Waste to Worth Transformation

Confederation of Indian Industry

National Circular Economy Framework

Roadmap for a Sustainable & Resilient India

SECOND EDITION | NOVEMBER 2024

Published by Confederation of Indian Industry (CII), The Mantosh Sondhi Centre; 23, Institutional Area,
Lodi Road, New Delhi 110003, India,
Tel: +91-11-45771000,
Fax: +91-11-24626149;
Email: info@cii.in;
Web: www.cii.in

ACKNOWLEDGEMENT

The Confederation of Indian Industry (CII) extends heartfelt gratitude to all its esteemed members, industry leaders, academic and research professionals, and every stakeholder who contributed to the development of the second edition of the National Circular Economy Framework. This edition expands upon the foundation laid in 2023, now encompassing 16 focus materials, thanks to the invaluable insights and collaborative spirit of these stakeholders and the CII Waste to Worth Technologies community.

We extend our gratitude to **Prof Ajay Kumar Sood, the Principal Scientific Advisor to the Govt.** of India for the invaluable advice and leadership throughout the development of this framework.

We are grateful to **Dr. Monoranjan Mohanty,** Mission Director, The Office of PSA, Govt of India for his guidance. The richness of ideas, recommendations, and suggestions encapsulated in the book are testament to the quality of the extensive deliberations held with Dr. Mohanty and the CII team.

The vision behind this effort to bring out the second edition of the framework with 16 focus materials originated with **Mr. Masood Mallick,** Chairman of CII National Committee on Waste to Worth Technologies and MD & CEO of Re Sustainability Limited. We express our sincere appreciation for his outstanding thought leadership.

We extend our sincere gratitude to **Re Sustainability Limited** for its substantial role in developing this document, contributing the vast majority of the effort, insights, and expertise. CII also thanks **GRP Limited, Blue Planet Environmental Solutions,** and **Landbell Green Forest Solutions** for their valuable inputs.

CII acknowledges with immense gratitude the dedicated efforts of the following authors whose expertise and insights have brought this document to life: Dr. Y. Malini Reddy, Mr. Bobby Kurien, Mr. Adithya Dhamodharan, Mr. Nikhil Cherian, Mr. Zorawar Singh, Ms. Priya Poomalil, Mr. Manvendra Tey, Mr. G Sai Shiva from Re Sustainability Limited and Mr. Harsh Gandhi and Ms. Bhavana B. from GRP Limited. Their commitment to advancing Circular Economy principles in India is evident in the depth and breadth of knowledge presented in their respective chapters.

CII also appreciates the contribution from the supporting authors: Mr. Purushotham Rao Koti, Mr. Surya B, Mr. Nasarullah Md., and Mr. Bhaskar Boge from Re Sustainability Limited; Mr. Prashant Singh and Mr. Deepak Sar from Blue Planet Environmental Solutions; and Mr. Saurabh Shah from Landbell Green Forest Solutions.

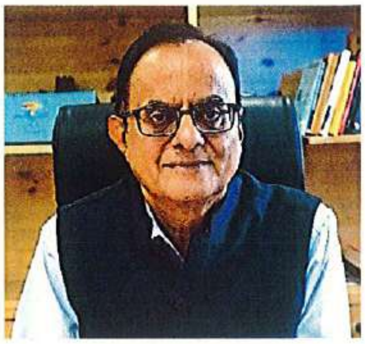
CII extends special thanks to **Mr. Sanjiv Kumar,** Head – Policy and Strategy, Re Sustainability Limited, whose constant support and strategic guidance proved invaluable to this effort, and
Mr. Subash Koduri, Sustainability Lead at Re Sustainability Limited, for his role as editor of this document, weaving together diverse expertise and shaping the framework into its final form.

It is hoped that this framework will serve as a valuable resource for the Indian Environment Sector, contributing significantly to the promotion of a Circular Economy in India.

अजय के. सूद
भारत सरकार के प्रमुख वैज्ञानिक सलाहकार
Ajay K. Sood
Principal Scientific Adviser to the Govt. of India

सत्यमेव जयते

विज्ञान भवन एनेक्सी
मौलाना आजाद मार्ग, नई दिल्ली–110011
Vigyan Bhawan Annexe
Maulana Azad Road, New Delhi - 110011
Tel. : +91-11-23022112
Fax: +91-11-23022113
E-mail : sood.ajay@gov.in
office-psa@nic.in
Website : www.psa.gov.in



MESSAGE

I extend my compliments to the Confederation of Indian Industry (CII) on the release of the second edition of the National Circular Economy Framework (NCEF). The vision for a sustainable and self-reliant India is guided by the vision of Hon. Prime Minister of India. The NCEF is playing a valuable role in advancing our national commitment to a resource-efficient future, offering clear pathways and actionable strategies for stakeholders across sectors.

India has reinforced its commitment to circularity through initiatives under the Viksit Bharat mission and the LiFE (Lifestyle for Environment) movement, which promote sustainable practices and responsible resource use across communities and industries. National missions like the National Clean Air Mission, Swachh Bharat Mission, and the National Resource Efficiency Policy have also integrated circularity, aiming to reduce waste, enhance recycling, and optimize resources in alignment with these broader goals.

Over the past year, India has made notable strides in embedding circularity, from sustainable packaging and enhanced waste-to-wealth projects to the development of eco-industrial clusters. Our leadership in the G20, together with the establishment of the Resource Efficiency and Circular Economy Industry Coalition (RECEIC), highlights India's commitment to advancing Circular Economy principles globally.

This second edition of the NCEF builds on past achievements, incorporating new insights and expanding its focus to priority areas such as End-of-Life Vehicles (ELV), textiles, agriculture, and e-waste—sectors vital to resource security and economic advancement. Emphasizing life cycle assessments, data-driven monitoring, and cross-sector collaboration, it sets clear objectives, selection criteria, and measurable targets, providing structured guidance and support to stakeholders in advancing India's Circular Economy.

I commend the CII 's National Committee on Waste to Worth Technologies for the dedication in advancing these goals. I am confident that this updated framework will drive meaningful change, fostering an economy that balances growth with environmental responsibility and social equity.

As we progress, I look forward to witnessing the transformative impact of NCEF on India's journey toward a circular, resilient, and self-reliant future.

Ajay K. Sood

(Ajay K. Sood)

Dated: 18th November. 2024

FOREWORD FROM THE CHAIRMAN

MASOOD MALLICK
Chairman – CII National Committee on Waste to Worth Technologies

Dear Members and Stakeholders,

Confederation of Indian Industry (CII) is committed to fostering a sustainable, impactful, and inclusive ecosystem in India. With a strong focus on advancing circular economy principles, CII actively promotes innovative technologies that enable waste-to-worth transformation.

Through its National Committee on Waste to Worth Transformation, CII addresses various facets of sustainability and circularity. The committee emphasizes waste management and handling while advocating for policy reforms, advancing regulatory frameworks, and fostering human resource development. Additionally, it recognizes industries for exemplary waste management practices and publishes insightful reports on pertinent sustainability topics.

CII's efforts aim to drive transformative change by integrating technology and circular practices into mainstream industry, aligning with national and global sustainability goals.

The second edition of the National Circular Economy Framework (NCEF) builds on the momentum and significant strides made since its launch last year. The framework's development was a collaborative achievement, uniting voices from industry, government, and academia. The NCEF has since become a part of the national lexicon on circularity, establishing itself as a foundational guide steering enterprises and policymakers toward a Circular Economy that is both economically viable and environmentally sustainable. It has catalyzed a new paradigm in waste management and resource utilization, influencing shifts in government policies.

The framework's influence was further underscored in February 2024 when Hon'ble Prime Minister of India acknowledged its importance in national policy discussions, reinforcing its strategic role in advancing India's resource efficiency goals. Additionally, the Union Budget 2024-2025 has given considerable attention to Circular Economy initiatives, assigning dedicated budgets to support and scale resource efficiency and sustainability efforts across sectors.

Building upon this, the second edition of NCEF broadens the framework's reach by expanding action plans from four to sixteen, aligned with NITI Aayog's focus materials. This allows the addressing of a wider range of materials critical to India's sustainability goals. In this edition, the NCEF traces India's progress in the circular economy, offering key insights into the nation's journey and achievements to date. Further, the takeaways from global movements have been mapped for the industry to draw inspirations and expand strategies on Circular Economy Parks (CEPs).

It is envisaged that the CII membership and relevant stakeholders will find this framework useful and it will encourage them to examine the connected needs of understanding principles of circularity.

MESSAGE FROM THE DIRECTOR GENERAL

CHANDRAJIT BANERJEE
Director General, CII

India possesses immense potential to be a global leader in the circular economy. In addition to enhancing resource efficiency and recycling, adopting a circular economy can significantly contribute to resource conservation and climate change mitigation. Among its sustainability initiatives, the Confederation of Indian Industry (CII) has placed special emphasis on promoting waste management technologies through the transformational 'Waste to Worth Movement'.

The National Circular Economy Framework (NCEF) serves as a concise roadmap for India's transition to a circular economy and guides the development of new business models. While the inaugural edition of the NCEF last year reflected on the industry's efforts to promote sustainability and circularity in waste management practices, I am pleased to see that the current edition of the framework emphasises the life cycle assessment to strengthen understanding of circular principles, thereby promoting innovation in the 'Waste to Worth' transformation sector.

NITI Aayog has identified eleven key elemental blocks as high priorities for circular economy initiatives. Building on this, the framework has identified sixteen key materials, including plastics, construction and demolition waste, and textile waste, for targeted action. By prioritising these materials, the framework aims to reduce waste and conserve resources to protect the environment.

This edition of NCEF focuses on the key milestone targets, the scale, and the timeline for sixteen sectors that align with the eleven focus areas identified by NITI Aayog. Thus, the focus on waste management in areas of Lithium Ion (Li-ion) batteries, scrap metal (ferrous and non-ferrous), gypsum, toxic and hazardous industrial waste, solar panels, used oil waste, etc., is consistently maintained. These sectors are high-volume and are expected to generate significant value in terms of both circularity and impact on the economy.

I am happy to see that this edition of NCEF also outlines actionable steps and collaborative opportunities for stakeholders to drive sector-specific circular economy initiatives. It provides a valuable reference for stakeholders and policymakers, enabling them to promote circular economy practices that benefit both the economy and the environment.

It is envisaged that this edition of NCEF will enable India to pave the way for a greener and more sustainable future. By prioritising circular economy principles, the country would achieve significant environmental and economic benefits, ensuring a prosperous and resilient future for future generations.

EXECUTIVE SUMMARY

The National Circular Economy Framework (NCEF) introduced in 2023, was a collaborative effort to guide India's transition to a sustainable, resource-efficient economy. By uniting government, industries, and communities in adopting Circular Economy principles, the framework emphasizes resource conservation, waste reduction, and climate resilience, aligning with India's commitments to Nationally Determined Contributions (NDCs), United Nations Sustainable Development Goals (UNSDGs), and the Lifestyle for Environment (LiFE) mission.

NCEF 2024 builds on this foundation, expanding the scope of focus materials while strengthening emphasis on resource security, carbon reduction, and energy efficiency. This edition aligns with global developments, such as the G20's endorsement of circular practices and the formation of the Resource Efficiency and Circular Economy Industry Coalition (RECEIC), positioning India as a leader in sustainable economic development.

Building on the first edition, NCEF 2024 articulates the Confederation of Indian Industry's (CII) vision for advancing the Circular Economy with a heightened focus on life cycle assessment. It aims to further strengthen the shared understanding of circular principles among partners, addressing challenges and enhancing innovation, technological advancement, and actionable initiatives. The document expands awareness of circular solutions across sixteen sectors, supports cross-sector collaboration, and plans to strengthen data management for consistent progress tracking and adaptable policy updates. It also sets measurable targets to lower transition costs and structure project pipelines for sustainable financing.

The NCEF provides a strategic framework for developing business models that maximize the value, utility, and lifespan of materials and assets while aiming to eliminate waste across production and consumption cycles. The framework is organized into two main sections:

Part 1 outlines a comprehensive framework applicable to all focus materials, detailing objectives to reduce virgin material use, conserve resources, and enhance competitiveness. It includes criteria for material selection based on usage, environmental impact, and resource value potential and is guided by the core principles of Prevention, Upcycling, Recycling, and Energy Recovery, which emphasize lifecycle-based design and value retention. Additionally, Part 1 presents key strategies for implementation, including policies and measures for effective application, along with processes for monitoring and evaluation.

Part 2 offers material-specific Circular Economy action plans, expanding on 2023's focus by adding liquid waste, scrap metal, li-ion batteries, solar panels, gypsum, hazardous waste, used oil, agriculture waste, tires, end-of-life vehicles, and textiles. This broader scope targets materials with high potential for waste reduction, resource recovery, and environmental benefits. These plans incorporate strategic targets and policies, supported by essential regulations, incentives, public-private partnerships, and monitoring and evaluation mechanisms aligned with national and global standards.

This document reaffirms India's commitment to a resource-resilient Circular Economy, providing a roadmap for sustainable growth that integrates economic development with environmental responsibility and social equity through collaboration, education, and targeted action.

TABLE OF CONTENTS

Part 01 - **National Circular Economy Framework**

Part 02 - **Circular Economy Action Plan for Focus Materials**

PART 01

National Circular Economy Framework

Chapter 1

STRATEGIC IMPORTANCE OF CIRCULAR ECONOMY *for* INDIA

1.1. INTRODUCTION

India's economy is advancing at a significant pace, solidifying its position as a global economic force with rapidly growing urban centers. This surge in development, paired with escalating resource consumption driven by rising living standards, is placing immense pressure on the nation's natural resources. Left unaddressed, this strain could jeopardize resource security, economic stability, and long-term resilience. Embracing circularity is not just an option but an imperative—an essential strategy to safeguard resources, ensure economic vitality, and secure a sustainable future for generations to come.

Circularity refers to the circular flow and efficient use and reuse of resources, materials, and products. The Circular Economy goes beyond resource efficiency and recycling, and its adoption helps reduce waste, conserve resources, and mitigate climate change, contributing to a more sustainable future for India.

India has the potential to be a leader in the Circular Economy. Given its rich cultural heritage of reuse, reduction, and repair, India can decouple economic growth from resource consumption and environmental damage by promoting Circular Economy principles. This can lead to a more prosperous and equitable society, while also reducing environmental degradation and dependence on imports, thereby securing its resource base and ensuring progress towards a resource secure, Aatma Nirbhar (self-reliant) resilient nation.

> CIRCULARITY IS ESSENTIAL FOR INDIA TO ACHIEVE RESOURCE SECURITY, ECONOMIC STABILITY, AND RESILIENCE, POSITIONING THE NATION AS A LEADER IN GLOBAL CLIMATE ACTION.

The release of the National Circular Economy Framework (NCEF) marked a significant step in guiding India's journey toward a Circular Economy. This second edition builds upon that foundation, furthering discussions, refining priorities, and capturing both national and global progress in the circularity.

India's transition to a Circular Economy also aligns with its Nationally Determined Contribution (NDC) targets for reducing greenhouse gas emissions, United Nations Sustainable Development Goals (UNSDGs) commitments to responsible consumption and production, and the Mission Lifestyle for Environment (LiFE), which aims to inspire sustainable choices. At the G20 summit held in new Delhi in September 2023, the critical role of the Circular Economy, Extended Producer Responsibility (EPR), and resource efficiency was acknowledged with the launch of the Resource Efficiency and Circular Economy Industry Coalition (RECEIC). This global commitment includes advancing sound waste management practices, substantially reducing waste generation by 2030, and emphasizing zero-waste initiatives.

The National Circular Economy Framework (NCEF) enables the achievement of the vision and mission enumerated by the Hon'ble Prime Minister and the G20 declaration. It serves as a strategic framework that enables industries, the business community, and investors to engage in a sustainable economic model. With updated action plans, expanded priorities, and insights into progress, this edition aims to provide clarity and guidance on achieving India's Circular Economy goals, supporting a resilient and sustainable future.

INDIA'S ECONOMIC DEVELOPMENT MUST ALIGN WITH THE PRINCIPLES OF CIRCULARITY, ELIMINATING WASTE AND POLLUTION, CIRCULATING PRODUCTS AND MATERIALS (AT THEIR HIGHEST VALUE), AND REGENERATING NATURE.

PM Narendra Modi
In his essay on Circular Economy at narendramodi.in, February 2024

The economic models based on circularity focus on sustainable green growth, moving from a consumption and disposal-based linear economy to a system that extends the life of products and materials and minimises waste so that it has many environmental, climate, social and economic benefits. The aim is to increase lending to innovative Circular Economy projects that systematically design out waste, extend the life of assets and close material loops. The Circular Economy is also an opportunity for economic and industrial renewal with a corresponding increase in investments.

The document strives to provide guidance on developing new business models. It also details the targets to be achieved, scale, and timeline for sixteen sectors, with an emphasis on the trade-off between new and recycled products from these identified sectors. These sectors align with the focus areas identified by NITI Aayog and consist of high-volume sectors that are expected to generate significant value in terms of both circularity and economy. The document also outlines actionable steps and collaborative opportunities for stakeholders to drive sector-specific Circular Economy initiatives.

CII aims to form a Stakeholder Board shortly to offer advisory services, facilitate networking and sharing best practices, connect stakeholders, and provide access to financing for Circular Economy projects. Building on the foundation laid in the first edition, the document aims to:

- Articulate CII's (industries) vision to advance the Circular Economy, with a stronger focus on life cycle assessment.
- Foster a shared understanding of the Circular Economy, among project partners, addressing both challenges and opportunities and emphasizing collaborative innovations, technological advancements, and tangible on-ground actions.
- Increase awareness of circular solutions among project promoters and other stakeholders for sixteen sectors, facilitating cross-sector and value chain collaboration.
- Establish a structured data management mechanism to track and monitor progress effectively. The aim is to develop a robust, review-ready policy framework that is updated as needed, facilitating consistent due diligence and reporting across Circular Economy projects.
- Set measurable targets for collaboration among partners and stakeholders, identifying strategies to reduce the cost of transitioning to circularity and structuring project pipelines to ensure sustainable financing.

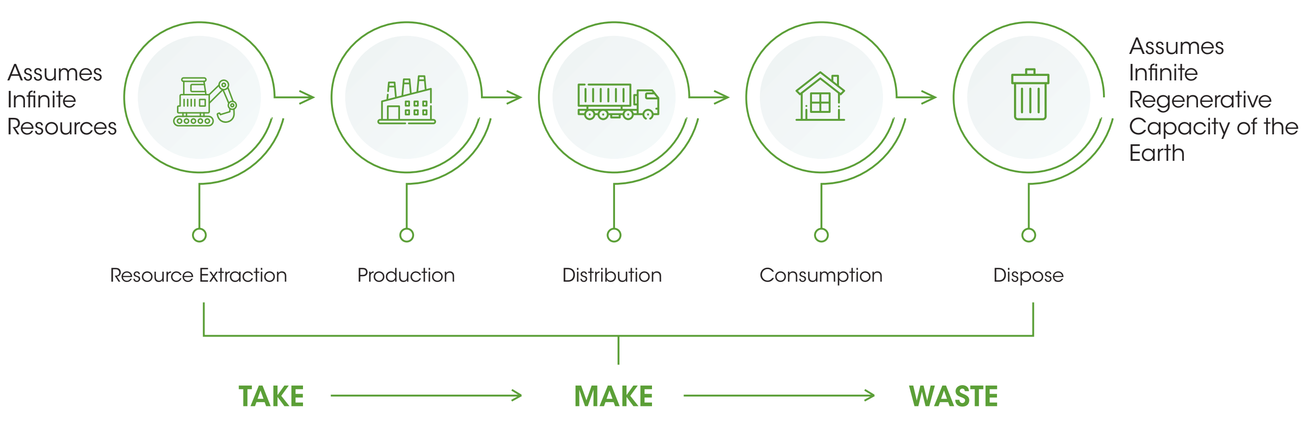
The following sections will explore the linear and Circular Economy in more detail, highlighting the key differences between the two models, the importance of circularity for India, and the benefits of transitioning to a Circular Economy.

1.2. FROM A LINEAR TO A CIRCULAR ECONOMY

a. Understanding the Linear Economy

The linear economy is an economic system that operates on a "take-make-waste" model. In this system, raw materials and resources are extracted from the environment to manufacture products. These products are then consumed and eventually discarded as waste at the end of their lifecycle. This approach is considered unsustainable as it assumes that resources are abundant and can be continuously extracted without significant consequences. However, as the demand for goods and services continues to rise, this linear model leads to resource depletion, environmental degradation, biodiversity loss, and a growing waste problem. The different stages of linear economy are presented in Figure 1-1.

Figure 1-1: Linear Economy



While effective in generating economic growth, the linear economy imposes significant environmental and social costs. Continuous resource extraction depletes finite reserves like fossil fuels, minerals, and timber, thereby raising costs and placing a strain on supply chains. This extractive approach often results in habitat destruction, deforestation, and loss of biodiversity. Manufacturing processes generate substantial greenhouse gas emissions and waste, further degrading air, soil, and water quality. The one-directional flow of resources in this model leads to high waste generation and adds to landfills causing long-term ecosystem damage. Further, marginalized communities disproportionately suffer from these impacts, bearing health risks and pollution associated with resource extraction and waste disposal, exacerbating social inequalities.

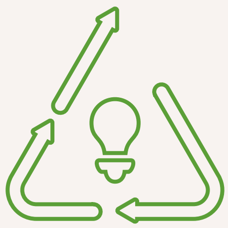
Moving forward, it is critical for industries to recognize these impacts and take steps towards adopting sustainable practices that foster resilience, resource efficiency, and social responsibility.

b. Understanding the Circular Economy

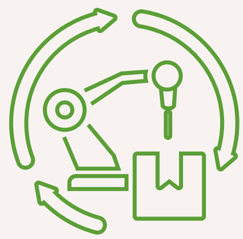
A Circular Economy is an economic system that aims to reduce waste and pollution by keeping products and materials in use for as long as possible. It is a closed-loop system that minimizes the use of virgin resources and maximizes the reuse and recycling of materials. The Circular Economy takes a holistic approach to economic development, considering the environmental and social impacts of all economic activities. In a fully Circular Economy, waste is minimized by designing products and industrial processes so that resources are kept in use in a perpetual flow, and by ensuring that unavoidable waste or residues are recycled or recovered.

The Circular Economy is characterized by the following

REDUCE resource consumption and waste production to lessen environmental impact.

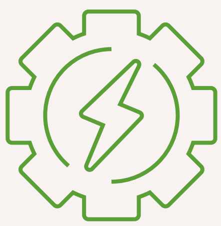


UPCYCLE waste materials into higher-value products, extending their lifecycle.



REMANUFACTURE by recreating products from discarded components, highlighting resource regeneration.

REUSE products and materials to minimize resource extraction.



REPAIR items instead of replacing them, promoting resourcefulness and sustainability.

RECYCLE, converting materials into new products to keep resources in use and out of landfills.

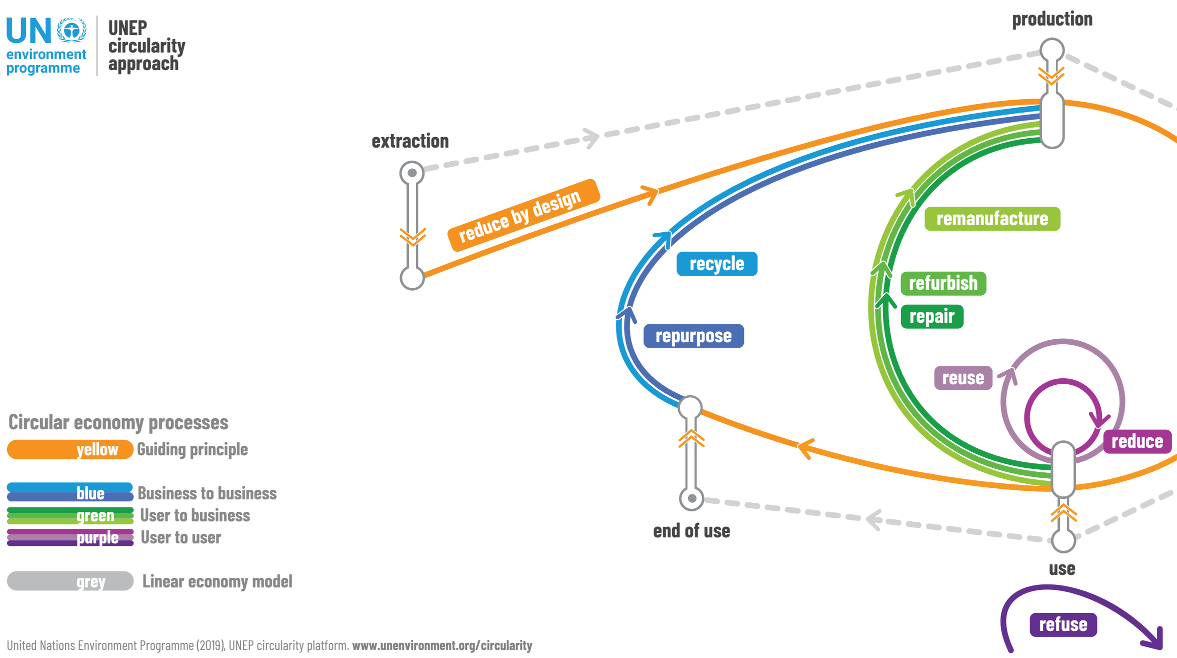
In comparison to the linear economy, the Circular Economy offers numerous positive impacts: it reduces environmental harm by minimizing resource extraction and waste disposal, conserves resources through increased efficiency, and drives economic growth by creating jobs and business opportunities. Additionally, it promotes social equity by providing employment for marginalized groups and addressing environmental inequality, ultimately contributing to a more sustainable and resilient future.

c. Conceptual Models for Circular Economy

Two influential models—the UNEP circularity model and the Ellen MacArthur Foundation's framework—offer insights into how Circular Economy principles can be practically applied.

The UNEP model presented in Figure 1.2 emphasizes closed-loop value retention processes at multiple levels, including user-to-user, user-to-business, and business-to-business exchanges. This model encourages resource efficiency at each step—from design to disposal—seeking to maintain the value of products, components, and materials while minimizing environmental impact.

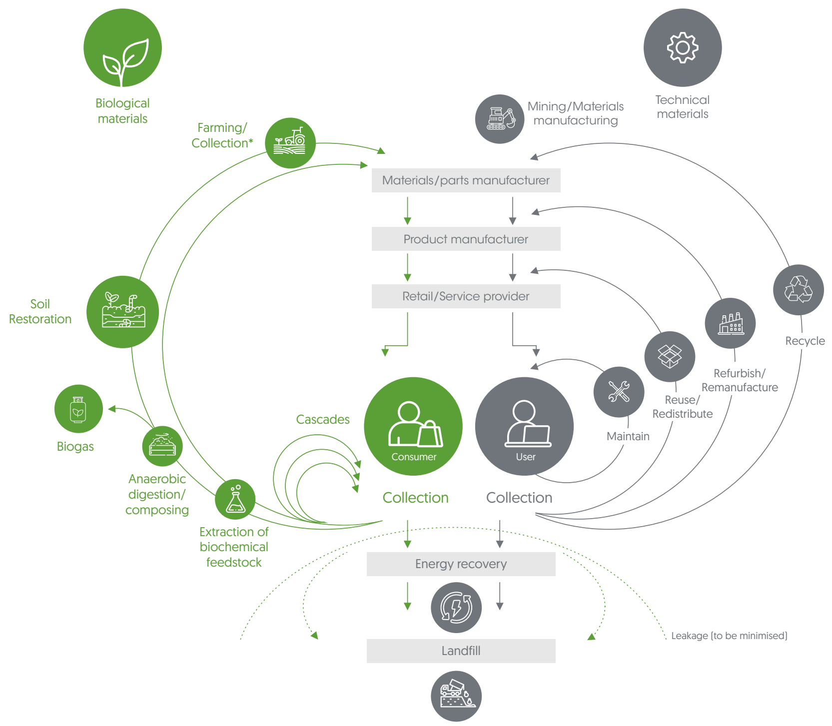
Figure 1-2: The UNEP (2019), Circularity Platform #



Circularity | UNEP - UN Environment Programme

The Ellen MacArthur Foundation model, presented in Figure 1.3 promotes systemic change across entire supply chains by integrating circularity from the design stage, making it possible to avoid waste before it's even generated. The model comprises two cycles: a biological cycle, in which residues are returned to nature after use, and a technical cycle, where products, components or materials are designed and marketed to minimize wastage. The approach prioritizes durable product design, modular components, and regenerative practices, which support a resilient and restorative economy that functions harmoniously with nature.

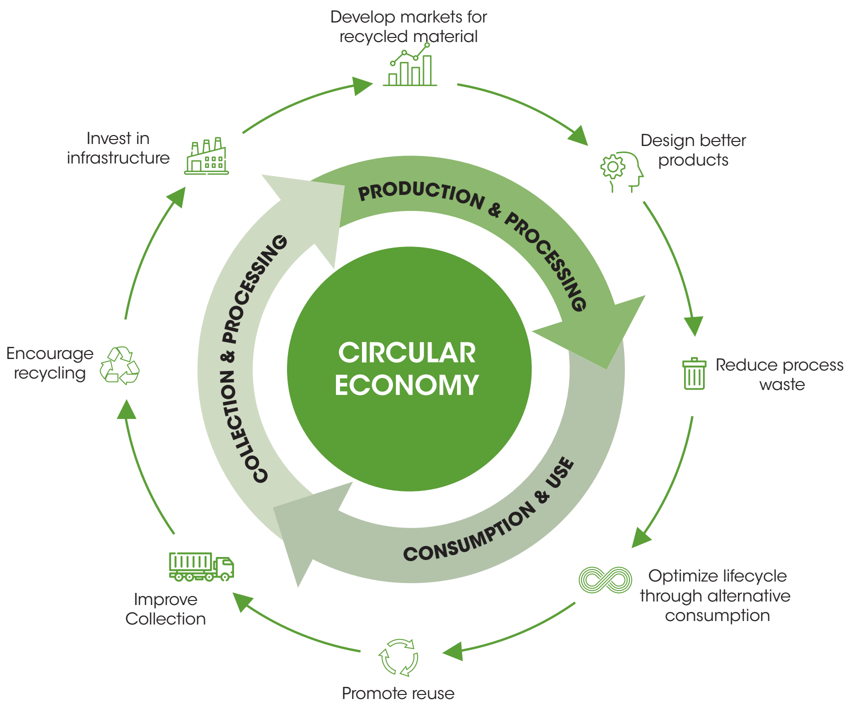
Figure 1-3: The Ellen MacArthur Circular Economy diagram##



Ellen MacArthur Foundation, "Towards the Circular Economy" (2013), p. 24

Together, these models offer complementary perspectives. The UNEP model emphasizes multi-level engagement to optimize resource cycles within sectors, while the Ellen MacArthur Foundation's approach focuses on systemic design and sustainable material flows. This circular way of producing and consuming decouples economic growth from the extraction and consumption of materials. As such, a Circular Economy offers a way to hedge future resource and material supply chain risks for companies and increase their resilience to decreasing supplies and increasing price uncertainty and volatility. This will reduce resource dependency, spur innovation and increase competitiveness. Figure 1-4 below presents how to mainstream/ implement Circular Economy.

Figure 1-4: Implementation of Circular Economy



d. Advancing the SDGs through Circular Economy Practices

The Circular Economy contributes to the achievement of multiple SDGs by minimizing waste generation and pollution, creating new jobs and businesses, and reducing the usage of resources.

1.3. GLOBAL MOVEMENT TOWARDS CIRCULAR ECONOMY

Over the past year, the global movement towards a Circular Economy (CE) has gained significant momentum, with governments, industries, and organizations implementing circular practices to address environmental challenges and seize economic opportunities. According to estimates from Accenture, McKinsey, and PwC, the global Circular Economy market could reach up to $4.5 trillion by 2030 and potentially $25 trillion by 2050. This opportunity is driven by resource scarcity and environmental sustainability, with circular business models expected to play a central role in global economic strategy.

a. Circular Economy Initiatives globally

Countries worldwide have introduced policies that mandate or encourage circular practices, while leading corporations across various sectors are integrating sustainability, waste reduction, and resource recovery into their supply chains. Financial incentives, such as tax benefits and subsidies, are increasingly supporting industry transitions to circular models, and Extended Producer Responsibility (EPR) frameworks hold producers accountable for managing the end-of-life impact of their products. Sweden for example, offers tax reductions on repair services to encourage reuse, while the UK's Plastic Packaging Tax imposes fees on packaging with less than 30% recycled content. UK has also introduced Green Bonds to fund circular projects, while Italy provides grants for sustainable material innovation, and South Africa supports waste-to-energy projects.

Recognizing Circular Economy projects as sustainable assets, major banks and investment firms have launched funds focused on renewable energy, recycling infrastructure, and sustainable design. Financial institutions such as BlackRock HSBC, ABN AMRO, and Rabobank have announced funds and credit facilities to invest in circular projects and innovations.

Advancements in digital and material technologies are enhancing Circular Economy models globally. Blockchain traceability, IoT-enabled waste stations, and AI-driven recycling improve efficiency and resource recovery, while innovations in biodegradable plastics, chemical recycling, smart packaging, and eco-friendly materials support sustainable, circular product lifecycles.

Further, public awareness initiatives and events also play a vital role in promoting circular practices and driving action among consumers and industries. Together, these efforts highlight the accelerating shift toward a Circular Economy, now widely seen as fundamental to achieving sustainable economic growth.

GLOBAL POLICY INITIATIVES PROMOTING CIRCULAR PRACTICES

- The European Union's Circular Economy Action Plan (CEAP) mandates sustainable product design, increased recycled content, and recyclability across sectors.
- Germany aligns with CEAP, targeting 63% plastic packaging recycling, and 65% e-waste collection.
- France's Anti-Waste Law (AGEC) bans single-use plastics (SUP) by 2040, mandates 30% recycled plastic in packaging by 2025.
- The Netherlands aims for a fully Circular Economy by 2050, with a 50% raw material reduction target by 2030, mandatory textile waste management through EPR.
- Japan and China are focusing on industry symbiosis through eco-industrial parks, where companies share resources and reuse waste. Japan introduced Eco-Town Program in 1997 and China initiated the "Circular Economy Promotion Law," in 2005 which includes provisions for transforming industrial parks into eco-industrial parks.
- South Korea has a plastic waste reduction policy that includes a phased ban on single-use plastics and aims for a 20% plastic waste reduction by 2025
- Outside Europe and Asia, California targets a 25% reduction in SUP by 2032, New Zealand plans to ban specific SUPs by 2025, Canada's Zero Plastic Waste by 2030 strategy mandates EPR across provinces by 2025, Chile's EPR Law targets 90% recycling for tires and 60% recycling for packaging by 2030.

CORPORATE INITIATIVES ADVANCING CIRCULAR PRACTICES

- Electronics firms are implementing take-back programs to minimize e-waste (Dell, Apple, HP, Microsoft, Nokia).
- Fashion brands are promoting product longevity through repair and resale (Gucci, Patagonia).
- Consumer goods giants are committed to 100% recycled plastic packaging (Unilever, Procter & Gamble), and plastics companies are innovating chemical recycling (Dow Chemical, BASF).
- Construction firms are using recycled materials and eco-friendly cement (LafargeHolcim, CEMEX) while automakers (BMW) are reclaiming end-of-life vehicle resources.
- Food and beverage companies (Nestlé, PepsiCo) are adopting circular farming and biogas, and battery manufacturers (Tesla, Volkswagen) are focusing on closed-loop metal recycling.
- Other initiatives include oil recycling (Valvoline, Shell), gypsum reprocessing (Saint-Gobain, Knauf), scrap metal recycling (Nucor, ArcelorMittal), solar panel recycling (First Solar, SunPower), waste-to-energy projects by waste management providers (Veolia, Clean Harbors, Waste Management Inc., Re Sustainability Ltd, SUEZ) and wastewater treatment innovations (Veolia, SUEZ) for reducing freshwater demand in domestic and industrial use.

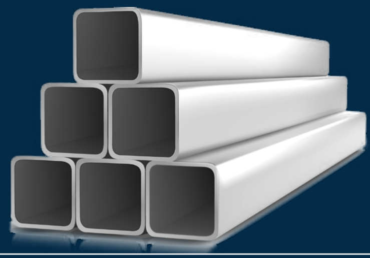
b. Decarbonisation through Circular Economy and Material Recovery

Decarbonization, the process of reducing carbon emissions across industries, has become a global priority in the fight against climate change. One impactful way to achieve decarbonisation is through material recovery—particularly with metals, plastics, and glass. By replacing virgin resources with recycled materials, we can achieve significant carbon savings, as recycling consumes far less energy than extracting and processing raw materials.

MATERIAL CHOICES SUBSTANTIALLY IMPACT THE CARBON FOOTPRINT, AS THE EMBEDDED CARBON WITHIN THESE MATERIALS IS A SIGNIFICANT COMPONENT OF OVERALL EMISSIONS. SUSTAINABLE SELECTION OF LOW-CARBON MATERIALS IS THUS ESSENTIAL FOR REDUCING THE CARBON FOOTPRINT AND ADVANCING CLIMATE GOALS, COMPLEMENTING THE DECARBONIZATION EFFORTS ENABLED BY MATERIAL RECOVERY.

for STEEL

recycling scrap can ***CUT EMISSIONS BY AROUND 58%,*** *with the energy-efficient electric arc furnace process further lowering greenhouse gases.*

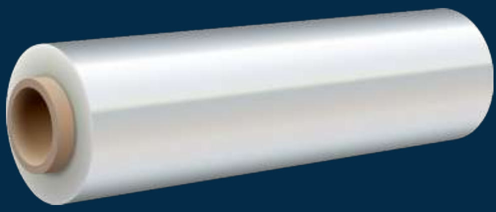


recycling ALUMINUM

SAVES UP TO 95% *of the energy required to produce it from bauxite, translating to a reduction of* ***UP TO 9 TONS OF CO_2 PER TON RECYCLED.***

recycled PLASTICS

have a carbon ***FOOTPRINT THAT IS 30-80% LOWER THAN NEW PLASTICS,*** *helping to address both emissions and plastic waste issues.*



recycled GLASS

REDUCES CO_2 EMISSIONS *by* ***APPROXIMATELY 20%*** *since it melts at lower temperatures, saving energy during production.*

Carbon markets provide recyclers with revenue opportunities, incentivizing further material recovery. Successful carbon projects worldwide underscore the power of material recovery as a key driver of sustainable, low-carbon economies.

- In the **VOLUNTARY CARBON MARKET (VCM),** companies buy carbon credits to offset emissions voluntarily. Recyclers can earn these credits by proving emission reductions through recycled materials, providing extra income and driving investment in efficient recycling technologies.
- **THE INDIAN CARBON TRADING SYSTEM (CCTS)** enables trading of credits from emission reduction activities. By optimizing processes and using recycled materials, recyclers can earn tradable credits, promoting sustainable practices with financial returns.
- **ARTICLES 6.2 AND 6.4 OF THE PARIS AGREEMENT** support international carbon markets. Article 6.2 enables cross-border credit trading, while Article 6.4 focuses on emission reduction mechanisms. Aligning with these frameworks allows recyclers to access global markets, boosting revenue potential.

1.4. IMPORTANCE OF CIRCULAR ECONOMY FOR INDIA

Circularity is deeply embedded in Indian culture, positioning the country as naturally suited and advantaged to adopt a Circular Economy model. India's traditions and values emphasize respect for nature, minimalism, and community sharing, which are key principles of circularity - reduce, reuse, and recycle.

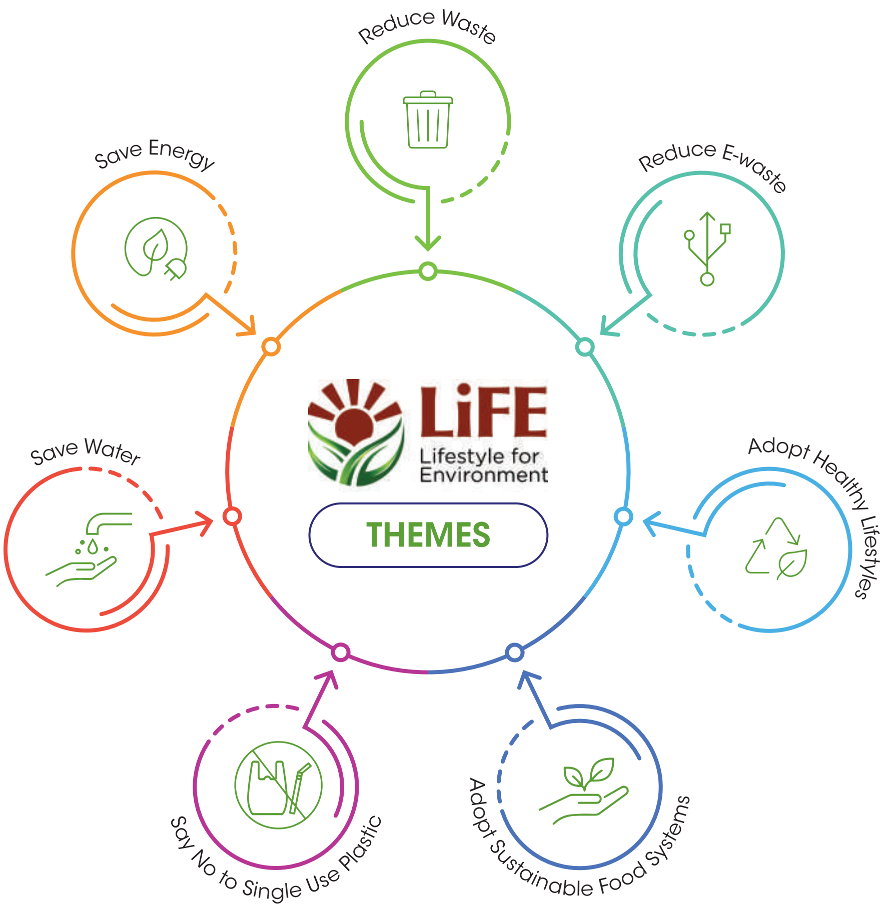
- Respect for nature is seen in rituals and festivals like Vasant Panchami and Chhath Puja that honor the environment.
- Yoga and meditation focus on essentials and discourage excess.
- Joint family systems and community kitchens foster sharing and resource reuse.
- Leftover food is often repurposed into new dishes, and scraps are composted or used as animal feed.
- Everyday items, such as glass bottles and plastic containers, are also repurposed until they reach the end of their usable life.
- Traditional methods like crop rotation and natural fertilizers sustain soil health and conserve water.
- Textiles made from durable natural fibers, like cotton and wool, are reused and recycled.
- Crafts incorporate recycled materials, with artisans transforming discarded items into products like bags and home decor.

Building on these deeply rooted cultural values, India has taken a proactive step towards sustainability through the Lifestyle for Environment (LiFE) initiative. The honorable Prime Minister of India, Shri Narendra Modi ji launched LiFE initiative on June 5, 2022, which aims to inspire a global movement focused on sustainable living and behavioral shifts to combat climate change.

Drawing from India's traditional values, LiFE encourages individuals and communities to adopt pro-environmental behaviors. Its core principles include mindful utilization, encouraging thoughtful and efficient use of resources, and fostering a community of "pro-planet people" committed to environmental stewardship

Through these efforts, LiFE aspires to influence broader industrial and policy shifts, establishing a foundation for sustainable consumption and production on a large scale. There are seven themes in Mission LiFE, as presented in Figure 1.5.

Figure 1.5: LiFE Themes



How Circular Economy can support LiFE Initiative?

The Circular Economy can support the LiFE initiative in a number of ways. For example, it can help to:

- **REDUCE WASTE GENERATION:** The Circular Economy focuses on reducing waste generation at the source. This can be done by designing products for durability and reparability, and by encouraging consumers to reuse and recycle products. This aligns with the LiFE principle of mindful and deliberate utilization of resources.
- **PROMOTE SUSTAINABLE CONSUMPTION:** The Circular Economy promotes sustainable consumption by shifting the focus from product ownership to product access. This can be done through business models such as product-as-a-service and leasing. This aligns with the LiFE principle of pro-planet people, as it encourages consumers to make choices that are good for the environment.
- **CREATE NEW JOBS AND BUSINESSES:** The Circular Economy creates new jobs and businesses in sectors such as recycling, repair, and refurbishment. This aligns with the LiFE principles as it shows that sustainable living can be compatible with economic growth and prosperity.

1.5. IMPERATIVE FOR NATIONAL CIRCULAR ECONOMY FRAMEWORK IN INDIA

India, the world's third-largest energy consumer, is facing a growing resource dilemma. With a rapidly expanding population, urbanization, and industrial growth, the country's resource consumption is projected to soar in the coming decades, putting immense pressure on both domestic resources and the environment. This increasing resource intensity, if left unchecked, could have far-reaching economic, environmental, and social consequences.

India's import dependence for critical resources is a cause for concern. The country relies heavily on imports to meet its demand for essential resources, including:

- **LITHIUM:** India imports nearly 100% of its lithium, a crucial component in electric vehicle batteries.
- **COBALT:** India imports 90% of its cobalt, another essential mineral for high-performance batteries.
- **NICKEL:** India imports 80% of its nickel, a critical component in stainless steel production.
- **CRUDE OIL:** Over 80% of India's crude oil demand is met through imports.
- **COKING COAL:** India imports 70% of its coking coal, essential for steelmaking.
- **COPPER:** India imports 50% of its copper, a vital material for electrical wiring and construction.

At the same time, India's resource consumption is projected to grow exponentially between now and 2075. By 2075, India's energy demand is expected to increase by 150-200%, driven by rising incomes, infrastructure development, and a growing middle class. Similarly, the demand for metals is anticipated to surge by 300%, while the demand for non-metallic minerals is expected to double.

The increased mining and resource extraction associated with India's growing consumption will have significant environmental and carbon footprint related consequences. Mining activities contribute to deforestation, habitat destruction, air and water pollution, and soil degradation. Additionally, the processing and transportation of resources release greenhouse gases, exacerbating climate change.

As a resource-intensive economy with limited natural reserves, India stands to benefit significantly from embracing a Circular Economy. This approach can help reduce dependence on new resources, generate jobs, boost economic growth, and enhance public health by reducing pollution. This transition towards a Circular Economy can therefore bring about substantial economic, environmental, and social benefits:

- **ECONOMIC VALUE CREATION:** Circular Economy practices can create new jobs and businesses in resource recovery, remanufacturing, and sustainable product design, fostering economic growth and innovation.
- **ESTIMATED JOB CREATION POTENTIAL:** 10 million jobs by 2050.
- **PROJECTED ECONOMIC VALUE:** $2 trillion by 2050.
- **CARBON EMISSION REDUCTION:** By reducing resource extraction and waste generation, Circular Economy can significantly lower India's carbon footprint, contributing to climate change mitigation efforts.
- **POTENTIAL CARBON EMISSION REDUCTION:** 44% by 2050.
- **CONTRIBUTION TO CLIMATE GOALS:** Aligns with India's commitment to reducing emissions by 30-35% by 2030.
- **ENVIRONMENTAL PRESERVATION:** Circular Economy can minimize environmental damage by reducing the need for new resource extraction, preventing pollution, and conserving natural ecosystems.

- **REDUCED WASTE GENERATION:** 50% reduction in waste generation by 2050.
- **WATER CONSERVATION:** 20% reduction in water consumption by 2050.
- **BIODIVERSITY PROTECTION:** Preservation of natural habitats and ecosystems.
- **REDUCED IMPORT DEPENDENCE AND RESOURCE SECURITY:** Circular Economy can enhance India's resource security by reducing the need for imports and promoting domestic resource efficiency.

India's resource dilemma demands a paradigm shift in resource management. Circular Economy offers a transformative approach that can address the challenges of import dependence, environmental impact, and resource scarcity while creating economic opportunities, fostering sustainable development, and aligning with India's vision of Aatma Nirbhar Bharat. By embracing circularity, India can secure a future of resource abundance, environmental sustainability, and economic prosperity.

