs improve the longevity of devices, which will reduce the sale and thereby manufacturing of new devices resulting in less electronic devices being put into the market. This reduction is shown as the WEEE avoided in the waste impact numbers. Similarly, GHG emissions would be avoided as reduction in the consumption of raw material and utilities due to reduction in manufacturing of new devices. In the GHG impact addition emissions produced from repair process are also included.

Refurbish and Resell business model

As a result of policy on incentivizing consumer takeback additional volumes of used devices could be brought back into the recommence market. Proposed policy interventions help build consumer trust & will generate demand for refurbished devices. This will incentivize the refurbishers to refurbish more devices rather than selling them as-is. To model this in the systems change scenario, it was assumed 25% of the total devices going into idle inventory per year will move to resell refurbish business models and 25% of the total resold devices will move to refurbish & resell business models. It is assumed that 5-15% of the increase in sales of refurbished devices comes from the consumers who would have bought new devices. For the economic impact gross profits from the increase in refurbished devices sales as well as the loss of profits from reduced new devices sales are also included in the calculation. The economic impact for the refurbish and resell business model hence gives the incremental net effect on the gross profits of overall industry. For the social impact, calculations remain same as the repair business model. WEEE and GHG avoided are calculated from reduction in the use of virgin materials due to reduced new devices sold. GHG emissions avoided considers emissions added during repair and refurbishment processes.

Recycle business model

The economic impact comes from the increased volumes of WEEE to formal recyclers and from the increased value extracted from the waste. The increased volume of waste would require more skilled and unskilled labor to recycle WEEE or repair if any device could be repaired. For policy "Developing aggregation and dismantling zones in targeted geos" it is assumed through benchmarking with Europe's WEEE recycling percentage, that total inflows to formal recyclers could increase from 22% to 40%. "Development of granular 3rd party auditable WEEE standards/ certifications" is assumed to reduce the leakage of WEEE from 30% to 10%. While "Incentivize high-capacity advanced recycling facilities" is assumed to reduce leakage to 5%, improve formal collection to 15% and revenues from WEEE recycling by 25%. The waste impact is calculated as the total weight of WEEE that could be diverted to formal sector recycling. The

GHG impact considers the GHG emissions avoided as a result of recycled raw materials replacing virgin materials, and the difference in the GHG footprint of both results in the GHG emissions avoided.

PaaS business model

The business case for PaaS is developed under the baseline assumption that starting from 2023, by the end of 2035 total PaaS market will constitute 2% of the overall market share of new devices sold. There are certain other logical assumptions taken to model the impact of PaaS model. Such as, there would be 3 PaaS cycles of 1 year each for smartphones & 4 cycles for laptops. After the completion of all PaaS cycles, the device could either be given for recycling or can be sold as a refurbished device depending on the condition of the device. For 1st year the monthly price of the service is taken as 4% of the ASP which reduces by 20 to 25% each year. For the economic impact the factors considered are the revenue from PaaS core business along with profits from recycling and selling refurbished devices. The cost components included in the modelling are the product costs, logistics cost, repair, and refurbishing cost. The social impact figures include jobs from blue collar employees to repair technicians to executives. The waste figures are calculated in the form of total devices sent to recycling after completion of 3 years of PaaS cycle and GHG emission figures also include GHG gases added due to additional logistics & repair services.

OUT OF SCOPE

Electrical and Electronic Equipment: EEE apart from smartphones and laptops are not included in quantitative modelling.

Industry players: Financial sector can play an important role to provide insurance/warranty options on refurbished devices or financing options in PaaS business model which is not included in scope.

Market share in BAU scenario: Change in market share of different industry players across business models is not considered. The market share of used devices in Resell and Refurbish business models, is assumed to remain constant. Cannibalization of new smartphone sales because of re-commerce market in the BAU scenario is assumed negligible. The percentage of WEEE recycled by formal recyclers is assumed to remain the same, though absolute values will increase with the increase in WEEE. The market share of brands, multi-brand start-ups and MSME players and informal players is assumed to remain the same.

Economic impact: The effect of inflation on manufacturing, recycling, or repair costs and on the average selling price of the devices is not included in quantitative modelling.

Social Impact: Social impact considers only the direct jobs created because of policy implementation. Indirect jobs arising due to overall industry development are not part of the scope. Social impact does not consider employment generation in the informal sector.

GHG emissions impact: Emissions from logistics and transport of used or EOL devices are not accounted for in the quantitative modelling.

ACKNOWLEDGEMENT

The study acknowledges the steer and inputs provided by secretariate and industry members of ICEA. The research was supplemented by interviews with over 40 leading experts from MeitY, NITI Aayog, OEMs, Formal recyclers, multi-brand start-ups and MSMEs service providers, etc. Findings were also accompanied by ICEA supported workshop, attended by over 30 leading industry experts, that provided key insights to guide the outputs. The insights shared during these interactions were used to validate baselines, assumptions, and logic, while developing the policy solution across the circular business models.

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GLOSSARY

MSME	Micro, Small and Medium Enterprise
BAU	Business As Usual
WPCB	Wasted Printed Circular Boards
EPR	Extended Producer Responsibility
WEEE	Waste Electric and Electronic Equipment
EEE	Electric and Electronic Equipment
OEM	Original Equipment Manufacturer
PaaS	Product as a Service
KYC	Know Your Customer
B2G	Business to Government
MEITY	Ministry of Electronics and Information Technology
EHS	Environment, Health & Safety
CPCB	Central Pollution Control Board
CMET	Centre for Materials for Electronics Technology
GPP	Green Public Procurement
CENELEC	European Committee for Electrotechnical Standardization
LiFE	Prime Minister Mission of Lifestyle for the Environment

PRO	Producer Responsibility Organization
PCB	Printed Circular Boards
PSU	Public Sector Undertaking
C2C	Customer to Consumer
C2B	Customer to Business
PLI	Production Linked Incentives
PMP	Phased manufacturing Programme
EMC 2.0	Electronics Manufacturing Clusters
RoHS	Restriction of Hazardous Substances
LCA	Life Cycle Assessment
DFS	Dell Financial Services
ULB	Urban Local Bodies
SPCB	State Pollution Control Board
SPECS	Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors
GHG	Greenhouse Gases
WF – REP Tool	WEEE Forum Reporting Tool
R2	Responsible Recycling standard

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