Considering the imperative for Circular Economy, NITI Aayog, in consultation with the Ministry of Environment and Forest and Climate Change (MoEFCC), identified 11 areas to facilitate transitioning from linear to Circular Economy and to give an impetus to India's Aatma Nirbhar Bharat Abhiyaan. The identified areas include:

01 Municipal Solid Waste *and* Liquid Waste

02 Scrap Metal *(Ferrous and Non-ferrous)*

03 Lithium Ion (Li-ion) *Batteries*

04 Tyre and Rubber *Recycling*

05 Gypsum *Waste*

06 End-of-life *Vehicles (ELVs)*

07 Electronic *Waste*

08 Toxic and *Hazardous* Industrial Waste

09 Used Oil *Waste* (generated *from* tools *and* machines)

10 Agriculture *Waste*

11 Solar *Panels*

STATE ACTIONS ADVANCING CIRCULAR ECONOMY IN INDIA

- **Nationwide ban on identified single-use plastic** items, including straws, cutlery, ear buds, packaging films, and cigarette packets, among others implemented uniformly by all states from July 1, 2022.
- **Plastic Waste Management Rules** are implemented by Maharashtra (2018), Madhya Pradesh (2019), Rajasthan (2019), West Bengal (2019), Tamil Nadu (2019), Karnataka (2016), Kerala (2019), and Uttar Pradesh (2018), among others, requiring producers and brand owners to collect and recycle plastic products.
- **E-waste management policies** are introduced by several Indian states, including Odisha (2020), Maharashtra (2018), Karnataka (2017), Uttar Pradesh (2019), and Tamil Nadu (2010), to encourage responsible e-waste disposal, promotes recycling of electronic products, and incentivizes businesses involved in e-waste management.
- **Renewable Energy Policies** by Andhra Pradesh (2015), Tamil Nadu (2019), and Karnataka (2014-2021) promote the use of recycled materials, reflecting a commitment to integrating Circular Economy principles in the renewable energy sector.
- **The State Waste Management Rules** by Uttar Pradesh (2019) and Haryana (2019) require all waste generators to segregate and dispose of waste sustainably, while Karnataka's Solid Waste Management Policy (2012) promotes waste reduction, reuse, and recycling.
- Tamil Nadu **Green Building Policy,** 2014, mandates the use of recycled materials in the construction of new buildings.
- Andhra Pradesh State Policy on **Renewable Energy,** 2015, promotes the use of recycled materials in the generation of renewable energy.
- **Industrial Policy** by Telangana (2015) and Gujarat (2020), provide incentives to businesses that adopt circular practices.
- Punjab **Eco-Friendly Sand Mining Policy,** 2018 promotes the use of alternative materials, like recycled construction debris, to reduce reliance on natural sand, thereby supporting resource conservation.
- **Eco tourism policies** by several states in India, including Kerala (2008), Himachal Pradesh (2016), Sikkim (2011), Uttarakhand (2015), and Rajasthan (2020), emphasize sustainable practices, community engagement, and environmental conservation, supporting a Circular Economy approach within the tourism sector.

1.6. CHALLENGES IN INDIA'S TRANSITION TO A CIRCULAR ECONOMY

Lack of awareness

Insufficient infrastructure and Investment

Regulatory/ Policy barriers

Supply Chain Complexity

Transitioning to a Circular Economy presents both significant opportunities and complex challenges for India. While India's rich cultural heritage, supportive policies, growing business initiatives and startup engagement, and public awareness and community action act as strong enablers, numerous barriers still need to be addressed to ensure a successful transition:

- **Lack of awareness:**
  Many businesses and consumers remain unaware of the concept and benefits of Circular Economy.
- **Insufficient infrastructure and Investment:**
  Key infrastructure, such as recycling, composting facilities, and technology for sustainable design, is limited. Additionally, investment in technologies that facilitate recycling, repair, and sustainable production is still lacking, slowing the adoption of Circular Economy practices.
- **Regulatory/Policy barriers:**
  Existing policies can inadvertently create obstacles. For example, regulatory complexities may discourage businesses from implementing circular practices like remanufacturing or material recovery.
- **Supply Chain Complexity:**
  Transitioning supply chains to align with circular principles is challenging due to the complexity and fragmentation of supply chains across India. Sourcing sustainable materials, managing logistics, and ensuring end-of-life product management require coordinated efforts across sectors.

Despite the challenges, the transition to a Circular Economy is well underway. Several businesses and governments are already implementing Circular Economy principles, and as its adoption spreads, its benefits will become more evident. A well-defined framework that can provide strategic direction, aligning policies, and facilitating collaboration across sectors can accelerate this transition.

The National Circular Economy Framework (NCEF) was developed as a result of the felt need for a structured approach for industries, policymakers, and citizens to adopt circular practices on a national scale. The framework was designed to address India's specific resource challenges, reduce environmental impact, and support economic resilience. NCEF builds on initiatives like LiFE, aligns with traditional Indian values of conservation and resourcefulness and sets clear pathways for sustainable development, reinforcing India's commitment to a sustainable future.

References:

1. Mission LiFE
   https://missionlife-moefcc.nic.in/

2. G20 New Delhi Leaders' Declaration, New Delhi, India, 9-10 September 2023
   https://www.g20.org/content/dam/gtwenty/gtwenty_new/document/G20-New-Delhi-Leaders-Declaration.pdf

3. Wautelet, Thibaut. (2018). Exploring the role of independent retailers in the Circular Economy: a case study approach. 10.13140/RG.2.2.17085.15847.

4. Ellen MacArthur Foundation, Towards the Circular Economy Vol. 1: an economic and business rationale for an accelerated transition (2013).

5. Circular Innovation Council: `Circular Economy: Beyond Recycling'
   https://circularinnovation.ca/circular-economy/

6. UNEP, UNDP and UNFCCC secretariat. 2023. Building Circularity into Nationally Determined Contributions (NDCs) - A Practical Toolbox User Guide. Nairobi
   https://doi.org/10.59117/20.500.11822/43594

7. UNEP building circularity platform
   https://buildingcircularity.org/

8. "The Circular Economy: An Indian Perspective" by Confederation of Indian Industry https://www.cii.in/PressreleasesDetail.aspx?id=78471

9. "India's Circular Economy: A Pathway to Sustainable Development" by World Resources Institute (WRI)

10. "Circular Economy for Sustainable Development in India" by India Brand Equity Foundation (IBEF) https://www.ibef.org/

11. "Circular Economy: A Business Imperative for India" by The Energy and Resources Institute (TERI) https://wsds.teriin.org/2018/files/teri-yesbank-circular-economy-report.pdf

12. "India's Resource Dilemma and the Promise of Circular Economy" by NITI Aayog

13. "Circular Economy in Municipal Solid and Liquid Waste" by Ministry of Housing and Urban Affairs

14. NITI Aayog website https://niti.gov.in/

15. Narendra Modi Official Website: https://www.narendramodi.in/

16. "Circular Economy Action Plan" by European Commission (2020). https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en

17. "Circular Economy in Action: Scaling Up Circular Business Models" by World Economic Forum (2021). https://www.weforum.org/agenda/2021/02/circular-economy-scaling-up-business-models/

18. "Building Circularity into Nationally Determined Contributions (NDCs): A Practical Toolbox User Guide" by United Nations Environment Programme (UNEP) (2023). https://buildingcircularity.org/

19. "The Macroeconomic Impact of Circular Economy Transition: A Country-Level Analysis" by PricewaterhouseCoopers (PwC) (2020). https://www.pwc.com/gx/en/services/sustainability/publications/circular-economy-transition.html

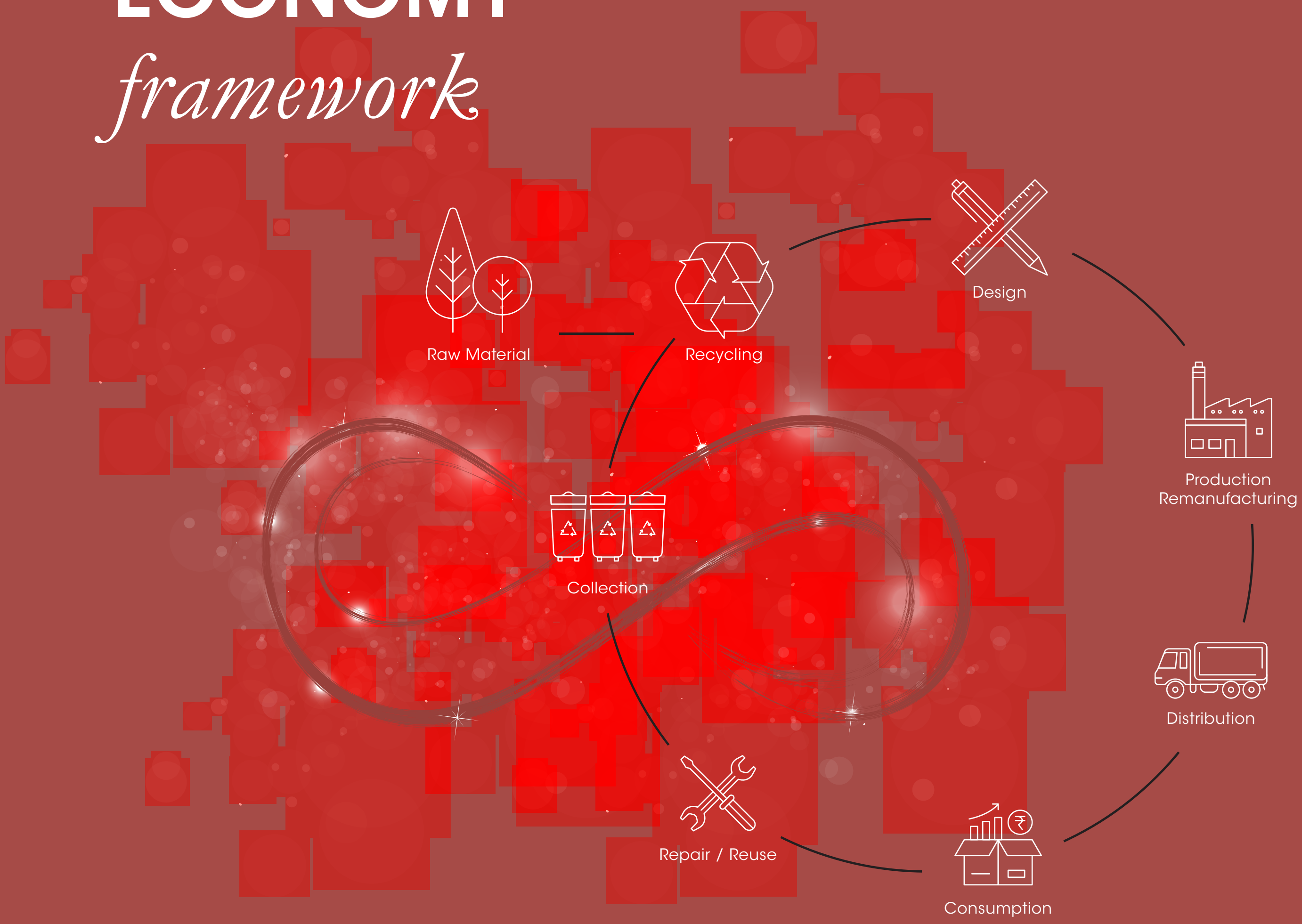
20. "Accelerating the Circular Economy: Scaling Solutions for a Sustainable Future" by Accenture Strategy (2021). https://www.accenture.com/us-en/insights/strategy/circular-economy-scaling-solutions

21. "Circular Economy and Climate Action in Developing Countries" by International Finance Corporation (IFC) (2021). https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/circular-economy-and-climate-action-in-developing-countries

22. "UNEP Circularity Platform" by United Nations Environment Programme (UNEP) (2021). https://www.unep.org/resources/toolkits-manuals-and-guides/unep-circularity-platform

Chapter 2

NATIONAL CIRCULAR ECONOMY *framework*



2.1. INTRODUCTION

National Circular Economy Framework (NCEF) provides a clear and consistent vision for the transition to a circular economy. This can help to align the efforts of government, businesses, and the society towards common goals. There are many compelling reasons to introduce a framework on circular economy at a national level to reap a wide range of economic, environmental, and social benefits.

The NCEF attempts to provide key strategies to overcome the challenges such as: (a) lack of markets for recycled products; (b) lack of awareness and understanding of the circular economy concept; (c) lack of infrastructure for waste collection, sorting, and recycling etc.

2.2. OBJECTIVES OF NCEF

The NCEF is a roadmap for India to transition to a more sustainable economy. By implementing the framework, India can reduce waste, increase resource efficiency, and create a more sustainable future for its citizens. The NCEF helps: (a) reduce reliance on imported resources; (b) decouple economic growth from resource consumption; (c) reduce resource consumption and pollution; (d) enhance resource security; (e) reduce costs and improve competitiveness; (f) attract investments; (f) enhance public health; (g) create job opportunities

2.3. FOCUS MATERIALS

The initial implementation of the NCEF with a focused set of key materials last year has laid a strong foundation, enabling the inclusion of additional materials beyond those covered in the first edition of this document. The expanded materials list aligns with sectors identified by NITI Aayog as high-priority for circular economy initiatives, presenting significant resource value opportunities and high environmental impact:

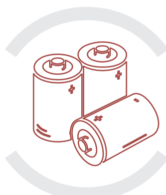
Municipal Solid Waste

Domestic Wastewater

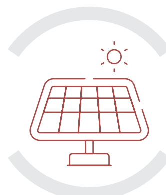
Industrial Wastewater

Scrap Metal

E-Waste



Lithium-Ion Battveries



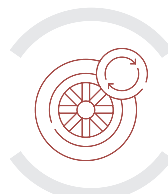
Solar Panels

Gypsum

Toxic and Hazardous Waste

Used Oil

Agricultural Waste



Tyre and Rubber Recycling

End-of-Life Vehicles

Plastics

Construction & Demolition Waste

Textile Waste

2.4. PRINCIPLES

The NCEF is based on the following four principles – Prevention, Upcycling, Recycling, and Energy Recovery, as detailed below:

- **PREVENTION:**
  The first priority is to prevent waste from being generated in the first place. This can be done through product design, reuse, repair, refurbishing and remanufacturing.
  - **Product design and life extension:**
    Products should be designed to be durable, reusable, reparable, refurbishing and remanufacturing-friendly. This can be done by using high-quality materials, designing for modularity, and making it easy to disassemble and repair products. An example of this approach is a modular smartphone designed for durability, where users can easily replace or repair individual components like the battery or screen, extending the device's lifespan and reducing waste.
  - **Reuse:**
    Products should be reused whenever possible. This can be done through product-as-a-service models, rental and sharing schemes etc.
  - **Repair, refurbishing, and remanufacturing:**
    Products should be repaired, refurbished, and remanufactured whenever possible. This can be done by making spare parts and repair manuals available, and by providing financial incentives for repair and refurbishment.
- **UPCYCLING:**
  Waste should be upcycled whenever possible. This means converting waste into new products of higher value. For example, plastic waste can be upcycled into new plastic products, or food waste can be upcycled into compost or animal feed.
- **RECYCLING:**
  Waste should be recycled whenever possible. This means converting waste back into materials that can be used to make new products. For example, paper waste can be recycled into new paper products, and metal waste can be recycled into new metal products.
- **ENERGY RECOVERY:**
  Waste that cannot be recycled or upcycled should be used to generate energy. This can be done by burning waste to generate electricity, or by converting waste to biogas. Energy recovery can help to reduce the amount of waste that is sent to landfills and incinerators; However, it is important to note that energy recovery is not a substitute for prevention, reuse, and upcycling, as it still generates some pollution and greenhouse gas emissions.

The ultimate goal of the circular economy is to achieve zero waste. This means that no waste is sent to landfills or incinerators. This can be achieved through a combination of the above principles.

CHOICE OF APPLICATION OF PRINCIPLE(S)

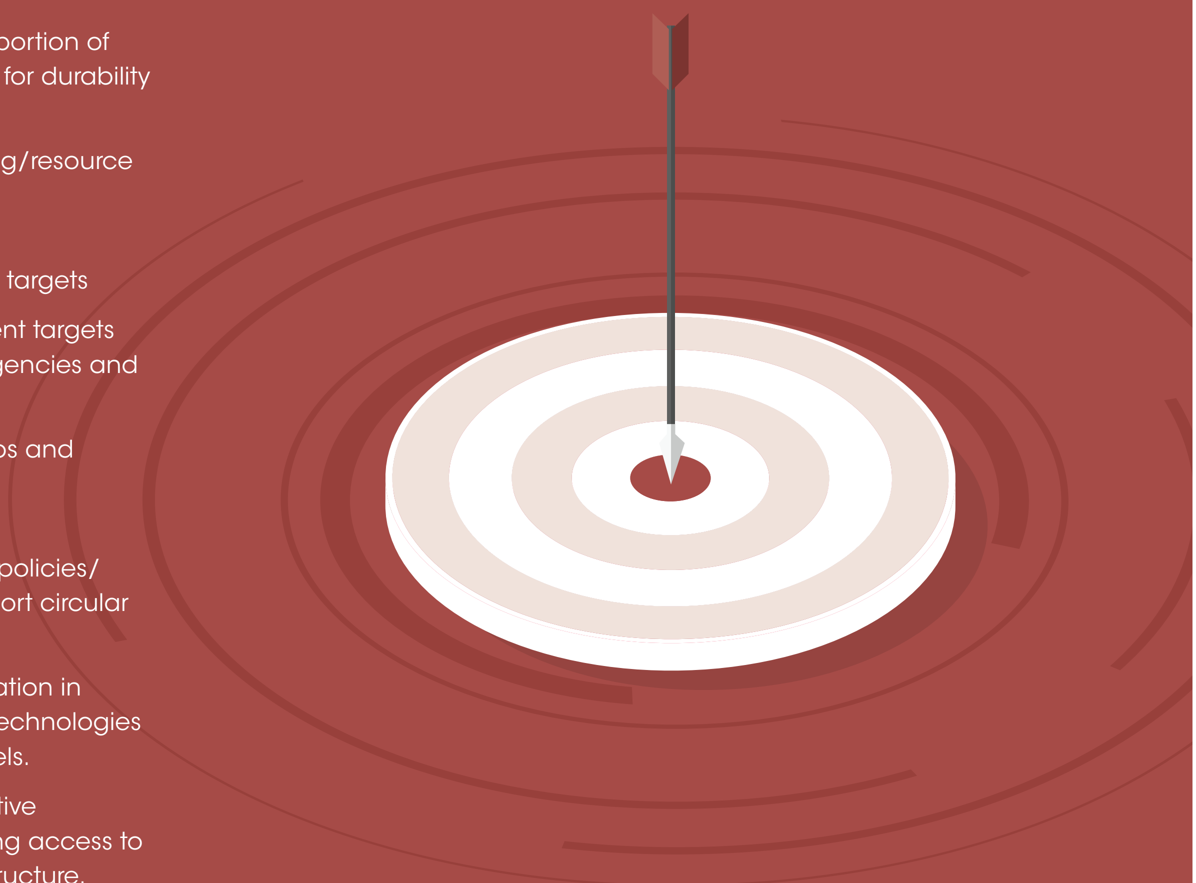
'Retained Value' is a measure of the value that is retained in a product or material after it has been used. It is calculated as the percentage of the original value of the product or material that is still present after it has been used. The retained value of products and materials varies depending on the product or material and the method used to extend its life. In general, reuse, repair, refurbishment, and remanufacture have a higher retained value than recycling. The choice of right method (reuse, repair, refurbish etc.) shall be the one that will extend the life of the product or material while maximizing the retained value.

2.5. TARGETS

Targets provide a clear roadmap for all the stakeholders to work towards specific goals in the transition to a circular economy. They establish a shared vision and direction for sustainable economic development, providing a basis for measuring the effectiveness of the policies and other measures. Aligned with the Government of India's targets, missions, and policies, these targets encourage accountability, strategic planning, and long-term commitment across sectors.

NCEF aims to set ambitious targets for India to reduce waste, enhance resource efficiency, and foster a sustainable economy, with specific goals outlined in Part 2 (Circular Economy Action Plan for Focus Materials). Both quantitative and qualitative targets are defined for each material, with periodic reviews and revisions led by industry professionals. The Confederation of Indian Industry (CII) validates these targets and will monitor progress, ensuring alignment with national objectives and facilitating continuous improvement. The list of possible targets is presented below.

- Reduction in use of virgin materials
- Reduction in waste generation at source
- Increase in the proportion of products designed for durability and repairability
- Increase in recycling/resource recovery rate
- Extended Producer Responsibility (EPR) targets
- Circular procurement targets (for government agencies and large corporations)
- Creation of new jobs and businesses
- Development and implementation of policies/regulations to support circular economy.
- Promotion of innovation in circular economy technologies and business models.
- Creation of supportive ecosystem, including access to finance and infrastructure.
- Community engagement and education



2.6. KEY STRATEGIES FOR IMPLEMENTATION – POLICIES AND MEASURES

The successful implementation of the NCEF in India requires a multi-dimensional approach that engages all stakeholders, drives innovation, and aligns policies and regulations. By employing these key strategies, India can forge a path towards a more sustainable, efficient, and resilient circular economy, ultimately benefiting both the environment and the economy. The following key strategies are proposed for successful implementation of NCEF across various sectors:

- **REGULATIONS:**
  The government could strengthen existing regulations or introduce new regulations that require businesses to adopt circular economy practices such as reduction of waste, increase of resource efficiency etc.
- **INCENTIVES:**
  The government could provide incentives to businesses that adopt circular economy practices. The incentives can be both financial (viability gap funding) and non-financial.
- **PUBLIC AWARENESS:**
  The government could raise public awareness of the circular economy and the benefits of adopting circular economy practices. This could be done through education campaigns, workshops, and other outreach activities.
- **INVESTMENT IN RESEARCH AND DEVELOPMENT:**
  The government can either invest or facilitate investments in R&D to develop and deploy innovative technologies and solutions that support circularity. It shall provide incentives for businesses and start-ups to innovate in areas like recycling, renewable energy, and sustainable materials.
- **PROMOTION OF PUBLIC-PRIVATE PARTNERSHIPS (PPPS):**
  PPPs can play an important role in accelerating the transition to a circular economy. By bringing together the resources, expertise, and innovation of both the public and private sectors, PPPs can help to develop and implement circular economy solutions at scale.
- **CIRCULAR ECONOMY KNOWLEDGE NETWORK:**
  The network can serve as a platform for sharing knowledge and best practices, facilitating collaboration and innovation, and building capacity. The network can host regular events, develop and maintain a knowledge base, facilitate formation of working groups and partnerships etc.
- **CIRCULAR ECONOMY PARKS:**
  Circular economy parks, also known as eco-industrial parks or resource recovery parks, may be established in different parts of the country. The circular economy parks are designated areas designed to promote resource efficiency and waste reduction through collaborative efforts among businesses and other stakeholders. These parks provide a physical infrastructure and supportive environment for businesses to adopt circular economy principles, such as: industrial symbiosis, circular supply chain management, waste valorization, access to shared infrastructure etc.
- **INSTITUTIONAL FRAMEWORK:**
  National Circular Economy Authority (NCEA) may be established which can implement the national circular economy strategy, coordinate the activities of different industries and agencies, reform the regulations to make them more conducive to the circular economy, invest in research and development etc.

To ensure the successful implementation of NCEF, the above key strategies must be employed across various sectors and stakeholders. Chapter 4 presents each of the above key strategies in detail.

2.7. MONITORING AND EVALUATION

MONITORING involves collecting data on the implementation of the NCEF and its impacts. The data shall be collected regularly and should be disaggregated by the focus material, sector, region, and other relevant criteria. **EVALUATION** involves analysing the data to assess the progress of the framework, identify challenges, and make recommendations for improvement, based on clear and transparent criteria.

A robust Monitoring and Evaluation (M&E) system (including regular reporting on key performance indicators and outcomes for each focus material) needs to be implemented to track the progress of NCEF. M&E can be conducted by the government, professional organizations, academia etc. It is important to ensure that all stakeholders are involved in the M&E process, so that the data collected is comprehensive and representative.

The data collected for M&E can be used to: (a) track progress towards the 'targets' set by the NCEF for each of the focus material; (b) identify challenges and areas for improvement; (c) inform decision-making about the implementation of the framework; and (d) communicate the progress and impacts of the framework to different stakeholders. Based on the outcome of the M&E, the NCEF may be revised to reflect evolving circumstances and emerging opportunities. M&E is very critical to ensure that the NCEF is successful in achieving its goals and objectives.

Going further, the NCEF aims to develop an M&E framework to map sectoral progress and establish national-level metrics to measure India's overall circular economy advancement. This year, NCEF will develop a comprehensive framework that includes key metrics to capture progress on resource efficiency, waste reduction, and circular economy impact across sectors.

2.8. NEXT STEPS

It is important to take the following steps to ensure the NCEF remains relevant and effective in the long term, and that it is able to adapt to changing circumstances:

- **REVISION OF NCEF:**
  The NCEF shall be revised periodically to reflect evolving circumstances and emerging opportunities based on learnings from M&E, stakeholder engagement, tracking global trends, and identifying emerging technologies and solutions. Also, the scope of NCEF shall be expanded from time to time to cover new focus materials based on the learnings and the progress made.
- **STAKEHOLDER ENGAGEMENT:**
  Multi-stakeholder engagement shall be carried out regularly to address the key challenges identified in implementing the NCEF and achieving its objectives.
- **INTEGRATION OF CIRCULAR ECONOMY INTO OTHER POLICIES AND PROGRAMS:**
  Efforts shall be put in place to align the circular economy with other national priorities, such as climate change mitigation or economic development.
- **SUPPORT FOR MEASURING CIRCULAR ECONOMY PROGRESS:**
  The NCEF aims to develop a Monitoring and Evaluation (M&E) framework and dashboard to track sectoral and national-level circular economy progress. Indicative metrics include Material Circularity, Resource Productivity, Recycling and Recovery, Waste Generation per Capita, and Carbon Emissions Reduction. Additional indicators such as Employment in Circular Sectors, Investment in Circular Initiatives, EPR Compliance, Environmental Impact, Consumer Behavior, and Product Lifespan could provide a comprehensive view of circular economy advancement, enabling strategic, data-driven decision-making. Working groups comprising experts from industry, academia, policy, and government will be formed to drive these efforts.

References:

1. Circular Transition Indicators V3.0 Metrics for business, by business by World Business Council for Sustainable Development (WBCSD https://www.wbcsd.org/contentwbc/download/14172/204337/1

2. Resource Efficiency and Circular Economy: Priorities for Sustainable Growth in India, by NITI Aayog (2021). https://www.niti.gov.in/resource-efficiency-and-circular-economy

Chapter 3
IMPLEMENTATION OF NCEF – *enabling principles*

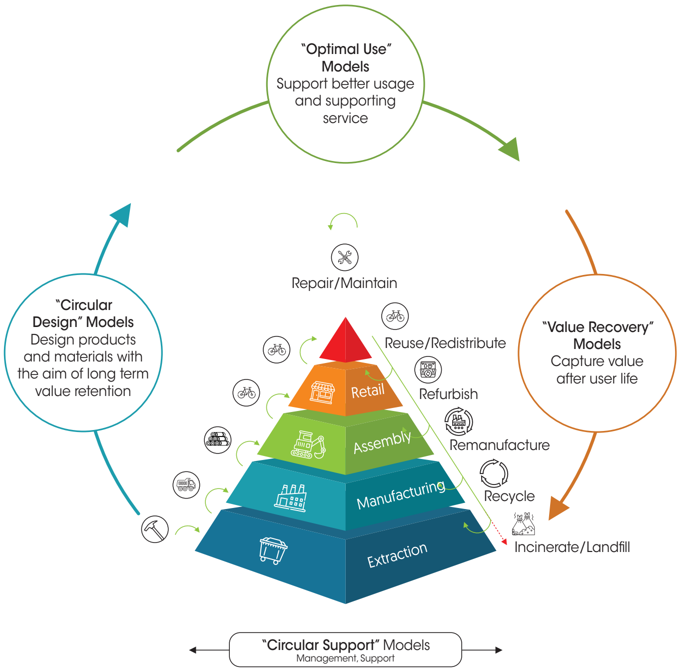
3.1. INTRODUCTION

The NCEF helps India transition from linear economy to circular economy by providing a roadmap for conservation of resources, reduction in reliance on virgin materials, reduction in waste and ecological footprint, creation of jobs and more equitable society. The successful implementation of an NCEF requires a number of enabling principles, which are the foundation on which the framework is built.

The four enabling principles for implementation of the NCEF are: **PREVENTION, UPCYCLING, RECYCLING, AND ENERGY RECOVERY.** Accelerating these four principles requires governments and companies to not only rethink resource usage, but also embrace redesign, adopting new business models centered on dematerialization, longevity, refurbishment, remanufacturing, capacity sharing, and enhanced reuse and recycling.

Reference is often made to three circular business model categories, each of which focuses on a different phase of the value chain: (a) the design and manufacturing phase; (b) the use phase; and (c) the value recovery phase. These different business models can be illustrated in what is called a Value Hill, shown in Figure 3-1.

Figure 3-1: Circular economy business models in the Value Hill*



*Elisa Achterberg, Jeroen Hinfelaar, Nancy Bocken, "The Value Hill Business Model Tool: identifying gaps and opportunities in a circular network" (2016)

3.2. PREVENTION

Prevention is the most important principle of the circular economy as the first priority is to prevent waste from being generated. This can be achieved through: (a) product design and life extension; (b) reuse; and (c) repair, refurbishing and remanufacturing. This mainly comes from optimal use models. It focuses on the development of existing or new products and processes that seek to optimize circularity. Products are designed to last longer and/or be easy to maintain, repair, upgrade, refurbish, remanufacture, or recycle. Additionally, new materials are developed and/or sourced, e.g., bio-based, less resource-intensive, or fully recyclable. The risks related to financing such innovations do not differ much from financing other innovation or Research, Development, and Innovation (RDI) projects.

A. PRODUCT DESIGN AND LIFE EXTENSION

Products should be designed to be durable, reusable, and reparable. This means using high-quality materials, designing products with fewer parts, and making it easy for consumers to repair products if they break. Here are some means through which life extension can be achieved.

- **Strategic material selection:** Selection of materials should be done consciously during the design phase with priority to the materials with minimal environmental impact and a high potential for circularity.
- **Design for disassembly and repair:** Products should be designed in a way that makes them easy to disassemble and repair. This will make it easier to extend their lifespan and to recycle their components.
- **Use of recycled materials:** Products should be made using recycled materials whenever possible. This will help to reduce the demand for virgin materials.
- **Durability:** Products should be designed to be durable and to last for a long time. This will help to reduce the need for replacement and to minimize waste.
- **Modular design:** Products should be designed in a modular way so that components can be easily replaced or upgraded. This will help to extend their lifespan and to make them more adaptable to changing needs.
- **Efficiency:** Products should be designed to be efficient in their use of resources. This will help to reduce the environmental impact of their production and use.
- **Reusability:** Products should be designed to be reused or upcycled at the end of their lifespan. This will help to reduce the amount of waste that is generated.
- **Extended Warranty Services:** Products should come with extended warranty to ensure they remain functional during their intended lifespan.

Product design and life extension are crucial aspects of circular economy implementation. By incentivizing eco-design principles such as modularity, standardized components, and durability, manufacturers can create products that are easier to repair, reuse, and recycle. Extended Producer Responsibility (EPR) schemes can further encourage manufacturers to take responsibility for the end-of-life management of their products, driving innovation in sustainable design. Additionally, public procurement policies can prioritize products with longer lifespans, sending a clear signal to the market about the demand for durable goods.

B. REUSE

In the context of circular economy, Reuse refers to the practice of extending the lifespan of products and materials without significantly altering their form or function. This involves finding new uses for items that would otherwise be discarded, thereby reducing waste generation and conserving resources. Reuse plays a crucial role in minimizing the need for new resource extraction and processing, contributing to environmental protection and sustainable development.

The primary components of reuse in circular economy include:

- **Product Design for Reusability:** Incorporating design principles that enhance product reusability is essential to extend product lifespans and facilitate reuse. This involves creating durable products from robust materials, adopting standardized components for easy compatibility and interchangeability, and using modular designs that allow for straightforward disassembly, repair, and replacement of individual parts.
- **Product Sharing and Rental Services:** Promoting product sharing and rental services can significantly reduce individual ownership and encourage the utilization of products on a temporary basis. This involves:
    - **Platform Development:** Establishing online or physical platforms that connect product owners with potential renters or borrowers, facilitating access to shared products.
    - **Rental Infrastructure:** Creating a network of rental centers or drop-off locations to ensure convenient access and handling of rented products.
    - **Maintenance and Repair:** Providing maintenance and repair services to ensure the continued functionality and quality of rented products, extending their lifespan.
- **Second-hand Markets and Product Donation Programs:** Developing vibrant second-hand markets and promoting product donation programs can provide alternative avenues for product reuse. This involves:
    - **Marketplaces and Platforms:** Establishing online or physical marketplaces for buying and selling second-hand products, providing a centralized hub for reuse transactions.
    - **Donation Networks:** Creating networks of charities or non-profit organizations that collect and redistribute donated products to those in need, giving them a second life.
    - **Product Certification and Quality Control:** Implementing quality control measures and certification programs to ensure the safety and reliability of secondhand products, fostering consumer confidence in reuse.

C. REPAIR, REFURBISHING, AND REMANUFACTURING

Repair involves fixing broken products so that they can be used again. Refurbishing involves restoring used products to their original condition. Remanufacturing involves disassembling used products and then reassembling them using new or recycled parts. Repair, refurbishing, and remanufacturing are all valuable strategies for extending the lifespan of products. By providing access to affordable and skilled repair services, ensuring the availability of spare parts and components, and offering training and certification programs for repair technicians, governments can support the growth of the repair sector.

The primary components of repair and refurbishment in circular economy, include:

- **Product Design for Repairability:** Incorporating design principles that enhance product repairability is essential to facilitate repair and refurbishment. This involves using modular construction for easy disassembly and access to components, adopting standardized parts to ensure compatibility with available repair services, and providing user-friendly repair manuals with detailed instructions and troubleshooting guides to empower both users and technicians in effective repairs.

- **Repair Infrastructure and Service Networks:** Establishing a robust repair infrastructure and network of skilled repair technicians is crucial to support repair and refurbishment activities. This involves:

  - **Repair Centers and Workshops:** Creating a network of repair centers and workshops equipped with the necessary tools, equipment, and expertise to handle a wide range of repair needs.
  - **Training and Certification Programs:** Developing and implementing training and certification programs for repair technicians, ensuring a skilled workforce capable of performing high-quality repairs.
  - **Accessibility and Convenience:** Providing convenient access to repair services through strategically located repair centers, mobile repair options, and online support platforms.

- **Spare Parts Availability and Supply Chains:** Ensuring the availability of quality spare parts and maintaining a reliable supply chain are essential for effective repair and refurbishment. This involves:

  - **Inventory Management:** Maintaining adequate inventories of spare parts to meet repair needs, considering product lifespans and repair frequency.
  - **Reverse Logistics and Part Recovery:** Implementing reverse logistics systems to collect and recover used parts from discarded products, providing a source of spare parts for refurbishment.
  - **Partnerships with Manufacturers:** Collaborating with manufacturers to ensure access to original spare parts and technical support, enabling high-quality repairs.

- **Incentives for Product Return and Reuse:** Encouraging both consumers and manufacturers to participate in product return and reuse initiatives helps retain items within the circular economy, reducing waste.
- **Return and Buy-Back Programs:** Manufacturers can offer incentives, like store credit, for consumers to return products that are still functional, enabling reuse, refurbishment, or recycling.
- **Exchange Programs:** Consumer-to-consumer exchanges and manufacturer-supported swap events extend product lifespans by matching items with new owners.
- **Manufacturer Refurbishment:** Manufacturers can refurbish returned items for resale, offering consumers affordable options while reducing waste.
- **Design Incentives:** Rewards for manufacturers who design products optimized for reuse, refurbishment, and return..

KABADIWALA:
Connects households and businesses with waste pickers for recycling and reusing materials.

RENTOMOJO:
Offers furniture and appliance rentals, promoting reuse and reducing individual ownership.

GOONJ:
Repurposes donated clothes into items like bags and mats.

OLX INDIA:
Facilitates buying and selling of second-hand products.

WASTE VENTURES INDIA:
Works with municipalities to collect waste and divert reusable materials from landfills.

REVIVE:
Promotes repair of electronics and appliances to reduce waste.

DONATE-A-BOOK:
Collects used books for underserved communities, extending their lifespan.

3.3. UPCYCLING

Upcycling is a sustainable design and waste reduction practice that involves taking discarded or unused items and transforming them into products of higher value or quality. Unlike recycling, which often involves breaking down materials to create new ones, upcycling focuses on creatively reusing existing materials without significant alteration. This can help to create new products and business models. Redesigning products for other uses can also be a valuable upcycling strategy. By designing products for disassembly and recyclability, manufacturers can make it easier for materials to be recovered and used in new products. Examples of upcycling include: turning used tires into playground equipment, turning old clothes into new bags, turning broken glass into jewellery, turning old shipping containers into restaurants etc.

KEY ASPECTS OF UPCYCLING INCLUDE:

- **Creativity:**
  Upcycling involves innovative thinking and creative approaches to repurpose materials in unexpected ways.
- **Value Addition:**
  The goal is to enhance the value or quality of the original item, creating something new and often more valuable than the sum of its parts.
- **Resource Efficiency:**
  Upcycling reduces waste by utilizing existing materials, contributing to a more sustainable and environmentally friendly approach to consumption.

Several upcycling approaches and examples are highly relevant for India, given the country's diverse culture, resource availability, and environmental challenges, as presented below:

TEXTILE UPCYCLING:

- **Example:**
  Transforming old saris or textile scraps into unique garments, accessories, or home decor items.
- **Relevance:**
  India has a rich textile heritage, and upcycling textiles aligns with sustainable fashion practices.

PACKAGING UPCYCLING:

- **Example:**
  Designing packaging materials from upcycled cardboard or biodegradable materials.
- **Relevance:**
  With a growing concern about plastic waste, upcycled packaging aligns with India's push for sustainable packaging solutions.

E-WASTE UPCYCLING:

- **Example:**
  Extracting valuable materials from electronic waste to create new electronic components or devices.
- **Relevance:**
  India faces challenges with e-waste management, making upcycling a crucial aspect of minimizing environmental impact.

WASTE-TO-ART PROGRAMS:

- **Example:**
  Creating artwork or decorative pieces from discarded materials, such as plastic bottles, paper, or metal scraps.
- **Relevance:**
  India has a vibrant art and craft tradition, and waste-to-art initiatives can tap into this cultural aspect while promoting sustainability.

UPCYCLED FASHION:

- **Example:**
  Repurposing old fabrics or garments to create new, stylish clothing items.
- **Relevance:**
  India is a major player in the textile and fashion industry, making upcycled fashion a fitting approach to reduce textile waste.

FOOD WASTE UPCYCLING:

- **Example:**
  Converting food waste into compost or biogas for energy.
- **Relevance:**
  With a significant population engaged in agriculture, upcycling food waste supports sustainable farming practices.

UPCYCLED CONSTRUCTION MATERIALS:

- **Example:**
  Using reclaimed wood or repurposed metal for construction projects, like furniture or building components.
- **Relevance:** Upcycling in construction aligns with India's growing infrastructure needs and can contribute to sustainable building practices.

UPCYCLED FURNITURE AND HOME GOODS:

- **Example:**
  Crafting furniture or home decor items from discarded or surplus materials.
- **Relevance:**
  India has a strong tradition of craftsmanship, and upcycled furniture aligns with the growing interest in sustainable and artisanal products.

UPCYCLING IN AGRICULTURE:

- **Example:**
  Using agricultural waste for composting or creating innovative solutions for irrigation systems.
- **Relevance:**
  Agriculture is a major sector in India, and upcycling practices can enhance resource efficiency.

WATER TREATMENT BY-PRODUCT UPCYCLING:

- **Example:**
  Using sludge from water treatment plants as raw material for construction, like bricks or tiles.
- **Relevance:**
  India's water management efforts can benefit from creative reuse of treatment by-products, reducing landfill burden and supporting sustainable construction.

AUTOMOTIVE UPCYCLING:

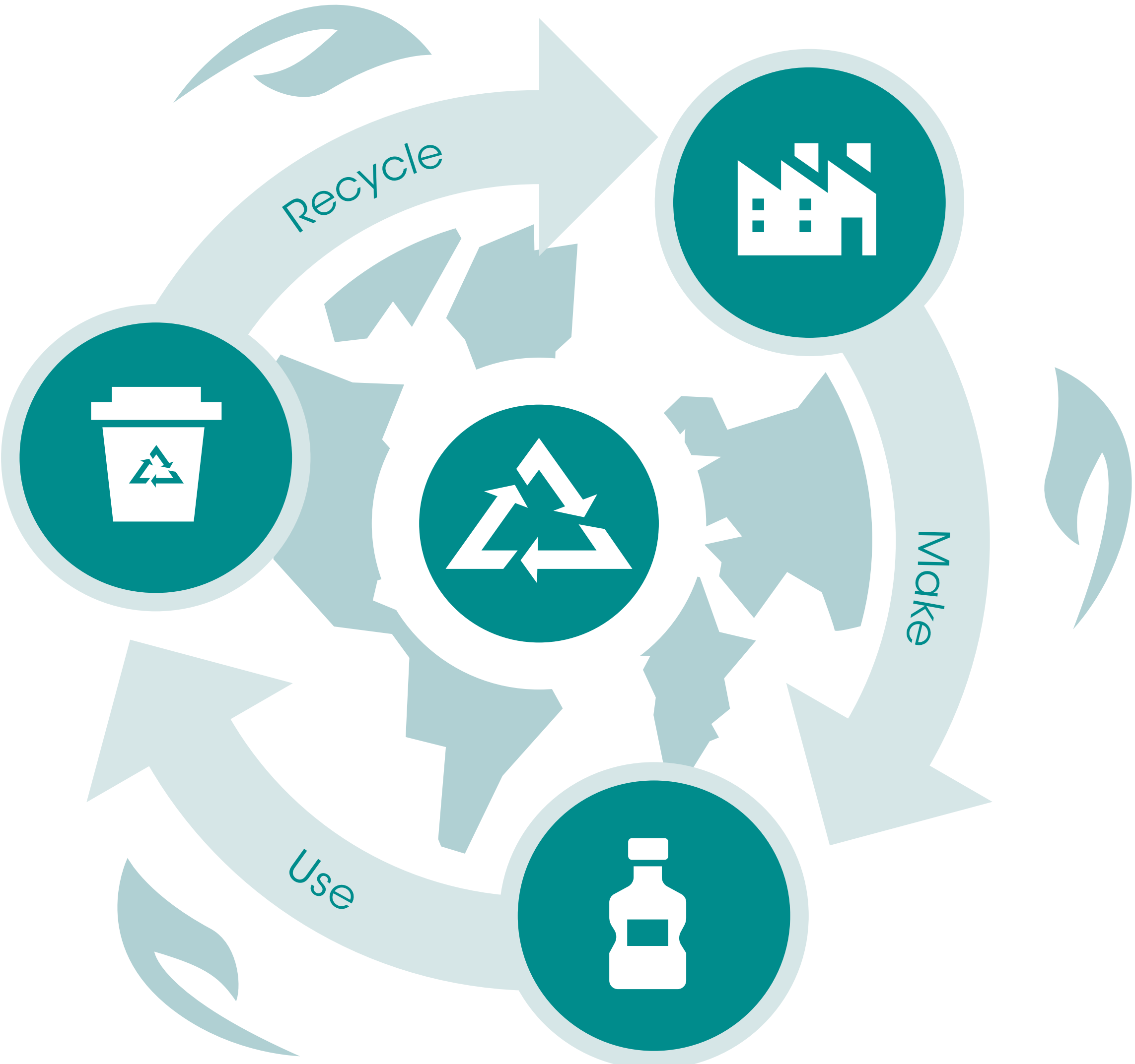
- **Example:**
  Repurposing used tires, engine parts, or metal scraps into furniture, playground equipment, or art.
- **Relevance:**
  With the expanding automotive industry in India, upcycling vehicle components reduces waste.

COLLABORATIVE UPCYCLING HUBS:

- **Example:**
  Establishing collaborative spaces where artisans and innovators can share resources and ideas for upcycling projects.
- **Relevance:**
  Encourages community engagement and supports the growth of a circular economy.

These approaches leverage India's cultural, economic, and environmental context, providing sustainable solutions to address waste challenges and contribute to the circular economy.

3.4. RECYCLING



Recycling is a critical component of the circular economy, as it allows materials to be recovered from waste and used to create new products. Recycling is the process of converting waste materials into new materials, which can be done through a variety of mechanical, chemical, and biological processes. This helps to reduce the need for virgin materials and conserve natural resources.

KEY COMPONENTS OF A 'RECYCLING ECOSYSTEM' INCLUDE:

- **Collection and Segregation:** The first step in recycling is the efficient collection and segregation of waste materials. This involves establishing effective waste collection systems, educating the public on proper waste segregation at the source, and incentivizing waste pickers to collect and segregate waste effectively. A well-organized waste collection and segregation system ensures a steady supply of quality recyclable materials for further processing. Smart recycling bins equipped with sensors and IoT technology can further enhance collection efficiency by automatically sorting waste and notifying when bins need to be emptied.

- **Sorting and Pre-processing:** Once collected, recyclable materials undergo sorting and pre-processing to prepare them for further processing. This involves separating different types of materials, removing contaminants, and cleaning the materials to meet the specifications of downstream recycling facilities. Effective sorting and pre-processing are essential for producing high-quality recycled materials that can be used in manufacturing new products. AI-enhanced sorting technologies can improve accuracy in identifying and separating materials, leading to higher-quality recycling outcomes.
- **Material Processing and Recycling:** Material processing involves breaking down the sorted and pre-processed recyclable materials into their basic components or transforming them into usable forms. This may include shredding, melting, or chemically treating the materials to prepare them for recycling. The specific processing methods depend on the type of material being recycled.
- **Manufacturing and Product Design:** Recycled materials are used as feedstock in the manufacturing of new products, replacing virgin resources and reducing the environmental impact associated with resource extraction and processing. Product design plays a crucial role in maximizing the use of recycled materials and ensuring the recyclability of products at the end of their lifespan.
- **Extended Producer Responsibility (EPR):** EPR schemes can also play a key role in promoting recycling. By holding producers accountable for the recycling of their products, EPR schemes can provide funding for recycling programs and encourage brand owners to design products that are easier to recycle. Additionally, targets for recycled content in products can help to create demand for recycled materials.
- **Market development:** Market development encompasses a range of strategies aimed at increasing the demand for recycled materials and expanding the market for recycled-content products. This involves initiatives such as: supporting businesses that utilize recycled materials through financial incentives, etc.; investing in recycling infrastructure; and promoting research and development for innovative recycling technologies. Blockchain technology can further enhance market transparency by tracking the journey of recycled materials, building consumer trust in recycled-content products. Competitions encouraging innovative uses of products fostering collaboration among designers, manufacturers, and recyclers, to drive creative, market-ready solutions that further support the circular economy.
- **Demand Creation:** Demand creation focuses on building consumer awareness and encouraging environmentally conscious purchasing. Educating consumers on the benefits of recycled products through public awareness campaigns, eco-labeling, and certifications can help shift consumer preferences. Partnerships with retailers to highlight recycled-content products and promote eco-friendly options also support demand creation, reinforcing a circular economy mindset among consumers.

CONSUMER EDUCATION AND AWARENESS FOR SUSTAINABLE CONSUMPTION

Educating and empowering consumers is critical to fostering sustainable consumption patterns within a circular economy. By ensuring clear and accessible information on product care, maintenance, repair, and end-of-life options, consumers can make informed choices that extend product life, reduce waste, and conserve resources.

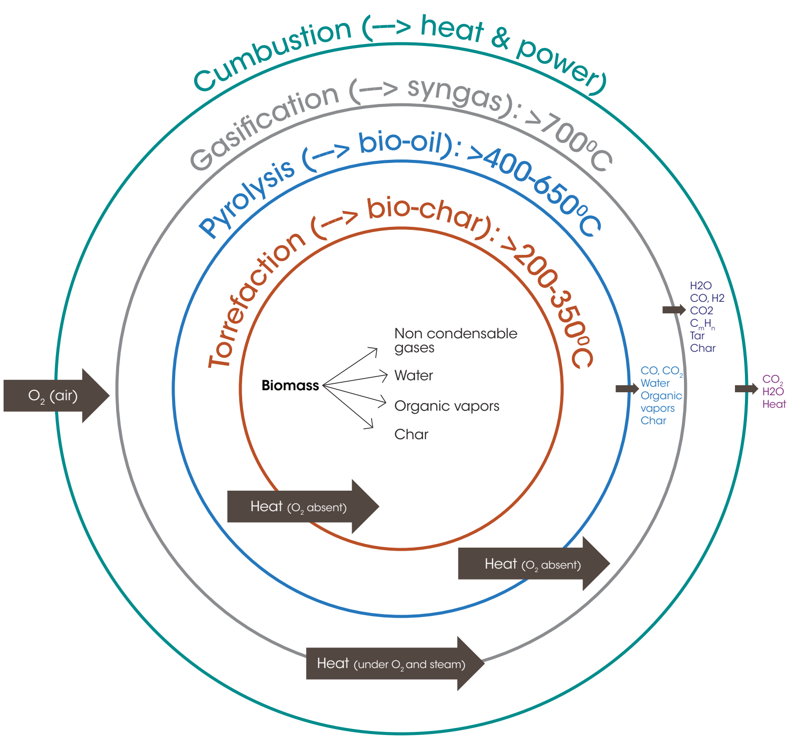
- **Product Circularity Information:** Providing details on material sourcing, energy efficiency, repairability, and recyclability to help consumers make informed choices.
- **Awareness Campaigns:** Public awareness initiatives highlighting the environmental and economic advantages of sustainable practices, such as reuse, repair, and upcycling.
- **Repair and Maintenance Guidance:** Providing easy-to-access guides and tutorials on product maintenance and repair enables consumers to prolong the functionality of their items. Supporting right-to-repair initiatives that advocate for accessible repair information, parts availability, and fair repair practices.
- **Sustainable Consumption Education:** Integrating sustainable consumption practices into school curricula and community programs supports long-term behavioral change, instilling a circular economy mindset from a young age.
- **Community-Based Recycling Hubs:** Establishing local recycling hubs, encourages residents to bring recyclable materials and provides educational resources on recycling. Partnering with local recyclers and introducing recycling credits or reward systems (e.g., points or rebates) can further incentivize responsible recycling behavior among community members and businesses.

3.5. ENERGY RECOVERY

In the context of circular economy, energy recovery refers to the process of extracting and utilizing energy from waste materials that would otherwise be disposed of in landfills or incinerated. This involves converting waste into usable forms of energy, such as electricity, heat, or biofuels, thereby reducing the reliance on fossil fuels and minimizing greenhouse gas emissions. Energy recovery plays a crucial role in transitioning towards a more sustainable and resource-efficient economy.

The primary components of energy recovery in circular economy include:

- **Waste-to-Energy (WTE) Technologies:**
  A diverse range of waste-to-energy (WTE) technologies exist, each with its own advantages and limitations. These technologies can be categorized into three main groups:
  - **Incineration:**
    Incineration involves burning waste derived fuels at high temperatures to generate heat and steam, which can be used to produce electricity or provide district heating.
  - **Anaerobic Digestion:**
    Anaerobic digestion breaks down organic waste in the absence of oxygen, producing biogas, a methane-rich fuel that can be used for electricity generation or transportation.
  - **Gasification:**
    Gasification converts waste into a combustible gas called syngas, which can be used to generate electricity or produce synthetic fuels.
- **Advanced Fuel Production Technologies:**
  Promising technologies such as 'torrefaction' are available to produce high energy density solid fuels from waste/biomass. Torrefaction is a thermochemical process (typically conducted at 200 to 350 oC in an inert atmosphere) that converts waste into a solid fuel with improved properties, including higher energy density, reduced moisture content, and improved grindability. The solid fuel generated from torrefaction can be used in a variety of applications including co-firing in coal-fired power plants, direct combustion in biomass boilers etc.



- **Energy recovery in the form of solid/liquid or gaseous fuels:** Energy can be recovered from waste in the form of solid, liquid, or gaseous fuels. Plastics to diesel, green coal from refuse derived fuel, compressed biogas from landfills, biochar from pyrolysis plants, syngas from gasification etc. are different examples of energy recovered from waste.
- **Waste Pre-processing and Stream Management:** Effective waste pre-processing and stream management are essential to optimize energy recovery processes and increase the energy density of waste derived fuels. This involves:

- **Waste Segregation:** Separating different types of waste materials to ensure optimal processing and prevent contamination.
- **Waste Characterization:** Analyzing the composition and calorific value of waste streams to determine the most suitable energy recovery technology.
- **Waste Preparation:** Pre-treating waste materials to remove contaminants, adjust moisture content, improve processing efficiency.

- **Energy Conversion and Utilization:** The energy extracted from waste through WTE technologies can be utilized in various ways:

- **Electricity Generation:** Waste-derived energy can be converted into electricity using turbines or generators, providing a renewable source of power.
- **Heat Production:** Waste heat generated during energy recovery processes can be used for district heating systems, providing warmth to buildings and reducing reliance on fossil fuels.
- **Biofuel Production:** Waste-derived biogas or syngas can be processed into biofuels, such as biomethane or methanol, offering alternatives to fossil-based fuels for transportation and industrial applications.

- **Emerging Technologies in Energy Recovery:**
- **Carbon Capture and Storage (CCS):** Integrating CCS with WTE facilities allows capturing CO_2 emissions, significantly reducing greenhouse gases released during waste-to-energy processes.

- **Artificial Intelligence (AI) Optimization:**
  AI algorithms can optimize energy recovery plant operations by predicting optimal temperatures, fuel mix, and processing rates.
- **Circular Biochar Production:**
  Biochar, a carbon-rich material produced during pyrolysis, can be used as a soil amendment to improve agricultural productivity and sequester carbon, aligning with carbon-negative goals.
- **Emissions Control and Environmental Protection:**
  Energy recovery processes must incorporate effective emissions control measures to minimize the environmental impact. This involves:
  - **Flue Gas Treatment:**
    Flue gas treatment systems remove pollutants and particulates from combustion exhaust, preventing air pollution.
  - **Wastewater Treatment:**
    Wastewater generated during WTE processes is treated to remove contaminants and prevent water pollution.
  - **Continuous Monitoring and Compliance:**
    Continuous monitoring of emissions and adherence to environmental regulations ensure responsible energy recovery practices.
- **Policy and Regulatory Framework:**
  Supportive policies and regulations play a critical role in promoting energy recovery and ensuring its sustainability. This includes:
  - **Feedstock Tariffs and Incentives:**
    Providing financial incentives for the use of waste materials as feedstock for energy recovery, encouraging the adoption of this technology.
  - **Regulatory Standards and Emission Limits:**
    Establishing clear regulatory standards and emission limits for WTE facilities to protect environmental quality.
  - **Public-Private Partnerships (PPPs) and Grants:**
    Government support to WTE projects through PPP, offering grants and low-interest loans for infrastructure development.
  - **Research and Development Funding:**
    Investing in research and development to improve energy recovery technologies, enhance efficiency, and reduce environmental impacts. Innovation grants can be extended to companies investing in these areas.

By effectively implementing these components, energy recovery can play a significant role in transitioning India towards a circular economy, reducing waste disposal, minimizing reliance on fossil fuels, and promoting sustainable energy production.

3.6. LANDFILLING (COMMON TREATMENT FACILITY)

Globally, best practices emphasize that landfills should serve as a last resort within the waste management hierarchy. While the goal of circular economy is to minimize waste and maximize resource efficiency, there will always be some material (or fraction of the material) that reaches the end of its life cycle and require disposal. In instances where materials cannot undergo reuse, repair, upcycling, recycling, or are unsuitable for energy recovery, a responsible approach is essential.

Common treatment facilities, particularly landfills, prove to be the best choice for disposal of such waste to ensure the materials are disposed of in a safe and environmentally responsible manner. However, given that landfills are perpetual, robust environmental controls and long-term geotechnical stability are key considerations. With advancements in technologies facilitating reuse, recycling, and resource recovery, the necessity for landfill disposal gets minimized.

3.7. APPLYING DESIGN THINKING, EMBEDDED ENERGY, AND LIFE CYCLE COSTING FOR CIRCULAR ECONOMY SUCCESS

As we conclude this chapter, we turn to practical tools that enable businesses to operationalize circular principles effectively. By integrating design thinking, embedded energy and carbon analysis, and life cycle costing, companies can build sustainable, resilient models aligned with circular economy goals.

Through **Design Thinking,** businesses can apply creative approaches to design products and systems that support circularity throughout the entire lifecycle—from material selection to end-of-life management. This methodology goes beyond reimagining products alone, encouraging a redesign of the systems surrounding them to foster sustainable operations.

Embedded energy refers to the total energy used throughout a product's lifecycle, covering stages like material extraction, manufacturing, transportation, and disposal. This includes direct energy (such as fuel used in production), and indirect energy (like the energy needed to produce raw materials. Reducing embedded energy can give businesses a competitive edge by emphasizing efficient processes, renewable energy sources, and sustainable material choices.

Embedded carbon quantifies the total greenhouse gas emissions generated across a product's lifecycle, expressed in carbon dioxide equivalent (CO_2e). This includes emissions from extraction, production, transportation, and disposal, offering a clear measure of environmental impact. Minimizing embedded carbon aligns with corporate sustainability objectives and enhances brand reputation by reducing the carbon footprint.

Life cycle costing (LCC) provides a complete picture of ownership costs from production through end-of-life. LCC includes maintenance, disposal, and potential savings from recycling, offering a long-term view of economic value. By capturing these extended costs, LCC highlights the financial benefits of circular products and encourages investments that deliver both economic and environmental returns.

These strategies empower businesses to lower environmental impacts, develop circular systems, and promote sustainable consumption patterns, ultimately achieving circularity that benefits both the environment and the bottom line. Chapter 4, delves deeper into specific implementation strategies.

References:

1. Elisa Achterberg, Jeroen Hinfelaar, Nancy Bocken, "The Value Hill Business Model Tool: identifying gaps and opportunities in a circular network" (2016)

2. Leonidas Matsakas, Qiuju Gao, Stina Jansson, Ulrika Rova, Paul Christakopoulos, "Green conversion of municipal solid wastes into fuels and chemicals", Electronic Journal of Biotechnology (https://www.sciencedirect.com/science/article/pii/S0717345817300040)

3. https://www.ellenmacarthurfoundation.org/

4. Ekins, P., Domenech, T., Drummond, P., Bleischwitz, R., Hughes, N. and Lotti, L. (2019), "The Circular Economy: What, Why, How and Where", Background paper for an OECD/EC Workshop on 5 July 2019 within the workshop series "Managing environmental and energy transitions for regions and cities", Paris

Chapter 4

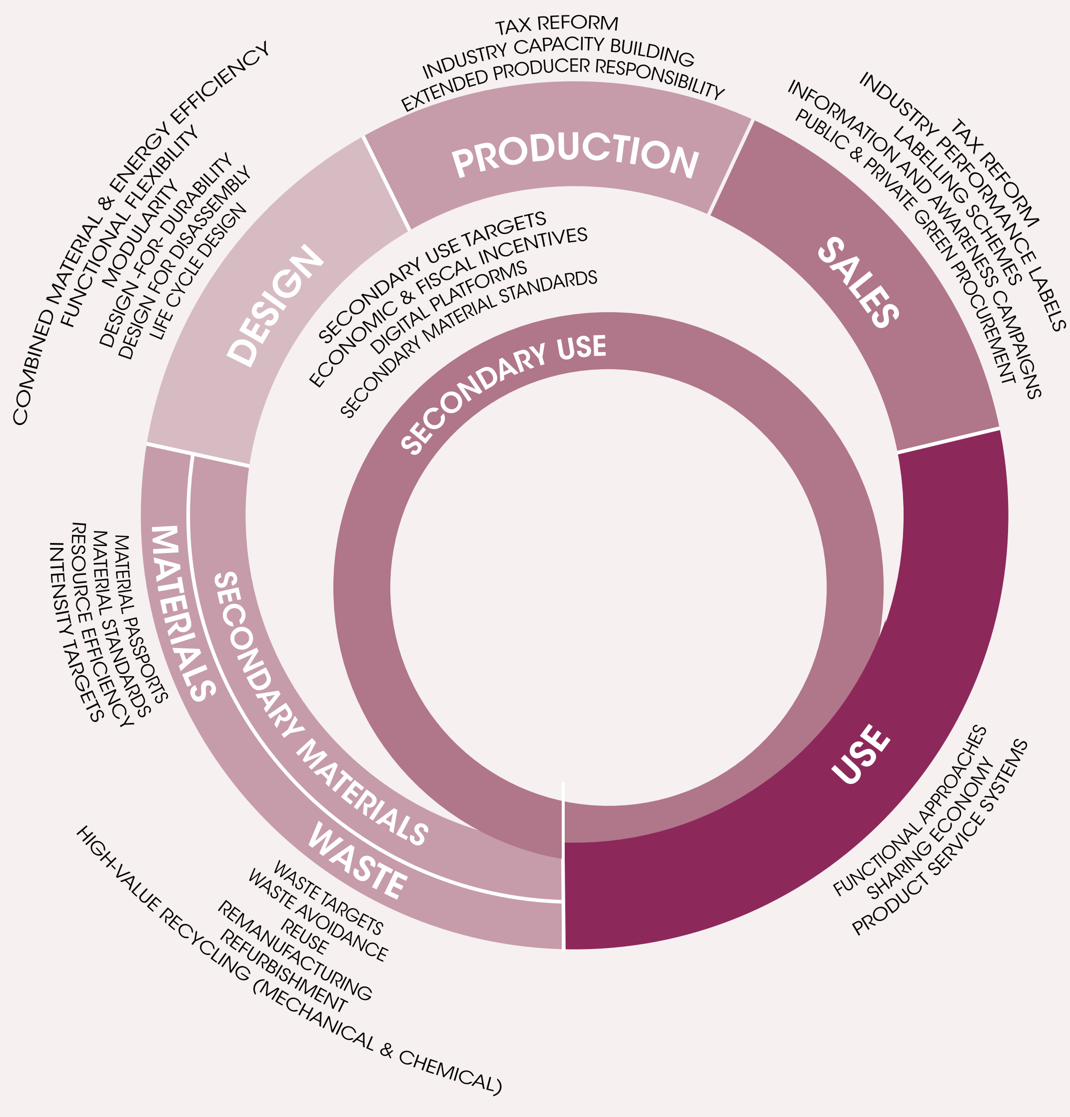
IMPLEMENTATION OF NCEF – *key strategies*

The NCEF provides a roadmap for making the transition to a Circular Economy, which is essential for addressing the challenges of climate change, resource scarcity, and pollution. The implementation of NCEF requires a number of key strategies, including: regulations, incentives, public awareness, investment in R&D, public-private partnerships etc. This chapter discusses each of these key strategies in detail and provide examples of how they can be implemented in practice. By implementing the key strategies discussed in this chapter, India can create the conditions necessary for a successful transition to a Circular Economy.

4.1. POLICY AND REGULATIONS

Policy interventions are essential for advancing the Circular Economy. These include regulatory standards, design requirements, extended producer responsibility, and public awareness initiatives. Figure 4-1 outlines key interventions at each stage, highlighting their role in facilitating the transition.

Figure 4-1: Policy Interventions to Support Circular Economy



Source: 'Policy Levers for a Low-Carbon Circular Economy' by Circle Economy, Nov 2017

The National Resource Efficiency Policy (NREP), introduced as a draft in 2019, is a comprehensive policy that aims to promote sustainable production and consumption patterns, enhance resource efficiency, and reduce the environmental impact of economic activities. The NREP includes measures to encourage the adoption of circular business models, such as product-as-a-service, leasing, and sharing, and promotes the use of recycled materials. It recommends various policy instruments to enhance resource efficiency across different life cycle stages. Figure 4.2 illustrates these recommendations:

Policy instruments for implementing resource efficiency at different life cycle stages

Life Cycle Stages	Policy Instruments
Extraction	• Taxes on virgin materials • Restrictions on mining of materials • Differential pricing • Pricing of virgin materials to intenrnalize cost to environment • Mandating good mining practices
Design	• Life Cycle Assessment based standards • Standards for longevity, durability etc. • Environment technology verification scheme • Research partnerships • Grants for Research and Development
Production	• Product Taxes • Emission or performance standards • Advisory services for SMEs • Soft loans to green SMEs
Consumption	• Deposit refund schemes • Pay-as-you throw pricing for waste collection systems • Product restrictions or bans • Labelling and certification schemes • Behaviourally informed interventions • Green Public Procurement
Recycling	• Tax benefits for recycled materials • Standards for recycled materials • Platforms to match supply and demand of secondary raw materials • Promoting industrial symbiosis • Grants for Research and Development
Waste Disposal	• Landfill and incineration taxes • Bans/restrictions on landfill • Information on dismantling products • Take-back schemes • Soft loans to construct waste disposal facilities

Regulations are an important tool for implementing the NCEF as they establish clear and standardized guidelines for industries, businesses, and individuals to follow in their pursuit of Circular Economy practices. This provides a common framework for sustainable operations. Strengthening existing regulations and introducing new regulations will help the transition. The next section provides an overview of related policies and regulations.

A. AN OVERVIEW OF EXISTING POLICIES AND REGULATIONS

Effective implementation of the NCEF relies on a strong foundation of supporting policies and initiatives. Table 4-1 provides a comprehensive overview of India's commitment to a Circular Economy. This table outlines the list of existing and evolving framework of key policies, rules, regulations, missions, schemes, and initiatives that support and promote circularity across various sectors. This compilation showcases the multifaceted approach adopted by the government to promote sustainable development and resource efficiency.

Table 4-1: Overview of Policy Landscape in India

	Policy / Rules & Regulations	Mission/Scheme/Initiative
Resource Extraction	**National Mineral Policy, 2019:** Emphasizes sustainable mining practices and the efficient utilization of mineral resources.	**Critical Mineral Mission** proposed in Union Budget 2024-25 for domestic production, recycling of critical minerals, and overseas acquisition of critical mineral assets. **National Solar Mission** aims to establish India as a global leader in solar energy and to reduce country's reliance on fossil fuels. This mission helps reduce the environmental impact associated with mining and extraction of fossil fuels. **Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) Scheme** aims to significantly increase EV adoption (eg. Proportion of EV sales to 30% in private cars and 70% in commercial vehicles) and to reduce dependence on fossil fuels.
Design	**National Design Policy, 2007:** Promotes eco-friendliness, ecology, and sustainability as key criteria for good design. It encourages the use of recycled and renewable materials, and emphasizes product life extension.	**National Mission** on Sustainable Habitat (NMSH) with five thematic areas, namely (i) Energy and Green Building, (ii) Urban Planning, Green Cover and Biodiversity, (iii) Mobility and Air Quality, (iv) Water Management, and (v) Waste Management.
Production/Manufacturing	**National Steel Policy, 2017:** Promotes the use of scrap in steel production to enhance resource efficiency. **National Policy on Biofuels, 2018:** Promotes the use of biomass and waste for biofuel production. **Make in India, 2014:** This initiative aims to boost domestic manufacturing while promoting resource efficiency and sustainable practices. It encourages the adoption of clean technologies and resource-efficient processes.	**Zero Defect Zero Effect (ZED) Scheme:** This scheme promotes the adoption of quality management systems and environmentally friendly practices in manufacturing.

	Policy / Rules & Regulations	Mission/Scheme/Initiative
Consumption		**Bureau of Energy Efficiency Standards:** These standards set energy efficiency requirements for various appliances and equipment, promoting energy conservation and reducing resource consumption. **Task Force on Sustainable Public Procurement in 2018:** While no comprehensive legislation exists, the government is increasingly promoting sustainable procurement practices. The Ministry of Finance set up a Task Force on Sustainable Public Procurement in 2018 to develop guidelines and promote green procurement in government agencies.
End-of-Life	**Steel Scrap Recycling Policy, 2019:** This policy promotes the recycling of steel scrap to conserve resources and reduce environmental impact. **Ash Utilization Notification, 2021:** aims to achieve 100% utilization of ash generated from coal and lignite-based thermal power plants; mandates thermal power plants to achieve 100% utilization of current ash generation in a 3 to 5-year cycle and legacy ash in 10 years. **Plastic Waste Management Rules, 2016 (amended 2018, 2021, 2022, and 2024):** Focuses on phasing out single-use plastics, promoting alternatives, and implementing EPR for plastic producers. **E-Waste (Management) Rules, 2022 (amended 2023, 2024):** Aims to ensure environmentally sound management of e-waste through EPR and the establishment of proper collection and recycling infrastructure. **Bio-Medical Waste Management Rules, 2016:** Governs the generation, segregation, transportation, treatment, and disposal of biomedical waste.	**Swachh Bharat Abhiyan:** This national campaign, launched in 2014, focuses on sanitation and waste management, including source segregation, waste collection, and processing. It promotes resource recovery and recycling. **Voluntary Vehicle Fleet Modernization Program:** Launched in 2021, the program aims to reduce pollution and improve fuel efficiency by encouraging the scrapping of old, polluting vehicles in favor of newer, environmentally friendly ones. **Sustainable Alternative Towards Affordable Transportation (SATAT) Scheme:** Promotes extraction of economic value in the form of Compressed Bio Gas (CBG) and bio-manure from biomass, municipal waste, agriculture residue etc. **Draft National Resource Efficiency Policy (NREP) 2019:** aims to reduce reliance on virgin materials and enhance resource efficiency through recycling and reuse across seven major sectors: automotive, plastic packaging, building and construction, electrical and electronic equipment, solar photovoltaic, steel, and aluminum.

	Policy / Rules & Regulations	Mission/Scheme/Initiative
	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (amended several times including in 2023 and 2024): Regulates the management and transboundary movement of hazardous waste and mandates Extended Producer Responsibility (EPR) for different materials such as tyres, used oil, non-ferrous metals etc. **Hazardous and Other Wastes** (Management and Transboundary Movement) Amendment Rules, 2022 dated July 21, 2022 mandates EPR for manufacturers and importers of new tyres and for the importers of waste tyres. **Hazardous and Other Wastes** (Management and Transboundary Movement) Second Amendment Rules, 2023 dated September 18, 2023 (came into force from April 1, 2024) mandates EPR for Producers (manufacturers/ importers) of base oil/lubrication oil and importers of used oil. **DRAFT Hazardous and Other Wastes** (Management and Transboundary Movement) Second Amendment Rules, 2024 dated August 14, 2024 seek to introduce EPR framework for non-ferrous metals (may come into force from April 1, 2025). **Construction and Demolition Waste Management Rules, 2016:** Promotes recycling and reuse of construction and demolition waste. New set of Rules proposed in 2024, which will come into force from April 2025, mandates EPR. **Batteries (Management and Handling) Rules, 2022 (amended 2023):** Implements EPR for battery producers to ensure proper collection and recycling / refurbishment.	

	Policy / Rules & Regulations	Mission/Scheme/Initiative
	Solid Waste Management Rules, 2016: Focuses on municipal SWM, including segregation at source, composting, and bio-methanation. **Draft End-of-Life Vehicles (Management) Rules, 2024:** The draft Rules establish EPR for automobile manufacturers (producer of vehicles) starting in April 2025 to promote the environmentally appropriate disposal of End-of-Life Vehicles (ELVs). **Draft Liquid Waste Management Rules, 2024:** Focuses on environmentally sound management of wastewater (domestic/ industrial) including its reuse. The Rules shall come into force from October 1, 2025.	

Note: The policies and the initiatives listed above are further supported by numerous guidelines and Standard Operating Procedures (SOPs) that provide guidance/ instructions for implementation and ensure effective execution.

A. AN OVERVIEW OF EXISTING POLICIES AND REGULATIONS

Effective implementation of the NCEF relies on a strong foundation of supporting policies and initiatives. Table 4-1 provides a comprehensive overview of India's commitment to a Circular Economy. This table outlines the list of existing and evolving framework of key policies, rules, regulations, missions, schemes, and initiatives that support and promote circularity across various sectors. This compilation showcases the multifaceted approach adopted by the government to promote sustainable development and resource efficiency.

B. RECENT POLICY DEVELOPMENTS - SINCE THE LAUNCH OF 1ST EDITION NCEF IN 2023

The policy landscape surrounding Circular Economy in India is constantly evolving. Since the publication of the first edition of the NCEF in November 2023, the Government of India has continued to advance its commitment to circularity through the introduction of new policies and amendments to existing ones. This section provides an update on these key developments, highlighting the evolving policy landscape that supports India's transition to a Circular Economy. Some of the notable policy improvements or initiatives include:

- **Viksit Bharat:**
  In December 2023, the Prime Minister launched "Viksit Bharat @2047: Voice of Youth", an ambitious vision to transform India into a developed nation by its centenary of independence. This vision encompasses economic prosperity, social advancement, environmental sustainability, and effective governance. The Circular Economy plays a pivotal role in achieving "Viksit Bharat 2047" by promoting resource efficiency, job creation through new circular supply chains, and meeting sustainability and equity goals. Furthermore, integrating Circular Economy principles aligns with national priorities such as Aatma Nirbhar Bharat, Swachh Bharat, and Skill India.

- **Construction and Demolition Waste Management Rules, 2024 (Draft):**
  On July 29, 2024, the Ministry of Environment, Forest and Climate Change (MoEF&CC) notified the draft rules which will come into force on April 1, 2025. This comprehensive revision of the existing regulations strengthens measures for waste management and utilization, aligning them with Circular Economy principles. Key additions include EPR, environmental compensation, and a centralized online monitoring system for improved compliance assessment.

- **Extended Producer Responsibility for Used Oil:**
  The Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2023, came into force on April 1, 2024, introducing EPR for used oil. Producers (manufacturers/ importers) of base oil/ lubrication oil and importers of used oil are now obligated to recycle used oil by purchasing EPR certificates from registered recyclers.

- **Plastic Waste Management (Amendment) Rules 2024:**
  The amendment defines biodegradable plastics more rigorously, requiring them not only to degrade biologically but also to not leave behind any microplastics. This aims to prevent the release of harmful microplastics into the environment.

- **Extended Producer Responsibility for Non-Ferrous Metals (DRAFT):**
  To promote resource efficiency and reduce environmental impacts, MoEF&CC notified the draft "Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2024" on August 14, 2024. Effective April 1, 2025, these rules introduce a new EPR mechanism for non-ferrous metals. The notification requires that the products manufactured using non-ferrous metals like aluminium, copper, and zinc should contain certain quantities of recycled material. From FY 2027-28 and beyond, there will be a minimum requirement of 5% recycled content for all the aforementioned non-ferrous metal products including aluminium, copper, and zinc. This move by the policy aims to cut down reliance on primary resources and, subsequently, the environmental damages linked with extracting and processing raw metals. Recycled content requirements will increase gradually over the next few years: (a) FY 2029: The minimum recycled content for all non-ferrous metal products will be 10%; and (b) FY 2031: Targets are divided as per the product type, with 10% for aluminium products, 20% for copper products, and 25% for zinc products.

- **End-of-Life Vehicles (Management) Rules, 2024 (Draft):**
  The draft Rules will establish EPR requirements for automobile manufacturers (producer of vehicles) starting in April 2025 to promote the environmentally appropriate disposal of End-of-Life Vehicles (ELVs). The recycling of End-of-Life Vehicles refers to recycling of steel from End-of-Life Vehicles.

- **Liquid Waste Management Rules, 2024 (Draft):** MoEF&CC notified the draft "Liquid Waste Management Rules, 2024" which shall come into force from October 1, 2025. The Rules focus on environmentally sound management of wastewater including its reuse. The Rules address liquid waste, including wastewater, sludge, and faecal sludge. It aims to minimize waste, manage collection and treatment, and promote the reuse and safe disposal of treated wastewater and sludge. The Rules emphasize the importance of proper handling, treatment, and disposal of sludge to prevent environmental contamination.

The recent policy developments listed above reflect the government's commitment to promoting sustainable practices and transitioning to a Circular Economy. This commitment is further exemplified by the Union Budget 2023-24, which includes significant allocations for green initiatives.

GREEN INITIATIVES IN UNION BUDGETS 2023-24 AND 2024-25: KEY ALLOCATIONS & UPDATES

- **Energy Transition Budget**
  - **2023-24:** Allocated ₹35,000 crore to support green growth and energy transition.
  - **2024-25:** The overall budget for the Ministry of New and Renewable Energy (MNRE) was increased to ₹19,100 crore, up from ₹12,850 crore, to expand renewable infrastructure, reflecting continued focus on clean energy.
- **National Green Hydrogen Mission**
  - **2023-24:** Initial allocation of ₹19,700 crore to launch the mission, aiming to reduce carbon emissions and fossil fuel reliance.
  - **2024-25:** Annual allocation for the mission increased significantly from ₹100 crore to ₹600 crore to accelerate green hydrogen production and innovation, positioning India as a global player in hydrogen technology.
- **Battery Energy Storage Systems (BESS)**
  - **2023-24:** Supported with Viability Gap Funding to establish 4,000 MWh of energy storage capacity.
  - **2024-25:** Allocation of ₹96 crore for BESS projects, continuing the push for renewable energy storage solutions to enhance grid stability and reliability.
- **Biogas and Bio-CNG Initiatives**
  - **2023-24:** Dedicated ₹10,000 crore to establish 300 community-based biogas plants and 200 bio-CNG plants, with a focus on urban areas.
  - **2024-25:** No new allocation details specified, though waste-to-energy projects remain a priority under other green energy schemes.
- **EV Infrastructure and PM E-DRIVE Scheme (New in 2024-25)**
  - **2024-25:** A major new allocation of ₹109 billion to support the electric vehicle (EV) sector, with specific subsidies for e-two and three-wheelers, e-ambulances, and e-trucks. Additionally, ₹43.91 billion is designated for public transport agencies to acquire over 14,000 electric buses, emphasizing green mobility infrastructure.
- **Green Credit Programme**
  - **2023-24:** Introduced as a market-based initiative to incentivize eco-friendly actions across sectors, including waste management, tree plantation, and water conservation.
  - **2024-25:** Continued emphasis on this program, though without a specific new allocation, aiming to strengthen green markets through tradable environmental credits.
- **PM-PRANAM Initiative (New in 2024-25)**
  - **2024-25:** Launched to promote balanced fertilizer use and reduce agricultural environmental impact. Funded by savings from reduced chemical fertilizer subsidies, with 50% of these savings transferred as grants to compliant states and union territories.

C. STRENGTHENING OF EXISTING REGULATIONS

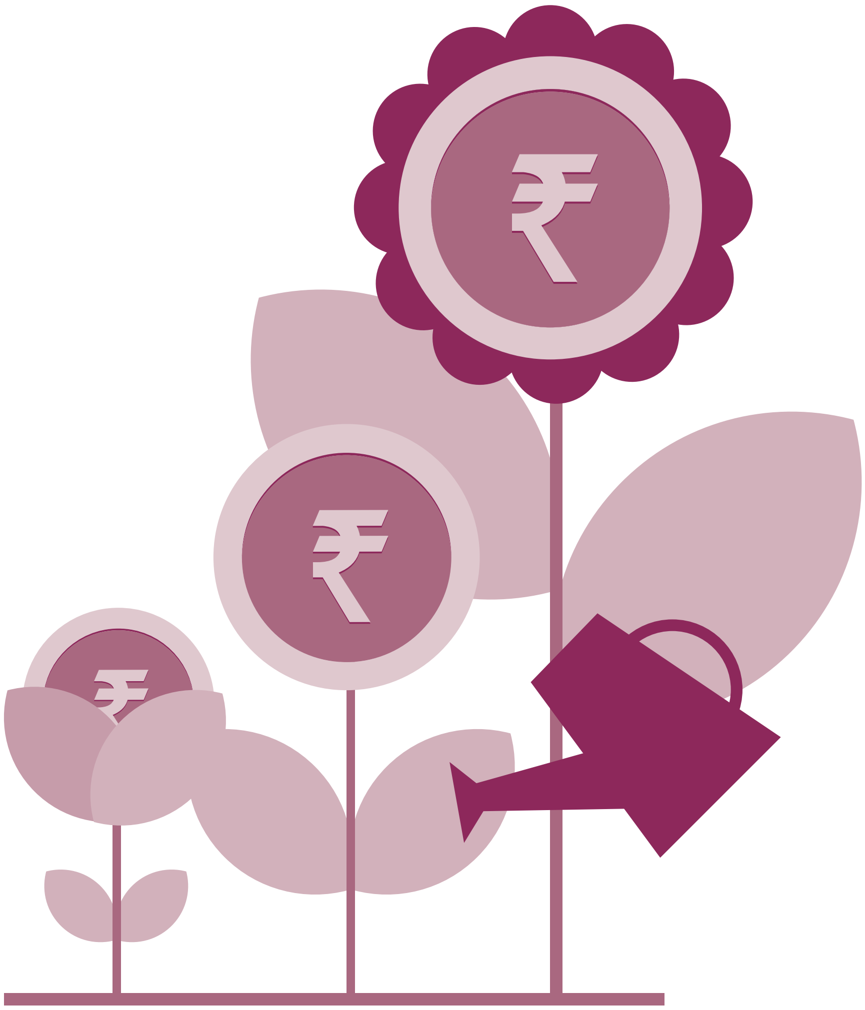
- **Extended producer responsibility (EPR) schemes:** EPR schemes require producers to be responsible for the end-of-life management of their products. This encourages design for durability, reparability, and recyclability, ultimately reducing waste generation. The existing scope of EPR may be expanded to many other sectors, in a phase-wise manner.
- **Green Credits:** The list of eligible activities under green credits program may be revised periodically to include all the Circular Economy initiatives by different businesses.
- **Ban on single-use products:** The scope of existing ban on single-use plastics may be revised periodically to include more items under the ban. In addition, materials other than plastics, which are considered single-use products, may also be phased out or banned.
- **Waste Management Rules:** In addition to the existing rules related to municipal solid waste, hazardous waste, e-waste, plastic waste etc., new rules may be introduced to cover a wide range of waste categories (waste tyres, agricultural waste etc.).

D. INTRODUCTION OF NEW REGULATIONS

- **Public Procurement Policies:** Public procurement policies in India can be changed to give preference to products and services that are circular in design and production.
- **Recycled content mandates:** Recycled content mandates require products to contain a certain percentage of recycled materials. This can help to increase the demand for recycled materials and create markets for them
- **Prevention of greenwashing:** New regulation(s) may be introduced to combat greenwashing, where businesses falsely claim to be environmentally responsible. The regulations should ensure accurate and transparent reporting, ensuring that businesses back their claims with real initiatives/actions.
- **Product Design Standards:** Product design standards in India can be strengthened to require products to be designed for durability, reparability, and recyclability. In addition, 'eco-design' requirements can be set to require products to be designed to minimize their environmental impact throughout their life cycle.
- **Repair, Refurbishment, and Recycling Standards:** The recycling sector currently has significant unorganized activity, often operating without standardized practices. To ensure quality, safety, and a level playing field, stronger regulations are needed to enforce uniform recycling standards. This will help bring the informal sector into compliance, foster market development, and enhance trust in recycled products.
- **Eco-Labeling and Certification:** Introduce eco-labeling for products that meet Circular Economy standards, giving consumers a simple way to identify sustainable products. Certification programs can also promote transparency and accountability in Circular Economy practices.
- **Reporting on Circular Economy Performance:** Businesses may be mandated to report on their Circular Economy performance in a detailed manner. The existing reporting frameworks such as 'Business Responsibility and Sustainability Report (BRSR)' may be amended to include a section on Circular Economy performance.
- **Regulations to prevent planned obsolescence:** The government could introduce regulations to prevent planned obsolescence, which is the practice of designing products to fail prematurely.

The above list of regulations is only an indicative list to present an overview of different possibilities. New regulations may be introduced in consultation with different stakeholders, such as government agencies, industry associations, and environmental groups, with a common goal of achieving a Circular Economy.

4.2. INCENTIVES TO BUSINESSES



A. FINANCIAL INCENTIVES

- **Viability Gap Fund (VGF):**
  To accelerate the transition to a circular economy, government may consider providing VGF to support projects related to development of infrastructure such as recycling facilities and repair centres.
- **Grants and loans:**
  Governments can provide grants or loans to businesses to help them implement Circular Economy initiatives.
- **Loan guarantees:**
  Governments can provide loan guarantees to businesses to reduce their risk of borrowing money to invest in Circular Economy projects.
- **Reduced Import Tariffs on Sustainable Inputs:**
  To support businesses sourcing recycled or eco-friendly materials, governments could reduce tariffs on sustainable inputs, making them more accessible and affordable for businesses.

B. NON-FINANCIAL INCENTIVES

- **Public procurement:**
  Governments can give preference to businesses that offer Circular Economy products and services when making public purchases.
- **Awards and recognition:**
  Governments can give awards or recognition to businesses that are leading the way in promoting the Circular Economy.

- **Technical assistance and training:** Governments can provide technical assistance and training to businesses to help them implement Circular Economy practices.
- **Regulatory Simplification for Circular Businesses:** Streamlining permits, inspections, and regulatory requirements specifically for businesses engaged in recycling, repair, or reuse can reduce operational barriers and incentivize circular business models.
- **Resource Exchange Platforms:** Governments can support or establish online platforms where businesses can trade by-products, waste, or surplus materials, promoting industrial symbiosis and reducing resource waste.
- **Ecosystem Building through Business Clusters:** Developing Circular Economy business clusters or eco-industrial parks can foster collaboration, resource sharing, and innovation among businesses, enhancing efficiency and reducing costs.

4.3. PUBLIC AWARENESS ON CIRCULAR ECONOMY

A. PUBLIC EDUCATION CAMPAIGNS BY GOVERNMENT AND THE BUSINESSES

Public awareness is essential for the successful transition to a Circular Economy. The public needs to understand the importance of the Circular Economy, the benefits it offers, and the role they can play in making it happen. There are a number of ways to raise public awareness of the Circular Economy. Here are a few examples:

- **Public education campaigns:** Governments, businesses, and non-profit organizations can launch public education campaigns to raise awareness of the Circular Economy and its benefits. These campaigns can use a variety of channels, such as television, radio, social media, and print media.
- **Community events:** Community events, such as festivals and fairs, can be used to raise awareness of the Circular Economy and promote Circular Economy businesses and products.
- **Social media:** Social media platforms can be used to share information about the Circular Economy and to engage with the public on this issue.
- **Partnerships:** Governments, businesses, and non-profit organizations can partner together to raise public awareness of the Circular Economy. These partnerships can help to reach a wider audience and to deliver more effective messaging.

In addition to these general awareness-raising activities, it is also important to target specific audiences with tailored messages. For example, businesses need to understand the economic benefits of the Circular Economy, while consumers need to understand the environmental and social benefits. Here are some specific examples of public awareness campaigns and initiatives that are promoting the Circular Economy around the world:

- The Ellen MacArthur Foundation's "A New Plastics Economy" initiative is working to raise awareness of the problem of plastic pollution and to promote the transition to a Circular Economy for plastics.
- The European Commission's "Circular Economy Action Plan" includes a number of measures to raise public awareness of the Circular Economy, such as developing educational materials and launching social media campaigns.
- The United Kingdom's "Circular Economy Strategy" includes a number of measures to raise public awareness of the Circular Economy, such as working with businesses to develop Circular Economy products and services and launching public education campaigns.

These are just a few examples of the many ways that public awareness can be raised for the Circular Economy. By working together, governments, businesses, and non-profit organizations can create a more informed and engaged public, which is essential for the successful transition to a Circular Economy.

B. INTEGRATION OF 'CIRCULARITY' CONCEPT IN SCHOOL CURRICULUM

Incorporating circularity into the school curriculum is essential for several reasons. It helps students understand the pressing issues of climate change, resource scarcity, and pollution, and how the Circular Economy offers solutions to these challenges. Additionally, learning about circularity prepares students for the future job market, as the Circular Economy is generating new roles and opportunities across various sectors. It empowers students to make informed, sustainable choices in their purchases and lifestyles. By integrating circularity into education, students will build the values and habits needed for sustainable living.

4.4. INVESTMENT IN RESEARCH AND DEVELOPMENT FOR CIRCULAR ECONOMY

Investment in R&D for Circular Economy is essential for the transition to a more sustainable future. By investing in R&D, governments, businesses, and academia can help to develop the technologies and practices that support the Circular Economy and the solutions needed to reduce waste and pollution, improve resource efficiency, and create new economic opportunities.

By prioritizing R&D, India can position itself at the forefront of the global Circular Economy movement towards a more resource-efficient and environmentally conscious economy. Some of the areas where R&D investment is needed to support the transition to a Circular Economy in India include:

- **Product design:**
  R&D should facilitate design of products with modular components that can be easily replaced and design of appliances with built-in diagnostic tools that make it easier to identify and fix problems. R&D should also make 'material substitution' opportunities available to replace harmful raw materials with eco-friendly raw materials. R&D should also look into opportunities such as '3D-Printing' to reduce waste and minimize cost.
- **New materials and technologies:**
  Development of new materials and technologies can be used to create products that are more durable, repairable, and recyclable. Examples include self-healing materials, biodegradable and compostable materials, new recycling technologies etc. Also, development of new materials and coatings that are more resistant to corrosion, wear, and abrasion could extend the life of products such as cars, appliances, and tools.
- **Utilization of digital technologies:**
  R&D shall be carried to make best use of readily available technologies including artificial intelligence, internet of things, block chain etc. to enable Circular Economy through multiple means.
- **Industrial symbiosis opportunities:**
  R&D initiatives may focus on opportunities for industrial symbiosis, where one industry's by-products or waste can be used by another industry. For example, slag from copper industry can be used as aggregate in construction industry.
- **Expanding the range of materials for recycling:**
  R&D shall focus on developing technologies to extract as much resource as possible from different waste streams and enable a wide range of materials fit for recycling. In addition, R&D shall also focus on improving the quality of recycled materials.
- **Circular business models:**
  R&D should support the exploration and implementation of circular business models, including product-as-a-service, sharing platforms, and closed-loop supply chains, which prioritize resource efficiency and waste reduction.
- **Development of markets for recycled products:**
  R&D should focus on technological advancements to produce high-quality recycled products that are comparable to virgin products in terms of performance and cost. R&D should identify different means to develop sustainable markets for recycled products through various means such as product certification programs, recycled content mandates, environmental awareness etc.

4.5. PROMOTION OF PUBLIC-PRIVATE PARTNERSHIPS FOR CIRCULAR ECONOMY

Public Private Partnerships (PPPs) are partnerships between the public and private sectors to achieve common goals. PPPs can play an important role in promoting the Circular Economy by bringing together the resources, expertise, and innovation of both sectors. There are a number of ways that PPPs can be used to support the Circular Economy. PPPs can be used to:

- Develop and implement Circular Economy infrastructure and technologies
- Promote research and development of Circular Economy solutions
- Provide financial support for Circular Economy projects
- Raise awareness of the Circular Economy and its benefits

PPPs can play a significant role in accelerating the transition to a Circular Economy. By working together, the public and private sectors can develop and implement the solutions needed to create a more sustainable future. Here are some of the benefits of PPPs for the Circular Economy:

- **Increased investment:** PPPs can help to increase investment in Circular Economy projects. This is because PPPs can bring together the resources of both the public and private sectors.
- **Accelerated innovation:** PPPs can help to accelerate innovation in the Circular Economy. This is because PPPs can bring together the expertise of both the public and private sectors.
- **Shared risk:** PPPs can help to share the risk of Circular Economy projects. This is because the public and private sectors can share the costs and benefits of these projects.
- **Increased public awareness:** PPPs can help to increase public awareness of the Circular Economy and its benefits. This is because PPPs can involve a wide range of stakeholders, including businesses, governments, and non-governmental organizations.

Here are some examples of PPPs that are supporting the Circular Economy around the world:

- In the Netherlands, the Circular Economy Covenant is a PPP between the government and businesses to reduce waste and increase the use of recycled materials. The Covenant has helped to reduce waste by 20% in the Netherlands.
- In the United Kingdom, the Ellen MacArthur Foundation's Circular Economy 100 is a global network of businesses, governments, and other organizations working to accelerate the transition to a Circular Economy. The network has helped to develop a number of PPP projects, such as the Circular Cities and Regions Initiative.
- In China, the Chinese government has launched a number of PPP initiatives to support the Circular Economy. For example, the government has partnered with businesses to develop Circular Economy industrial parks and to promote the use of recycled materials in the construction industry.

INDIA CURRENTLY LACKS DEDICATED PPPS FOCUSED ON CIRCULARITY, THOUGH SOME WASTE MANAGEMENT PROJECTS INCORPORATE PRINCIPLES LIKE RESOURCE RECOVERY AND RECYCLING. EXPANDING PPPS IN THE CIRCULAR ECONOMY HOLDS IMMENSE POTENTIAL, AND IMMEDIATE ATTENTION TO THESE COLLABORATIONS CAN DRIVE SUSTAINABLE RESOURCE MANAGEMENT.

4.6. CIRCULAR ECONOMY KNOWLEDGE NETWORK

The government could create a knowledge network to share information and best practices on Circular Economy. The knowledge network (hosted by a not-for-profit industry led organization such as CII) should act as a platform for sharing knowledge and best practices on the Circular Economy. It could bring together stakeholders from different sectors, including government, business, academia, and civil society, to collaborate on the development and implementation of Circular Economy solutions. The knowledge network could enable Circular Economy in India in multiple ways, some of which are mentioned below:

- **Innovation in the Circular Economy:**
  The network could provide a platform for businesses and researchers to share ideas and collaborate on the development of new Circular Economy technologies and solutions. This would help to accelerate the pace of innovation in the Circular Economy.
- **Capacity building and training:**
  The network could provide training and capacity building opportunities to policymakers, businesses, and other stakeholders on the Circular Economy. This can help to ensure that they have the skills and knowledge they need to develop and implement Circular Economy policies and programs.
- **Development of skilled workforce:**
  The network could provide training and education programs to help workers develop the skills they need to work in the Circular Economy. This would help to create a pool of skilled workers that businesses can draw from as they transition to a Circular Economy.
- **Development of new markets for recycled materials and circular products:**
  The network could help to raise awareness of the benefits of using recycled materials and circular products. This could help to create new markets for these materials and products.
- **Partner with other knowledge networks:**
  The network could partner with other Circular Economy knowledge networks across the globe to share knowledge and resources on the Circular Economy.
- **Regular events and workshops:**
  The network could organize regular events and workshops to bring together stakeholders from different sectors to learn from each other and to collaborate on Circular Economy projects.
- **Awareness on Circular Economy:**
  The network could raise awareness on Circular Economy through various means including: conducting workshops at educational institutions; developing and disseminating educational resources such as reports, infographics, and videos; sharing educational content on social media etc.
- **Policy advocacy:**
  The network, composed of members from different stakeholder groups, could leverage learnings from workshops, knowledge sharing sessions, and other knowledge networks across the globe to identify the need for revision of existing policies or for creation of new ones to accelerate the transition to a Circular Economy. The network could engage with policymakers to advocate for Circular Economy policies and programs by providing inputs on the development and implementation of different policies and programs.

4.7. CIRCULAR ECONOMY PARKS

Circular Economy parks, also known as eco-industrial parks or resource recovery parks, may be established in different parts of the country. The Circular Economy parks are designated areas designed to promote resource efficiency and waste reduction through collaborative efforts among businesses and other stakeholders. These parks provide a physical infrastructure and supportive environment for businesses to adopt Circular Economy principles, such as:

- **Industrial Symbiosis:**
  Fostering synergies between industries to exchange waste, byproducts, or energy resources, reducing the need for external inputs and minimizing disposal.
- **Circular Supply Chain Management:**
  Promoting closed-loop systems where products are designed for disassembly, reuse, or remanufacturing, extending their lifespan and reducing reliance on virgin materials.
- **Waste Valorization:**
  Investing in technologies and processes to transform waste streams into valuable resources, creating new economic opportunities and reducing environmental impact.

Circular Economy parks offer a range of benefits to businesses, including:

- **Cost Savings:**
  By reducing resource consumption, waste disposal costs, and energy expenses, businesses can improve their profitability and sustainability.
- **Access to Shared Infrastructure:**
  Parks often provide shared facilities, such as waste treatment plants, recycling centers, or renewable energy sources, which can reduce individual capital investments and operational costs.
- **Knowledge Sharing and Collaboration:**
  The proximity of businesses within a park facilitates collaboration, knowledge exchange, and the development of innovative solutions.
- **Regulatory Support and Incentives:**
  Governments often provide incentives, to businesses operating in Circular Economy parks, encouraging adoption of sustainable practices.

Examples of Circular Economy parks around the world include:

- **Kalundborg Symbiosis in Denmark:**
  This renowned eco-industrial park has operated for over 50 years, showcasing successful examples of industrial symbiosis, with multiple industries exchanging waste and energy streams.
- **Eco-Industrial Park of As Pontes in Spain:**
  This park focuses on the valorization of waste from the pulp and paper industry, turning it into valuable products such as biofuel and biofertilizers.
- **Circular Economy Park of the Eastern Metropolitan Region in Thailand:**
  This park aims to reduce waste generation and promote resource recovery in the region, involving various industries, including food processing, electronics, and construction.

Upcoming Circular Economy Parks (CEPs) in Maharashtra will be strategically located across Aurangabad, Ratnagiri, near Pune, and Nagpur, each dedicated to specific waste streams: shipbreaking in Ratnagiri, e-waste and auto parts near Pune, steel scrap in Aurangabad, and a multi-purpose national hub in Nagpur. Rajasthan is also advancing a CEP in Jaipur focused on recycling e-waste, plastics, and batteries. Telangana, in collaboration with Kitakyushu City, Japan, is setting a global precedent by developing eco-model cities to showcase sustainable urban planning. **Although these initiatives have been announced, not a single CEP has been established yet. Telangana and Rajasthan are expected to be among the first to establish CEPs.**

CONCEPTUAL DESIGN OF CEPs

Despite the immense nation-building potential of CEPs, India has only just begun to tap into this transformative approach. To scale this vision, CEPs can be developed as both cluster and mega models, tailored to the unique needs of each region. The following section explores conceptual frameworks for implementing cluster parks focused on specific waste streams, as well as larger, multi-purpose mega parks that serve as hubs for Circular Economy collaboration and innovation.

Circular Economy Parks (CEPs) in India can be envisioned at two complementary levels
Cluster and Unified (Mega) parks. While Cluster CEPs are location-specific hubs catering to the needs of particular industrial clusters, Unified CEPs function as large, multi-functional sites that drive circularity across multiple sectors at regional or a state level. Together, these two models create a cohesive framework for advancing sustainable resource management, fostering cross-sector collaboration, and promoting Circular Economy principles nationwide.

The following sections outline the distinct roles, structures, and benefits of the Unified and Cluster CEPs.

UNIFIED CEPS

Unified CEPs, or mega parks, are large-scale, multi-functional circular hubs that operate as central catalysts for circularity across an entire state or region. With a proposed area of 100-250 acres, these parks are designed to handle diverse waste streams from multiple industrial clusters, promoting cross-sector collaboration, advanced recycling technologies, and extensive educational outreach. Their scale and integrated structure position them as enablers of state-wide Circular Economy initiatives.

Further, these parks are designed to foster collaboration across industrial sectors and clusters. By creating opportunities for partnerships and resource sharing, these parks facilitate a circular ecosystem where waste from one sector can become an input for another, maximizing resource efficiency.

Design features

Unified CEPs are designed with a spatial progression, moving from public-facing areas to intensive recycling zones to ensure educational outreach, skill development, and operational efficiency:

- **Public Awareness and Educational Hub:**
  The entrance of the park serves as a community and educational space, welcoming school groups, students, and the general public to learn about Circular Economy principles. With museum displays, interactive exhibits, guided tours, and hands-on learning experiences, this area encourages public awareness and inspires future generations to embrace sustainability. It also includes spaces for start-up incubation to foster innovative ideas.
- **Skill Development and Incubation Zone:**
  Progressing inward, this zone focuses on skill development, vocational training, and incubation for Circular Economy startups. Equipped with training centers, R&D labs, analytical facilities, and collaborative workspaces, it supports workforce development and innovation, providing the skills and technology necessary to advance circular practices.

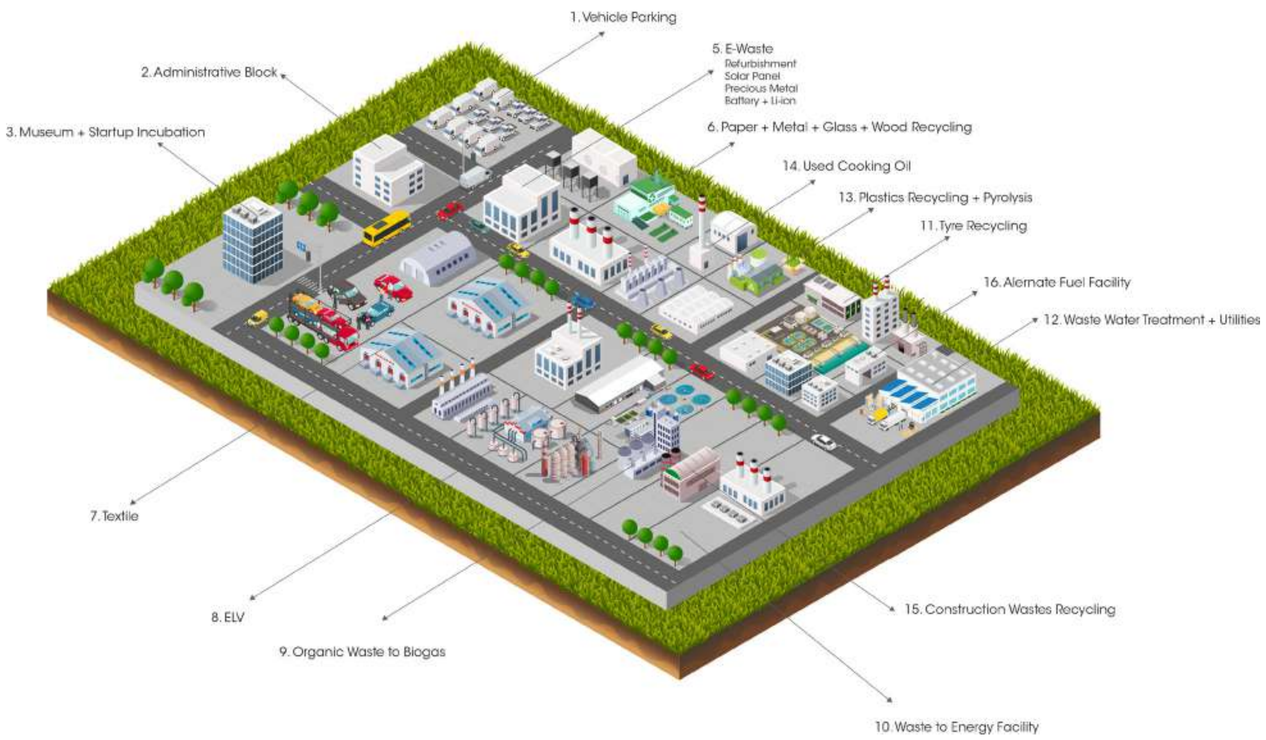
> GIVEN THE COMPELLING NEED AND VAST SCOPE FOR GROWTH, EVERY STATE SHOULD AIM TO ESTABLISH ITS OWN CE PARK, LEVERAGING A MIX OF PUBLIC-PRIVATE PARTNERSHIPS (PPPS) AND SUPPORT FROM STATE AND NATIONAL GRANTS TO DRIVE SUSTAINABLE DEVELOPMENT AND RESOURCE EFFICIENCY.

- **Basic Recycling Zone:**
  This intermediate zone handles non-intensive recycling processes, such as sorting, material recovery, and upcycling. Designed for testing and scaling Circular Economy innovations, it provides an ideal environment for piloting new recycling methods and business models, essential for material recovery and reducing waste.

- **Intensive Recycling and Processing Zone:**
  The core of the park is dedicated to intensive recycling and processing, including activities such as metal recovery, plastics reprocessing, and e-waste dismantling. This zone utilizes advanced recycling technologies and large-scale processing facilities to maximize resource recovery from complex waste streams, thus supporting circularity in various industrial sectors.

- **Renewable Energy and Sustainability Hub:**
  Integrated throughout the park, renewable energy solutions power the facilities, demonstrating the circular principles of sustainability and energy efficiency. Solar, wind, and bioenergy installations contribute to self-sufficiency and reduce the environmental footprint of recycling operations.

A conceptual layout of the park is presented below.



resustainability.com

CLUSTER CEPS

Cluster CEPs are designed as localized hubs tailored to specific industrial clusters within a state. Spanning 30-50 acres, these parks target industries in close proximity to promote circular practices on a focused scale. The primary aim of cluster parks is to serve the circular needs of a specific industry, facilitating streamlined waste management, recycling, and resource recovery aligned to the unique demands of the local industries. This approach will require multiple cluster CEPs to be developed in a state.

Key Features and Benefits:

Location-Specific Focus:
Cluster CEPs cater directly to the waste streams of a particular industrial cluster, such as automotive, electronics, textiles, or chemicals. This approach maximizes resource recovery and minimizes logistics, enhancing efficiency.

Efficient Land Use:
With a smaller footprint, cluster parks can be integrated within or near existing industrial zones, reducing transportation costs and emissions associated with waste handling and resource movement.

Targeted Recycling and Resource Recovery:
Each cluster park can specialize in a specific types of waste or recycling methods aligned with nearby industries, such as metal recovery, plastic recycling, or e-waste dismantling and achieve operational efficiencies.

> SUCCESSFUL CEPS CAN BE IMPLEMENTED VIA WELL-STRUCTURED PPP PROJECTS WITH STATE AND NATIONAL GRANT FUNDING. IN ADDITION TO LAND AND PERMITS, GOVERNMENT-BACKED VIABILITY GAP FUNDING (VGF) TO HELP OFFSET INITIAL COSTS AND MARKET-BASED MECHANISMS TO ENCOURAGE PRIVATE SECTOR INVOLVEMENT, PRODUCT OFFTAKE AGREEMENTS TO STABILIZE DEMAND ARE ESSENTIAL FOR CREATING CONSISTENT REVENUE STREAMS FOR RECYCLED MATERIALS.

4.8. INSTITUTIONAL FRAMEWORK

To create an improved institutional framework around enabling the Circular Economy at scale in India, the following areas of focus are proposed:

- **Establish a clear vision and roadmap for the Circular Economy.** This should be done through a consultative process that involves all stakeholders, including government, businesses, academia, and civil society.
- **Identify and address key institutional gaps.** This may include things like establishing new institutions, reforming existing ones, and improving coordination between different agencies.
- **Invest in capacity building.** This is needed to ensure that all stakeholders have the knowledge and skills necessary to implement the Circular Economy.
- **Create a supportive environment for innovation.** This could include things like providing funding for research and development, and providing viability gap funding for businesses that develop new circular technologies and business models.

Here are some specific steps that can be taken:

1. **Establish a National Circular Economy Authority (NCEA).** The NCEA would be responsible for developing and implementing the national Circular Economy strategy. It would also coordinate the activities of different ministries and agencies, and provide support to businesses and other stakeholders.
2. **Reform the existing regulatory framework.** The current regulatory framework is not conducive to the Circular Economy. For example, there are no extended producer responsibility schemes in place for most products. The NCEA should work with other ministries and agencies to reform the regulatory framework and make it more supportive of the Circular Economy.
3. **Invest in research and development.** The NCEA should invest in research and development of new circular technologies and business models. This could be done through public-private partnerships or by providing grants to academia and businesses.
4. **Create a Circular Economy fund.** The government should establish a Circular Economy fund to provide financial support to businesses that are developing and implementing circular practices. This fund could be used to provide loans and grants to businesses.
5. **Develop a national Circular Economy curriculum.** The NCEA should work with the Ministry of Education to develop a national Circular Economy curriculum for schools and universities. This will help to ensure that all students learn about the Circular Economy and its importance.

By taking these steps, we can create an improved institutional framework that will enable the Circular Economy to thrive in India.

The structure of a National Circular Economy Authority (NCEA) for India could be as follows:

- **Governing body:** The governing body would be responsible for setting the overall direction of the NCEA and overseeing its implementation. It would be composed of representatives from government, businesses, academia, and civil society.

- **Executive committee:** The executive committee would be responsible for implementing the decisions of the governing body and managing the day-to-day operations of the NCEA. It would be composed of technical experts and representatives from key stakeholders.
- **Technical committees:** The technical committees would be responsible for providing technical expertise to the NCEA on specific aspects of the Circular Economy. They would be composed of subject matter experts from government, businesses, academia, and civil society.
- **Secretariat:** The secretariat would be responsible for providing administrative and technical support to the NCEA. It would be composed of permanent staff and seconded staff from government and other stakeholders.

The NCEA could be structured as an autonomous body under the Ministry of Environment, Forest and Climate Change. This would give it the independence and flexibility required to carry out its mandate effectively.

The NCEA would have a number of functions, including:

- Developing and implementing the national Circular Economy strategy.
- Coordinating the activities of different ministries and agencies on the Circular Economy.
- Providing support to businesses and other stakeholders in implementing the Circular Economy.
- Promoting research and development on the Circular Economy.
- Raising awareness and understanding of the Circular Economy.

The NCEA would play a vital role in enabling the transition to a Circular Economy in India. By providing a central platform for coordination and collaboration, and by providing support to businesses and other stakeholders, the NCEA can help to accelerate the adoption of circular practices across all sectors of the economy.

In addition to the above, the NCEA could also have the following functions:

- Developing and implementing standards for recycled materials and products. This would help to ensure that recycled materials and products meet the required quality standards.
- Providing financial incentives to businesses that adopt circular practices. This could be done through grants, viability gap fund etc.
- Promoting the development of Circular Economy infrastructure. This could be done by providing funding for the construction of waste management facilities, recycling plants, and other infrastructure that is needed to support the Circular Economy.
- Regulating the use of resources and the disposal of waste. This would help to ensure that resources are used efficiently and that waste is disposed of in a sustainable manner.

The NCEA could, therefore, play a pivotal role in mainstreaming the Circular Economy in India.

In addition to the above, it is also important to ensure that the institutional framework is inclusive and equitable. This means that all stakeholders, including marginalized communities, should have a voice in the development and implementation of the Circular Economy strategy. It is also important to ensure that the benefits of the Circular Economy are shared equitably. By creating an improved institutional framework that is inclusive and equitable, we can ensure that the Circular Economy is a success for all of India.

References:

1. Policy Levers for a Low-Carbon Circular Economy' by Circle Economy, Nov 2017
2. Resource Efficiency and Circular Economy in the Indian Context - Module 3 by The European Union – Resource Efficiency Initiative (EU-REI)

PART 02

Circular Economy Action Plan for Focus Materials

Chapter 1

CIRCULAR ECONOMY ACTION PLAN *for* FOCUS AREAS

1.1. INTRODUCTION

In alignment with NITI Aayog's focus areas, the NCEF has identified 16 key focus areas/materials for targeted action. These materials, which include plastics, construction and demolition waste, and textile waste (added to NITI Aayog's March 2021 list), were selected due to their widespread use, significant environmental impact, and potential for resource recovery. Prioritizing these materials promises substantial benefits in waste reduction, resource conservation, and environmental protection. The list of 16 focus areas/materials include:

- Municipal Solid Waste
- Domestic Wastewater
- Industrial Wastewater
- Scrap Metals (Ferrous & Non-Ferrous)
- Electronic Waste
- Lithium Ion Batteries
- Solar Panels
- Gypsum
- Toxic and Hazardous Industrial Waste
- Used Oil
- Agriculture Waste
- Tyre and Rubber
- End of Life Vehicles (ELV)
- Plastics
- Construction & Demolition Waste
- Textiles

1.2. KEY ELEMENTS IN THE CIRCULAR ECONOMY FRAMEWORK FOR FOCUS MATERIALS

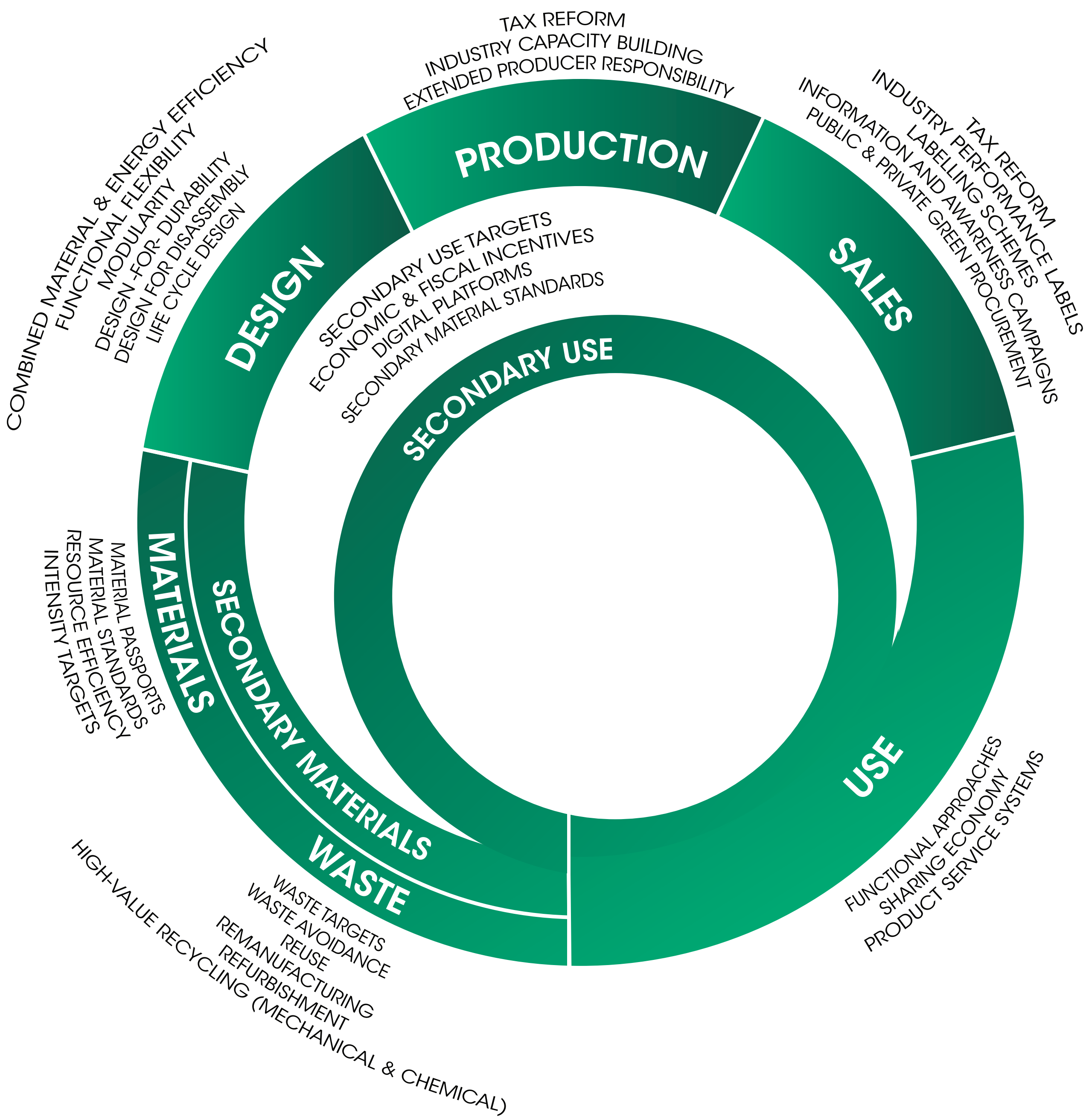
Listed below are possible key elements for any focus material, encompassing a range of strategies and considerations aimed at circular economy:

- **Material Flow Analysis and Lifecycle Assessment:** Conducting comprehensive material flow analysis and lifecycle assessments provides a clear understanding of the environmental impact and resource flows associated with focus materials. This informs decision-making and helps identify areas for improvement.
- **Product Design for Circular Economy:** Design plays a crucial role in ensuring focus materials are conducive to circularity. Products should be designed to be durable, reusable, reparable, and refurbishing and remanufacturing-friendly. This can be done by using high-quality materials, designing for modularity, and making it easy to disassemble and repair products.
- **Incentives for Circular Practices:** Providing economic incentives, such as viability gap fund/grants encourages businesses to adopt circular practices and invest in technologies that support the sustainable management of focus materials.
- **Extended Producer Responsibility (EPR):** EPR schemes require producers to take responsibility for the end-of-life management of their products. This helps to ensure that products are collected and recycled properly. The scope of EPR
- **Reuse Standards and Guidelines:** Establishing clear standards and guidelines for the reuse of products/materials is essential to ensure that reused products/materials meet quality and safety standards.
- **Collection and sorting infrastructure:** In order to recycle materials effectively, there needs to be adequate collection and sorting infrastructure in place.
- **Recycling targets:** Recycling targets set ambitious goals for the amount of a particular material that should be recycled. This helps to increase the demand for recycled materials and create a more circular market.
- **Recycling Infrastructure and Technologies:** Adequate recycling infrastructure with advanced recycling technologies play a key role in effectively processing and extracting value from the materials.
- **Certification and Standards for Recycled Content:** Establishing certification and quality standards for products containing recycled focus materials ensures that they meet specified criteria, instilling confidence in consumers and supporting the growth of circular markets.
- **Market Development and Demand Generation:** Stimulating demand for products made from recycled or reused focus materials is crucial. This involves creating markets, incentivizing procurement practices, and educating consumers about the benefits of choosing products with circular content.
- **Research and Development (R&D):** Investing in R&D focused on focus materials is essential for driving innovation in recycling technologies, product design, and materials science. This leads to more efficient and sustainable approaches to managing these materials.
- **Stakeholder Engagement and Collaboration:** Engaging stakeholders from government, industry, academia, and civil society fosters collaboration, knowledge exchange, and collective action towards sustainable focus material management.
- **Regulatory Framework and Enforcement:** A robust regulatory framework with clear enforcement mechanisms ensures compliance with circular economy principles. This includes setting targets, standards, and penalties for non-compliance.

1.3. POLICY INTERVENTIONS TO SUPPORT CIRCULAR ECONOMY

Policy interventions play a critical role in supporting the transition to a circular economy. These interventions include regulatory standards, design requirements, extended producer responsibility, public awareness etc. **Figure 1-1** below presents the key policy interventions at each stage which can play a critical role in supporting the transition to a circular economy.

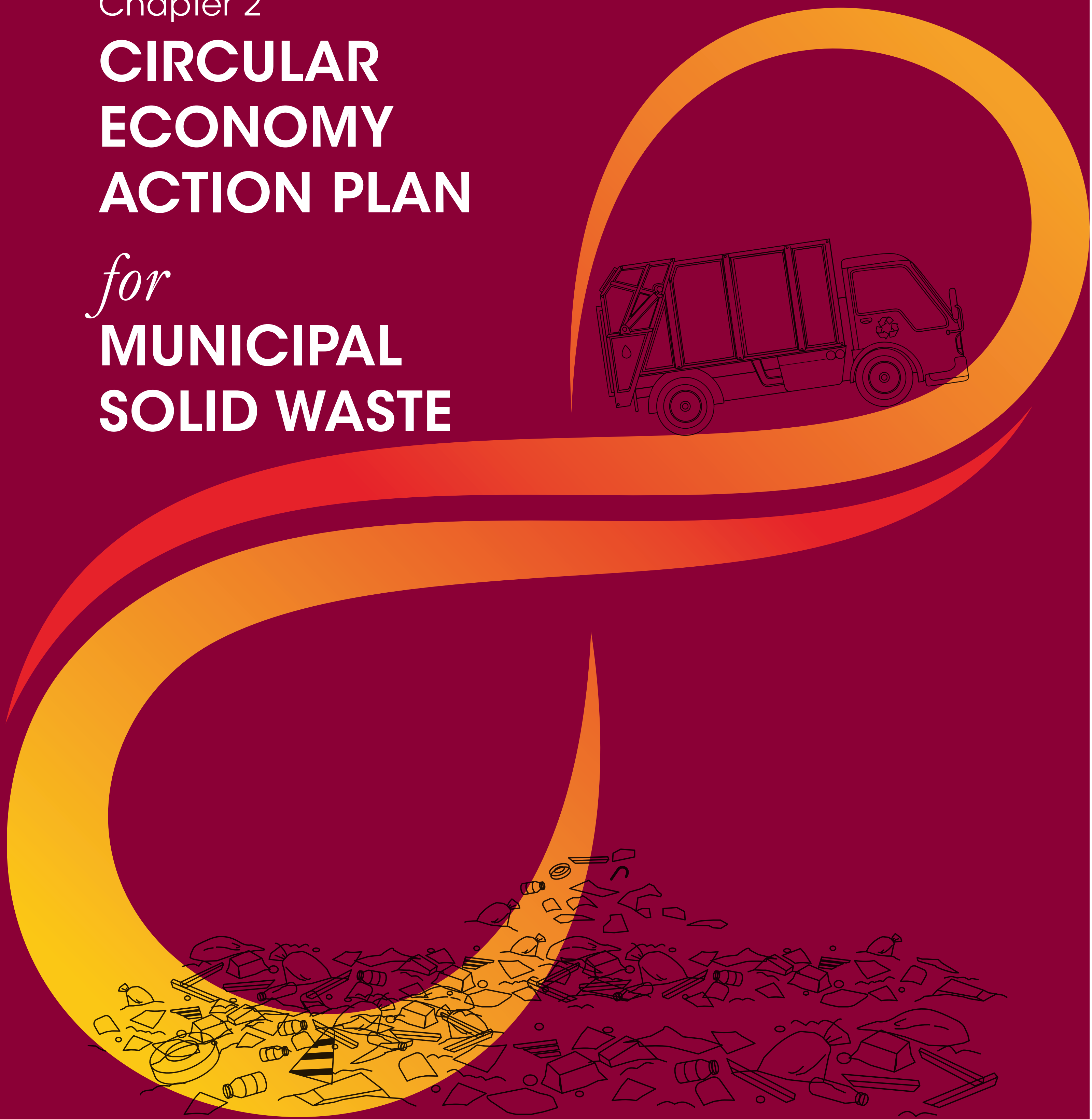
Figure 1-1: Policy Interventions to Support Circular Economy



Source: 'Policy Levers for a Low-Carbon Circular Economy' by Circle Economy, Nov 2017

Chapter 2

CIRCULAR ECONOMY ACTION PLAN *for* MUNICIPAL SOLID WASTE



2.1. INDUSTRY OVERVIEW

Every year, more than 2 billion tonnes of Municipal Solid Waste are generated worldwide. This number is expected to jump to 3.4 billion tonnes over the next 30 years, posing its management as a major governance challenge. In Lower Middle-Income Countries like India, the MSW is projected to double in volume by 2050. At present, India generates roughly 50 to 62 million MT per year. Central Pollution Control Board estimates the average per capita waste in the country to be 123.45 grams per day. However, urban inhabitants have a waste footprint of 330 – 550 grams per day. India's urban population is expected to grow from the current 377 million to 600 million by 2030 and to 814 million by 2050. Accordingly, MSW is set to generate 165 million MT by 2030 and 436 million MT by 2050 in India.

In India, dry waste comprises about 33% to 35% of the MSW. This dry fraction which comprises nearly 46% plastics is regarded as the most valuable stream owing to the high economic value of recyclables. About 50% of MSW comprises of wet waste. In other words,nearly 150–250 kg of organic carbon is present in every tonne of waste, and the microorganisms transform it into landfill gas consisting of 45-60% Methane and 40-60% Carbon dioxide by anaerobic processes. This will translate to 41.09 million tonnes of annual GHG emissions from MSW by 2030.

Improper MSW management leads to a 'triple-planetary crisis' as landfills and open dumps contribute to 4% of global GHG emissions and airborne pollutants leading to climate change, causing irreversible damage to local biota accelerated biodiversity loss, and significant pollution leading to the death of 400,000 to 1 million people every year globally. Damage caused by mishandled plastics to the marine environment alone is estimated at 13 billion USD annually. International Labor Organization (ILO) estimates that 40% of all people in the informal sector globally were in roles related to waste management and sanitation. As per the Global Waste Management Outlook 2024, embracing circular economy in solid waste management can have significantly reduce GHG emissions, potential loss of species, and human health from waste relative to 2020 by a factor of 154%,79%, and 153% respectively.

Over the past few years, there has been a rapid shift in the strategic direction of waste management in the country. The flagship programmes of the Government of India – the Swacch Bharat Mission, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and the Smart Cities programme – have all created an enabling environment to drive the transformation towards recycling and resource recovery.

The present status of solid waste D2D collection, source segregation, and treatment plants/capacity are maintained in the Swacch Survekshan website. Swachh Survekshan – India's benchmarking and ranking tool – has also evolved to capture the measures that take a city towards source segregation, material reprocessing and zero-landfills.

As per the latest figures by GoI, India has close to 10,000 solid waste processing facilities to cater to various MSW fractions which include – mixed domestic waste, dry wastes, wet wastes, domestic hazard wastes, and sanitary wastes. The current door-to-door collection and waste segregation throughout the country stand at 88.29% and 94.6% respectively.

2.2. CURRENT STATUS

Treatment and processing technologies adopted by various states and UTs in India include **windrow composting, vermicomposting, pit composting, biomethanation, organic waste convertors, RDF / pelletization plants, Material Recovery Facilities (MRFs), Waste-to-energy (WtE) plants, incinerators,** etc. As per official figures, India processes 54% of the total waste and disposes off 24% in sanitary landfills. Thebalance, a gap of 22% (incl. the 8% uncollected waste) amounts to 37,373 TPD. As per the National Action Plan for MSW management, waste recycling is to be prioritised over waste processing, waste-to-energy (WtE), and landfilling.

The estimated figures on different recyclables projected by the Ministry of Housing & Urban Affairs for India MSW are given in the table below. At present, India recoversslightly over 50% of its dry waste streams or roughly only 19% of its MSW is recycled which is on par with the global average. However, these figures do not account for rejects and leakages which is very significant for India.

Table 2-1: Recyclables in Municipal Waste

Waste	MSW share	Daily generation (TPD)	Recovery	Qty (TPD)
Plastic	15%	21,750.00	60%	13,050.00
Paper & cardboard	7%	10,150.00	60%	6,090.00
Glass & Ceramics	1%	1,450.00	20%	290.00
Metal	1%	1,450.00	50%	725.00
Textiles	5%	7,250.00	30%	2,175.00
Tyres & Rubber	1%	1,450.00	80%	1,160.00
Others	3%	4,360.15	33%	1,455.08
Total Dry Waste	33%	47,860.15	-	24,945.08

Source: Circular Economy in Municipal Solid & Liquid Waste, MoHUA 2021

The Solid Waste Management (SWM) Rules of 2016, notified by the Ministry of Environment, Forest and Climate Change (MoEF&CC), created a new mandate for source-segregation of waste into 3 streams namely biodegradable, dry wastes, and domestic hazardous so that it can be turned into wealth via recovery, reuse and recycling.

The Waste Wise Cities document prepared by the Center for Science and Environment and NITI Aayog has identified best practices and innovations in Solid Waste Management in selected Indian cities/towns right from source segregation to zero landfill city model, that can be replicated elsewhere. Some of the recent emerging global trends in MSW management include:

Table 2-2: Global Trends in MSW Management

Parameter	Feature	Description
Collection & Transport	Web-based GIS	Information regarding the most reliable routes, number of residents, number of contracts, their validation, and potential frauds.
	GSM-based Waste Bin Monitoring	Sensors are placed in public garbage bins to detect a certain optimum level of waste. As the garbage reaches the threshold level, indication will be transferred to the controller which will further give indication to driver of collection truck for emptying bin urgently
Segregating & Sorting	Automatic segregating system	Optical sorting, eddy current sorting, multi compartment bins, and optical sensor based sorting technologies
	Automatic Bottle Sorting System	Comprised on sizing, aligning and clearing machine, along with color identification sensors.
Disposal	Micro-turbine	Technology Modern landfills have microturbines for generation of electricity from landfill gas
	Fuel Cell	Technology Energy from fuel is converted into electrical energy in an electrochemical cell is called fuel cell. Fuel supply and oxidizing agent react to generate electricity.
	Bioreactor technology	Enhance the rate of decomposition, circulation of leachate and increase in the growth of microbes, which decompose municipal waste. The waste is then dried by Conventional landfill technology.

2.3. GAPS AND CHALLENGES

1. Lack of Personal Awareness

- Open dumping of waste in unauthorized areas.
- Burning of trash, particularly in rural regions.
- Disposal in low-lying areas, leading to environmental hazards.
- Lack of segregation at the source, causing mixed waste streams.
- Weak enforcement of source segregation regulations, resulting in widespread non-compliance.

2. Lack of Community Awareness

- **"Not in My Backyard" (NIMBY)** attitude hampers the establishment of necessary waste processing facilities.
- Community resistance to local waste treatment facilities due to perceived negative impacts, limiting facility placement.

3. Challenges Common to Indian Cities

- Rapid urban population growth overwhelms existing waste management systems.
- Insufficient coordination between formal sectors (such as Urban Local Bodies, or ULBs) and informal sectors, reducing operational efficiency and scalability.

4. Lack of Sufficient Infrastructure

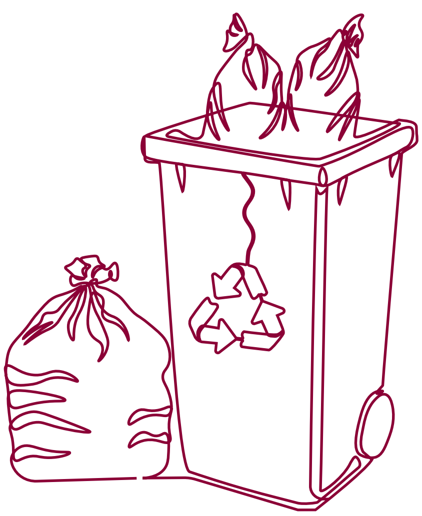
- Inadequate infrastructure for managing legacy waste and remediation of old dumpsites.
- Improper handling of Organic Fraction of Municipal Solid Waste (OFMSW) leads to contamination and mixed waste streams.
- Composting and wet waste management require extensive land, storage facilities, and protection from monsoon rains.
- Limited solutions for specialized waste streams, including coconut shells, human hair, textiles, tyres, rubber, sanitary waste, and multilayer packaging (MLP) waste.
- Lack of skilled operators and manpower to sustain and optimize existing waste processing facilities.
- Insufficient secondary stations for the collection, storage, and transfer of waste, impacting logistical efficiency.
- Inefficient resource management, with cities collecting all waste streams daily, regardless of low generation rates and volumes.
- Overburdened Urban Local Bodies (ULBs) due to understaffing and insufficient training, affecting service delivery.
- Non-adherence to scientific management in existing dumpsites, leading to increased environmental and health risks.

5. Gaps in Policies

- Limited progress in framing and enforcing bylaws at the ULB level per SWM Rules 2016, including the notification of user and tipping fees, spot fines, and penalties for non-segregation.
- Lack of policy incentives to promote source segregation and the use of recycled products or sustainable alternatives.
- Extended Producer Responsibility (EPR) policies cover only a few waste streams (e.g., plastics, tyres, and e-waste), leaving other significant streams unaddressed.

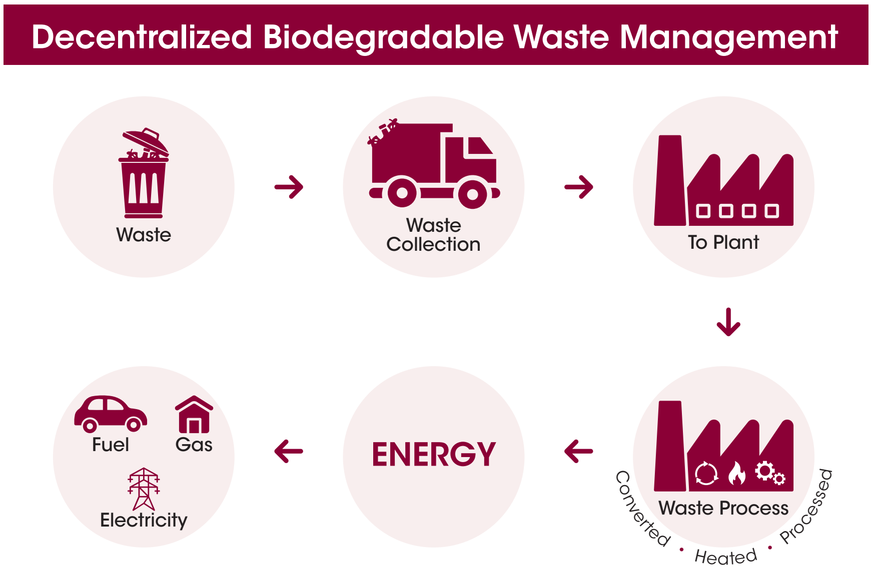
6. Insufficient Private Sector Participation through PPPs

- PPPs are currently limited, with most models focused on processing. Expanding PPPs specifically in collection, transport, recycling, and processing could provide much-needed investment, technology, and expertise to address treatment capacity gaps. Although PPP models across the waste management value chain could offer significant benefits, especially in the treatment stage, these remain largely unexplored due to regulatory, financial, and policy barriers that need to be addressed.



2.4. PROPOSED FRAMEWORK

There are a wide variety of problems/challenges in waste management in India. Every town/city needs to implement its unique strategy often employing a myriad of solutions. Some of the potential solutions in managing solid wastes are:



- Surveying and doing 'as-is' studies at ward level, city-level infrastructure and sanitation staff
- Regular meetings with all key stakeholders - SafaiKaramcharis Union, NGOs, Citizens, Municipal staff and private contractors
- States and local authorities must be transparent to the public and open to criticism regarding waste generation and management data
- Implementation and strict enforcement of By-laws including spot fines
  - **Source segregation and Management**
  - Involvement of private sector (Ex) UrbaSer Sumeet, Chennai
  - Mobilizing NGOs in bringing behavioral change at the ground level
  - Local participation & SHGs (Self Help Groups) involvement
  - Integrating the informal sector into mainstream SWM by issuing them ID cards [Pune, Mysuru, Taliparamba (Kerala)] and establishing their right to collect waste from the household level in particular areas mainly Resident Welfare Associations (RWAs). The waste collectors collect dry recyclables, wet biodegradable, and domestic hazardous waste as mandated by the SWM Rules 2016. The recyclables are then transported to the decentralized facilities. Wherever bio-degradable waste is processed within the colonies, recyclables can be further channelized.
- **Decentralized Biodegradable Waste Management** - Organic waste consists of more than half of the solid waste that we generate as a country. This means that if we take care of our organic waste, half of our waste woes will go away
  - ULBs should develop mechanisms for the sale of compost produced via these facilities
  - There needs to be a costing mechanism with different strategies beyond NPK values to promote the sales of compost
- The key focus in SWM at the ULB level should be on 100% segregated D2D collection, and source segregation
- Gradual and strict implementation of multi-bin systems to get highly sorted waste streams.
- **Technological Interventions**
- Information and Communication Technology (ICT) solutions such as Radio Frequency Identification (RFID)-based technology to improve the city's D2D waste collection efficiency and GPS technology to track the movements of its waste collection vehicles.
- Facilitation and adoption of technologies, for instance, RDF plants and Waste-to-Energy plants in North-eastern Indian states where it is still not adopted.

2.5. ENABLERS

- **MoEFCC in coordination with CPCB, MoHUA, and other allied ministries**
  - Come with a national waste prevention program
  - To develop a common methodology to measure food waste and define relevant indicators.
  - To take action to encourage recovery of critical raw materials, and prepare a report on best practices and options for further action at the national level.
  - Expanding EPR to more dry waste streams - Paper, textiles, rubber, metals, and glass.
  - Mandating the use of at least 25% recycled materials in non-food grade packaging
  - Mandating the use of at least 25% use of RDF in cement kilns
  - MoEF&CC to make Sanitary Landfill (SLF) a separate waste management facility outside ULB/ UDD domain, operating on a landfill fee model.
  - National policy for marine plastic Policy for mainstreaming of informal workers, mandating their formalization
  - Make waste management as priority sector for lending and environmental clearances
  - National Level Uniform Tariff Policy to be implemented.
  - Mandate use of mono-polymers in the production of the packaging products. e.g., PET bottles with HDPE cover/ cap and PPP films avoided, to enhance recycling
  - Come up with a mechanism for single window clearance
  - Allocate lands to set-up Waste Management Parks, Recycling zones
- **Ministry of Power and MNRE**
  - Fix Tariff Charges for the power generates from the WtE plants
  - Facilitate the development of infrastructure for the WtE facilities
- **States, ULBs and Nagar Panchayats in coordination with SPCB:**
  - Notify by-laws and circular economy guidelines with national-level guidelines
  - Introduce landfill tax for dumping / direct disposal of any waste in landfill
  - Focus on Zero Waste to Landfill approach through the Concessionaire/ RWAs/ WMAs
  - ULBs shall come up with a strategy to utilize Leachate and Ash from WtE plants
  - Empower safaikaramcharis to levy fines/ penalty on unsegregated waste and to refuse collection
  - ULB-level dashboard for digitally capturing dry waste
  - States to provide incentives to private developers to invest in the biogas economy
  - Suitable capacity building and training of personnel engaged in MSWM at State/ ULB level. National and international successful models need to be disseminated to ULBs
  - Separate stream for Household Hazardous waste.
  - Tie-ups with manufacturers under EPR and waste to energy plants for RDF use.
- **Ministry of Chemicals & Fertilisers in promoting wet waste management**
  - MoCF to extend Market Development Assistance (MDA) for city compost to compost produced out of biomethanation and tag sale of compost with chemical fertilizers
- **Households, businesses, industries, informal sector, NGOs CBOs, SHGs, FBOs**
  - In collaboration with ULBs, undertake waste management awareness generation and provide a number of solid waste management related services
  - Including waste management in the school curriculum to build the next generation of resource-conscious people
- **Private Industries and Waste management companies**
  - Proactively highlight best practices and challenges to the nodal PCB.
  - Listing current challenges faced in recycling different solid waste material streams in Smart India Hackathons

2.6. GOALS AND TARGETS

Aspect	Proposed Target	2025	2030
Collection	Door to Door collection rate [%] *(Aligns with SBM 2.0 objectives)* *[Baseline: As per Swachh Survekshan 2023, 94.6% of wards in India had 100% D2D collection]*	96	100
Collection	Percentage of households practicing source segregation (%) *(Aligns with SBM 2.0 objectives)* *[Baseline: As per Swachh Survekshan 2023, 88.29% of wards in India practice source segregation)*	90	100
Dry Waste	Replace coal with RDF in cement industries to increase Thermal Substitution Rate (TSR) in percentage. *[Basis for target: Voluntary targets set by leading cement industries to achieve about 25-30% TSR by 2030]*	10	15
Dry Waste	Increase in recycling rate of MSW dry fraction (%) by establishing Material Recovery Facilities (MRFs) *[Aligns with MoHUA 'Circular Economy in Municipal Solid and Liquid Waste']*	75	85
Wet Waste	Generation of ~ 2 million tons of CBG per annum by 2030 [MMTPA] *[Aligns with MoHUA 'Circular Economy in Municipal Solid and Liquid Waste']*	0.5	2
Wet Waste	Setting up of min. 200 TPD biomethanization plants in all the ULBs exceeding 1 million population (~75 cities) *[Aligns with MoHUA, SATAT]*	25	75
Wet Waste	Mandate for fertilizer units to utilize compost in their production process (% of compost)	7.5	12
Disposal	Remediation of legacy dumpsites (%) (Aligns with SBM 2.0 objectives) *[Baseline: As per SBM Urban Dashboard, remediation completed at about 25% of the legacy dumpsites]*	65	100

Recycling targets of specific dry waste streams:

Recyclables	2025	2030
Plastics	80%	90%
Paper & cardboard	80%	90%
Glass & Ceramics	50%	65%
Metal	80%	90%
Textiles	60%	75%
Tyres & Rubber	80%	90%

Note: *Data for the year 2025 is taken from MoHUA's Circular Economy in Municipal Solid and Liquid Waste document, while the 2030 targets are projected.*

2.7. IMPACT POTENTIAL

The reuse and recycling of materials are essential for conserving natural resources, minimizing landscape and habitat disruption, and reducing biodiversity loss. Recycling, especially of critical raw materials like metals, alleviates supply risks, including price volatility, availability challenges, and import dependence.

MoHUA estimates that processing 50% of urban wet waste through bio-methanation could generate an additional annual economic contribution of ₹2,460 crores. This approach also presents significant employment potential, with an estimated 1 crore man-days for construction activities and an ongoing requirement of 60 lakh man-days for operation and maintenance. Additionally, bio-methanation offers extra economic benefits over composting, with estimated additional returns of ₹42,570 for each 50 TPD processed.

As per MoHUA, material recycling facilities (MRFs) can play a transformative role in promoting circularity in dry waste management. By implementing MRFs, recovery values could increase from ₹5,187 crores annually to ₹17,023 crores by 2025, adding an estimated ₹11,836 crores to the economy each year.

References:

1. State of Waste Management Report [TERI 2023]https://www.teriin.org/sites/default/files/2023-10/1695795956State%20of%20Waste%20Management%20Report.pdf
2. MSW Management: The pitiable situation of Municipal Solid Waste Management [TERI, 2022] https://www.teriin.org/article/msw-management-pitiable-situation-municipal-solid-waste-management
3. Circular Economy in Municipal Solid & Liquid Waste [MoHUA, 2021]https://mohua.gov.in/pdf/627b825fd31b3Circular-Economy-in-waste-management-FINAL.pdf
4. Towards a Circular Economy – Waste Management in EU [EU, 2017]https://www.europarl.europa.eu/RegData/etudes/STUD/2017/581913/EPRS_STU(2017)581913_EN.pdf
5. Global Waste Management Outlook, 2024 https://wedocs.unep.org/bitstream/handle/20.500.11822/44939/global_waste_management_outlook_2024.pdf?sequence=3
6. Transitioning to a Circular Economy: An evaluation of the World Bank Group's Support for MSW Management (2010-20)https://ieg.worldbankgroup.org/sites/default/files/Data/Evaluation/files/MunicipalSolidWasteManagement.pdf
7. The National Action Plan for Municipal Solid Waste Management https://cpcb.nic.in/uploads/MSW/Action_plan.pdf
8. https://sbmurban.org/swachh-bharat-mission-progess
9. Swachh Survekshan Toolkit website [Jul - Dec 2023]https://ss2023.sbmurban.org/#/dashboard
10. CPCB MSW Annual Report 2021-22https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2021-22.pdf
11. Waste-Wise Cities https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf
12. Segregate, Segregate, Segregate [CSE, 2020]https://www.cseindia.org/how-good-are-the-best--10155
13. Recent Trends to global SWM processing Techhttp://tumkuruniversity.ac.in/oc_pg/es/Recent%20trends%20in%20global%20solid%20waste%20processing%20technologies.pdf

Chapter 3

CIRCULAR ECONOMY ACTION PLAN *for* DOMESTIC WASTEWATER

3.1. INDUSTRY OVERVIEW

India generates approximately 72,368 MLD of wastewater in urban areas and 39,604 MLD in rural regions. Currently, only 28% of urban wastewater is treated, and rural wastewater management remains largely decentralized, with minimal formal treatment infrastructure in operation(NITI Aayog, 2022).Untreated wastewater contributes to water pollution in rivers, lakes and groundwater.The National Mission for Clean Ganga (NMCG) also highlights that untreated sewage is a primary factor affecting water quality in river systems like the Ganges. Similarly, NITI Aayog's Composite Water Management Index (CWMI) points out that untreated wastewater is a major contributor to ground water contamination, ecosystem harm and health risks.

The wastewater sector is critical to key economic sectors such as agriculture, industry, and urban development. Treated wastewater can be reused in agriculture for irrigation or in industries for processes like cooling in power plants and oil refineries. Additionally, wastewater treatment helps recover valuable resources such as energy (from biogas) and nutrients like phosphorus and nitrogen, which can be converted into plant fertilizers. In the construction industry, it can also be used for concrete mixing, dust suppression and other construction activities. Treated wastewater helps in environmental protection by restoring groundwater balance and reducing pollution, while contributing to public health by minimizing waterborne illnesses.

India's wastewater management sector has enormous potential for growth, with an expected compound annual growth rate (CAGR) of 11.76% from 2022 to 2029, projected to reach US$11.199 billion by 2029 (NITI Aayog,India Infrastructure, 2022). This growth will be driven by urbanization, infrastructure development, and government initiatives like Swachh Bharat Mission - Urban (SBM-U) 2.0, which targets 100% wastewater treatment by 2030.

3.2. CURRENT STATUS

India is increasingly adopting circular economy principles in wastewater management, with progress varying across regions. The national and state-level wastewater policies, regulations, and guidelines aim to promote water reuse, resource recovery, and decentralized treatment systems. The key policies shaping wastewater management include:

Policy/Program	Year	Focus/Key Points
National Urban Sanitation Policy (NUSP)	2008	Promotes decentralized sanitation solutions and reuse of treated wastewater for non-potable uses.
National Water Policy	2012	Encourages treated wastewater reuse in industrial and agricultural applications, especially in water-scarce areas.
Atal Mission for Rejuvenation and Urban Transformation (AMRUT)	2015, 2021	Aims for 100% wastewater treatment through building and rehabilitating STPs; promotes recycling for non-potable uses.
Swachh Bharat Mission – Urban (SBM-U)	2014, 2021	Targets 100% wastewater treatment via decentralized systems; promotes reuse of treated water for industrial and landscaping uses.
Swachh Bharat Mission – Gramin (SBM-G)	2014, 2021	Focuses on eliminating open defecation and establishing decentralized wastewater and faecal sludge management in rural areas.
Jal Jeevan Mission (JJM)	2019	Primarily provides safe drinking water to rural households; also promotes greywater management and water conservation.
National Mission for Clean Ganga (NMCG)	2014	Encourages wastewater treatment and resource recovery, including biogas generation from sludge.
Faecal Sludge and Septage Management (FSSM) Policy	2017	Supports decentralized wastewater management in non-sewered areas; promotes safe treatment and reuse of faecal sludge.
Central Pollution Control Board (CPCB) Guidelines	Various	Sets effluent discharge standards, promotes treated wastewater reuse for non-potable applications, and upholds the "polluter pays" principle.
National Framework on Safe Reuse of Treated Water (SRTW)	2022	Provides guidelines for safe reuse of treated wastewater for non-potable purposes; establishes quality standards and risk management practices.

These policies provide the following incentives to businesses to adopt circular economy principles in wastewater management:

- **Capital subsidies and grants** for investments in STPs and water recycling systems (e.g., 50% capital grants under the NUSP, and performance-based grants up to ₹500 crore under AMRUT).
- **Subsidized loans** for infrastructure development, including setting up decentralized wastewater systems under SBM-U 2.0.(e.g., cities eligible for up to ₹2 crore per city for reuse projects).
- **Long-term government contracts and co-financing** through Public-Private Partnerships (PPP) for constructing and operating wastewater treatment infrastructure. (e.g., PPP models supported by AMRUT and NMCG with performance-linked funding).
- **R&D funding and technology grants** for innovative wastewater management technologies, such as nutrient recovery and greywater recycling systems.(e.g., up to 90% capital subsidies for greywater management systems in rural areas under JJM).
- **Differential tariffs and polluter pay** to drive compliance with circular principles (by CPCB).

Best Practices in Wastewater Management in India

Indian states and cities are advancing in wastewater reuse and resource recovery:

Initiative	States/Cities	Summary
State Policies on Wastewater Reuse	Jharkhand, Maharashtra, Rajasthan, Tamil Nadu	Policies mandate treated wastewater for industrial use; Chennai supplies it to industries at lower rates.
Water Reuse for Non-Potable Uses	Chennai, Bengaluru, Delhi, Chandigarh	Reused for industrial cooling, park irrigation, and landscaping, conserving freshwater resources.
Agricultural Reuse	Surat, Ahmedabad, Mysuru	Promotes treated wastewater for irrigation, reducing reliance on freshwater in agriculture.
Decentralized Systems	Indore, Bengaluru	Local greywater recycling alleviates pressure on centralized systems, promoting reuse in communities.
Resource Recovery	Pune, Mysuru	Initiatives for biogas from sewage sludge convert waste into energy and fertilizers.
Public-Private Partnerships (PPP)	Bengaluru, Nagpur, NMCG cities	PPPs enhance treatment capacity, sharing financial and operational responsibility.
Nutrient Recovery	Maharashtra, Telangana, Odisha	Treated sludge is composted for agricultural use, supporting nutrient cycling as per FSSM policy.
Groundwater Recharge	Kochi	Integrates wastewater and stormwater systems for flood prevention and groundwater replenishment.

3.3. GAPS, CHALLENGES AND LEARNINGS FROM OTHER COUNTRIES

Despite a supportive policy environment and successful practices in some Indian states, several challenges still hinder the full adoption of circular economy principles in wastewater management. India has developed an extensive framework promoting wastewater reuse, resource recovery, and decentralized systems, yet gaps remain in infrastructure, regulation, enforcement, public acceptance, and the service sector.

A primary challenge is the lack of a unified regulatory framework, leading to inconsistent standards across states. This disparity complicates the standardization of water reuse, especially in agriculture and construction. Additionally, enforcement and monitoring gaps across states limit consistent adoption of wastewater reuse and resource recovery mandates.

Local governments, particularly in small towns, often lack the skills and capacity to plan Public-Private Partnership (PPP) projects or manage advanced wastewater systems, slowing the adoption of innovative treatment and resource recovery technologies. Infrastructure deficits in existing STPs also pose significant challenges. While India has over 1,469 treatment plants with a total capacity of 31,841 MLD, they only cover 43.9% of total sewage needs, leaving major treatment gaps. Many plants remain outdated, inefficient, or underutilized, limiting effective wastewater management.

Further, despite policies like SBM-U 2.0 and FSSM supporting decentralized systems, adoption remains low in particularly in rural and smaller urban areas. Dependence on centralized systems continues, which often proves inefficient or overburdened. The service sector for decentralized wastewater systems is also underdeveloped, offering limited technical support for installation, refurbishment, operation, and maintenance—especially in smaller towns.

While policies encourage resource recovery, including biogas generation and nutrient extraction, essential infrastructure to support these processes is lacking, particularly in rural areas. Additionally, PPP models are less viable in small and medium towns due to limited commercial prospects and higher risks, reducing investments where decentralized systems are most needed.

A further challenge is the underdeveloped market for treated wastewater reuse. With no established market, many treatment plants discharge treated water into drains, resulting in economic losses as valuable resources remain underutilized. The informal sector also presents challenges, particularly in faecal sludge management, where unregulated practices contribute to worker safety risks and environmental contamination.

Public resistance and low acceptance of treated wastewater, driven by limited awareness and misconceptions, continue to hinder broader adoption. Lastly, data gaps and monitoring limitations make evaluating the effectiveness of decentralized systems and resource recovery difficult, impeding informed policy adjustments.

Addressing these challenges is crucial for realizing the full potential of wastewater circularity in India.

Best Practices and Lessons from Other Countries

Many countries around the world have implemented successful wastewater management practices, demonstrating innovative circular economy principles. These examples offer valuable lessons for India:

Country	Initiative	Summary
Singapore	NEWater Program	Advanced treatment of wastewater for reclaimed water meets 40% of demand, targeting 55% by 2060, reducing import dependency.
Netherlands	Nutrient and Energy Recovery	Nutrient recycling and biogas from sludge generate renewable energy and sustainable fertilizers, creating revenue streams.
Denmark	Energy-Positive Treatment	Aarhus plant produces 192% of its energy needs, cutting emissions and saving €2 million annually in energy costs.
Israel	Agricultural Water Recycling	Recycles 85% of wastewater for irrigation, providing 50% of agricultural water and saving $2 billion annually.
Japan	Greywater Recycling and Decentralized Systems	Greywater recycling reduces potable water use by up to 40%, supported by private-sector investment in urban areas.
Germany	Public-Private Partnerships (PPP)	PPPs enhance wastewater infrastructure, with a 15% efficiency boost and cost savings in Berlin's water utility.
United States	Nutrient Trading in Chesapeake Bay	Nutrient trading reduces nitrogen pollution and saves $50 million, driving sustainable water management practices.
Australia	Decentralized Rural Systems	Integrated rainwater and greywater recycling reduce water costs by 20-30% in rural areas, supporting local efficiency.

3.4. PROPOSED FRAMEWORK

VISION

India's vision for circular economy in wastewater management is to transform wastewater into a resource through reuse, recycling, and resource recovery, while ensuring environmental sustainability, public health and economic growth.

APPROACH

The approach for circular economy in wastewater management is to integrate both decentralized and centralized systems, enabling modular, adaptable treatment in rural areas and smaller towns while providing comprehensive solutions for larger urban centers. Localized and large-scale facilities alike create business opportunities in water reuse and resource recovery, supported by financial incentives that make circular practices commercially attractive. Supported by robust policy frameworks, digital monitoring tools, and community engagement, this approach establishes an ecosystem where wastewater assets benefit industries, agriculture, municipalities, and communities reducing freshwater demand and building long-term resilience.

3.5. ENABLERS AND STRATEGIES FOR SUCCESSFUL IMPLEMENTATION

To transition effectively to a circular economy in wastewater management, India must adopt a combination of regulatory reforms, market-based incentives, and strategic partnerships that drive innovation and infrastructure development.

1. Regulatory Reforms and Market Incentives

- ***Mandate Water Reuse Targets*** in a phased manner to progressively reduce freshwater demand.
- ***Enforce Differential Tariffs*** where treated wastewater is priced lower than freshwater for non-potable use, incentivizing sectors like construction, power, and agriculture to switch to recycled water.
- ***Strengthen Compliance and Outcome-Based Monitoring*** across all centralised and decentralised STPs for real-time data on discharge quality and resource recovery.
- ***Uniform quality standards*** should align treated wastewater with end-use requirements, following CPCB guidelines that categorize water quality based on suitability for industrial, agricultural, potable reuse, and ground or surface water recharge.

2. Investment in Technological Innovation and Resource Recovery

- ***Support Advanced Treatment Technologies*** by prioritizing R&D funding for emerging wastewater treatment technologies, including membrane bioreactors, sludge-to-energy conversion systems, and nutrient recovery technologies
- ***Implement Pilot Programs and Nature-Based Solutions*** especially in peri-urban and rural areas, offering a cost-effective and sustainable alternative where conventional systems may be economically unfeasible.
- ***Promote Resource Recovery Standards*** capturing valuable resources such as phosphorus and nitrogen in wastewater treatment processes, with applications in agriculture.

3. Green Financing Mechanisms and Public-Private Partnerships (PPP)

- ***Develop Green Bond Initiatives:*** Introduce green bonds as a funding source for wastewater infrastructure projects, offering long-term returns for investors and providing capital for technology upgrades and expansion.
- ***Expand PPP Models*** with a focus on Viability gap funding (VGF) to attract private investment in smaller towns and underserved areas.
- ***Standardize PPP Procurement Norms*** across states to facilitate smoother and faster project approvals, enhancing private sector understanding and confidence in entering regional wastewater projects.
- ***Encourage Low-Interest Loans for SMEs*** working on decentralized wastewater solutions and resource recovery technologies, fostering innovation and sector growth.

4. Capacity Building for Local Governments and Inclusion of the Informal Sector

- ***Provide Training*** to local governments to manage both centralized and decentralized systems effectively.
- ***Establish a Knowledge-Sharing Platform at national level*** to enable local governments to learn from successful projects.
- ***Formalize Informal Sector Roles*** into formalized maintenance, waste collection, and sludge management roles, providing training and safety standards.

5. Smart Technologies for Monitoring, Compliance, and Data Management

- ***Expand Real-Time Monitoring Systems*** to treatment facilities similar to the IoT-based monitoring by NMCG.
- ***Predictive Analytics and Maintenance as a Service*** allowsenhanced participation by private sector in pre-emptively address issues at facilities.
- ***Data-Driven Decision Platforms*** like the MoEFCC's ENVIS to integrate real-time reporting and making the treatment data available to improve policy alignment and public transparency.

6. Market Development, Urban Resilience, and Service Models

- ***STP as a Service (SaaS)*** business models where private operators finance, install, and operate decentralized treatment plants, charging clients based on the volume of wastewater treated. Bengaluru's PPP model for sewage treatment has shown SaaS's potential for scalability.
- ***Develop a Market for Treated Wastewater*** by facilitating buyer-seller linkages for treated wastewater, similar to the partnerships in Tamil Nadu, where treated water is sold to industrial parks at a fraction of freshwater costs.
- ***Develop Private Sector Service Ecosystem for Decentralized Systems*** offering spare parts, auxiliary services, and technical expertise thereby creating reliable service networks that enhance system longevity and encourages uptake.
- ***Integrate Wastewater for Urban Resilience and Planning*** by aligning with Sponge City and Eco-City principles.
- ***Industry Forums with enhanced focus on Wastewater Reuse*** to inform and drive policy, practice and adoption.
- ***Industry-Academia Linkages for Innovation and Workforce Development*** to support research, innovations, and building a skilled workforce.

7. Nutrient Recovery and Energy Generation

- ***Mandate Nutrient Recovery Standards*** in all STPs.
- ***Set up Energy-Positive Wastewater Plants*** by encouraging models like Denmark's Aarhus plant, which generates 192% of its energy needs.
- ***Incentivise Bioenergy production in Treatment Facilities*** from sludge.

8. Public Awareness and Demand Generation

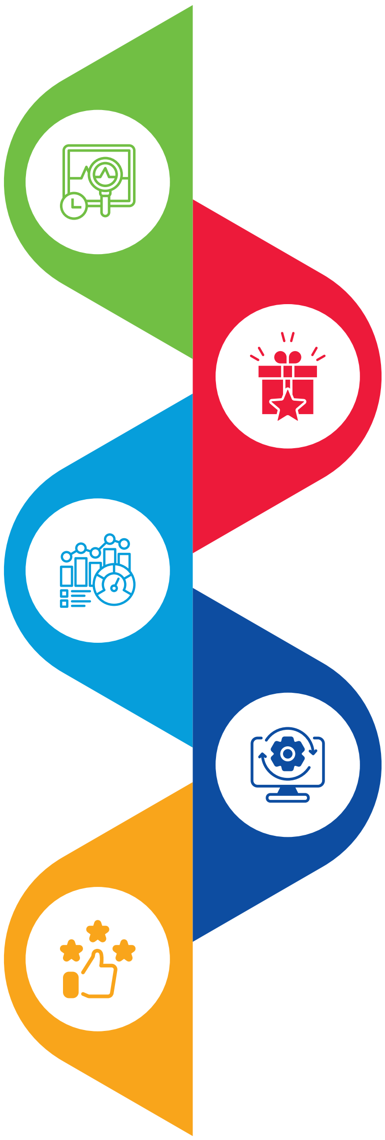
- ***Encourage Municipalities to Run Targeted Public Awareness Campaigns*** to promote wastewater reuse.
- ***Engage Industry and Agricultural Stakeholders*** through workshops and forums focused on wastewater.
- ***Impact Reporting*** on the outcomes of reuse initiatives to build public trust.

3.6. GOALS AND TARGETS

Integrated Target Table for Urban and Rural Wastewater Management

S. No.	Proposed Target	Target by 2027	Target by 2030
1.	**Comprehensive Wastewater Treatment in Urban Areas** (Aligns with CPCB, NUSP, SBM-U 2.0,)	50% of urban wastewater treated, with focus on cities over 1 million population	100% treatment coverage in all urban areas
2.	Recycle Treated Wastewater for Industrial and Non-Potable Uses (Aligns with National Water Policy, CPCB)	30% of treated wastewater recycled for non-potable applications	50% recycling for non-potable uses like landscaping, cooling, and industrial processes
3.	**Increase Adoption of Decentralized Wastewater Systems in Tier-2 and Tier-3 Cities** (Aligns with NUSP, AMRUT)	30% of Tier-2 and Tier-3 cities to adopt decentralized systems	50% coverage in smaller cities
4.	**Ensure Compliance with Sewage Treatment Standards and Nutrient Recovery** (Aligned with MoEFCC, CPCB, FSSM policy)	60% of STPs compliant with CPCB standards with 30% nutrient recovery (phosphorous and nitrogen) from sewage sludge.	100% of STPs are compliant with CPCB standards with 50% nutrient recovery from sewage sludge.
5.	**Increase Nutrient Recovery from Sewage Sludge** (Aligned with NMCG, CPCB)	30% nutrient recovery (phosphorous and nitrogen) from sewage sludge processed for bio-fertilizer production	50% nutrient recovery (phosphorous and nitrogen) from sewage sludge processed for bio-fertilizer production
6.	**Achieve Safe Greywater Management in Rural Areas** (Aligned with JJM)	50% of rural households equipped with greywater management systems.	75% greywater management coverage across rural households
7.	**Universal Faecal Sludge and Septage Management in Rural Areas** (Aligned with SBM-G)	50% of rural villages to have FSM systems.	100% FSM coverage in rural areas.

Monitoring and Evaluation for Urban and Rural Targets



Real-Time and Predictive Monitoring:

Deploy IoT sensors and predictive analytics on digital platforms to monitor STPs and decentralized systems in real time, ensuring compliance with CPCB and MoEFCC standards.

Incentives for Performance:

Implement performance-based incentives to encourage regions that meet wastewater targets, driving innovation and circular practices.

Annual Reporting and Performance Tracking:

Ministries, including MoHUA, MoEFCC, and the Ministry of Jal Shakti, release yearly reports tracking progress in wastewater treatment and resource recovery across urban and rural areas, incorporating municipal performance data.

Local Monitoring Systems:

Establish state and village-level mobile platforms to track water reuse and FSM, feeding data into national reports for transparency.

Mid-Term Review (2027):

Conduct a 2027 evaluation to assess progress on 2030 goals, focusing on nutrient recovery, system scalability, and alignment with national programs.

3.7. IMPACT POTENTIAL

Adopting a circular economy in wastewater management offers wide-ranging environmental, resource, social, and economic benefits that promote sustainable growth.

- **Environmental and Resource Benefits:** Circular wastewater practices reduce pollution, protecting ecosystems and minimizing untreated sewage discharge into rivers like the Ganges by 2030. Reusing treated wastewater in industry, agriculture, and landscaping helps conserve freshwater. Additionally, resource recovery from STPs enables bio-fertilizer and biogas production, supporting renewable energy goals and sustainability.
- **Reductions in GHG Emissions and Resource Depletion:** Biogas recovery from wastewater offsets fossil fuel use, aiding carbon neutrality. These practices also reduce dependence on freshwater and synthetic fertilizers, conserving natural resources and lessening environmental impact.
- **Social, Public Health and Economic Benefits:** Expanding wastewater infrastructure, especially decentralized systems, creates jobs in construction, operations, and maintenance, boosting opportunities in Tier-2 and Tier-3 cities. Improved sanitation infrastructure enhances public health, reduces waterborne diseases, and promotes social equity, particularly in rural areas.
- **Cost Savings and Business Opportunities:** Reusing treated wastewater for industrial cooling and construction lowers operational costs, while bio-fertilizers cut agricultural expenses. PPPs drive private investment in advanced treatment, biogas production, and nutrient recovery, supporting economic growth and creating new business avenues through resource efficiency and green technology innovation.

References:

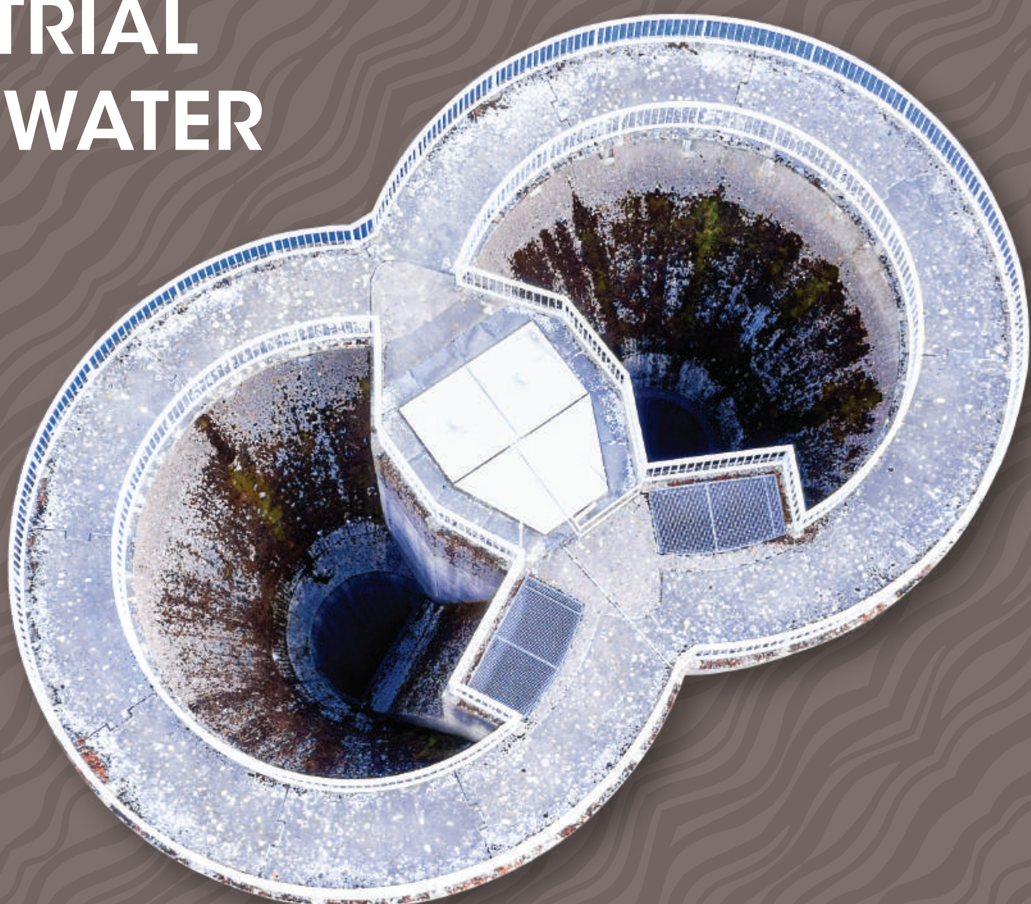
- Central Pollution Control Board (CPCB) Guidelines on Treated Wastewater Reuse (https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2020-21.pdf)
- Ministry of Housing and Urban Affairs (MoHUA) Resources (https://mohua.gov.in/upload/uploadfiles/files/93.pdf)
- National Action Plan for Climate Change (NAPCC)by Ministry of Environment, Forest, and Climate Change (MoEFCC). (https://moef.gov.in/climate-change-action/)
- NITI Aayog. (2022). Wastewater Economic Opportunity in India: Scoping Report on Resource Recovery in the Wastewater Sector. (https://www.niti.gov.in/sites/default/files/2022-09/Waste-Water-A4_20092022.pdf)
- Swachh Bharat Mission – Urban (SBM-U) 2.0, Ministry of Housing and Urban Affairs (MoHUA).(https://sbmurban.gov.in/)
- National Water Policy (2012),Ministry of Jal Shakti, Government of India.(http://mowr.gov.in/sites/default/files/NWP2012Eng6495132651_1.pdf)
- Atal Mission for Rejuvenation and Urban Transformation (AMRUT) & AMRUT 2.0.,MoHUA. (https://amrut.gov.in/)
- Jal Jeevan Mission (JJM),Ministry of Jal Shakti, Government of India. (https://jaljeevanmission.gov.in/)
- Swachh Bharat Mission – Grameen (SBM-G), Ministry of Jal Shakti, Government of India. (https://swachhbharatmission.gov.in/sbmcms/index.htm)
- Faecal Sludge and Septage Management (FSSM) Policy (2017),MoHUA.(https://mohua.gov.in/cms/fssm-policy.php)
- National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti, Government of India.(https://nmcg.nic.in/)

Case Studies:

- Singapore – NEWater Program: pub.gov.sg/newater
- Netherlands – Nutrient Recovery and Energy from Sludge: Science
- Denmark – Energy-Positive Wastewater Treatment (Aarhus): Water Science and Technology
- Israel – Wastewater Recycling for Agriculture: Water Research
- Japan – Greywater Recycling and Decentralized Systems: IWA Publishing
- Germany – Public-Private Partnerships (PPP):: Water Utility Journal
- United States – Nutrient Pollution Control (Chesapeake Bay): wri.org
- Australia – Decentralized Wastewater Management in Rural Areas:Environmental Engineering and Management Journal

Chapter 4

CIRCULAR ECONOMY ACTION PLAN *for* INDUSTRIAL WASTEWATER



4.1. INDUSTRY OVERVIEW

4.1.1. Introduction

Water is the most vital natural resource, sustaining life in all its forms. Our primary sources, including groundwater, surface water, and seawater, are finite and increasingly at risk from pollution caused by domestic and industrial activities. This contamination, combined with growing global water stress, underscores the urgent need for better water management, especially as population growth, pollution, and climate change put additional strain on water security.

Historically, water scarcity has played a significant role in the decline of civilizations, including the Maya, Indus Valley, and Egyptian kingdoms, which faced severe water shortages and climate pressures. Today, India—a developing economy housing nearly 18% of the world's population—faces a similar challenge. Rapid urbanization and industrial expansion have spurred economic progress, but with it, an increased demand for water and a rise in wastewater generation, which necessitates sustainable management practices.

Water is essential to many industrial processes, from manufacturing to energy production. Yet only a small portion of this water becomes part of the final product or evaporates; most of it turns into wastewater. This often contains harmful chemicals, posing significant environmental risks if untreated. With water scarcity worsening worldwide, effective wastewater management is critical not only for environmental protection but also for sustaining industrial productivity. Industries consume a significant share of water resources, so ensuring sustainable use is essential for economic stability and ecological balance. Many industries are adopting practices to improve water-use efficiency, reduce consumption, and recycle wastewater, which helps protect ecosystems, reduce environmental impact, and safeguard resources for the future.

The overexploitation of water and poor management of industrial wastewater have serious environmental and societal consequences. Wastewater discharge often contaminates rivers, lakes, and groundwater. According to NITI Aayog, 70% of India's surface water is contaminated, with a significant share due to industrial sources. The Central Pollution Control Board (CPCB) reported nearly 2,900 grossly polluting industries in India in 2023, with a portion non-compliant with environmental standards, contributing to pollution in 311 river stretches. In water-scarce regions, industrial use exacerbates the strain on resources needed for agriculture and domestic purposes.

Environmental impacts of industrial wastewater include contamination by heavy metals, toxins, and nutrients that disrupt ecosystems, harm plant and animal life, and degrade soil quality. This contamination affects agriculture and food security as soil fertility declines. Furthermore, untreated wastewater releases gases like methane and ammonia, contributing to greenhouse gas emissions and climate change, underscoring the need for sustainable wastewater practices.

The **societal impacts** are equally concerning. Communities near industrial zones face health risks from contaminated water sources, with an increased likelihood of diseases like cholera and cancer. Studies show that in areas irrigated with untreated wastewater, health costs are higher, underscoring the burden of poor water quality on vulnerable populations. Industrial water pollution also threatens livelihoods, as it disrupts water bodies that are essential for fishing, farming, and daily needs, often forcing communities to seek less sustainable income sources. Disadvantaged populations suffer disproportionately, lacking resources to demand better waste management or access to clean water. Social impacts also include the loss of cultural and recreational values, as polluted rivers and lakes degrade local quality of life and sense of community.

Effective wastewater management is crucial for preserving public health, ensuring equitable access to clean water, and sustaining water resources. The industrial sector must prioritize sustainable practices, including water reuse, recycling, and proper treatment, to protect ecosystems, support economic growth, and promote community well-being. As water scarcity intensifies, responsible wastewater management will be essential for securing resources for future generations and building a resilient, sustainable economy.

4.1.2. Current Industrial Wastewater Statistics and Projected Growth Rate

- **CETP Capacity and Wastewater Treatment (2022-2023)**

  As of 2022-2023, India has 201 Common Effluent Treatment Plants (CETPs) spread across 20 States/UTs. These CETPs have a total design capacity of 1,917 million litres per day (MLD). However, their operational capacity is significantly lower, at 1,137 MLD, reflecting a gap between designed potential and actual treatment. In 2021, India's manufacturing clusters generated approximately 13,500 MLD of industrial wastewater. So a large quantity of water is still not treated with the current operational capacity.

- **Water Availability and Projections**

  In 2021, the per capita annual water availability in India was 1,486 cubic meters, which is already nearing the threshold for water stress. By 2031, this is projected to drop to 1,367 cubic meters, pushing the country further into water-stressed conditions, with increasing challenges in meeting demand.

- **Projected Water Demand and Economic Impact**

  A study by the Central Water Commission in 2019 estimated India's usable water supply at 1,121 billion cubic meters (bcm). By 2025, water demand is projected to reach 1,093 bcm, and by 2050, it could rise to 1,447 bcm. The strain on water resources could lead to a 6% loss in GDP by 2050, posing serious economic and social challenges.

  The data underscores the critical need for effective reuse of industrial wastewater in India. With 201 Common Effluent Treatment Plants (CETPs) operating at only 59% of their design capacity, a significant portion of the country's industrial wastewater remains untreated. In light of these challenges, reusing industrial wastewater is not only a viable solution for mitigating environmental pollution but also essential for sustainable water management and economic stability.

4.2. CURRENT STATUS

According to the United Nation's report, on average, high-income countries treat about 70% of the municipal and industrial wastewater they generate. That ratio drops to 38% in upper middle-income countries and to 28% in lower-middle-income countries like India. This highlights the vast gap in wastewater management within the country, where nearly 72% of wastewater remains untreated. And in case of industrial wastewater, merely 8 percent of industrial wastewater is treated in any way in the developing nations. As India continues to face increasing water stress, addressing this treatment gap is essential to mitigating pollution, protecting public health, and ensuring the country's long-term sustainable development. Clearly, India still has a long way to go in improving its wastewater management infrastructure.

To address this growing crisis, regulatory frameworks are being developed by agencies like the Central Pollution Control Board (CPCB) to promote the reuse of treated urban wastewater (TUW) in sectors with high water demand. Zero Liquid Discharge (ZLD) technologies are gaining attention across industries as a way to mitigate this issue and reduce water wastage and curtail illegal discharges of wastewater. TUW and ZLD are yet to be made mandatory in all parts of the country

AND IN CASE OF INDUSTRIAL WASTEWATER, MERELY 8 PERCENT OF INDUSTRIAL WASTEWATER IS TREATED IN ANY WAY IN THE DEVELOPING NATIONS

4.2.1. Adoption of Circular Economy Solutions

Indian industries are now transitioning towards a circular economy, with a strong emphasis on recycling and reusing water. This shift is driven not only by the need for improved process efficiency but also by the increasing acceptance of green business practices, reflecting their commitment to sustainability and resource conservation.

TUW and ZLD are yet to be made mandatory in all parts of the country.Further challenges that contribute to in-effective wastewater management are high capital and operating costs, lack of proven technologies and equipment, lack of operating skills etc. Recently, The Energy and Resources Institute (TERI) developed a UV photocatalysis-based advanced oxidation technology to ensure ZLD compliance in CETPs. Renewable energy is also expected to play an increasingly important role in operating sewage and wastewater treatment facilities, while real-time monitoring, water usage control, leak detection, and improved water allocation systems will support the shift toward a circular water economy.

4.2.2. Current Policies – Overview

At present, management of industrial wastewater in India is as per provisions of the Water (Prevention and Control of Pollution), Act 1974.This Act marked the beginning of structured environmental management in India. The primary objective of the Act is prevention and control of water pollution ensuring that pollutants are not discharged into water bodies. The Act also specified water and effluent quality standards as well asmandated obtaining requisite permissions before discharge of wastewater into water bodies.

The October 7, 2024 Liquid Waste Management (LWM) Rules, issued by the Union Ministry of Environment, Forest, and Climate Change(MoEF&CC), mark a transformative step in India's approach to wastewater and sludge management. These rules are a significant advancement over the current regulatory frameworks, and add greater specificity and enforcement to India's liquid waste management strategies.

This development comes in the context of existing national missions such as Swachh Bharat Mission 2.0 (SBM 2.0), Atal Mission for Rejuvenation and Urban Transformation (AMRUT 2.0), and the National Mission for Clean Ganga (NMCG), each of which already sets targets for wastewater reuse. However, the introduction of LWM rules introduces new compliance frameworks that could create confusion due to overlapping targets. For example, SBM 2.0 mandates 20% wastewater reuse in smaller cities, while AMRUT 2.0 targets 20% reuse of total water demand and 40% reuse of industrial water demand. NMCG have set even higher targets as acquiring 50% reuse by 2025 and 100% by 2050. The LWM rules, in contrast, propose a phased approach with 20% reuse by 2027-28 and 50% by 2030-31 for bulk water users like industries and large housing societies, creating potential mismatches between various policies.

4.2.3 Key Highlights of the Draft LWM Rules:

- **Targeted Reuse:** The LWM rules mandate that bulk water consumers that have a consumption of more than 5000 litres per day or pollution load of more than 10 kg per day in terms of BOD; must reuse 20% of their wastewater by 2027-28, rising to 50% by 2030-31. This Extended User Responsibility (EUR) framework puts the onus on industries to treat and reuse their wastewater, addressing growing water scarcity and pollution challenges.
- **Comprehensive Sludge Management:** The rules emphasize the reuse of sewage sludge, in line with circular economy principles. India produces 8 million tonnes of sewage sludge annually (CPCB, 2021), and its proper treatment for safe agricultural use is essential to avoid environmental contamination. However, many smaller treatment plants lack the required technology to consistently treat sludge to safe levels, increasing the risk of hazardous materials like pathogens and heavy metals entering agricultural systems.
- **Monitoring and Reporting:** A monthly reporting requirement has been established for all centralized and decentralized treatment plants. These reports, which will include data on volumes treated, sludge management, and reuse outcomes, must be submitted to State Pollution Control Boards (SPCBs) and uploaded to a centralized portal. However, this raises concerns about the digital infrastructure in rural and smaller towns.

The core of the draft LWM is providing a structured framework for management of liquid wastes generated at multiple points- industries, households and other establishments both private and public. The LWP is a significant attempt towards sustainability, compliance and accountability in the water sector.

4.3. CHALLENGES FACED IN INDUSTRIAL WASTEWATER MANAGEMENT

1. **Heterogeneity in wastewater - quality and quantity:** Industrial wastewater composition and volume can vary significantly depending on the industry type, processes employed, raw materials used, and regional factors. This difference makes it challenging to design and operate treatment systems that can handle a wide range of contaminants efficiently. A sudden spike in pollutants or variations in flow rates can overload the treatment plant, reducing its efficiency and potentially leading to damage.

2. **Uncontrolled conveyance of effluent to the CETP:** Regulation and monitoring of effluent transportation to CETPs are often inadequate. Without proper oversight, untreated or partially treated wastewater may bypass required treatment steps, leading to environmental contamination. Additionally, uncontrolled conveyance can result in contamination during transport, particularly when waste volumes exceed the treatment plant's operational capacity.

3. **Inlet parameters above plant design loads:** CETPs are designed based on inlet effluent parameters like Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and suspended solids. However, in practice, the pollutant concentrations entering the plant often exceed these design specifications, reducing treatment efficiency and potentially leading to the discharge of untreated wastewater into the environment.

4. **Treatment system design:** The design of ETPs and CETPs may not adequately address the current and future needs of the industries they serve. Many plants lack adaptability for technological upgrades or increased waste loads, with some facilities even outdated. Furthermore, insufficient financial investment in upgrades and inadequate maintenance can further compromise their efficiency in treating effluent.

5. **Effluent and treated water conveyance:** Effective conveyance systems for both raw effluent and treated water are crucial for the success of CETPs. If the systems that transport effluent to the treatment plant or return the treated water back to industries or the environment are inefficient, it can lead to leaks, spills, and contamination of water sources, which ultimately compromise the entire treatment process.

6. **Improper business models for CETPs:** CETPs often suffer from unsustainable business models, where costing and pricing are not aligned with the operational needs of the plants. Most of the industries may underpay for the treatment of their effluent, and the lack of insufficient incentives for CETPs to upgrade their facilities without long-term financial planning can lead to operational inefficiencies.

7. **Improper CETP management models:** Many CETPs face issues due to poor management practices. This includes lack of proper monitoring of the facility, inadequate personnel training, and lack of proper technologies, which can result in operational inefficiency. Many of the CETPs operated by IDCs and other public bodies lack accountability.

8. **Lack of expertise:** Proper wastewater treatment requires skilled personnel who understand the complexities of industrial wastewater treatment processes and technologies. However, many ETPs and CETPs lack access to trained professionals, resulting in below par operation and maintenance of treatment systems.

9. **Technology (BAT>>>BEST) (solution-based, not norm-driven):** Although Best Available Technology (BAT) is often recommended for the treatment of wastewater, in order to genuinely accomplish sustainable water management, BAT must give way to Best Environmental Sustainable Technology (BEST). Rather than rigidly following outdated rules, CETPs should concentrate on developing solution-based strategies catered to local circumstances. Innovative, adaptable, and efficient technologies are required to address the challenges posed by diverse wastewater characteristics.

10. **Unclear legislation and standards:** The efficacy of CETPs is frequently limited by a lack of precise and strict rules. Operators find it challenging to assure compliance when standards for treatment, effluent quality, and monitoring are unclear. Furthermore, if regulations are not strictly enforced, businesses might not take their responsibilities to treat wastewater seriously, which could lead to the release of untreated effluent into the environment.

4.3.1. Challenges in Treating Industrial Wastewater for Reuse

1. **Inefficient Treatment Technologies:** Many industries continue to use conventional treatment techniques that are unable to adequately handle complex wastewater contaminants. Advanced technologies such as Zero Liquid Discharge (ZLD) are expensive and not extensively used, which results in inadequate treatment and damage to the environment due to the continuous release of untreated wastewater to environment. Also there are no clear regulations regarding disposal of salt recovered during the ZLD process.

2. **Lack of Reliable Data and Monitoring:** It is unable to manage wastewater effectively across industries due to inconsistent monitoring and a lack of trustworthy data. The lack of consistent tracking and real-time monitoring makes it more difficult for legislators to evaluate the effectiveness of therapy and enforce adherence to environmental laws.

3. **High Treatment Costs and Limited Financial Support:** Advanced wastewater treatment technology installation and operation come with high prices. Adoption of sustainable practices is discouraged by the fact that smaller firms frequently lack the capacity to implement these technologies.

   It is to be noted that the cost- of- inaction on water related challenges is always more than what needs to be incurred on setting up and managing effective treatment systems.

4. **Inadequate Infrastructure:** In order to manage wastewater, many industrial areas lack the necessary infrastructure, such as Common Effluent Treatment Plants (CETPs). Due to underfunding or overcrowding at existing plants, enterprises are forced to self-treat or illegally release untreated effluents, which exacerbates pollution.

5. **Delays in Tendering and Project Implementation:** There are large gaps between the capacity and needs of infrastructure due to bureaucratic inefficiencies and delays in the approval and implementation of wastewater treatment projects. Long tendering procedures cause important projects to lag and provide industries with insufficient alternatives for remedy.

6. **Limited Expertise and Contractor Availability:** Wastewater treatment plant design, construction, and effective operation are hampered by a lack of qualified contractors and operators. Ineffective operation and maintenance (O&M) procedures further reduce these facilities' efficacy by causing equipment malfunctions and less-than-ideal treatment results.

7. **Underutilized Resource Reuse Potential:** Although wastewater treatment can make it possible to reuse resources, enterprises frequently miss out on these opportunities because of obstacles related to money, technology, or awareness. Important by-products that could benefit the economy and environment but are underutilized include treated water, biogas, and fertilizers.

8. **Lack of awareness:** The most substantial barrier to the reuse of treated wastewater is the public perception and resistance to reuse the treated water. Many people are hesitant to accept recycled water due to fears about its safety and quality. This mistrust often arises from the lack of understanding of the treatment processes and the stringent standards that ensure the water is safe for use. Additionally, negative media coverage and misinformation can exacerbate these concerns, leading to hesitance to use the recycled water as a viable resource. Addressing these perceptions through awareness programs, educating public and transparent communication canpromote the use of treated wastewater reuse.

9. **Lack of adequate R&D** efforts that fosterinnovative technologies that accelerate reuse of treated water.

4.4. PROPOSED FRAMEWORK FOR INDUSTRIAL WASTEWATER MANAGEMENT

VISION

PROPOSED FRAMEWORK ENVISAGES

MAXIMISING COLLECTION AND TREATMENT OF WASTEWATER AND REUSE OF THE TREATED WATER ON A SUSTAINABLE BASIS THEREBY REDUCING DEPENDENCY ON FRESH WATER RESOURCES.

Wastewater, thereby, transforms as a valuable economic resource. Policies and regulations should now focus on achieving this vision. Policy framework has to be comprehensive and covering the entire country.

An effective policy framework should include:

1. Zero tolerance on illegal discharges of water
2. Mandatory periodic **"adequacy check"** on the technologies and processes adopted at the treatment plants by Independent Engineer.
3. Affordable pricing strategy to make the treated water costs at par with costs from existing sources
4. Fit-for-purpose quality rather than single set of standards for all types of wastewater and treated water usage.
5. Incentivising reuse both by way ofcapital subsidies and **"extended user responsibility"** benefits.
6. Ease in **"right of way"** permits to facilitate quick and effective distribution of treated water for reuse
7. Framework to be applicable over all water consuming sectors – agricultural, domestic and industrial.
8. Strict enforcement based on AI/IoT based monitoring.

As elaborated earlier, the draft LWM Rules, 2024 (which becomes effective in Oct 2025) is a step in the right direction. These Rules have a few issues that need to be reviewed before implementation. These are

1. **Enforcement and Monitoring:** The policy lacks clarity on how enforcement will be ensured across different areas. There are no concrete penalties mentioned for non-compliance or inaccurate reporting. Additionally, there are concerns regarding the ability of SPCBs to effectively monitor the large volume of data submissions.

   The rules should introduce specific penalties for violations and a detailed plan for inspections to ensure accountability, especially in less-resourced areas.

2. **Support for Small and Medium Enterprises (SMEs):** While larger industries may have the capacity to implement sophisticated wastewater treatment systems, SMEs may struggle with the costs. The LWM rules do not provide any specific financial or technical assistance for smaller businesses to meet these requirements.

3. **Alignment with Existing National Missions:** The LWM rules overlap with the targets set by SBM 2.0, AMRUT 2.0, and NMCG, leading to possible confusion and inconsistencies in implementation. For example, SBM 2.0 mandates reuse of 20% wastewater in smaller cities, while the LWM rules have their own reuse targets for larger consumers, potentially creating policy conflicts.

   The government should harmonize these targets across the various national missions to ensure uniform compliance and prevent confusion at the state and local levels.

4. **Economic Feasibility:** The cost of installing advanced wastewater treatment systems like Zero Liquid Discharge (ZLD or maintaining Effluent Treatment Plants (ETPs) could be prohibitive for some industries. The rules do not mention any economic support mechanisms for industries that may find compliance too expensive.

5. **Public Resistance and Awareness:** There remains significant public resistance to the use of treated wastewater, particularly in residential areas. Without public support, the success of these regulations is uncertain. Launching public awareness campaigns to educate communities on the benefits of wastewater reuse is crucial to ensuring compliance and success.

   The Liquid Waste Management (LWM) Rules of 2024 are a comprehensive and necessary step toward addressing India's escalating wastewater crisis. However, several gaps particularly in terms of enforcement, alignment with existing frameworks, and economic feasibility could hinder effective implementation. The LWM rules will need to address these gaps and integrate more robust financial, technical, and public engagement strategies to ensure a smoother transition and broader compliance across industries and municipalities. Further, aligning these rules with existing missions like SBM 2.0, AMRUT 2.0, and NMCG will be essential to avoid policy conflicts and ensure India meets its ambitious water reuse and pollution reduction targets.

4.5. ENABLERS/KEY STRATEGIES

The following strategies help enable the circular economy framework for industrial wastewater:

1. **Policy directives** as elaborated in earlier paragraphs which will enable desired interventions in the areas of water conservation, water replenishment and water restoration. These ultimately lead to water-positive strategies and net-zero impact strategies.
2. **Technology identification** and adoption based on expert advice on proven and appropriate technologies.
3. **Monetary supports**/ incentives by way of Government grants without which industry will not be able to afford the cost of the required interventions.
4. Costs to be incurred based on **life cycle cost.**
5. Projects to be implemented on a **PPP model** with the designer, developer having a long term responsibility in the effective functioning of the project.
6. **Market support** for treated water reuse by way of awareness programs and incentives.
7. Effective **sludge management** by adopting processes for resource and energy recovery from sludge.
8. Mandating **on-line monitoring** of process and treated water parameters.

4.6. GOALS AND TARGETS

S. No.	Suggested Target	Target by 2027	Target by 2030
1.	Minimum percentage of treated wastewater reused in water intensive industries (such as thermal power plants, pulp & paper, textile, and iron & steel industries) as a percentage of total freshwater consumption. *[aligns with draft Liquid Waste Management Rules, 2024]*	60%	90%
2.	Minimum percentage of wastewater recovered in ETPs and CETPs as a percentage of total wastewater handled. *[aligns with draft Liquid Waste Management Rules, 2024]*	70%	90%
3.	Percentage of industries to adopt Zero Liquid Discharge Systems or ensure that no liquid effluent is discharged outside their premises. *[projection of requirements mentioned in draft Liquid Waste Management Rules, 2024]*	80%	100%
4.	Percentage of new industrial clusters/parks established after the year 2024 having provision for CETP. *[Rationale: Economy of scale, better environmental performance and improved compliance]*	100%	100%

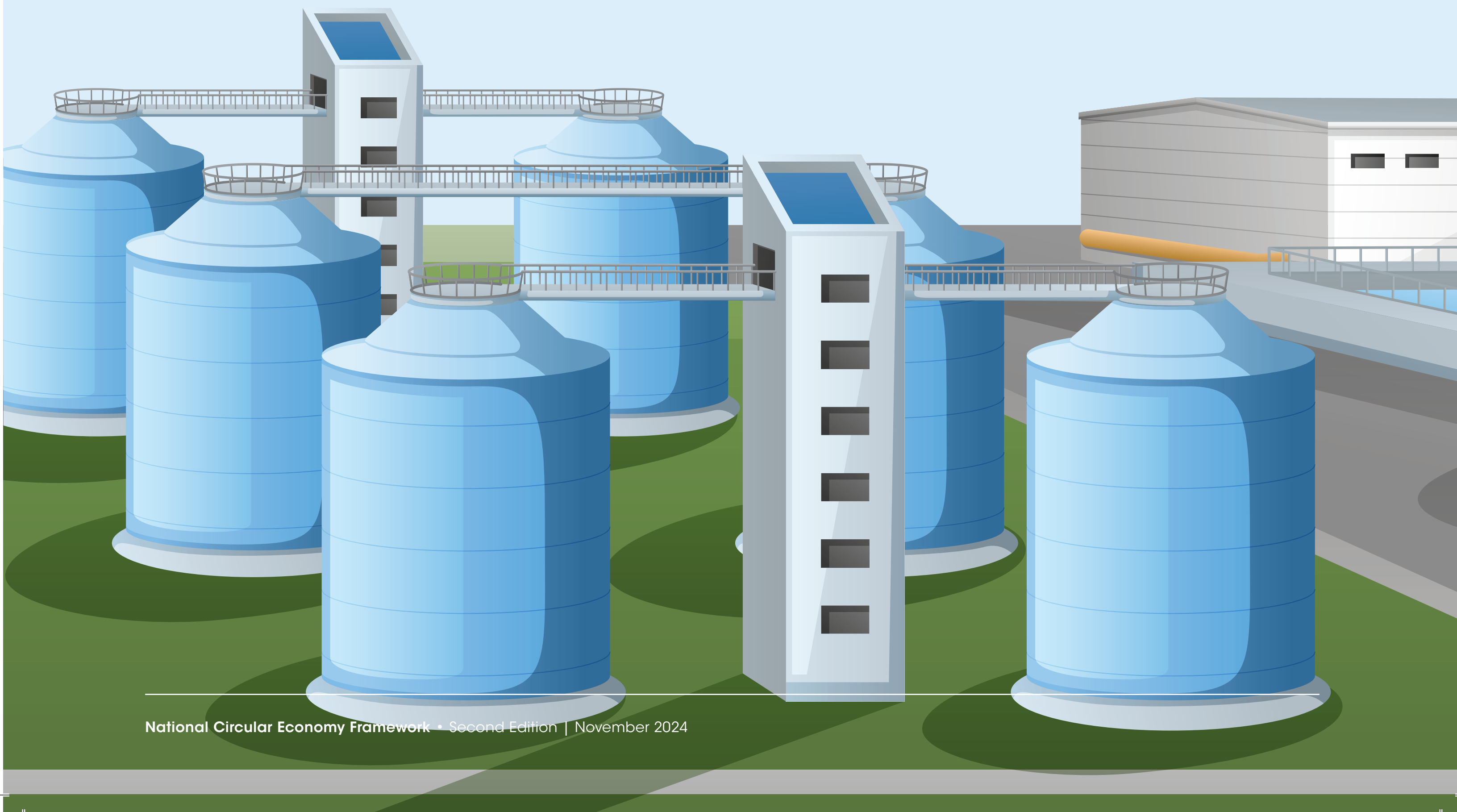
4.7. IMPACTS OF SUSTAINABLE WASTEWATER MANAGEMENT

A Policy Framework supporting sustainable wastewater management will yield several positive outcomes. Industries will gain the resilience to manage water-related stress, shocks, and uncertainties, benefiting in various ways:

- Ensured availability of consistently high-quality water
- Reduced dependency on external water suppliers
- Minimized withdrawal of raw water from natural sources
- Economic gains from optimizing water costs
- Cost savings from reduced need for contaminated water body remediation and rejuvenation

Communities around industrial areas also stand to benefit through:

- Enhanced environmental protection by preventing hazards linked to untreated or inadequately treated wastewater discharge
- Improved public health by reducing the spread of waterborne diseases
- Overall ecological improvement and sustainability

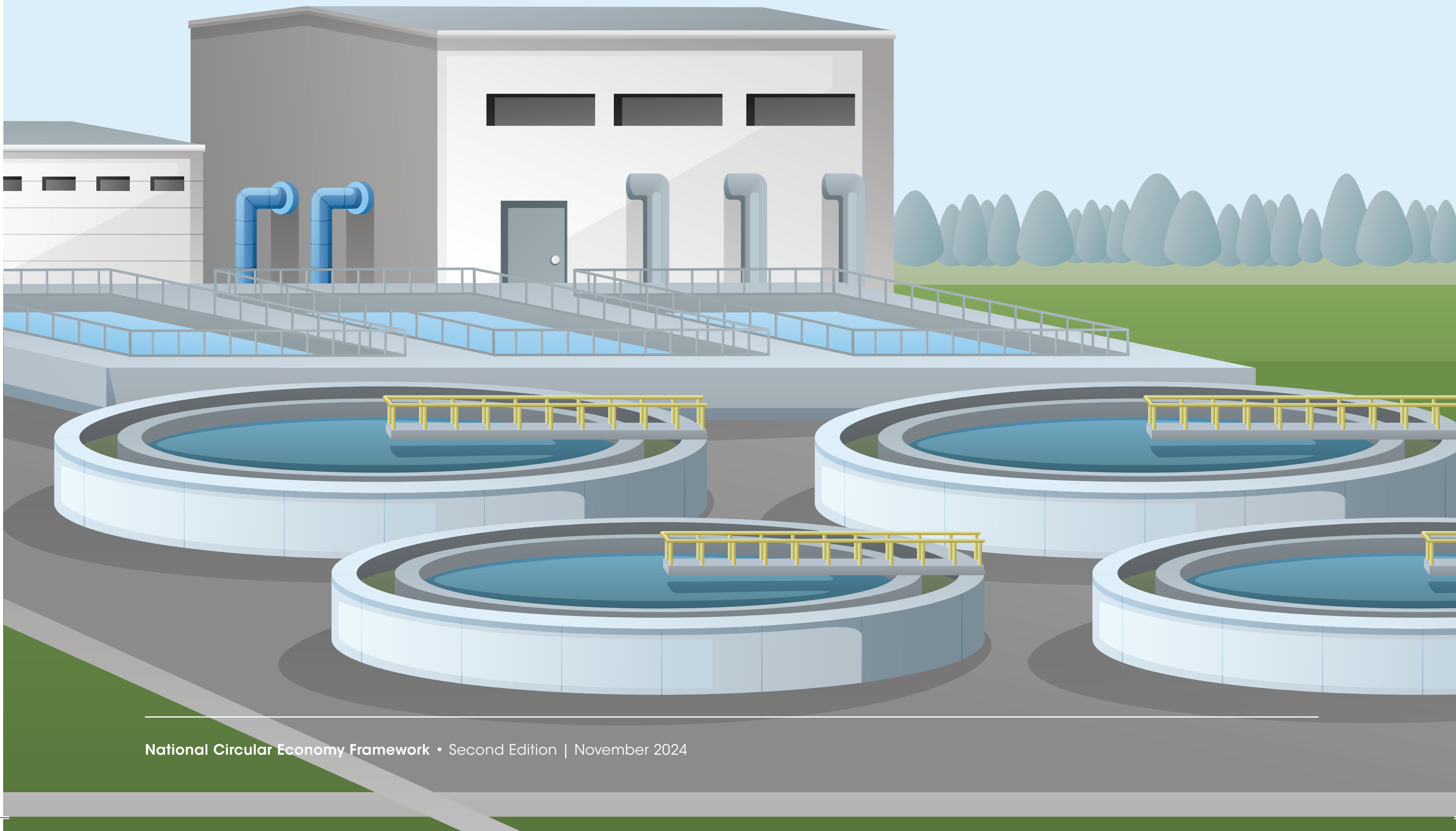


References:

1. Discharge of Industrial Wastewater into Rivers" - Government of India, Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation (Rajya Sabha, Unstarred Question No. 3599, Answered on 03.04.2023)

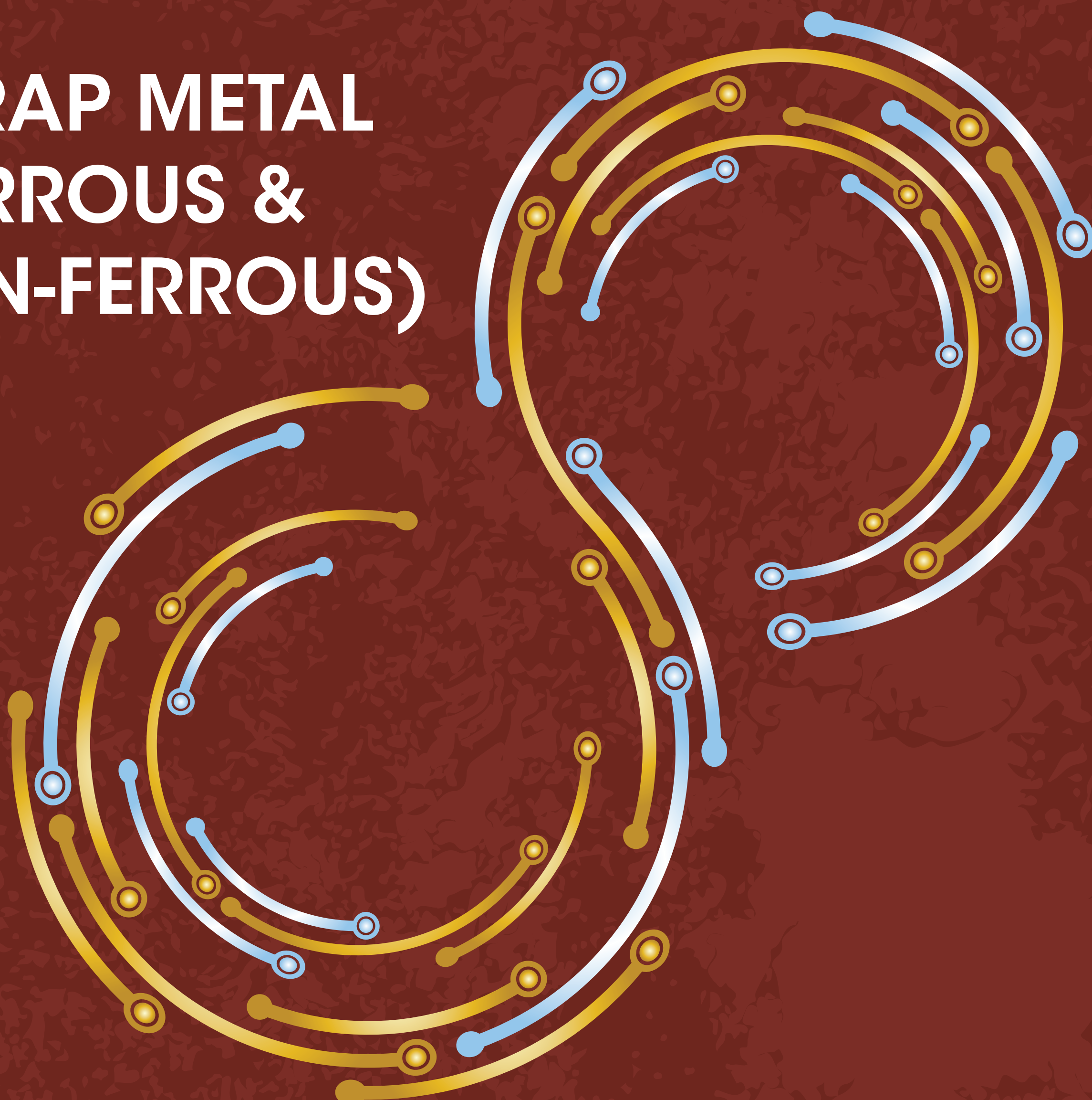
   https://sansad.in/getFile/annex/259/AU3599.pdf?source=pqars#:~:text=CPCB%20has%20identified%20 2859%20grossly,of%20India.

2. Rising Challenge by SumitaSinghal - State of India's Environment, Annual Edition 2023, Down to Earth, p. 459.
3. Natural Selection in Black and White: How Industrial Pollution Changed Moths - The Conversation. https://theconversation.com/natural-selection-in-black-and-white-how-industrial-pollution-changed-moths-43061
4. Caroline Grangier, ManzoorQadir, Murari Singh, Health Implications for Children in Wastewater-Irrigated Peri-Urban Aleppo, Syria, Water Qual Expo Health (2012) 4:187–195 DOI 10.1007/s12403-012-0078-7
5. CPCB Annual Reports- 2022-2023
6. India's 2024 Liquid Waste Management Rules: Challenges and Opportunities Ahead (downtoearth.org.in)
7. Draft LWM rules, 2024
8. https://jalshakti.gov.in/
9. https://nwm.gov.in/
10. https://nmcg.nic.in/
11. https://jalshakti-dowr.gov.in/
12. https://moef.gov.in/
13. https://amrut.gov.in/



Chapter 5

CIRCULAR ECONOMY ACTION PLAN *for* SCRAP METAL (FERROUS & NON-FERROUS)



5.1. INDUSTRY OVERVIEW

India produces 25 million tons of scrap and imports another 5 to 7 million tons, annually. The scrap metal market is projected to expand at a compound annual growth rate (CAGR) of 8.4% between 2020-2026, reaching $22 billion by 2026 from $13 billion in 2019. Increasing demand for recycled raw materials, urbanization and government regulations and support are enablers of this growth, with a majority of demand coming from construction and automotive sectors. Rising material costs, make scrap metal a more cost-effective option for industries compared to mining and processing raw materials. As of 2024, the Indian scrap recycling industry is valued at $11 billion – a 2.2% share of the global industry worth over $500 billion.

5.1.1. The Material Value Chain – A Circular Perspective:

An overview of the key stages focussing on environmental impact:

1. **Raw Material Extraction:** Mining operations for metals like iron ore, bauxite, and copper ore lead to land degradation, water pollution, and significant greenhouse gas emissions. For instance, iron ore mining contributes to deforestation and habitat loss.
2. **Manufacturing:** Processes such as casting, forging, and machining are energy-intensive and emit substantial CO_2. The design phase influences recyclability; products designed for durability and ease of disassembly are more conducive to recycling.
3. **Product Use and Repair:** Extending product lifespans through maintenance and repair reduces the need for new metal extraction, thereby conserving resources and minimizing environmental impact.
4. **End of Life:** In India, a significant portion of scrap collection occurs through informal channels, which often lack proper environmental controls, leading to pollution and health hazards.
5. **Recycling and Reprocessing:** Recycling metals is more energy-efficient than producing them from raw materials. For example, recycling aluminium saves up to 95% of the energy required for primary production.
6. **Secondary Raw Material:** Recycled metals re-enter the value chain, reducing the demand for virgin materials. Metals like steel and aluminium can be recycled indefinitely without quality loss.
7. **End-of-Life Disposal:** Not all scrap metal is recycled; some end up in landfills, leading to resource loss and potential environmental contamination. Urban mining—recovering metals from discarded products—offers a method to reclaim these resources.

Addressing the environmental impacts at each stage of the metal value chain is crucial for sustainable development.

Importance of Scrap Metal for Key Sectors of the Indian Economy

- **Steel and Construction:** Supports steel production by reducing reliance on iron ore and lowering CO_2 emissions, as encouraged by the National Steel Scrap Recycling Policy (2019).
- **Automotive:** Recycled steel and aluminum lower manufacturing costs and improve energy efficiency, with the Vehicle Scrappage Policy (2021) promoting metal recovery from end-of-life vehicles.
- **Electronics and Electrical:** Copper and aluminum from recycled sources are essential for wiring and components.
- **Manufacturing and Industrial Equipment:** Reduces production costs and boosts resource efficiency in machinery and equipment manufacturing.
- **Real Estate and Urban Development:** Recycled metals are integral to green building, reducing energy consumption in construction and promoting sustainable practices.
- **Energy:** Essential in renewable energy infrastructure, supporting sustainable resource use in wind turbines, solar panels, and EVs.
- **Defence and Aerospace:** Recycled metals like titanium and aluminum are critical for defence and aerospace manufacturing, lowering costs and environmental impact.
- **Packaging:** Recycling aluminum for packaging saves up to 95% of energy, aiding the packaging sector in waste reduction and circular economy efforts.

5.1.2. Negative Impacts of Scrap Metal

Negative Impacts of Scrap Metal on the Environment:

1. **Air pollution from metal corrosion:**
   Scrap metals, especially in open environments, corrode and release particulates and toxic compounds, degrading air quality.

2. **Soil Contamination from heavy metal leaching:**
   Toxic metals like lead, mercury, and cadmium from scrap metals seep into the soil, affecting fertility and entering the food chain.

3. **Water Contamination:**
   Scrap metals leach heavy metals into groundwater, contaminating drinking water supplies and when dumped near water bodies release metals into rivers and lakes, harming aquatic ecosystems.

4. **Toxic Waste Generation:**
   Metals like lead and mercury in scrap generate hazardous waste, posing long-term environmental risks.

5. **Biodiversity Loss:**
   Scrap metal piles near natural areas degrade habitats and expose wildlife to toxic substances, leading to biodiversity loss.

6. **Urban Degradation:**
   Accumulation of scrap metals in urban areas reduces aesthetic appeal and lowers property values.

Negative Social Impact of Scrap Metals:

1. **Health Hazards for Workers:**
   Workers in the informal sector face severe health risks from exposure to hazardous metals, causing respiratory issues and neurological disorders.The limited access to protective gear leads to frequent injuries and long-term illnesses. Communities near scrap yards suffer from poor air and water quality, leading to health issues.

2. **Child Labour and Exploitation:**
   The scrap industry employs many children, exposing them to dangerous conditions and exploitation. Workers are also exploited through low pay and due to lack of formal protections.

5.2. CURRENT STATUS – CIRCULAR ECONOMY OF SCRAP METALS

5.2.1. Government Initiatives furthering circularity of scrap metals:

- **The National Steel Scrap Recycling Policy (2019)** encourages the reuse of scrap metals and on developing efficient collection, processing, and recycling systems to meet industrial needs, thus fostering a more sustainable cycle for metal use.
- **The Vehicle Scrappage Policy (2021)** encourages the recycling of materials from end-of-life vehicles, recovering valuable metals like steel, aluminium, and copper.

5.2.2. Industries furthering circularity of scrap metal

- **Construction and Automotive Sectors:** The use of scrap metals in construction (for steel rebars, beams, etc.) and in automotive manufacturing (for vehicle parts) has increased significantly, reducing the carbon footprint and promoting sustainability. India aims to increase the share of scrap metal in steel production to 50% by 2047.
- **Urban Mining:** India is the third largest e-waste producer in the world. The concept of urban mining—recovering metals from discarded electronic goods and other urban waste—is another way India is pushing the circular economy. Metals like copper and aluminium from e-waste are reused, which reduces mining activities and conserves natural resources.

5.3. GAPS, CHALLENGES AND LEARNINGS

5.3.1. Gaps and Challenges

- **Informal Waste Management Sector:** India's informal waste management sector handles a majority of country's scrap metal (likely to be at least 60%) and poses significant challenges to circularity due to its unregulated nature. Small-scale collectors and informal recyclers use inefficient, manual methods for collection and sorting, leading to contamination and difficulty in processing high-quality scrap metal for reuse. Unsafe practices like burning insulated wires, release toxic fumes, harming both the environment and worker health. Additionally, the sector's fragmentation and lack of integration into formal systems hinder effective tracking, monitoring and reuse of materials, limiting progress toward a circular economy.
- **Infrastructure & Technology Gaps:** India faces a shortage of formalized scrap collection and processing centres, essential for managing its growing metal demand. To address this, the country needs to establish approximately 70 new scrap processing centres and around 300 collection centres to bridge the current deficit of 7 million tons of scrap metal. This gap is expected to widen as India's steel production targets increase to 300 million tons by 2030.

  Furthermore, the recycling infrastructure in India is underdeveloped, lacking advanced technologies such as shredders and modern processing units. This results in inefficient scrap processing and impurities in recycled metals, which compromises the quality of scrap available for industrial use, particularly in steelmaking.

5.3.2. International Best Practices

- **Advanced Recycling Technologies (Europe):** The EU uses sensor-based sorting technologies to improve the purity of recycled metals, boosting recovery efficiency. This enables it to have an enormous success rate with recycling, with 70% of all steel produced to date, still in use.
- **Electric Arc Furnace (EAF) Steelmaking (U.S.):** EAF steelmaking, which uses scrap metal, reduces energy consumption and produces 75% lower carbon emissions. In the U.S., 70% of steel is produced via EAF, whereas in India where are currently at 28%.
- **Extended Producer Responsibility (EPR) Policies (Japan):** Japan's EPR mandates manufacturers to manage the end-of-life disposal of products, leading to the recycling of 98% of automobiles and recovering 85-90% of metal from vehicles.
- **Zero-Waste Steel Plants (Sweden):** Sweden's steel industry aims for zero waste, with plants using by-products like slag for construction, contributing to a ~90% recycling rate for scrap metals.
- **Public-Private Partnerships (Netherlands):** The Netherlands promotes collaborative models between industries and government, with companies like Tata Steel Netherlands including 30% recycled content in its steel.

5.4. PROPOSED FRAMEWORK, APPROACHES & ENABLERS

5.4.1. Vision for Circular Economy of Scrap Metals

India envisions a sustainable, self-sufficient scrap metal ecosystem that fully supports a circular economy. The goal is to transition the scrap metal sector from its current informal, fragmented state to a structured, regulated system that integrates the informal sector and establishes robust nationwide infrastructure. By developing a network of processing and collection centers, India aims to streamline scrap metal collection, processing, and recycling to reduce dependency on metal imports and foster efficient resource utilization.

Public-private partnerships will play a key role in driving infrastructure, workforce training, and industry incentives to adopt circular design principles. This approach will encourage the reuse and disassembly of metal products, particularly within high-impact sectors such as automotive, construction, and electronics. Through collaboration and innovation, India will establish itself as a global leader in scrap metal recycling, achieving a fully integrated circular economy that supports sustainable economic growth, environmental stewardship, and resource independence.

5.4.2. Approaches to achieve the articulated vision

1. Inclusion of the Informal Sector

- **Current Challenge:** The informal sector processes a significant portion of India's scrap metals, often using inefficient and unsafe methods.
- **Approach:** Formalize this sector by providing financial incentives, training, and access to modern recycling tools, enhancing both recycling efficiency and worker safety. Government-led initiatives should focus on upskilling informal workers to operate advanced equipment and adopt safer practices.

2. Infrastructure Development

- **Current Challenge:** India lacks sufficient formal processing centers and advanced recycling technology to handle increasing scrap volumes.
- **Approach:** Address regional infrastructure gaps by establishing new processing and collection centers and investing in modern recycling technologies, such as automated sorting and shredding. These improvements will streamline collection, sorting, and metal recovery, drawing on successful models from the EU and USA.

3. Public-Private Partnerships (PPP)

- **Current Challenge:** The public sector alone cannot meet the substantial investment and innovation needs of an expanded recycling system.
- **Approach:** Foster public-private partnerships to jointly fund and expand recycling infrastructure. Incentivize private industries to co-invest in recycling technologies, creating a circular economy built on shared responsibilities and collective benefits.

4. Circular Design and Manufacturing

- **Current Challenge:** Many products are not designed for efficient recycling, repair, or disassembly, limiting material recovery.
- **Approach:** Encourage manufacturers to adopt circular design principles that facilitate disassembly and reuse, particularly in automotive and construction sectors. Regulatory mandates requiring recycled content in products will drive demand for scrap, supporting circularity in manufacturing.

5. Urban Mining and E-Waste Recycling

- **Current Challenge:** Valuable metals in e-waste remain underutilized, and e-waste recycling infrastructure is insufficient.

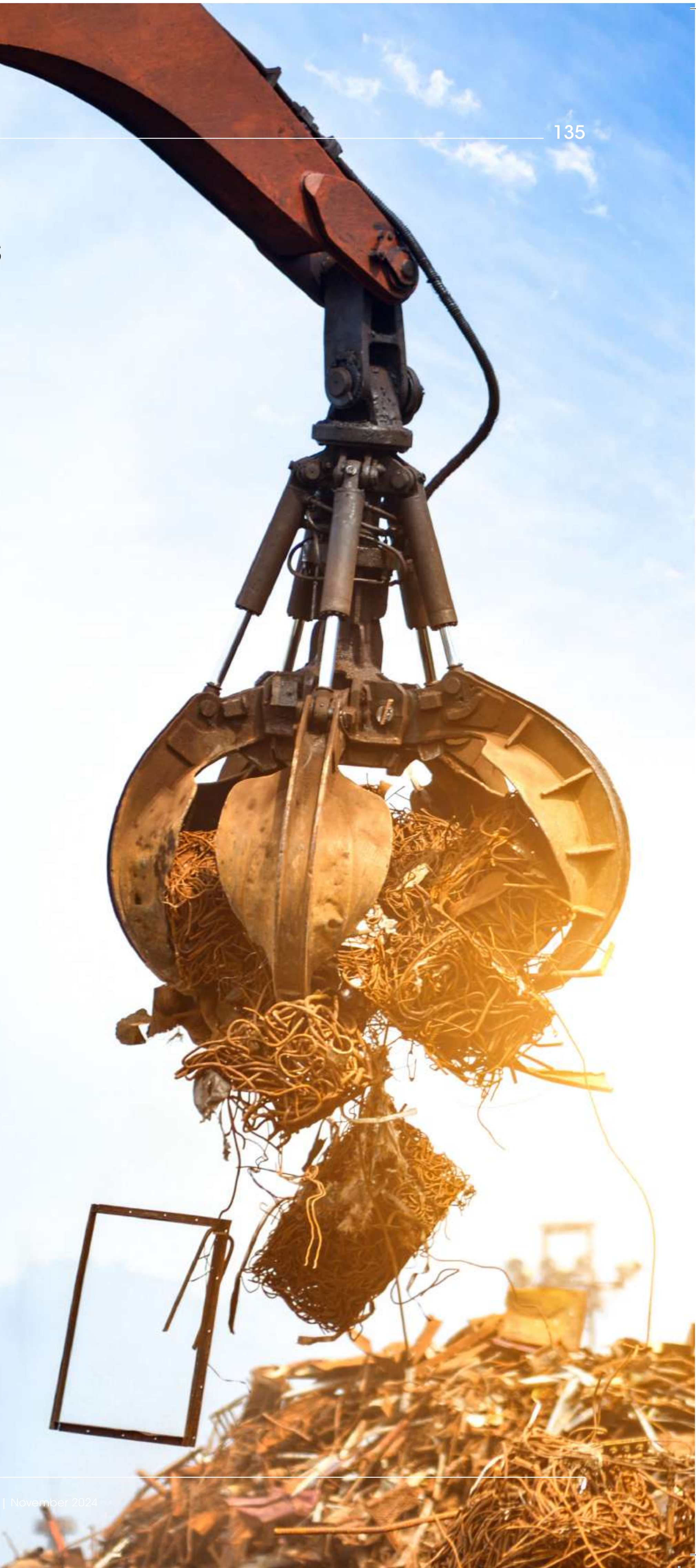
- **Approach:** Establish dedicated e-waste recycling facilities equipped with state-of-the-art technology to recover metals like gold, copper, and aluminium from electronic devices, tapping into urban mining as a valuable resource stream.

6. Data-Driven Policy and Regulatory Framework

- **Current Challenge:** Insufficient data and weak regulatory enforcement hinder the progress toward a circular economy.
- **Approach:** Develop a national database to track scrap metal generation, collection, and recycling rates, enabling data-driven decision-making and more responsive policy adjustments. Strengthen enforcement with penalties for non-compliance and implement tighter controls on scrap imports and exports.

7. Public Awareness and Incentives

- **Current Challenge:** Limited public awareness of recycling and circularity benefits hinders widespread adoption.
- **Approach:** Launch nationwide awareness campaigns to educate industries and consumers on the benefits of recycling and circularity. Encourage companies adopting recycled materials and circular design principles, fostering demand for recycled scrap and sustainable practices.



5.5. GOALS AND TARGETS

HAZARDOUS AND OTHER WASTES (MANAGEMENT AND TRANSBOUNDARY MOVEMENT) SECOND AMENDMENT RULES, 2024

To promote resource efficiency and reduce environmental impacts, MoEF&CC notified the draft "Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2024" on August 14, 2024. Effective April 1, 2025, these rules introduce a new EPR mechanism for non-ferrous metals. The notification requires that the products manufactured using non-ferrous metals like aluminium, copper, and zinc should contain certain quantities of recycled material.

From FY 2027-28 and beyond, there will be a minimum requirement of 5% recycled content for all the aforementioned non-ferrous metal products including aluminium, copper, and zinc. This move by the policy aims to cut down reliance on primary resources and, subsequently, the environmental damages linked with extracting and processing raw metals.

The roadmap towards reducing industrial waste, aiming to achieve at least 10% recycled content for aluminium products, 20% for copper, and 25% for zinc, is as given in the table below:

Sl. No.	Type of Metal	Minimum use of recycled materials out of the total weight of the new product (in percentage)			
		2027-28	2028-29	2029-30	2030-31
(i)	Aluminium	5	10	10	10
(ii)	Copper	5	10	15	20
(iii)	Zinc	5	10	15	25

Extended Producer Responsibility (EPR) obligation of the Producer of items made of non-ferrous metals as given in the 'Schedule-II' of the draft Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2024 is as given in the table below.

Sl. No.	Year (Y)	Recycling Target (by weight) - % of the quantity in the year (Y-X) where (X) is the life of the product
1	2025-26	10%
2	2026-27	10%
3	2027-28	30%
4	2028-29	30%
5	2029-30	50%
6	2030-31	50%
7	2031-32 onwards	75%

In addition to the EPR, to achieve the above vision, the following targets are proposed:

Target	2025	2030
Recycling Target for the non-ferrous metals for the major manufacturing industries *[Aligns with Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2024].*	Minimum of 10%	Minimum of 50%
Establish 70 scrap processing and 300 collection centres with modern recycling technology in 'Hub-and-spoke' model (% achievement) *[Aligns with National Steel Scrap Recycling Policy (2019)]*	25%	100%
Increase the steel scrap recycling rate (%) from current 30% to align with current global average *[In line with BCG Report 'Flattening the Curve' https://web-assets.bcg.com/ac/68/cbff54504c038167da342f9eb40d/bcg-et-circularity-report-digital.pdf]*	50%	90%
Inclusion of the informal sector through training programs, financial incentives, and access to modern recycling tools *[Aligns with National Steel Scrap Recycling Policy (2019)]*	Minimum of 25%	Minimum of 80%

5.6. IMPACT POTENTIAL

- **Economic Benefits:** India imports about 7 million tons of scrap metal annually, costing INR 24,500 crore. Achieving full circularity, will reduce this dependency by retaining valuable resources for domestic use, resulting in substantial foreign exchange savings. Job creation from formalizing the sector, advanced technologies and improved infrastructure, will contribute to India's GDP growth.

- **Environmental Benefits:** In steel production itself, using each ton of scrap can save approximately 1.1 tons of iron ore, 630 kg of coking coal, and 55 kg of limestone. Additionally, it significantly lowers energy consumption, reducing it from about 14 MJ/kg in the traditional blast furnace/ blast oxygen furnace (BF/ BOF) production route to under 11 MJ/kg in the electric arc furnace/induction furnace (EAF/IF route)—resulting in energy savings of 16-17%. This approach also decreases water usage and greenhouse gas emissions by 40% and 58%, respectively.

References:

1. How India's Metal Scrap Recycling Industry Growing - BW BusinessWorld
   https://businessworld.in/article/how-indias-metal-scrap-recycling-industry-growing-447133

2. Steel Scrap Recycling Policy 06.11.2019.pdf
   https://steel.gov.in/sites/default/files/Steel%20Scrap%20Recycling%20Policy%2006.11.2019.pdf

3. Circular Economy: How India plans metal scrapping centres - India CSR
   https://indiacsr.in/circular-economy-how-india-plans-metal-scrapping-centres/

4. National Vehicle Scrappage Policy: Advancing Automotive Circular Economy In India - Rail, Road & Cycling - Transport - India
   https://www.mondaq.com/india/rail-road-cycling/1111528/national-vehicle-scrappage-policy-advancing-automotive-circular-economy-in-india

5. India announces big `green steel' ambitions - Recycling International
   https://recyclinginternational.com/business/india-announces-big-green-steel-ambitions/55979/

6. How Does Scrap Metal Recycling Affect the Environment - P&T Metals
   https://www.ptmetals.com/blog/scrap-metal-environmental-impact/

7. Electronic Waste | Toxics Link
   https://toxicslink.org/electronic-waste

8. India Scrap Metal Recycling Market (2024-2030) - Trends, Outlook & Forecast
   https://www.6wresearch.com/industry-report/india-scrap-metal-recycling-market-2020-2026

9. Scrap Protectionism Threatens India's Recycling Future: Urgent Measures Needed
   https://www.business-standard.com/content/press-releases-ani/scrap-protectionism-threatens-india-s-recycling-future-urgent-measures-needed-124010600542_1.html

10. Steel as a Model for a Sustainable Metal Industry in 2050
    https://www.bcg.com/publications/2015/metals-mining-sustainability-steel-as-a-model-for-a-sustainable-metal-industry-in-2050

11. Exploring Why Metal Recycling Is Sustainable for Our Planet - P&T Metals
    https://www.ptmetals.com/blog/why-metal-recycling-is-sustainable/

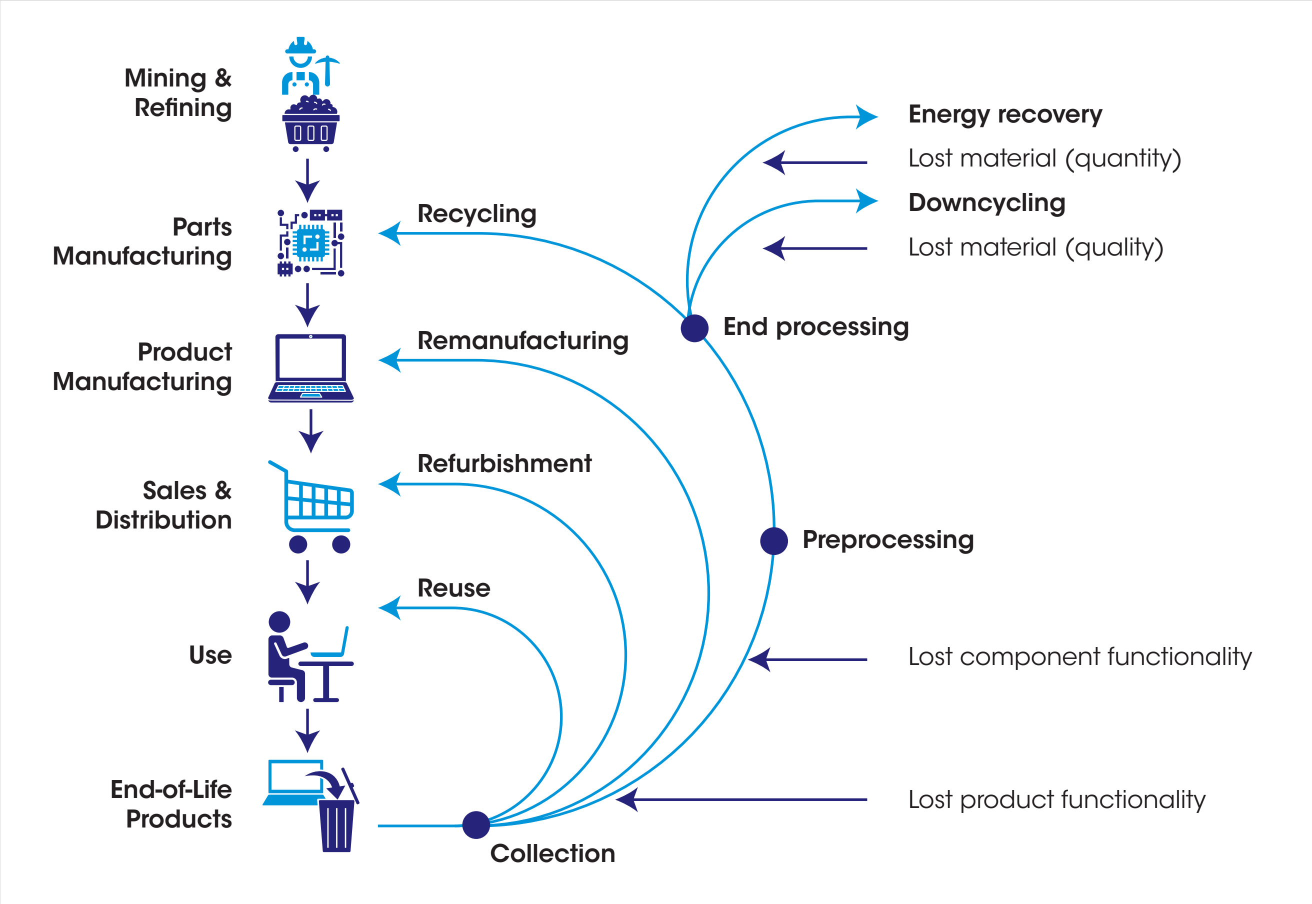
Chapter 6

CIRCULAR ECONOMY ACTION PLAN *for* ELECTRONIC WASTE

6.1. INDUSTRY OVERVIEW

E-Waste is rapidly increasing due to technological innovations, higher consumption, limited repair options, shorter product life cycles, and inadequate E-Waste management infrastructure—factors that are outpacing the rise in formal recycling by nearly fivefold. In 2022, only 22.3% of global E-Waste was formally documented as being recycled in an environmentally sound manner. An ideal E-Waste management process is illustrated in Figure 6-1.

Figure 6-1: An Ideal E-Waste Management



Source: *Parajuly, K. (2017). Circular Economy in E-Waste Management: Resource Recovery and Design for End-of-Life. SyddanskUniversitet.*

A record 62 billion kg of electronic waste (E-Waste) was generated globally by 2022, averaging 7.8 kg per person per year. Properly managed E-Waste can provide multiple recyclable streams, including glass (37%), metal (33%), and plastic (30%). In 2022 alone, E-Waste was estimated to contain 31 billion kg of metals, 17 billion kg of plastics, and 14 billion kg of other materials (such as minerals, glass, and composites).

Key findings from the Global E-Waste Monitor, 2024 include:

- In 2022, global E-Waste contained 31 billion kg of metals, of which an estimated 19 billion kg were recovered and reintegrated into the supply chain.
- Platinum-group and other precious metals, though present in lower quantities, are highly valuable. An estimated thousand kg of these metals were recycled through formal and informal methods.

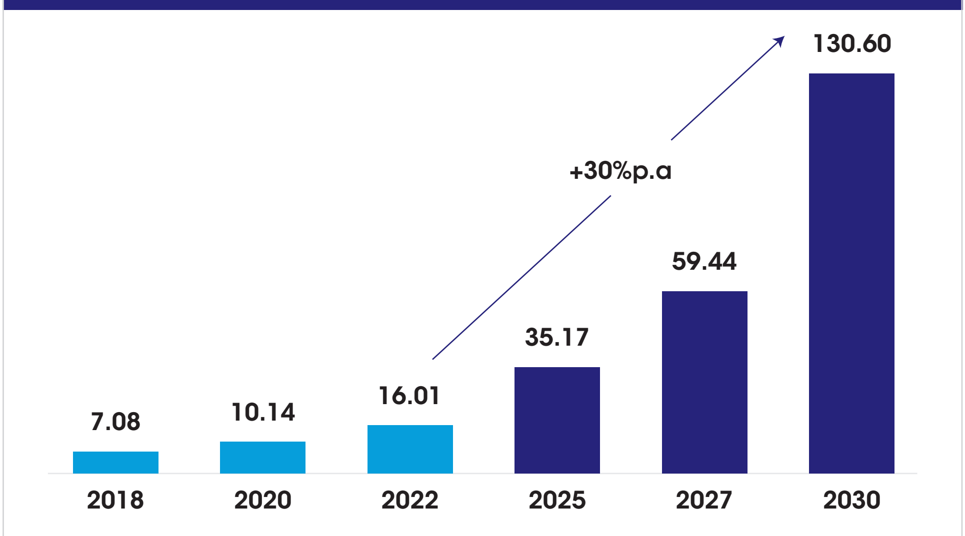
The scientific community concurs on the importance of recovering precious metals (such as silver, gold, platinum, and palladium) and rare earth elements (such as tantalum and gallium), particularly from waste printed circuit boards, which make up only 3–6% of E-Waste. Printed circuit boards (PCBs) often contain higher concentrations of these elements than natural ores, making them valuable for extraction.

In addition to established E-Waste streams, emerging streams are rising, with little regulation or established best available technologies (BAT) for management. Photovoltaic panels, for instance, are projected to contribute 2.4 billion kg of E-Waste by 2030. Space debris containing electrical and electronic equipment (EEE) is also increasingly acknowledged, with the European Space Agency aiming to be space debris-neutral by 2030.

Materials from E-Waste, especially precious metals, are expected to play a vital role in various manufacturing industries, including electronics, automotive, and renewable energy (e.g., for solar panels and wind turbines). By 2030, greenhouse gas (GHG) emissions from waste electrical and electronic equipment (WEEE) are expected to reach 254 million tons of CO_2 equivalent annually, with a loss of 17 billion kg of metals and an estimated net economic loss of $40 billion under the business-as-usual scenario.

In India, the Ministry of Environment, Forest, and Climate Change (MoEF&CC) reported that 1.6 million tons of E-Waste were generated in 2022. Of this, only 32.92% was formally collected, dismantled, recycled, or disposed of. According to NITI Aayog, E-Waste is growing by approximately 30% annually, projecting an estimated 13.06 million tons by 2030, as shown in the figure below.

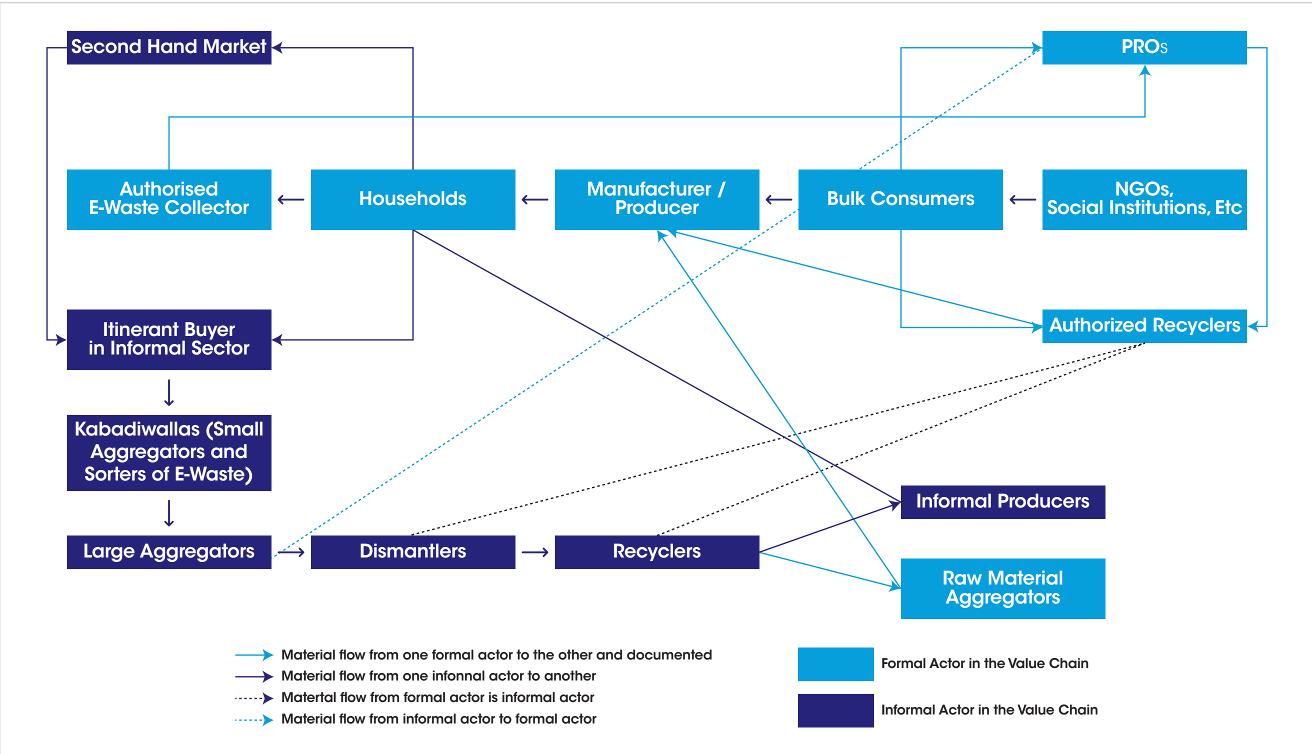
Urban WEEE Generated in India (1,00,000 Tones per year; FY)



6.2. CURRENT STATUS

Most of the existing and authorized E-Waste processors in India are dismantlers, collectors /preliminary recyclers/refurbishersand are not technologically advanced in precious metal recovery. Some studies point out that E-Waste in India is managed by the informal sector by more than 90%. Unlike most of the developed countries, the Indian E-Waste management system is not formally developed and is very ill-defined. The current material flows and value chains in E-Waste in India are intertwined with the formal and informal sectors as given in **Figure 6-2**.

Figure 6-2: Material Flow and Value Chain in E-Waste



Source: *NITI Aayog Draft on Strategy for secondary materials management for promoting resource efficiency (RE) and Circular Economy (CE) in Electrical and Electronic Equipment Sector*

At present, the majority of formal sectors in India are only limited to surface leaching, and there is a big gap in efficient recycling. The detailed processes involved in formal recycling are provided in **Table 6-1** in comparison with informal recycling processes. In informal processing, the majority of the metals including Gold and Copper are leached by open acid leaching followed by manual sieving in a very crude manner causing harm to the environment and handler.

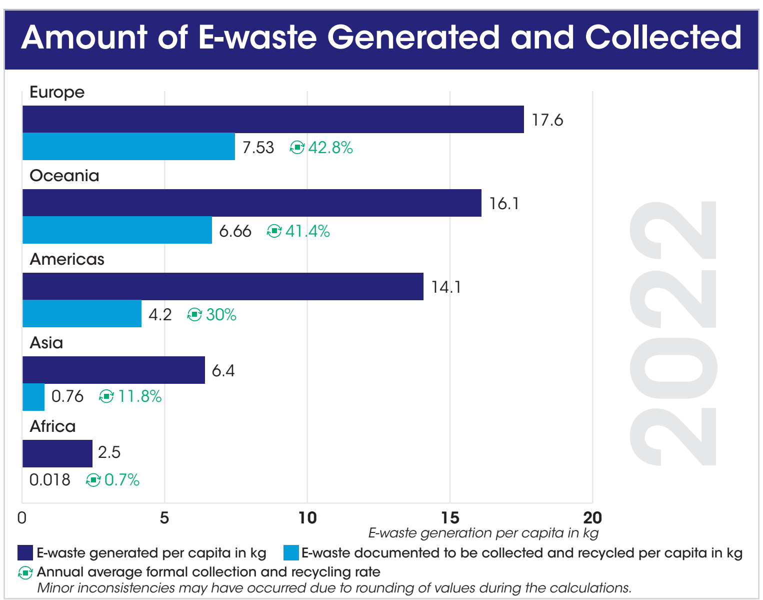
Table 6-1: E-Waste management processes followed by formal and informal recyclers

Formal Recyclers	Informal Recyclers
1. Collection	1. Collection
2. Dismantling	2. Dismantling
3. Component separation	3. Component separation
4. Surface leaching (Hydrometallurgy)	4. Component Harvesting
5. Mechanical crushing	5. Surface leaching
6. Density separation	6. Burning
7. Pyro & Hydrometallurgical recovery (Very limited / mostly on a pilot basis)	7. Hydro Leaching
	8. Melting (Pyrometallurgy)

The top states with maximum E-Waste processing units are Uttar Pradesh, Maharashtra, Karnataka, Rajasthan, Gujarat, Haryana, and Tamil Nadu. In recent years, the formal collection and recycling, nationally and globally has increased about 0.5 billion kg per year to 13.8 billion kg in 2022.

The documented formal collection and recycling rates vary significantly across regions, with Europe boasting a rate of 42.8 %. The overall E-Waste recycling capability globally is given in **Figure 6-3**.

Figure 6-3: E-Waste Generated and Documented as Formally Collected and Recycled by Region



Source: *The Global E-Waste Monitor 2024*

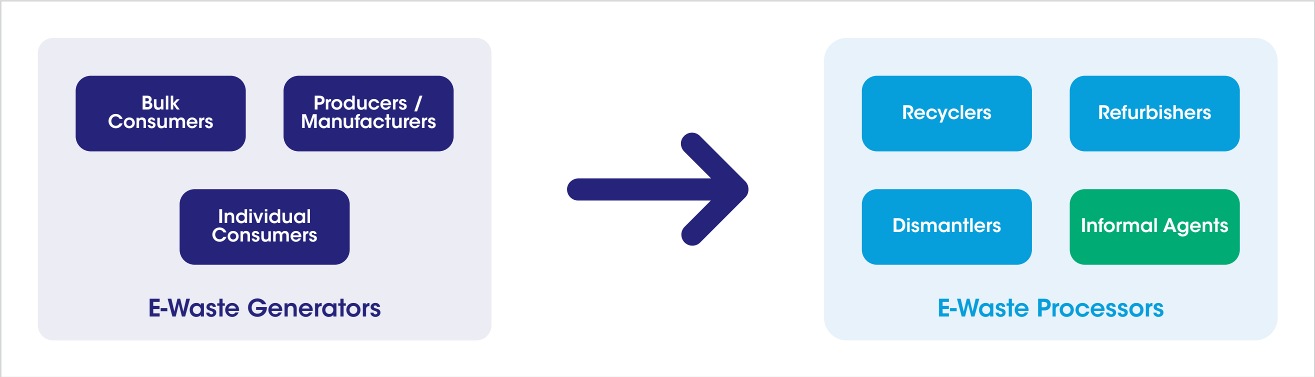
Recently, to increase the circularity in E-Waste handling and management in India, the Ministry has notified the E-Waste (Management) Rules, 2022 effective from 1st April 2023 which brought in the much anticipated (EPR) regime for E-Waste recycling to promote Circular Economy and scientific recycling/disposal of E-Waste. These rules have identified 106 different E-Waste items under EPR. Producers of notified electrical and electronic equipment (EEE), have been given annual E-Waste Recycling targets based on the generation from the previously sold EEE or based on sales of EEE as the case may be.

The Rules also emphasize the reduction in the use of hazardous susbstances in the manufacture of EEE and their components or consumables or parts or spares. Every producer of electrical and electronic equipment and their components or consumables or parts or spares listed in Schedule I shall ensure that, new electrical and electronic equipment and their components or consumables or parts or spares do not contain Lead, Mercury, Cadmium, Hexavalent Chromium, polybrominated biphenyls and polybrominated diphenyl ethers beyond a maximum concentration value of 0.1 per cent by weight in homogenous materials for lead, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers and of 0.01 per cent by weight in homogenous materials for cadmium.

6.3. CHALLENGES AND DRIVERS OF E-WASTE MANAGEMENT IN INDIA

The majority of the E-Waste Generators can be classified as shown in **Figure 6-4**

Figure 6-4: E-Waste Generators and Processors



The prevailing challenges in collecting material from generators include:

- At the level of Bulk Consumer, and Manufacturer / Producer - A value-driven approach focused on selecting the lowest bidder in Tenders / Bidding, with minimal regard for environmental factors or due diligence. There is also prevalent non-compliance, a lack of awareness about safe E-Waste processing, and limited pressure from regulatory authorities.
- At the level of Individual consumers – A lack of awareness about safe and sustainable disposal practices and the convenience of selling to the informal sector, which often offers higher financial returns.

The typical challenges faced by an authorized recycler include:

- High sourcing costs
- Insufficient volumes due to heavy competition from the informal sector
- Higher Capex and operational costs
- Low efficiencies and partial processing due to Inadequate Equipment / Limited technology
- Dependency on Exports

The informal sector offers significant strengths, including lower collection and sourcing costs due to minimal infrastructure requirements and extensive networks that reach residential areas nationwide. It operates with reduced capital expenditure and operational costs, bypassing many expenses typical of formalized sectors. Additionally, transactions in this sector are often non-GST, providing a further cost advantage. However, the informal sector frequently does not adhere to safety, environmental, and regulatory standards, posing risks to worker health and safety as well as environmental sustainability. This lack of compliance can lead to improper handling, unsafe dismantling practices, and hazardous waste disposal, which undermine sustainable management efforts and create long-term ecological and public health challenges.

6.4. PROPOSED FRAMEWORK

This section proposes a framework to enhance circularity in e-waste management, particularly focusing on bulk consumers. Currently, ambiguities in the definition of bulk consumers, lack of monitoring and enforcement, and inconsistent pricing for E-Waste recycling hinder progress towards a circular economy. The proposed framework attempts to address these challenges by proposing stricter categorization of bulk consumers, mandatory annual filings, standardized pricing mechanisms, and an integrated compliance rating system for recyclers. **Table 6-2** presents the current challenges and the proposed framework in a detailed manner.

Table 6-2: Proposed Framework along with existing scenario and challenges

Existing Scenario and Challenges	Proposed Framework
The definition of a bulk consumer in the E-Waste Rules states that any entity using at least one thousand units of listed electrical and electronic equipment (Schedule-I) in a financial year, including e-retailers, qualifies. However, this is not practically enforced, allowing many bulk consumers to exploit this loophole and avoid proper disposal.	The definition should be differentiated between IT and non-IT categories. IT companies with a minimum of 5 employees should fall under these rules, and the minimum threshold for non-IT bulk consumers should be set to 100 items instead of 1,000.
Only a limited number of bulk consumers are currently under Pollution Control Board (PCB) monitoring. Additionally, the E-Waste Rules 2022 do not mandate annual E-Waste filings for bulk consumers.	All bulk consumers should be regulated and required to submit annual filings.
There is no standardized pricing for E-Waste recycling, leading to market irregularities. For example, many bulk consumers sign MOUs with recyclers for disposal but request refurbishing prices, pressuring recyclers to compete with the informal sector.	The Ministry of Environment, Forest, and Climate Change (MoEFCC) and the Central Pollution Control Board (CPCB), with support from associations like the Material Recycling Association of India (MRAI), should establish minimum and maximum recovery prices for all the E-Waste items listed in the 2022 E-Waste Rules.
To prioritize environmental factors, a distinct integrated compliance rating should be introduced by recycling associations with regulatory support.	A minimum compliance rating should be legally mandated for bulk consumers when disposing of waste. Auction platforms should also qualify recyclers based on these ratings, which could include: • EHS compliance • Sustainability rating • Technology rating • Recycling efficiency • Material coverage
Recycling efficiency and due diligence practices are inconsistent.	The MoEFCC should consider establishing a dedicated recycling or sustainability wing to enhance recycling efforts within government bulk consumer sectors. This wing would conduct due diligence, qualify recyclers by region, and select them based on balanced ratings for E-Waste disposal.
E-Waste collection and disposal tracking is inadequate in residential associations and gated communities.	Residential associations and communities should be regulated as bulk consumers under the E-Waste management framework.

In addition to the above, the following recommendations may be adopted to formalize the informal sector:

- Kabadiwalas should be brought under the jurisdiction of Urban Local Bodies and be required to obtain licenses to carry out the collection process.
- Material Recovery Facility (MRF) centers should be promoted through PPP models, set up in clusters across cities, and kabadiwalas should be directed to sell their collected waste to these MRFs.
- MRFs should qualify and partner with efficient recyclers through a mandatory rating process to handle E-Waste responsibly.
- Although pricing may initially pose a challenge, over time, this system will stabilize, enabling kabadiwalas to purchase at lower prices while maintaining margins similar to those in the current system.

6.5. ENABLERS

The following initiatives could be implemented by the Government to foster a more supportive ecosystem for recyclers:

1. Provide viability gap funding, if necessary, for advanced recycling technologies through targeted policy interventions.
2. Establish a circular network among recyclers, categorizing them into levels (e.g., Levels 1–3) and clusters, and encourage them to collaborate within these groups rather than diverting materials back to the informal market for marginally higher prices.
3. Enforce stringent regulations with penalties for non-compliance.
4. Set standardized recovery prices as well as Extended Producer Responsibility (EPR) pricing.
5. Promote Information, Education, and Communication (IEC) programs by encouraging schools and colleges to hold annual E-Waste awareness campaigns.
6. Support the integration of informal processors into the formal sector by providing education and financial assistance.
7. Prioritize and incentivize startups and innovative technologies that enhance E-Waste collection mechanisms.

6.6. GOALS AND TARGETS

E-Waste (Management) Rules, 2022 introduced Extended Producer Responsibility (EPR) mandating producers of specified categories of electrical or electronic equipment to achieve recycling targets, only through registered recyclers of E-Waste, to ensure environmentally sound waste management. The producers of notified electrical and electronic equipment have been given annual E-Waste Recycling targets based on the generation from the previously sold EEE or based on sales of EEE as the case may be. Targets for the E-Waste recycling are as mentioned in the table below:

Table 6-3: Extended Producer Responsibility Targets

Sl. No.	Year (Y)	E-Waste Recycling Target (by weight)
1	2023 - 2024	60% of the quantity of an EEE placed in the market in year Y-X, where 'X' is the average life of that product
2	2024 - 2025	
3	2025 - 2026	70% of the quantity of an EEE placed in the market in year Y-X, where 'X' is the average life of that product
4	2026 - 2027	
5	2027 - 2028	80% of the quantity of an EEE placed in the market in year Y-X, where 'X' is the average life of that product
6	2028 - 2029 onwards	

Note: *The importers of used electrical and electronic equipment shall have 100% extended producer responsibility obligation for the imported material after end of life, if not re-exported.*

The Rules also emphasize the reduction in the use of hazardous substances in the manufacture of electrical and electronic equipment and their components or consumables or parts or spares.

Apart from the recycling targets as per EPR framework, the following targets listed in the table below may be considered.

Table 6-4: Proposed Targets

Sl. No.	Target	2030 Target
1	**Achieve 100% E-Waste recycling.** *[India recycled 43% of e-waste generated in 2022-2023 (Source: data.gov.in). Increasing this to 100% by 2030 significantly reduces environmental impact and promotes resource recovery]* Source: https://www.data.gov.in/search?title=e-waste%20 generation%29	100% of E-Waste generated to be recycled.
2	**Bring the top E-Waste generating cities under ULB control for e-waste management.** *[Note: 65 cities in India generate more than 60% of the total generated E-Waste. The proposed initiative ensures standardized and efficient E-Waste handling with modern technologies].* *[Basis: PSA Advisory (i.e., Advisory No. 23 on E-Waste Management in Smart Cities published in March 2023)]* (https://smartnet.niua.org/sites/default/files/annexure1_ advisoryonewastemanagementinsmartcities.pdf)	100% of top 65 E-Waste generating cities.
3	**Achieve 100% compliance with the EPR targets mandated under E-Waste (Management) Rules, 2022.** *[Ensures producers take responsibility for the entire lifecycle of their products, including end-of-life management, promoting a circular economy for electronics].*	100% compliance with EPR targets
4	**Establish at least one E-Waste Ecopark in each of the top 10 E-Waste generating states.** *Basis: Inspired by the government's initiative to set up an Ecopark in Delhi, this promotes the inclusion of the informal E-Waste sector and facilitates safe and sustainable recycling practices.* *(https://timesofindia.indiatimes.com/city/delhi/delhis-first-official-e-waste-eco-park-proposal/articleshow/111721371.cms)*	At least 1 Ecopark in each of the top 10 E-Waste generating states

6.7. IMPACT POTENTIAL

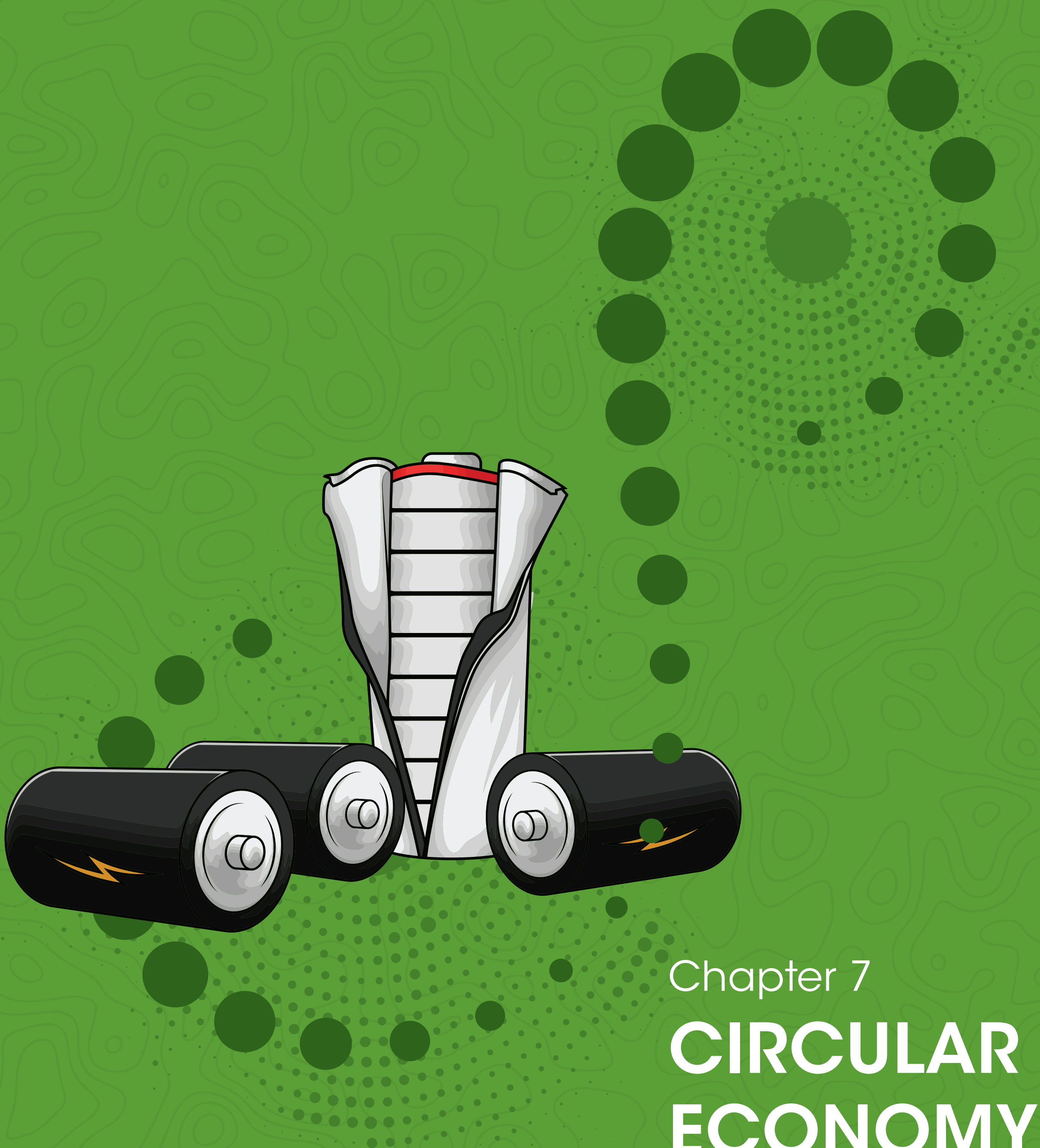
Benefits of formal E-Waste recycling include:

- Creating up to 36 jobs for every 10,000 tons of e-waste recycled.
- Reducing environmental impact by preventing the release of toxic substances, such as mercury and brominated flame retardants, into the environment.
- Conserving critical natural resources.
- Generating an estimated $23 billion in monetized value from avoided greenhouse gas emissions and recovering $28 billion worth of metals, which are reintroduced into the circular economy.

Furthermore, extending the lifespan of ICT devices by 50-100% could prevent 2.5 to 3.7 billion tons of CO_2 equivalent emissions and reduce e-waste generation by 25 to 38 million metric tons from 2026 to 2030.

References:

1. E-Waste (Management) Rules, 2022 - Central Pollution Control Board (CPCB). https://cpcb.nic.in/uploads/Projects/E-Waste/E-Waste_rules_2022.pdf
2. Global E-Waste Monitor 2024 - Cornelis P. Baldé, RuedigerKuehr, Tales Yamamoto, Rosie McDonald, Elena D'Angelo, ShahanaAlthaf, Garam Bel, OtmarDeubzer, Elena Fernandez-Cubillo, Vanessa Forti, Vanessa Gray, Sunil Herat, Shunichi Honda, Giulia Iattoni, Deepali S. Khetriwal, Vittoria Luda di Cortemiglia, YuliyaLobuntsova, Innocent Nnorom, NoémiePralat, Michelle Wagner, International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR). https://ewastemonitor.info/the-global-E-Waste-monitor-2024/
3. Circular Economy in E-Waste Management: Resource Recovery and Design for End-of-Life - Parajuly, K. (2017). https://portal.findresearcher.sdu.dk/en/publications/circular-economy-in-E-Waste-management-resource-recovery-and-desi
4. Electrical and Electronics Manufacturing in India - NEC – Assocham (2018). https://in.nec.com/en_IN/pdf/ElectricalsandElectronicsManufacturinginIndia2018.pdf
5. Biohydrometallurgical Recovery of Metals from Waste Electronic Equipment: Current Status and Proposed Process - Magoda, Kundani, and LukhanyoMekuto, Recycling, 7(5), 2022: 67.
6. Multi-objective Optimization of Heavy Metals Bioleaching from Discarded Mobile Phone PCBs: Simultaneous Cu and Ni Recovery using Acidithiobacillusferrooxidans - Arshadi, M., and S. M. Mousavi, Separation and Purification Technology, 147, 2015: 210-219.
7. Informal E-Waste Recycling in Delhi - Toxics Link. https://toxicslink.org/wp-content/uploads/2022/08/informal%20ewaste%20recycling%20in%20Delhi.pdf
8. Strategy for Secondary Materials Management for Promoting Resource Efficiency (RE) and Circular Economy (CE) in Electrical and Electronic Equipment Sector - NITI Aayog. https://www.niti.gov.in/sites/default/files/2019-03/E-Wastetrategy.pdf
9. E-Waste Roadmap 2023 for India: Compilation of Thought Pieces by Sector Experts - KaroSambhav. https://greene.gov.in/wp-content/uploads/2020/12/2020120916.pdf
10. India@ 70: Concerns and Opportunities in Waste Recycling in India - TERI. https://www.teriin.org/article/india-70-concerns-and-opportunities-waste-recycling-india
11. Disentangling the Worldwide Web of E-Waste and Climate Change Co-Benefits. https://www.sciencedirect.com/science/article/pii/S2773167722000115
12. List of Approved Dismantlers/Recyclers as per Authorization Issued by SPCBs/PCCs (As on 08/06/2023) - Central Pollution Control Board (CPCB). https://www.ndmc.gov.in/pdf/cpcb_approved_list_of_E-Waste_recyclers_dismantler.pdf
13. E-Waste (Management) Rules, 2022 in Force Since 1st April, 2023 - Press Information Bureau (PIB). https://pib.gov.in/PressReleasePage.aspx?PRID=1986201



Chapter 7

CIRCULAR ECONOMY ACTION PLAN *for* LITHIUM-ION BATTERIES

7.1. INDUSTRY OVERVIEW

Lithium-ion batteries (LIBs) have significantly evolved since their commercialization in 1991, becoming an essential technology across diverse applications. LIBs are now widely used, with use cases continually expanding alongside rising energy demands in innovative products and applications.

Material Value Chain

Key metals used in LIBs include lithium, cobalt, nickel, and non-ferrous metals like copper and aluminum. These critical metals are concentrated in various regions globally. Due to limited reserves of these metals in India, establishing efficient reuse and recycling systems is crucial to optimize the utilization of imported LIBs and maximize recovery of these metals by effectively recycling end-of-life (EOL) LIBs.

China leads in LIB advancements, having invested significantly in R&D and establishing extensive mining and refining facilities to secure the supply of metals needed for manufacturing cathode active materials (CAM). These facilities are located in China and other countries with rich metal reserves. LIB manufacturers are primarily based in China, South Korea, and Japan, where they also collaborate with electric vehicle (EV) manufacturers to set up battery production units for EVs.

Currently, Indian companies import LIB cells and batteries from manufacturers in China, Japan, and South Korea for use in electronics, power tools, and EVs, as there is no domestic cell manufacturing capability. Products incorporating LIBs are also imported as complete units or in CKD (Completely Knocked Down) and SKD (Semi-Knocked Down) form for assembly in India. However, this scenario may change as government schemes support cell manufacturing domestically, and key players in the EV sector express interest in establishing LIB production within India, aiming to reduce dependency on foreign sources and safeguard supply chains against geopolitical disruptions.

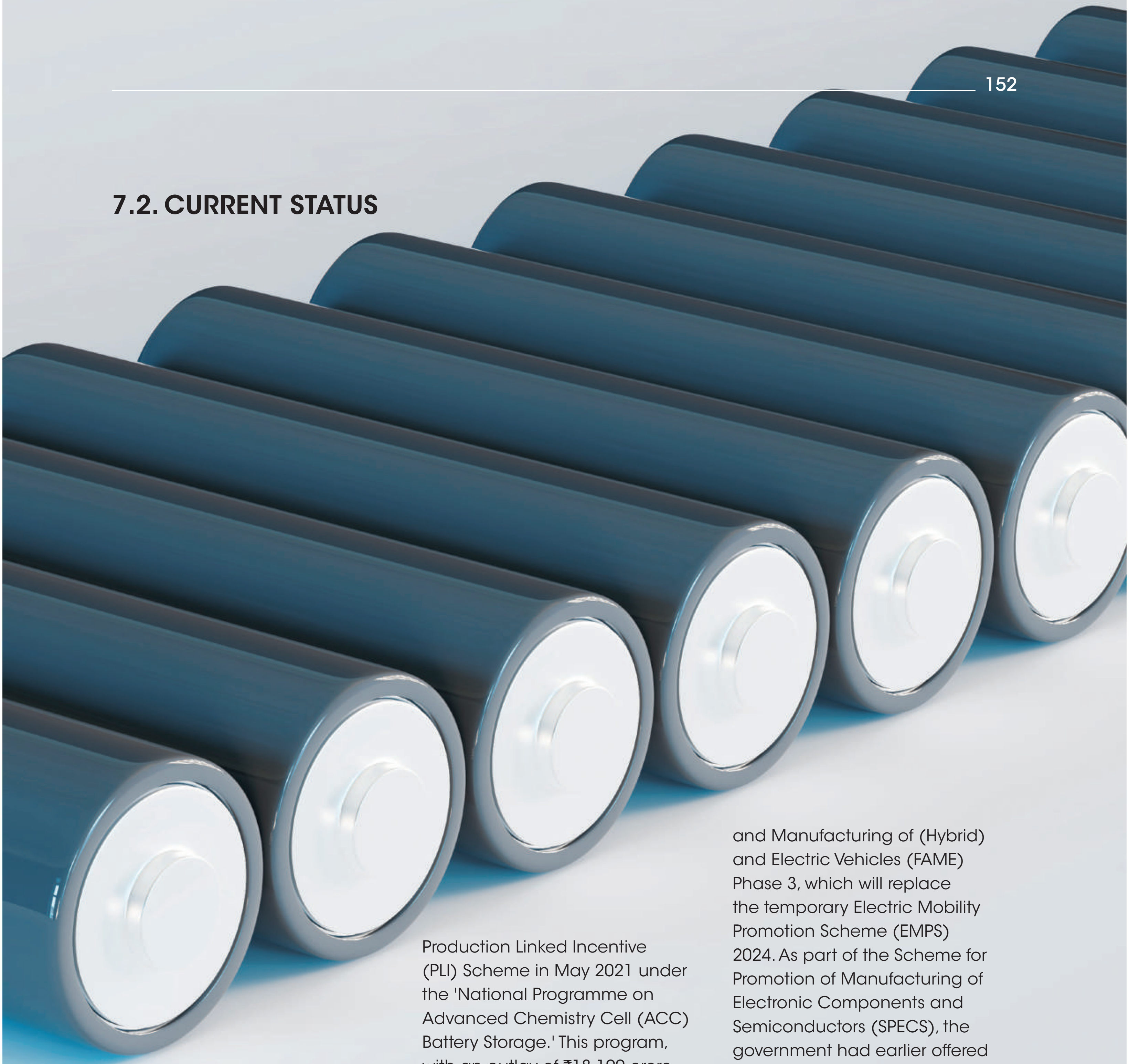
The Central Pollution Control Board (CPCB) has introduced regulations and digital platforms to streamline LIB tracking, a crucial step toward circularity in LIB. This system allows tracking of imported LIBs from the point of entry and requires producers to declare battery composition, detailing critical elements and metals. This data aids in benchmarking recycling output and enhancing efficiency in recycling and refining the black mass generated from EOL LIBs. The regulations also encompass LIB refurbishing, which is essential for reusing batteries in second-life or alternative applications.

Recycling EOL batteries will be a pivotal step for LIB sustainability, as with other waste streams. In India, LIBs are mainly recycled through mechanical and hydrometallurgical processes. Mechanical processes involve size reduction and sieving, resulting in the recovery of aluminum, copper, plastics, and black powder, known as Black Mass (BM). BM is further processed using hydrometallurgy to extract cobalt sulfate, nickel sulfate, manganese sulfate, and graphite. LIB materials can be recycled indefinitely without losing efficiency, making them suitable for manufacturing new LIBs or use in other applications.

Battery raw materials are sourced from various countries, including the Democratic Republic of Congo (for Cobalt), Australia, and Chile (for Lithium). These materials are refined to battery-grade standards at facilities in China or in plants operated by Chinese companies in other countries. The demand for cobalt may slow down as Lithium Iron Phosphate (LFP) chemistry cells become more prominent in 4W-EVs. Additionally, the demand for lithium carbonate, used in LFP, could be impacted by the emergence of Sodium-ion (Na-ion) cells, which offer a viable alternative for energy storage systems (ESS). Na-ion cells, suitable for stationary applications due to their low energy density, could eventually replace LFP and lead-acid batteries in storage solutions. Some Chinese car and battery manufacturers have started using Na-ion cells in low-end automotive applications, and China has announced plans to establish Na-ion cell manufacturing capacity.

While Li-ion cells are expected to remain the dominant technology for applications requiring high energy densities, such as EVs, substantial research is underway to develop better and more cost-effective cathode active materials (CAM) and anode active materials (AAM). For information communication and telecommunication (ICT) devices, Lithium Cobalt Oxide (LCO) and Nickel Manganese Cobalt (NMC) chemistries remain prevalent, with NMC cells also being used in 2W EVs.

7.2. CURRENT STATUS



India is taking significant steps in the manufacturing and recycling of lithium-ion batteries (LIB), as well as in incentivizing the faster adoption of electric vehicles (EVs) by individuals and organizations.

Manufacturing Initiatives and Government Incentives:

To promote domestic LIB manufacturing, the Government of India has launched the Production Linked Incentive (PLI) Scheme in May 2021 under the 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage.' This program, with an outlay of ₹18,100 crore, aims to establish a manufacturing capacity of 50 GWh of ACC. Under the scheme, beneficiary firms are required to invest ₹225 crore per GWh of committed capacity within two years. The scheme's performance period extends from January 1, 2025, to December 31, 2029, and its impact is anticipated in the near future.

Additionally, the government announced the Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles (FAME) Phase 3, which will replace the temporary Electric Mobility Promotion Scheme (EMPS) 2024. As part of the Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS), the government had earlier offered 25% capital expenditure incentive for approved LIB recycling projects with a minimum CAPEX of ₹2 crore, the continuation of the scheme is under consideration. These initiatives underscore India's commitment to fostering a circular economy for LIBs.

Regulatory Framework for Battery Waste Management:

The Battery Waste Management (BWM) rules, first issued in 2022

and amended in 2023, mandate that all LIBs entering India must be recorded. Key stakeholders—including manufacturers, producers, refurbishers, and recyclers—are required to register with the Central Pollution Control Board (CPCB) portal. This transparent data flow, including sales and purchase records, helps create an ecosystem focused on LIB circularity. The rules also delineate the roles of each stakeholder and emphasize structured information sharing through the CPCB's centralized portal, facilitating tracking of LIBs from import to end-of-life (EOL) recycling.

Extended Producer Responsibility (EPR) Targets:

The Battery Waste Management Rules, 2022, mandate Extended Producer Responsibility (EPR) for all types of batteries, including lithium-ion batteries commonly used in portable devices, industrial applications, and electric vehicles. EPR requires producers to be responsible for the environmentally sound management of waste batteries, including their collection, refurbishment, and/or recycling. A compliance cycle mechanism has been introduced for better tracking. The compliance cycle refers to the period within which producers of batteries must meet specific targets for the collection, refurbishment, and/or recycling of waste batteries. The duration of the compliance cycle varies depending on the type of battery:

- Portable Batteries: 10 years
- Industrial Batteries: 7 years
- Electric Vehicle Batteries:
  - o Two-wheelers: 7 years
  - o Three-wheelers: 7 years
  - o Four-wheelers: 14 years

During each compliance cycle, producers must achieve a mandatory waste battery collection target, which is a percentage of the quantity of batteries they placed in the market during specific years within that cycle. They must also ensure that 100% of the collected waste batteries are either refurbished or recycled.

The specific collection targets vary depending on the type of battery and the year within the compliance cycle. For instance, for portable batteries used in consumer electronics, the collection target starts at 50% for batteries placed in the market in 2017-18 and gradually increases to 70% for batteries placed in the market in 2019-20 and subsequent years.

By the end of each compliance cycle, 100% collection, refurbishment, and/or recycling of waste batteries is mandatory for all types of batteries. However, there is a provision for carrying forward up to 60% of the average quantity of batteries placed in the market per year during the compliance cycle to the next compliance cycle.

Summary of the EPR requirements for different types of Li-ion batteries is presented below:

Type of Battery	1st & 2nd Compliance Cycles (cycle duration)	Year 1		Year 2		Year 3		Year 4 and onwards
		Target Wt.	Sale Yr	Target Wt.	Sale Yr	Target Wt.	Sale Yr	Target for the next years till the end of compliance cycle and onwards
Consumer Electronics Rechargeable (CER)	2022-23 to 2031-32 (10 years) 2032-33 to 2041-42, and onwards	>=50%	17-18	>=60%	18-19	>=70%	19-20	Target >=70% of the sales in 5th preceding FY till 2031-32 and onwards
Portable batteries rechargeable except CER	2025-26 to 2034-35 (10 Years) 2035-36 to 2044-45, and onwards	>=50%	22-23	>=60%	23-24	>=70%	24-25	Target >=70% of the sales in 3rd preceding FY till 2034-35 and onwards
Industrial batteries	2022-23 to 2028-29 (7 years) 2029-30 to 2035-36, and onwards	>=40%	19-20	>=50%	20-21	>=60%	21-22	Target >=70% of the sales in 3rd preceding FY till 2028-29 and onwards
Electric Vehicles 3W, including e-rikshaw (L5, L5-M, L5-N, E-cart)	2026-27 to 2032-33 (7 Years) 2033-34 to 2039-40, and onwards	>=70%	21-22	>=70%	22-23	>=70%	23-24	Target >=70% of the sales in 3rd preceding FY till 2032-33 and onwards
Electric Vehicles 2W	2026-27 to 2032-33 (7 Years) 2033-34 to 2039-40, and onwards	>=70%	22-23	>=70%	23-24	>=70%	24-25	Target >=70% of the sales in 4th preceding FY till 2032-33 and onwards
Electric Vehicles 4W	2029-30 to 2042-43 (14 Years) 2043-44 to 2056-57, and onwards	>=70%	21-22	>=70%	22-23	>=70%	23-24	Target >=70% of the sales in 8th preceding FY till 2042-43 and onwards
Mandatory Waste Battery collection target, and 100% refurbishment and/or recycling target for every compliance cycle (Weight)		Collection of 100% Waste Battery and of 100% of refurbishment or recycling shall be mandatory by end of current compliance cycle against the Battery placed in the market during current compliance cycle. However, there may be a carry forward of up to 60% of the average quantity of Battery placed in the market per year during the current compliance cycle to the next compliance cycle.						

Requirements for Usage of Recycled Materials in the New Batteries: As per the Battery Waste Management Rules, 2022, producers shall have the obligation with respect to the minimum use of domestically recycled materials in new batteries as per the Table below.

S/No	Type of Battery	Minimum use of the recycled materials out of the total dry weight of a Battery (in percentage)			
		2027-28	2028-29	2029-30	2030-31 and onwards
1	Portable	5	10	15	20
2	Electric Vehicle	5	10	15	20
		2024-25	2025-26	2026-27	2027-28 and onwards
3	Automotive	35	35	40	40
4	Industrial	35	35	40	40

Requirements for Usage of Recycled Materials in the New Batteries: As per the Battery Waste Management Rules, 2022, producers shall have the obligation with respect to the minimum use of domestically recycled materials in new batteries as per the Table below.

S/No	Type of Battery	Recovery target for the year in percentage		
		2024-25	2025-26	2026-27 and onwards
1	Portable	70	80	90
2	Electric Vehicle	55	60	60
3	Automotive	55	60	60
4	Industrial	70	80	90

Current Recycling and Refurbishing Ecosystem: India's LIB recycling sector is predominantly based on mechanical processing, converting LIBs into black mass (BM), which is exported to other countries for further refining to obtain salts of lithium, nickel, magnesium, and cobalt for new battery manufacturing. The absence of cell manufacturers in India limits domestic recycling to BM production, which requires further refining to produce battery-grade material. Establishing a robust ecosystem for producing pre-CAM (pCAM) and cell manufacturing would support a truly circular LIB economy.Further, developments in AI are helping identify the state of health (SOH), state of charge (SOC), and depth of discharge (DOD) of EOL cells, enabling efficient segregation and reuse of these cells in second-life applications.

Safety and Informal Sector Challenges: Handling BM and other heavy metals poses significant health risks to those in the recycling sector. LIBs also present hazards such as thermal runaway, particularly if punctured or short-circuited, and carry electrical shock risks due to residual charges. The informal sector in India, often lacking proper safety protocols and scientific methods, is a prominent handler of new waste streams like LIBs. Currently, our country has low-skilled capacity to manage LIB waste, but the first wave of EOL EV batteries expected in 2-3 years will require trained manpower to safely handle this waste stream.India is taking big decisions on the manufacturing and recycling of LIB and also rolling out incentives for faster adoption of EVs by individuals and organizations.

GLOBAL SCENARIO

Manufacturing:
The race to lead in EV and LIB recycling is currently dominated by China, with the EU and the US working to catch up. In the US, the Inflation Reduction Act (IRA) introduces various incentives, including the Advanced Manufacturing Production Tax Credit (AMPC). This section of the IRA provides a tax credit of USD 35/kWh for cell production in the US, USD 10/kWh for module manufacturing, and tax credits covering 10% of the production costs for electrode active materials and critical minerals produced domestically. Additionally, the IRA offers significant benefits for automotive OEMs if their products use critical minerals from countries with which the US has a free trade or critical minerals agreement. As a result, Chinese companies have increased their plant capacities in the EU by 60%.

China remains the primary exporter of battery products, while the US has imposed a 25.4% tariff on battery cells imported from China. The EU and North America are focusing on localizing production to build a stable and sustainable ecosystem. The EU has also been pursuing critical raw materials agreements with countries rich in battery-related minerals. In the US, there is a trend of partnerships between battery producers and automotive OEMs to strengthen the domestic EV market.

Recycling:
Asia holds the largest capacity for LIB recycling, with China accounting for over half of the world's recycling capacity. In the past year, multiple LIB recycling projects were announced in the EU and North America; however, many of these projects have been delayed or canceled due to the declining prices of battery metals, which have impacted the profitability of recycled materials. This price decline continues to discourage some recyclers.

Despite these challenges, the demand for critical minerals has grown steadily over recent years, making LIB recycling a viable solution to meet future demand.

Demand for key energy transition minerals continued to grow strongly in 2023, propelled by the expansion of clean energy technologies

Demand outlook for selected minerals, 2021-2023

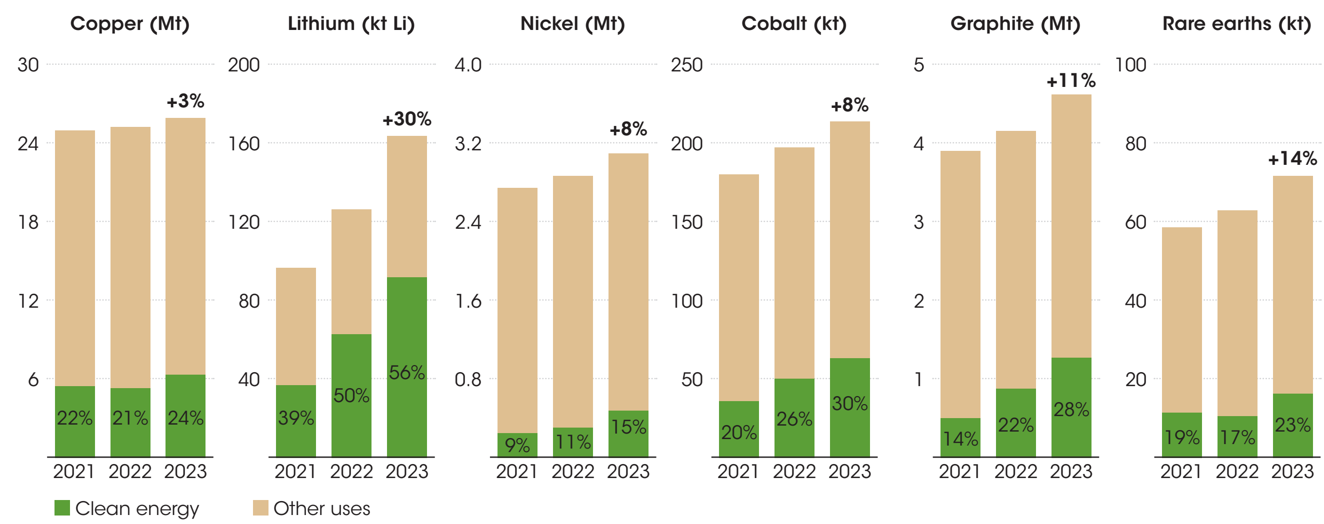


*Image Credit: International Energy Agency www.iea.org

7.3. PROPOSED FRAMEWORK

There is growing concern about the future scarcity of raw materials, especially in regions lacking natural resources or reserves of critical metals. The commitment to reducing carbon emissions to mitigate climate change is also becoming increasingly urgent.

India, a strong advocate of circularity, has recently expanded its sustainability focus to include LIBs. However, with limited expertise in cell manufacturing and recycling, India's actions will need to transcend geopolitical challenges to support a sustainable circular ecosystem for LIBs.

India's population of 1.4 billion will drive significant demand for LIBs. By 2030, India is projected to become a major consumer of portable electronics that use LIBs. One analysis estimates the demand for LIBs in consumer electronics to reach around 65,000 tons by 2030, with total LIB demand (including towers, grid storage, and EVs) expected to reach 1.5 million tons. This demand will generate proportionate waste, underscoring the urgent need for a circular ecosystem in the country. Building such an ecosystem will take time and continual development, but the BWM rules provide a foundation. The following steps can help further align this development with the vision of 'Viksit Bharat 2047.'

Skilled Workforce:
Training in alliance with the private sector on handling, testing, recycling, refurbishing, dismantling, and assembling can help develop the skilled workforce required to manage LIBs at scale. Streamlined visa processing for Chinese nationals with technical expertise can also be a forward-looking measure to meet these skill needs.

Awareness:
Educating the public on battery operation and safe charging is essential to develop safe alternative use channels and open reuse avenues at the local level. Awareness of safety protocols for handling and recycling LIBs will encourage best practices, while consumer awareness can motivate people to recycle EOL devices rather than disposing of them as domestic waste.

Refining Infrastructure:
Inviting companies from South Korea, China, Japan, and other countries through joint ventures could accelerate the development of battery-grade refining infrastructure and manufacturing of pCAM or cells. This approach would support skills development, ecosystem growth, and the expansion of ancillary businesses while minimizing resistance and delays associated with geopolitical issues. A public-private partnership (PPP) model could be an effective first step.

Export Restrictions:
Restricting the export of black mass while simultaneously developing refining and manufacturing infrastructure would support the growth of a circular LIB ecosystem, securing LIB materials that enter India through imports.

Enhanced Tracking:
Regulations mandating QR codes on each cell to specify batch information will become essential once domestic cell manufacturing begins. The government might also consider adopting the EU's battery passport concept once it is fully implemented, facilitating better tracking and improving circularity when cells reach their EOL.

R&D:
Beyond foundational R&D in LIB, once scaled infrastructure and expertise are established, research should focus on enhancing the performance of existing batteries and developing new battery chemistries.

Given that batteries are hazardous, their manufacturing, handling, and recycling require specialized skills to ensure safety and sustainability. While India may initially adopt refining, cell manufacturing, recycling, and assembly technology from other countries, building skilled local expertise is crucial for circularity and sustainable operations. Guidelines for domestic cell manufacturing could also specify standards for battery energy, size, and shape, with additional battery modules addressing any increased energy requirements.

7.4. GOALS AND TARGETS

In alignment with India's focus on circularity and sustainability for LIBs, the following goals address critical areas for development. Each goal aligns with relevant national policies, missions, or strategic initiatives.

Sl. No.	Goal	Target	Year
1	**Develop a skilled workforce for the LIB handling, recycling, and assembly** *[Aligns with the Skill India Mission to create a competent workforce]*	Train **5,000** skilled workers	2030
2	**Increase awareness about LIBs and their environmental impact. Encourage sustainable habits in LIB consumption.** *[Promotes a culture of reduce, reuse, and recycle among consumers to minimize environmental impact and maximize resource utilization.]*	Increase awareness among **50%** of LIB users	2030
3	**Boost domestic LIB refining and manufacturing.** *[Aligns with make in India and AtmanirbharBharat initiatives to promote self-reliance and domestic production of LIBs]*	Establish **at least five** refining and manufacturing facilities through joint ventures	2030
4	**Implement a robust LIB tracking system.** *[Aligns with the Battery Waste Management Rules, 2022 by ensuring traceability and accountability].*	Implement digital tracking for **100%** of LIB cells manufactured or imported	2030
5	**Invest in R&D for sustainable LIB technologies.** *[Aligns with the National Mission on Transformative Mobility and Battery Storage for Sustainable Growth]*	Establish **three** dedicated R&D centersfocusing on enhancing LIB energy density and recyclability	2030
6	**Incentivize local LIB manufacturing and sales.** *[Supports the Production Linked Incentive Scheme to boost domestic production and reduce reliance on imports].*	Provide viability gap fund to all companies manufacturing and selling LIBs in India **(100%)**	2027
7	**Restrict black mass (BM) exports to retain valuable resources.** *[Supports Atmanirbhar Bharat and the Circular Economy Action Plan for resource security].*	Implement phased export restrictions on BM, aiming for **80% reduction** in BM exports.	2030

7.5. IMPACT POTENTIAL

The Ministry of Mines in India has identified 30 minerals based on their economic importance and limited availability in the country's geological reserves. These minerals are essential for industries such as defence, electronics, renewable energy, telecommunications, and transportation, including many of the metals critical for lithium-ion batteries (LIBs). Developing infrastructure to support circularity in LIBs will lead to:

- Environmental benefits by reducing the need for mining battery materials and associated rare earth elements like neodymium, which are used in permanent magnets.
- Enhanced resource security and decreased dependency on LIB imports.
- Retention of critical minerals within India by reducing black mass exports.
- Increased job creation in LIB manufacturing, refurbishing, recycling, and other related ancillary industries.
- Progress toward achieving net-zero emissions through LIB adoption in vehicles, which helps reduce reliance on fossil fuels.
- Financial savings by reducing the $2.1 billion spent in 2023 on importing LIBs, primarily from China (85%), Japan, and South Korea, as swift development of domestic manufacturing, refining, and recycling infrastructure can help contain this outflow.

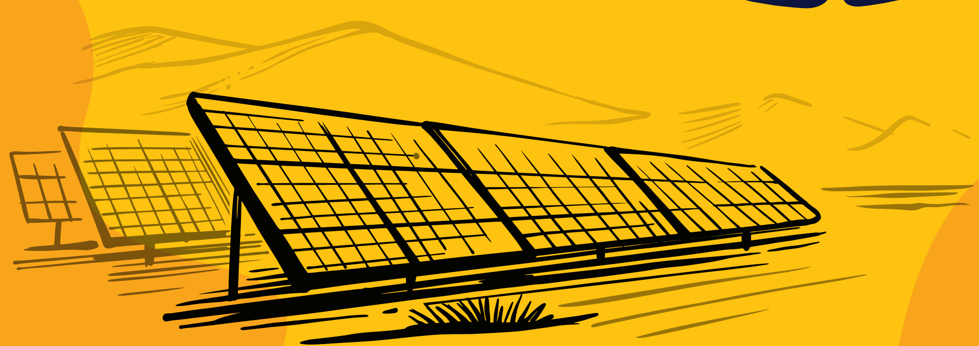
Now is the time to expand LIB use, reuse, and recycling while engaging private and public enterprises in a framework that promotes reuse, recycling, refining, and remanufacturing. By building capacities and acquiring the necessary skills, India can establish a circular economy for LIBs.

References:

1. National Programme on Advanced Chemistry Cell (ACC) Battery Storage - Ministry of Heavy Industries, India Provides critical policy background on incentives for cell manufacturing.
   https://www.mhi.gov.in
2. Global Critical Metals Outlook 2024
   https://www.iea.org/reports/global-critical-minerals-outlook-2024
3. Battery Monitor 2023
   https://www.rolandberger.com/en/Insights/Publications/Battery-Monitor-2023-An-assessment-of-the-current-and-future-battery-value.html
4. Battery Waste Management Rules 2022https://cpcb.nic.in/rules-5/

Chapter 8

CIRCULAR ECONOMY ACTION PLAN *for* SOLAR PANEL WASTE



8.1. INDUSTRY OVERVIEW

India's solar industry has seen exponential growth in recent years, particularly since 2015. According to the 2022 report by the International Energy Agency (IEA), India is now among the top three solar power generators globally, following China and the USA. As of September 2024, India's installed solar capacity has reached 90.76 gigawatts (GW).

The National Electricity Plan released by the Central Electricity Authority (CEA) sets a target of 500 GW of renewable energy capacity by 2030, rising to over 600 GW by 2032, with solar expected to contribute at least 50%. This ambitious plan is crucial for India to meet its net-zero commitment by 2070, made at the COP26 conference.

Solar panels have a typical lifespan of 25 to 30 years. However, recent years have seen a rising volume of prematurely decommissioned photovoltaic (PV) panels due to improper handling, installation, and product defects. These factors suggest a significant increase in solar waste in the coming years.

The figure below illustrates a typical silicon photovoltaic (PV) cell, showcasing the essential components and structure that enable the conversion of sunlight into electrical energy.

Figure 8-1: Typical Silicon PV Cell

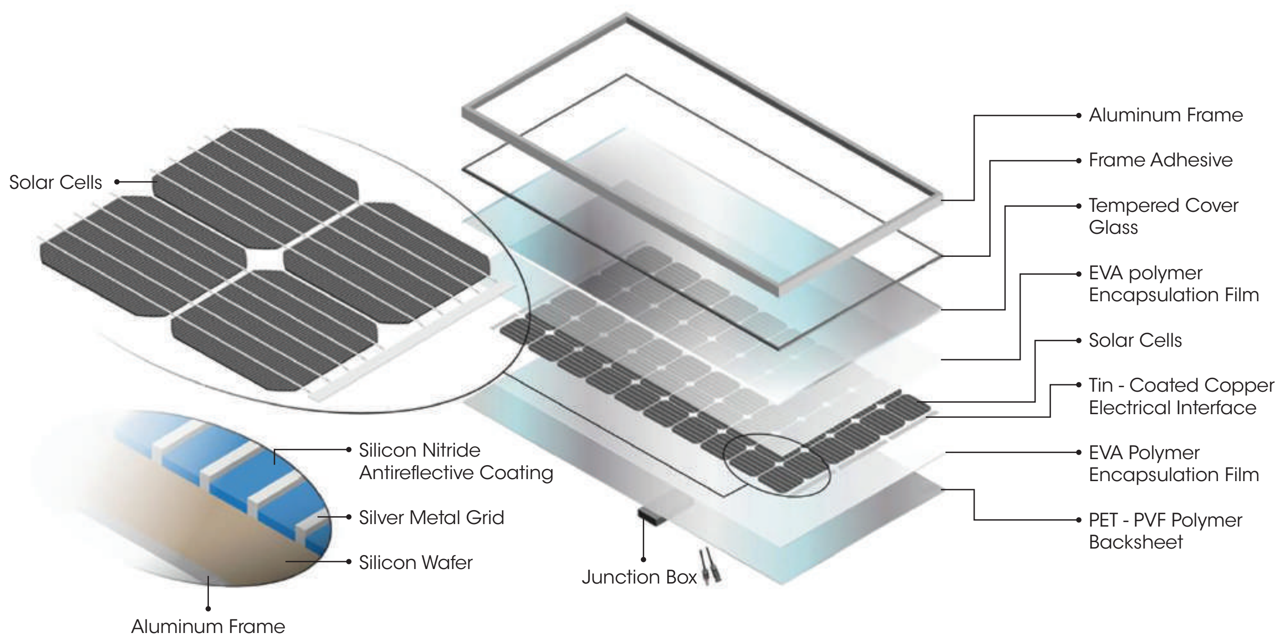
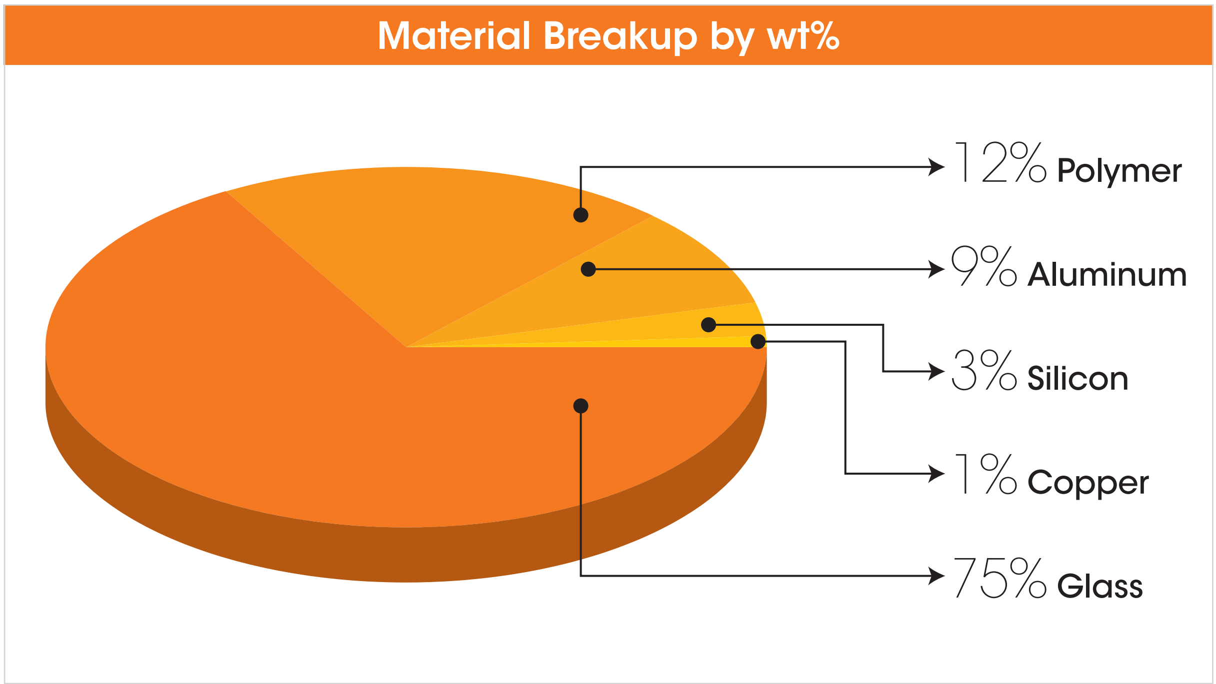


Image Source: Zhang, Bin, et al. "Aluminum saving and CO2 emission reduction from waste recycling of China's rooftop photovoltaics under carbon neutrality strategy." iScience 27.10 (2024).

Understanding the material composition of these cells is crucial for addressing end-of-life (EoL) management and promoting circularity in solar technology. A typical silicon PV cell is predominantly made up of glass (75%) and polymers (12%), with smaller amounts of aluminum (9%), silicon (3%), and copper (1%). This breakdown is relevant as it directs recycling efforts toward efficiently recovering these major materials, supporting sustainable practices in the solar industry and reducing environmental impact by reusing valuable resources.

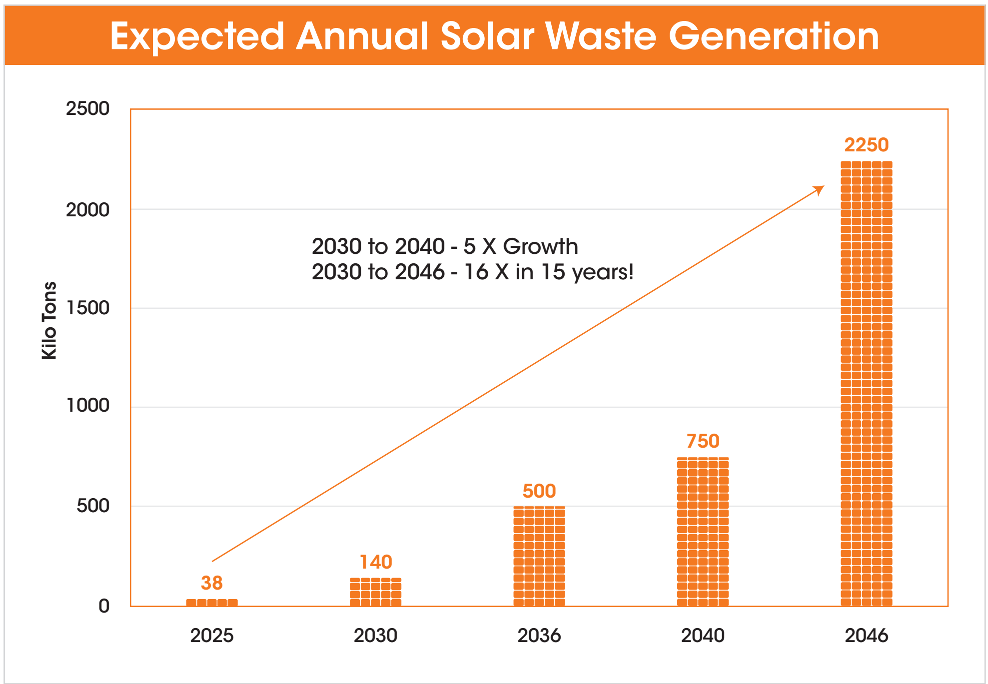
Figure 8-2: Weight Breakup of a Typical Silicon PV Cell



Silver is less than 0.1 %, hence not shown in break up .

Building on the material composition and recycling importance of silicon PV cells, understanding the projected scale of solar waste is crucial for effective circularity planning. The following diagram, illustrates the expected growth in solar waste over the coming years.

Figure 8-3:Expected solar waste in the coming years



Source: "Enabling a circular economy in India's Solar Industry" By Dr Akansha Tyagi & Team, CEEW

This anticipated waste includes several sources: transportation and handling losses, operational waste, and annual end-of-life (EoL) waste from decommissioned panels.

Notably, the states with the highest solar panel installations—Rajasthan, Gujarat, Karnataka, Tamil Nadu, and Andhra Pradesh—are expected to contribute approximately 70% of India's solar waste by 2030. This information underscores the need for targeted waste management strategies in these regions to support a circular economy in India's solar sector.

Brief overview of recycling technologies

Mechanical Recycling or Bulk Recycling can recycle upto 80% of the bulk weight. First, the copper wiring, plastic junction boxes and aluminium frames is physically removed, and the panel is delaminated by crushing and shredding to the desired size. Glass and laminate film is separated through manual and vibration screen.

Thermal Recycling or thermal delamination is subjecting the PV panels containing to a heating / pyrolysis process so that plastic undergoes removal, enabling easier separation of glass and film. The advantage is higher material recovery (95%) compared to mechanical recycling.

Chemical Recycling involvesthe dissolution of output of mechanical / thermal recycling in organic / inorganic solvents to extract precious metals like Silver, embedded Cu etc. Chemical delamination is still under the research stage, and there is a need to understand the additional environmental impact due to the inclusion of chemical solvents.

Table 8-1: Overview of Recycling Technologies

	Mechanical Recycling	Thermal Recycling	Chemical Recycling
Advantages	• Low CAPEX • Proven at commercial scale. • Can recover 80% of Bulk weight	• Higher recovery rate compared to mechanical • Employs pyrolysis process, which is well known in plastic recycling. • Commercial scale has started. • Can recover 95% of wt.	• Very high recovery rate including Silver (Ag) • Close to 100 % material recovery
Disadvantages	• Low recovery rates	• More CAPEX and adherence to pollution norms • No recovery of Ag	• High CAPEX • No commercial scale solution • Disposal of chemical solvents

8.2. CURRENT STATUS

Globally, India stands among the top five countries with the highest solar PV installations. India has seen explosive growth, from a mere 0.98 GW in 2010 to about 100 GW in 2024.

Policy support has been a major factor for driving growth of solar PV in India.The Jawaharlal Nehru National Solar Mission (JNNSM),launched in January 2010 as a joint initiative of the Central and State Government was a key policy tool for success of solar power.The target was initially set at 20 GW by 2022.In August 2021, the Government increased the target of 300 GW by 2030.

As a result, incoming solar PV waste is going to be a challenge that needs to be addressed. As per MNRE, the cumulative solar waste forecast is as follows.

Scenario	Cumulative waste forecast (Kilo tonnes) by 2025		Cumulative waste forecast (Kilo tonnes) by 2030		Cumulative waste forecast (Kilo tonnes) by 2040	
	Regular Scenario	Early Loss Scenario	Regular Scenario	Early Loss Scenario	Regular Scenario	Early Loss Scenario
MNRE	2	132	38	693	1279	4827

Early loss scenario considers loss due to defects, improper handling etc

As of November 2022, India did not have a dedicated policy for solar waste management. The E-Waste Management Rules (EWMR) 2022 brought end-of-life (EoL) solar PV modules under E-Waste regulations but has not yet mandated an Extended Producer Responsibility (EPR) framework for their recycling. Instead, it requires solar manufacturers to collect and store EoL PV modules until 2034, given the current lack of sufficient recycling infrastructure.

Regulations stipulate that every manufacturer and producer of solar PV modules must register on the Ministry of Environment, Forest, and Climate Change (MoEF&CC) portal and upload a list of manufactured modules, panels, or cells. Recyclers of these PV components are also required to recover materials based on standards that will be established by the Central Pollution Control Board (CPCB).

At present, India does not have a standalone commercial PV recycling plant. However, a 2.5 TPD-capacity pilot plant for mechanical recycling has been developed as part of the Solar Waste Action Plan project by Sofies India and Poseidon Solar. Laboratory-scale models for thermal and chemical recycling have also been developed by IIT-Bombay and the Centre for Materials for Electronics Technology (C-MET).

8.3. GAPS AND CHALLENGES

Absence of a Dedicated Solar Recycling Policy: Solar recycling is currently governed under the E-Waste Management Rules (EWMR) 2022, where it has been temporarily placed without a dedicated framework. As a result, there is no comprehensive policy specifically for the recycling of solar PV modules, and these modules are often treated as regular e-waste destined for disposal. Solar panels are exempt from recycling targets under EWMR, further limiting the incentive for organized recycling efforts. Additionally, while numerous incentives exist for new solar power investments, similar support for recycling infrastructure is lacking. A dedicated solar panel recycling policy is essential to promote circularity in this sector.

Insufficient Recycling Infrastructure and Knowledge: A significant barrier to effective solar PV recycling is the limited infrastructure and lack of technical expertise. The existing recycling facilities are inadequate, and a substantial portion of end-of-life (EoL) management, including recycling, is handled by the informal sector, which lacks the necessary skills and technology. Implementing targeted training, resources, and regulatory measures to promote environmentally sound practices is essential.Integrating the informal sector into formal recycling initiatives through supportive regulations can help expand recycling capacity and ensure adherence to sustainable standards.

Lack of Investment and Low Profitability: Setting up recycling facilities for managing solar PV waste requires substantial investment, yet solar module recycling is not currently seen as commercially viable. Key challenges include the absence of a dedicated policy and incentives, low waste volumes, technological limitations, and a lack of commercially scalable technology for high-value material recovery. Addressing these barriers through targeted investments and incentives could make recycling more attractive to investors.

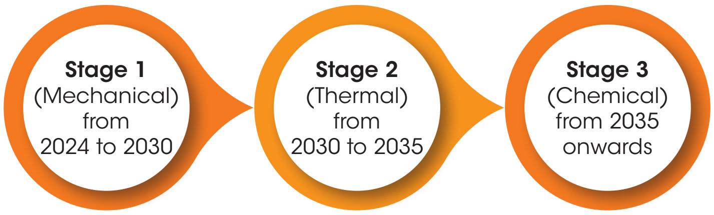
Lower Cost of Landfill and Incineration Compared to Recycling: At present, landfilling or incinerating solar panels is a far cheaper and more accessible option than recycling. This cost disparity discourages recycling efforts and increases the likelihood of PV modules ending up in landfills, which is not aligned with circularity principles.

8.4. PROPOSED FRAMEWORK

Stage wise recycling implementation: We propose that PV module recycling be implemented in stages. Current volumes of solar waste are relatively low, though they are expected to increase exponentially, and high-value recycling technology is still in the process of maturing.

We recommend implementing PV recycling in three stages.

- **Stage 1:** Bulk recycling or mechanicalrecyclingwhich has a low technological barrier and can be readily implemented.
- **Stage 2:** Thermaldelamination which is combination of mechanical and thermal recycling. There are commercial plants in Japan with this technology albeit on a small scale.
- **Stage 3:** High value recycling which involves adding chemical recycling to end stage / thermal recycling to recovery precious metals.



Introducing Regulations and Guidelines: To manage the anticipated exponential growth of solar waste, a dedicated policy under a nodal agency is essential. Key stakeholders, including the Ministry of Environment, Forest and Climate Change MoEF&CC, the Central Pollution Control Board (CPCB), NITI Aayog, the Solar Energy Corporation, producers, recyclers, think tanks, research institutes, NGOs, and international bodies like the International Solar Alliance (ISA) and the International Renewable Energy Agency (IRENA), should collaborate to develop a comprehensive solar recycling policy.

In Europe, the European Committee for Electrotechnical Standardization (CENELEC) has established standards and technical specifications for the collection, logistics, and treatment of PV modules to support efficient waste management practices. Standards such as 'TS 50625-2-4' and 'TS 50625-3-5' specifically address requirements for recycling and de-pollution of PV panels, serving as a valuable reference for developing similar standards in India.

Mandatory Recycled Content in Solar Panels: Similar to the CPCB's mandate on minimum recycling levels for plastic waste under the EPR 2022 rules, a similar requirement should be introduced for solar panels. Future solar panels should contain a specified amount of recycled content, as outlined in the goals and targets below. As discussed, recovering 80% of solar panel waste—such as glass, aluminum frames, and copper wiring—through mechanical recycling is feasible with existing technology.

8.5. ENABLERS

Source: "WATTS TO WASTE Exploring India's Solar Waste Landscape" By ISA

Policy Advocacy and Support: Develop comprehensive policies and regulations specifically addressing solar waste management, including guidelines for collection, transportation, recycling, and disposal. Ensure that these policies are in line with international best practices and standards. Based on India's current policy framework, the EPR mechanism will be most suited for assigning accountability to stakeholders in the EoL value chain.

Research and Development: Promote research and development initiatives focused on maximum extraction with minimum energy and environmental effects. Government to Government programs, University collaborations, International Collaborations are to be encouraged. Central Government ministry help is required in fostering G2G programs, especially on licensing best available technology globally for recycling and bringing them to India.

Encourage Circularity of Materials in Solar Panels: Solar panel design, materials, and manufacturing processes should be encouraged with an emphasis on recyclability and minimizing waste generation (example: usage of antimony free glass). Another key aspect will be the creation of markets for secondary raw materials generated from panels, with incentives for companies using them.

Financial Support and Incentives: Provide support in the form of viability gap fund (VGF) to recycling companies to promote their growth and viability.

International Collaboration: Foster partnerships and collaborations with other countries and international organizations to share best practices, knowledge, and technologies in solar waste management. Participate in global initiatives aimed at developing standardized processes for recycling solar panels.

Monitoring and Enforcement: Establish a monitoring and enforcement guideline to ensure compliance with regulations and guidelines for solar waste management. Regular audits and inspections should be conducted to verify that manufacturers, recyclers, and other stakeholders adhere to the prescribed standards.

Certification and Labelling: Establish certification standards and labelling mechanisms for solar products that promote recyclability and environmentally responsible manufacturing processes. This can incentivize manufacturers to design products with easier recyclability and provide consumers with information to make sustainable choices.

8.6. GOALS AND TARGETS

S.No.	Goal & Basis	2027 Target	2030 Target
1	**Establish a dedicated solar waste management policy within an EPR framework.** *[Provides a clear regulatory structure for responsible solar panel end-of-life management, drawing on best practices like EU standards (TS 50625-2-4 and TS 50625-3-5)]*	Release the first version of the solar panel waste recycling policy.	Fully implement the solar panel waste recycling policy nationwide.
2	**Establish sufficient solar panel waste recycling points.** *[Ensures convenient and accessible collection points for end-of-life solar panels, based on projected waste generation (0.12 million tons by 2025 and 0.6 million tons by 2030) and a capacity of 5,000 tons per annum per center].*	**60** recycling points operational nationwide.	**120** recycling points operational nationwide.
3	**Increase the number of advanced recycling centres for solar panels.** *[Promotes the use of thermal and chemical recycling to recover valuable materials and reduce environmental impact]*	**6 advanced recycling centres** established (approximately 10% of total recycling centres).	**25 advanced recycling centres** established (approximately 20% of total recycling centres).
4	**Introduce mandatory recycled content requirements in solar PV panels (similar to those in plastics).** • **Category 1:** Items that can be recycled mechanically, such as glass, aluminium frames, copper cables, and junction boxes. • **Category 2:** Items requiring more advanced recycling methods, like plastics, laminate glass, and silicone. • **Category 3:** Precious metals, including silver. *[Drives demand for recycled materials and encourages a closed-loop system for solar panel manufacturing].*	• Category 1 (mechanically recyclable): **25%** recycled content • Category 2 (advanced recycling): **0%** (due to technological limitations) • Category 3 (precious metals): **0%** (technology still in lab scale)	• Category 1: **40%** recycled content • Category 2: **10%** recycled content • Category 3: **0%** (can be targeted by 2035 since technology is still lab scale)
5	**Incentivize the use of circular and environmentally friendly materials in solar panel manufacturing.** *[Promotes the use of less harmful materials and encourages innovation in sustainable solar panel production]*	Suspend the **10%** import duty on antimony-free glass.	Continue suspension of import duty on antimony-free glass until domestic production capacity is sufficient.
6	**Provide financial incentives for solar panel recycling.** Basis: Supports the economic viability of solar panel recycling and encourages investment in this sector.	Offer **25% CAPEX incentives** for setting up solar panel recycling facilities, similar to the "Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors."	Continue and potentially expand financial incentives.

8.7. IMPACT POTENTIAL

Recycling solar panels has significant potential to drive environmental, social, and economic transformation in India's solar sector. By integrating solar waste into a circular economy framework, India can enhance sustainability in the industry, create jobs, reduce environmental impact, and foster responsible resource management. Key benefits include:

Environmental:

- Diverts panels from landfills, reducing waste.
- Lowers energy consumption and CO_2 emissions, as recycling is less carbon-intensive than raw material extraction.
- Enables the scientific handling of toxic elements in solar panels, such as cadmium, antimony, and lead, minimizing environmental contamination.

Social Benefits

- **Job Creation:** Solar recycling is expected to generate both direct and indirect employment, particularly in solar-intensive states like Rajasthan, Gujarat, Karnataka, Tamil Nadu, and Andhra Pradesh.
- **Safe Working Environment:** Compared to the informal sector, formal solar recycling facilities can provide a safer working environment, protecting workers from exposure to toxic elements.

Governance and Economic Benefits

- **Material Recovery and Circular Economy:** Recycling makes solar panels part of the circular economy. For example, from 1 MW of solar power capacity (approximately 86 tons), it's possible to recover:
  - 13 tons of aluminium,
  - 54 tons of glass,
  - 1 ton of silver and copper.
- **Reputational Benefits:** By promoting circularity, the solar sector enhances its reputation as a sustainable industry.

Economic Benefits

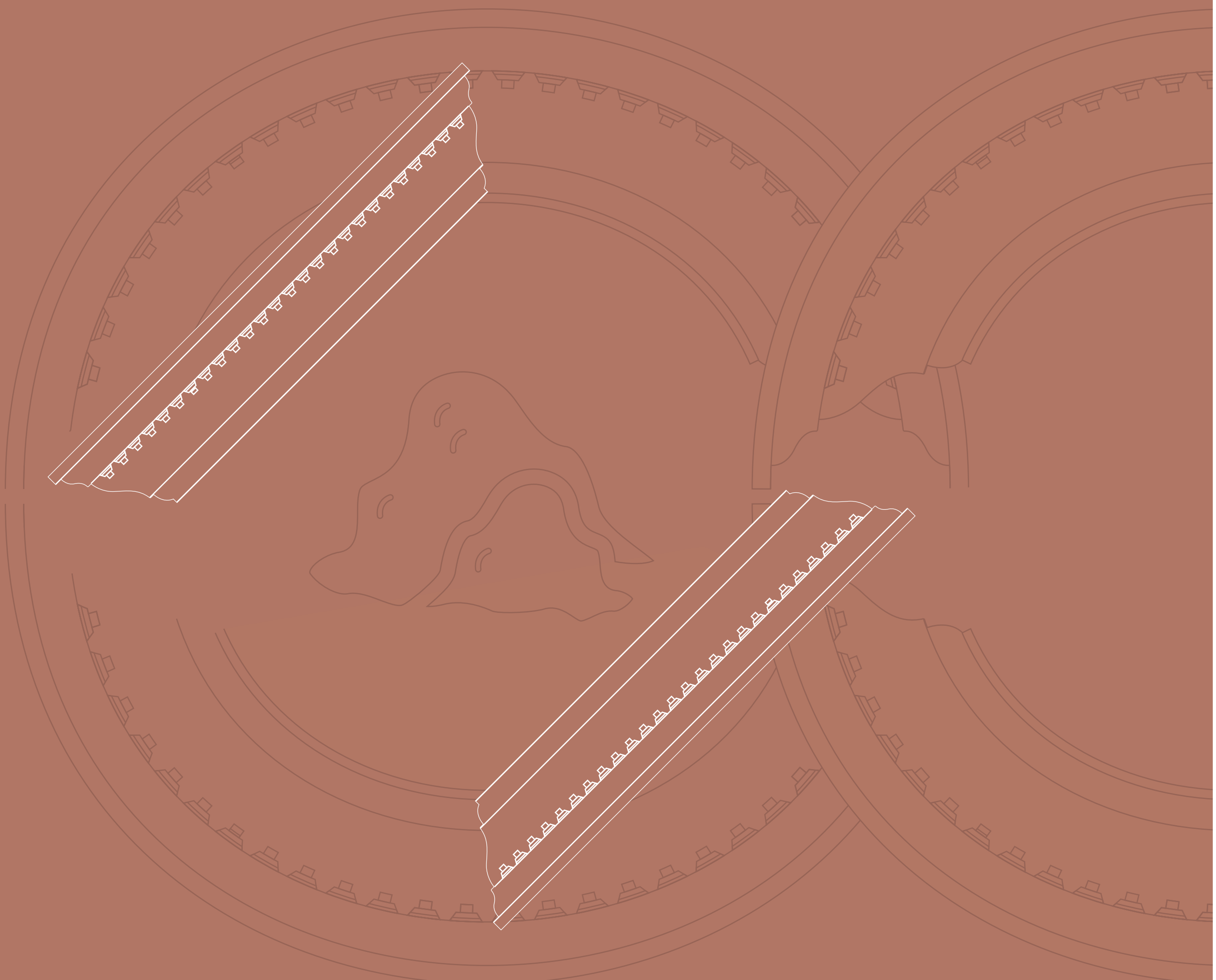
- **Foreign Exchange Savings:** Reduces the need for imports of critical materials like copper and silver, contributing to national foreign exchange savings.

References:

1. WATTS TO WASTE: Exploring India's Solar Waste Landscape - International Solar Alliance (ISA). https://isolaralliance.org/
2. Circular Economy and Standards for PV Modules in the EU - European Committee for Electrotechnical Standardization (CENELEC). https://www.cencenelec.eu/
3. Electronic Waste Management Rules (EWMR) 2022 - Ministry of Environment, Forest and Climate Change (MoEFCC), India. https://moef.gov.in/
4. National Electricity Plan - Central Electricity Authority (CEA), India. https://cea.nic.in/
5. The risky side of solar energy: A perspective on solar waste - The Economic Times https://energy.economictimes.indiatimes.com/news/renewable/the-risky-side-of-solar-energy-a-perspective-on-solar-waste/83199124
6. Enabling a Circular Economy in India's Solar Industry - Dr. Akansha Tyagi & Team, CEEW. https://www.ceew.in/
7. Digital Technologies for Efficient Waste Management in Europe - European Environment Agency. https://www.eea.europa.eu/themes/waste/waste-management/digital-technologies-will-deliver-more

Chapter 9

CIRCULAR ECONOMY ACTION PLAN *for* GYPSUM



9.1. INTRODUCTION

Gypsum, primarily composed of Calcium Sulfate ($CaSO_4 \cdot 2H_2O$), is a versatile raw material known for its beneficial properties, including non-toxicity, fire resistance, light weight, sound insulation, durability, low global warming potential, insect resistance, and excellent plasticity and workability, especially when combined with cement mixtures. The global market for gypsum-based products is projected to reach a valuation of USD 6.60 to 7.85 billion by the close of 2024. Further growth estimates indicate that the gypsum market is set to expand at a CAGR of 3.7% to 6.2%, reaching a market size between USD 9.15 and 13.76 billion by the end of 2033.

Gypsum is widely used in the construction industry, contributing 11.5% to the global construction chemicals market. Approximately 4–5% gypsum is added during clinker grinding to control cement hardening. Key applications of Gypsum, other than construction sector, include:

- **Medical:**
  Orthopedic casts, dental plasters, and prosthetics, valued for their molding and setting properties.
- **Agriculture:**
  Treatment for saline and alkaline soils, a source of calcium and sulfur, improving nitrogen efficiency, enhancing soil structure and filtration, and preventing algal blooms.
- **Pharmaceutical:**
  Recognized as a critical mineral for the sector by the Ministry of Mines.
- **Food Additives:**
  Approved by the FDA as a calcium source, it's used in brewing and as an ingredient in canned goods, flour, ice cream, and cheese.
- **Cosmetics:**
  Found in hair products, creams, and toothpaste.
- **Other Uses:**
  Classroom chalk, dinnerware molds, car window production, tennis clay courts, and as a color additive in drugs and cosmetics.

High-purity gypsum is used in land applications and fertilizers, while lower-grade gypsum is supplied to cement and gypsum board industries. The Bureau of Indian Standards (IS 1290 – 1965) specifies gypsum use in surgical plaster, ammonium sulfate, pottery, and soil reclamation, with additional standards for construction applications.

Gypsum waste, classified as non-hazardous, includes three main types: phosphogypsum (PG), a by-product from the production of phosphoric acid in the fertilizer industry; flue gas desulfurization gypsum (FGDG), generated from sulfur removal processes in coal-fired power plants; and red gypsum (RG), a waste product from titanium dioxide production. While these forms of gypsum waste are generally non-toxic, their effective management is essential to minimize environmental impact.

Recycling and repurposing these waste types—particularly in construction, agriculture, and soil remediation—can support circular economy goals, reduce landfill dependence, and promote sustainable resource use.

9.2. CURRENT STATUS

India produces around 2.50 % of the world's 150 million tonnes of natural gypsum. The country has a total reserve of recoverable cement and natural gypsum of 39 million tonnes, as per a 2010 report issued by the Indian Bureau of Mines (IBM); however, local production is limited due to the deep-seated reserves which are not feasible for mining. The shortage in gypsum supply in the Indian domestic market has led to the dependence on imports in the past decades from Oman, Iran, Thailand and small volume from Pakistan, Bhutan and East Asia. The gypsum import volume represents nearly 35 % of the total gypsum consumed by the Indian cement industry; Nearly 57 million tonnes of gypsum were imported from 2009 to 2023 alone.

The industry's demand for gypsum is expected to reach nearly 380 million tons cumulatively by FY 2037-2038 with a CAGR of 5.15 %. The limited availability of domestic gypsum will lead to supply constraints and increased dependence on imports, cumulatively needing to import nearly 180 million tonnes of imported gypsum. Considering the significant quantum of Gypsum requirements, the Indian Cement has been exploring alternate Chemical sources of Gypsum – FGD Gypsum (by-product from power industry), Phosphogypsum (Phosphoric acid fertiliser industry).

Table 9-1: Global Practices in Usage of Phosphogypsum and FGD Gypsum

S/No	Country	Phosphogypsum Usage	FGD Gypsum usage
1	Europe	Most Gypsum waste (GW) is currently landfilled in unused sites or within company premises. They are also disposed of in water bodies after tenfold dilutions	Primarily used in building materials, gypsum boards and in cement production
2	Japan	Phosphogypsum is used as raw material in Plaster, Gypsum board manufacturing and Cement Manufacturing.	Utilization rate of FGD gypsum is over 90%, of which cement industry accounts for about 30-40% and other main areas of utilization is Gypsum Board
3	Germany	Phosphogypsum is used as Raw material for building Products and Ammonium Sulphate production	75% of the FGD gypsum generated is being utilized predominantly in the areas of Plaster, Cement and Floor Screeds.
4	USA	For coastal locations, phosphoric acid plants can discharge Phosphogypsum for ocean disposal.	Majority of FGD gypsum is utilized for Gypsum board manufacturing sector, followed by cement industry & other areas such as structural filling, agriculture, mine reclamation
5	China	Majority of Phosphogypsum is used as fertiliser, followed by its usage in the manufacturing of sulphuric acid and cement, Gypsum building plasters	Major quantity of the FGD gypsum is utilized in Cement Manufacturing, Gypsum Board manufacturing and utilization of Gypsum as retarder, Gypsum block, mortar, wall insulation materials, building plaster, wall plaster

CPCB Guidelines for Handling and Management of Flue Gas Desulphurization (FGD) Gypsum, CPCB Guidelines on management & handling of Phosphogypsum generated from phosphoric acid plants (2012)

Under the US EPA, Phosphogypsum is classified TENORM (Technologically Enhanced Naturally Occurring Radioactive Material) as it contains heavy metals and radioactive elements from Rock matrix. It has directed Phosphogypsum to be placed in stacks (Gypstacks) and prohibited the sale as common Gypsum.

At present, the legacy stock of Phosphogypsum, in India is estimated to be about 70 million metric tons (MMT). Even though the Phosphogypsum has presence of undesirable trace radioactive elements, fluorine (about 1%) which causes ring formation in kilns and P2O5, it is widely used in cement manufacturing in India. Given that the total cement production in India during FY23 was 400 MMT, the cement industry has the potential to use about 16 MMT of Phosphogypsum annually as a resource.

Phosphogypsum production in India is limited, Ministry of Road Transport and Highways recently gave approval to use phosphogypsum stockpile for on-going road construction as analysis showed the performance to be as good as sand embankment. However, before the usage, CPCB directs the Phosphogypsum producing industries to stabilise, and shift the washed Phosphogypsum to the Phosphogypsum stack / intermediate storage /direct disposal for utilization / loading point for sale or disposal to control particulate emissions and dust. The following table shows comparison of properties of Phosphogypsum and Mined Natural Gypsum.

Table 9-2: Comparison of Properties of Phosphogypsum and Mined Natural Gypsum

Element	Unit	Phosphogypsum	Mined Gypsum
S	(%)	16.4	16.1
Ca	(%)	18.9	18.3
Si	(%)	3.35	0.82
P	(%)	0.34	0.01
Mg	(%)	0.01	0.04
Na	(%)	0.11	0.18
K	(%)	0.22	0.24
Al	(%)	0.02	0.06
Fe	(%)	0.3	0.01
Cu	(%)	0.09	—
Zn	(%)	0.15	—
Mn	(%)	0.05	—
40K	(Bq kg–1)	ND	302 ± 25
238U	(Bq kg–1)	3370 ± 32	21 ± 2
232Th	(Bq kg–1)	23 ± 6	25 ± 2
226Ra	(Bq kg–1)	1895 ± 39	39 ± 4

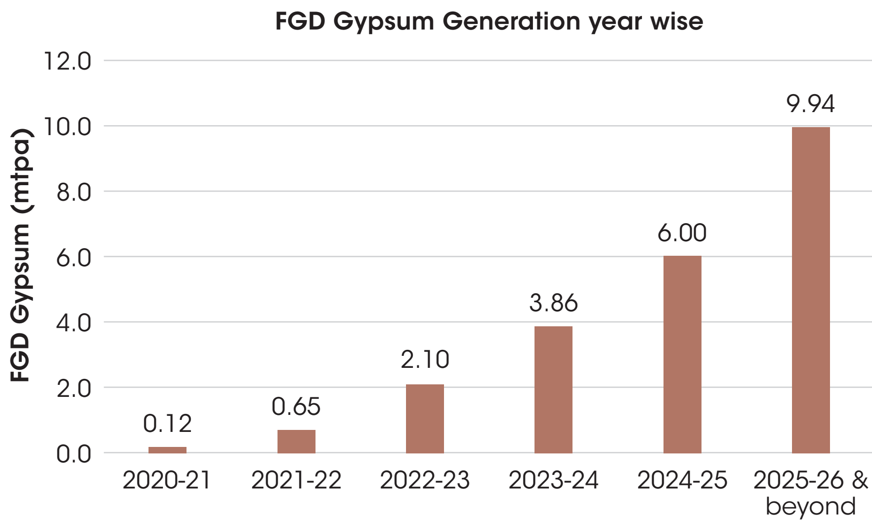
Source: Nayak, A. K., et al. "Efficiency of phosphogypsum and mined gypsum in reclamation and productivity of rice–wheat cropping system in sodic soil." Communications in soil science and plant analysis 44.5 (2013): 909-921.

On the other hand, usage of limestone in FGDs (Flue Gas Desulphurisation) for reduction of SO2 produces FGD gypsum. It is noteworthy that India had mandated all the thermal power plants to install FGD units (to cut sulphur emissions) by December 2026. The FGD gypsum generation in tonnes per annum per MW considering Plant utilisation or plant load factor (PLF) of 80% and 55% is presented in the table below:

Table 9-3: FGD Gypsum Generation in Thermal Power Plants

Unit Capacity (MW)	Specific Coal Consumption (kg/kWh)	FGD gypsum generation	
		TPA/MW @80% PLF	TPA/MW @55% PLF
Up to 250	0.764	100.7	69.25
250-500	0.684	90.18	62
500-600	0.584	76.99	52.93
Above 600	0.524	69.08	47.49

While the progress of adoption of FGDs in coal plants is slow, the projected Year-wise FGD Gypsum generation is expected to increase about to 9.94 million tonnes per annum (MTPA) with 55% PLF as shown in the image below and to 14.46 MTPA with 80% PLF. However, due to constraints in financial, logistics and manpower parameters, the expected gypsum generation is estimated at around 9.94 MTPA with an estimated cost of INR 1,500 per ton. Given the projected demand of 12 – 15 MTPA Gypsum, the whole FGD Gypsum generated can be consumed by the cement industry alone in the country.



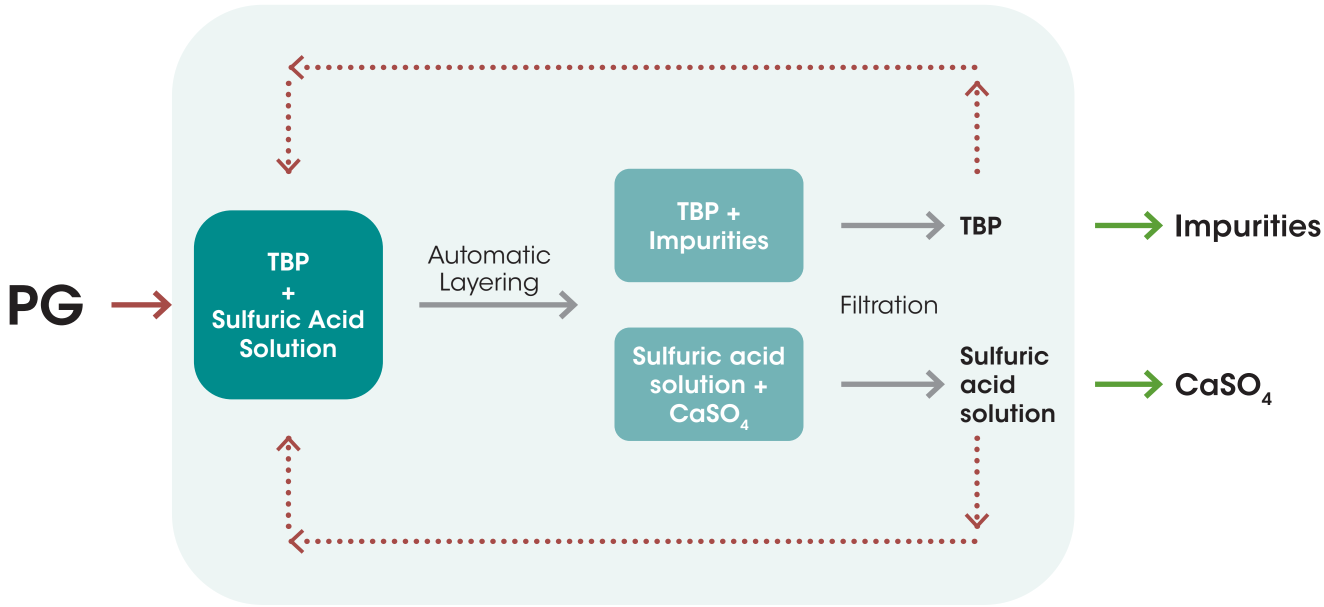
Source: CPCB Guidelines for Handling and Management of Flue Gas Desulphurization (FGD) Gypsum

For a developing nation like India, the rapid urbanization and infrastructural development creates a huge demand for Gypsum. Some recent developments include:

- Gypsum has been identified as a priority area for the circular economy by NITI Aayog.
- The government has imposed new duties on imports of certain gypsum products from China, Oman, and Iran to encourage local sourcing.
- To bridge the supply-demand gap, the Department for Promotion of Industry and Internal Trade (DPIIT) launched a recycling program for gypsum waste from fertilizer production and power plants in May 2023.
- The Indian Road Congress (IRC) has approved the use of neutralized phosphogypsum waste material for road construction under the National Highways Authority of India (NHAI).

Recently, scientific communities have come up with several purification processes for phosphogypsum to convert it to gypsum which includes a direct flotation process followed by NaSiO3 and mixed amine treatment, wet chemical conversion, TBP (TriButyl Phosphate) and sulphuric acid-based conversion as shown in the flowchart below:

Figure 9-1: Contaminant Removal to Extract Gypsum from Phosphogypsum



Source: Zhang, M., Fan, X. Preparation of gypsum with high purity and whiteness from phosphogypsum for CO2 mineral sequestration. Sci Rep 13, 4156 (2023). https://doi.org/10.1038/s41598-023-28251-6

9.3. GAPS AND CHALLENGES

While gypsum possesses inherent qualities that make it ideal for a circular economy, its full potential is hampered by a range of interconnected challenges. Table 9-4 below presents the specific challenges, analyzing the gaps that must be bridged to unlock a truly circular model for gypsum.

Table 9-4: Challenges and Mitigation Strategies

S/No	Challenges	Possible Mitigation Strategy
1	Wide-ranging impurities in synthetic gypsum along with high moisture content, make it unfit for direct use in cement manufacturing.	Pre-treatment is required. A Japanese company, Onoda Cement uses calcination to dehydrate phosphogypsum which is then neutralized with lime water to convert impurities to insoluble/ inactive calcium salts.
2	Variation in quality of synthetic gypsum from various sources and applications.	To overcome this challenge, manufacturers need to heavily invest in advanced quality control measures.
3	Competition from sourcing natural gypsum which remains widely available and cost-effective.	Synthetic gypsum manufacturers must innovate and demonstrate the environmental and economic benefits of their product.
4	Gypsum has a high transport freight cost.	Current tariff levels of industrial by-products should be revised to lower freight slabs to streamline movement to end-user industries.
5	Gypsum is by nature a sticky material that poses difficulties in loading, unloading and transportation	Regular Cleaning of dumpers and loading equipment used for Gypsum loading and unloading.
6	Low adoption in installing FGD units (to cut sulphur emissions) in power plants due to high capital expenditure.	Promote Investments to adopt FGD in power plants which shall generate huge FGD gypsum as by-product .

9.4. PROPOSED FRAMEWORK

Gypsum products are appropriate for closed-loop recycling as the raw material calcium sulphate ($CaSO_4.2H_2O$) is known to change its properties through a reversible hydration reaction. In 1999, TIFAC commissioned a one of the first techno-economic surveys on the "System approach for utilization of gypsum – a mineral resource" which had highlighted potential uses on land applications and in the construction sector.

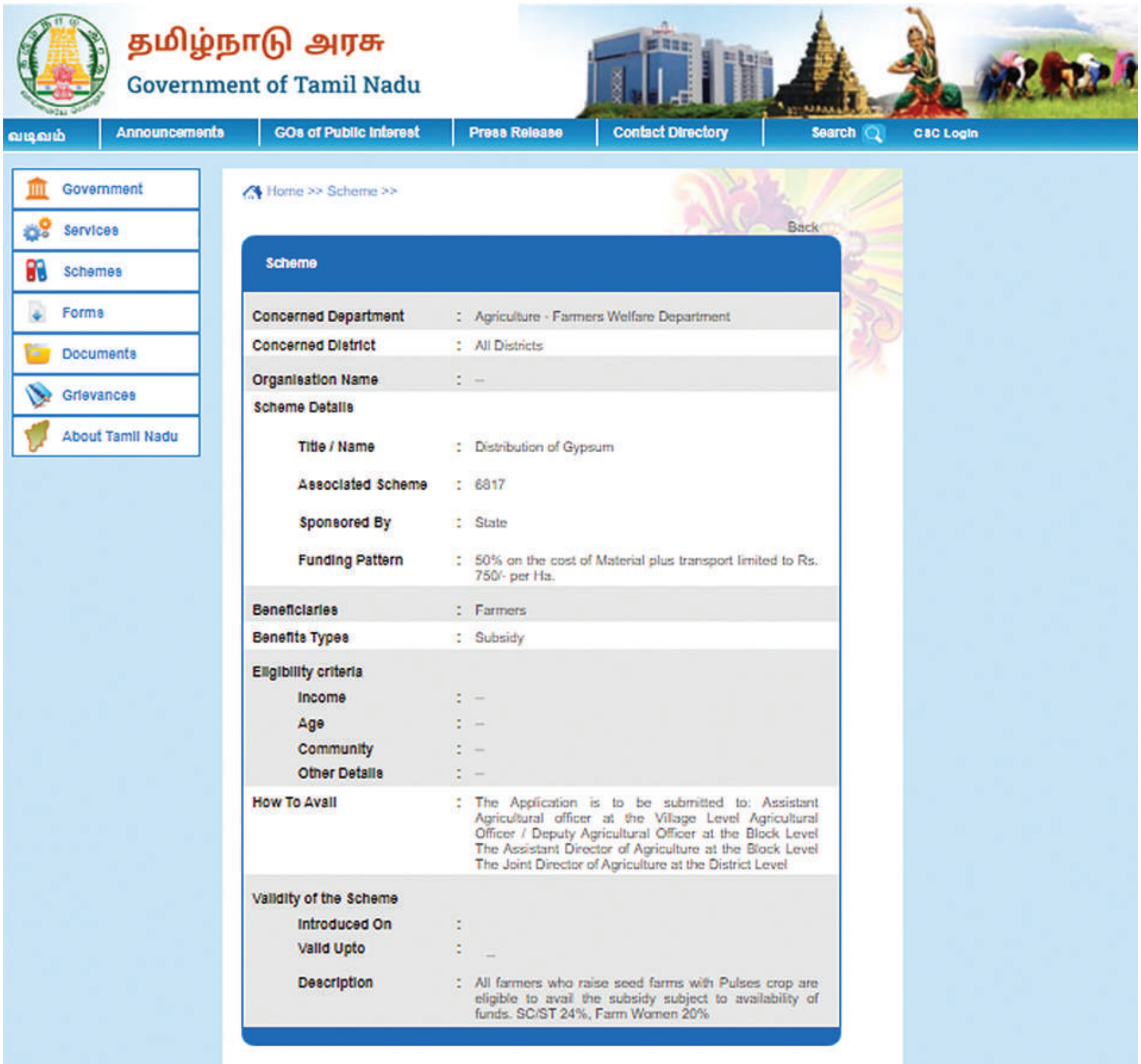
The following are some recommendations to promote the circular economy of synthetic gypsum waste.

- Promote phosphogypsum use as a building material in replacement of natural gypsum which can be coupled with tax duties on the import of gypsum.
- Conduct a detailed techno-economic analysis on the sourcing of synthetic gypsum and its usage.
- Promote technologies for pre-treatment of synthetic gypsum to meet quality standards in cement industries
- Promote investments in FGD installation in power plants which can produce a steady stream of synthetic gypsum as a by-product at a competitive price
- Promote synthetic gypsum usage in the phosphorus chemical industries
- Promote phosphogypsum use in agriculture
- Best practices to promote circular economy for gypsum products, especially in construction industries are - on-site segregation of GW, clear waste acceptance criteria, and clear recycled gypsum quality criteria

9.5. ENABLERS TO PROMOTE CIRCULAR ECONOMY

Globally, both the US EPA and the EU have taken measures to manage gypsum waste effectively, focusing on reducing landfill use, mandating gypsum wallboard recycling, and requiring the use of recycled gypsum in plasterboard. In India, several initiatives are in place to promote the sustainable use of gypsum.

To encourage the use of phosphogypsum in agriculture, it has been excluded from Schedule I of the hazardous waste category. Additionally, the governments of Telangana, Uttar Pradesh, and Tamil Nadu provide financial assistance to farmers, covering 50% of the cost of gypsum material and transportation. Meanwhile, the availability of FGD gypsum is projected to increase due to the government's mandate for thermal power plants to install FGD systems by the established deadline. State governments with these power plants are encouraged to make FGD gypsum available to farmers at competitive rates.



The Central Pollution Control Board (CPCB) and the Atomic Energy Regulatory Board (AERB) have issued specific guidelines to support the safe management and utilization of gypsum by-products:

- **CPCB Guidelines for Phosphogypsum:**
  These guidelines encourage the use of phosphogypsum generated from phosphoric acid plants in:

o Manufacturing gypsum boards, ammonium sulfate, and sulfuric acid,

o Soil reclamation and fertilizers,

o Cement as a retarder, and

o Other gypsum-based products like Plaster of Paris, ensuring compliance with BIS standards.

- **AERB Directive:**
  The AERB's 'Use of Phosphogypsum in Building & Construction Materials & in Agriculture' (Directive No. 01/09) provides standards to ensure the safe application of phosphogypsum in these sectors.

Similarly, CPCB guidelines for FGD gypsum outline its potential applications in gypsum board production, cement manufacturing, composite binders, soil amendments, and mine backfilling. These policies and guidelines collectively aim to maximize the sustainable and safe use of gypsum across industries in India.

9.6. CASE STUDIES

9.6.1. Sustainable business opportunities from waste Gypsum

Paradeep Phosphates, a Phosphate fertiliser manufacturer produces Phosphogypsum at the rate of over 5000 MT/day which is stored in stacks within premises. The legacy wastes are now repurposed for road construction, cement production and for Zypmite production. This strategic approach has not only addressed the challenge ensuring efficient evacuation and utilization of this by-product.

Phosphogypsum (MT)

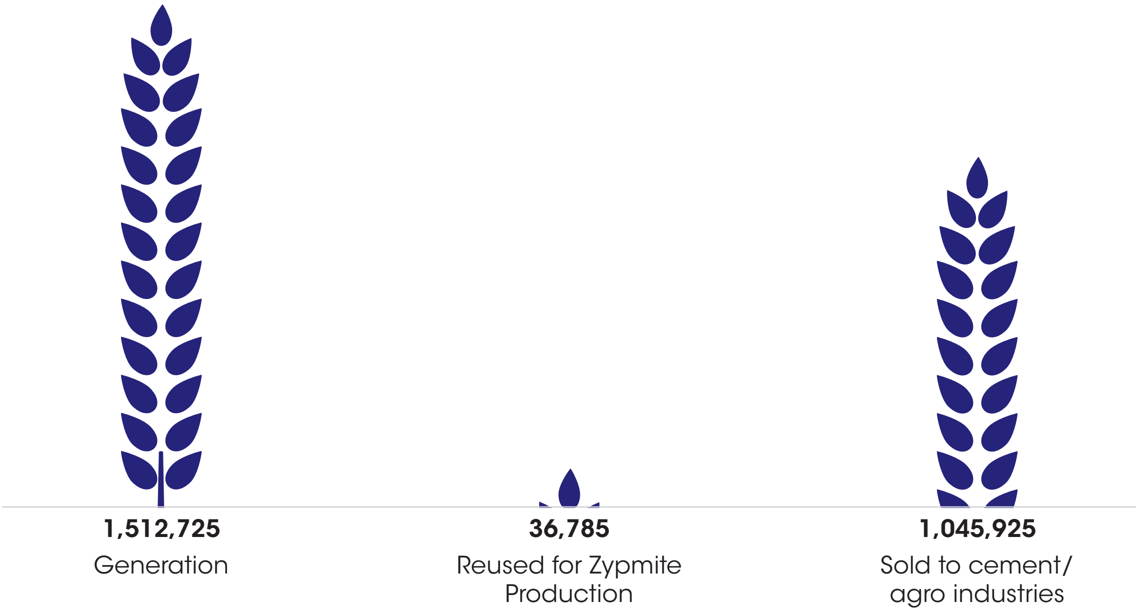


Image Source: Paradeep Phosphates https://www.paradeepphosphates.com/

9.6.2. Legacy waste for cement production

UltraTech Cement Limited has utilised utilized inland and coastal waterways to transport legacy phosphogypsum consignment of 57,000 metric tons (MT) in a bulk cargo carrier from Paradeep port in Odisha to their unit in Amreli, Gujarat. In a separate incident, UltraTech has sourced the Phosphogypsum from Indian Farmers Fertiliser Cooperative Limited (IFFCO) which will be utilised in cement production.

9.7. GOALS AND TARGETS

Targets	2025	2030
Increase the adoption of synthetic gypsum in cement production from the current 4% *[Basis: https://www.bizzbuzz.news/politics/cement-units-can-gain-by-dumping-mineral-gypsum-for-phosphogypsum-1214577]*	5%	10%
Reliance on imported gypsum which make up 35% of the gypsum in cement market *[Basis: https://indiancementreview.com/2023/07/17/scarcity-of-domestic-gypsum-supply-2/]*	30%	25%
Enhance recycling and ensure safe disposal of gypsum waste *[Basis: Aligning with CPCB guidelines on usage of Phosphogypsum, and FGD gypsum]*	30%	100%
Promote the use of stockpiled phosphogypsum in road construction, building constructions and agriculture *[Basis: https://pib.gov.in/PressReleasePage.aspx?PRID=1901441 (NHAI to Explore Use of Phosphor-Gypsum in National Highway Construction) and AERB Directive No. 01/09 (Use of Phosphogypsum in Building & Construction Materials & in Agriculture)]*	Minimum of 5%	Minimum of 10%

9.8. IMPACT POTENTIAL

Recycling of Gypsum waste helps in mitigating the following impacts:

- Natural Gypsum mining is associated with health hazards in the miners some of which includes pulmonary impairment, musculoskeletal symptoms, hypertension & diabetes.
- Methane (CH4), Carbon Dioxide (CO2), Hydrogen Sulphide (H2S) and other GHG emissions are also generated when plasterboard is landfilled, formed during the degradation of the lining paper.

Recycled Gypsum Waste when transported equal or less than 30 km results in environmental benefits when compared with natural gypsum production. The location and number of gypsum recycling plants or warehouses are hence considered crucial.

References

1. Eurogypsum Symposium on availability of raw materials from secondary resources: a key aspect of circular economy (2018) - UNECE
https://unece.org/fileadmin/DAM/energy/se/pp/unfc_egrm/egrc9_apr2018/24.04_RM/07_Christine.Marlet.pdf
2. Circular Economy of Gypsum - CMA India
https://www.cmaindia.org/circular-economy-of-gypsum
3. Gypsum Market Outlook 2023 to 2033 - Future Market Insights
https://www.futuremarketinsights.com/reports/gypsum-market
4. Gypsum based Product Market Trends (2024-2033) - Reports and Data
https://www.reportsanddata.com/report-detail/gypsum-based-product-market/market-trends
5. Critical Minerals for India - Ministry of Mines (June 2023)
https://mines.gov.in/admin/download/649d4212cceb01688027666.pdf
6. Gypsum Demand and Supply Scenario in India - Zawawi Minerals
https://zawawiminerals.com/wp-content/uploads/2014/03/Gypsum-Demand-and-Supply-Scenario-in-India.pdf
7. Efficiency of phosphogypsum and mined gypsum in reclamation and productivity of rice–wheat cropping system in sodic soil - Nayak, A. K., et al. Communications in Soil Science and Plant Analysis 44, no. 5 (2013): 909-921.
8. Synthetic Gypsum Market - Globe Newswire (2024)
https://www.globenewswire.com/en/news-release/2024/01/17/2810480/0/en/Synthetic-Gypsum-Market-is-projected-to-develop-at-a-CAGR-of-5-3-from-2023-to-2030-Persistence-Market-Research.html
9. CPCB Guidelines on management & handling of Phosphogypsum generated from phosphoric acid plants (2012) - CPCB
https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS9MYXRlc3RfNzRfRHJhZnRHdWlkZWxpbm
VzYXNPblBob3NwaG9neXBzdW1HZW5lcmF0ZWRGcm9tUGhvc3Bob3JpY0FjaWRQbGFudHMxOS4wNi4yMDEyLnBkZg==
10. CPCB Guidelines for Handling and Management of Flue Gas Desulphurization (FGD) Gypsum - CPCB
https://cpcb.nic.in/uploads/hwmd/Guidelines_HW_5.pdf
11. Indian Mines Yearbook 2022 - Indian Bureau of Mines
https://ibm.gov.in/IBMPortal/pages/indian-minerals-yearbook–2022
12. Indicators to measure the management performance of end-of-life gypsum: from deconstruction to production of recycled gypsum - Jiménez-Rivero, A., & García-Navarro, J. Waste and Biomass Valorization 7 (2016): 913-927.
13. NHAI to explore use of Phosphor-Gypsum in National Highway Construction - Press Information Bureau (2023)
https://pib.gov.in/PressReleasePage.aspx?PRID=1901441
14. UltraTech pioneers coastal waterway transport to address environmental challenges of phosphogypsum stockpile - UltraTech Cement
https://www.ultratechcement.com/corporate/media/stories/ultratech-pioneers-coastal-waterway-transport-to-address-environmental-challenges-of-phosphogypsum-stockpile

Chapter 10

CIRCULAR ECONOMY ACTION PLAN *for* TOXIC AND HAZARDOUS INDUSTRIAL WASTE

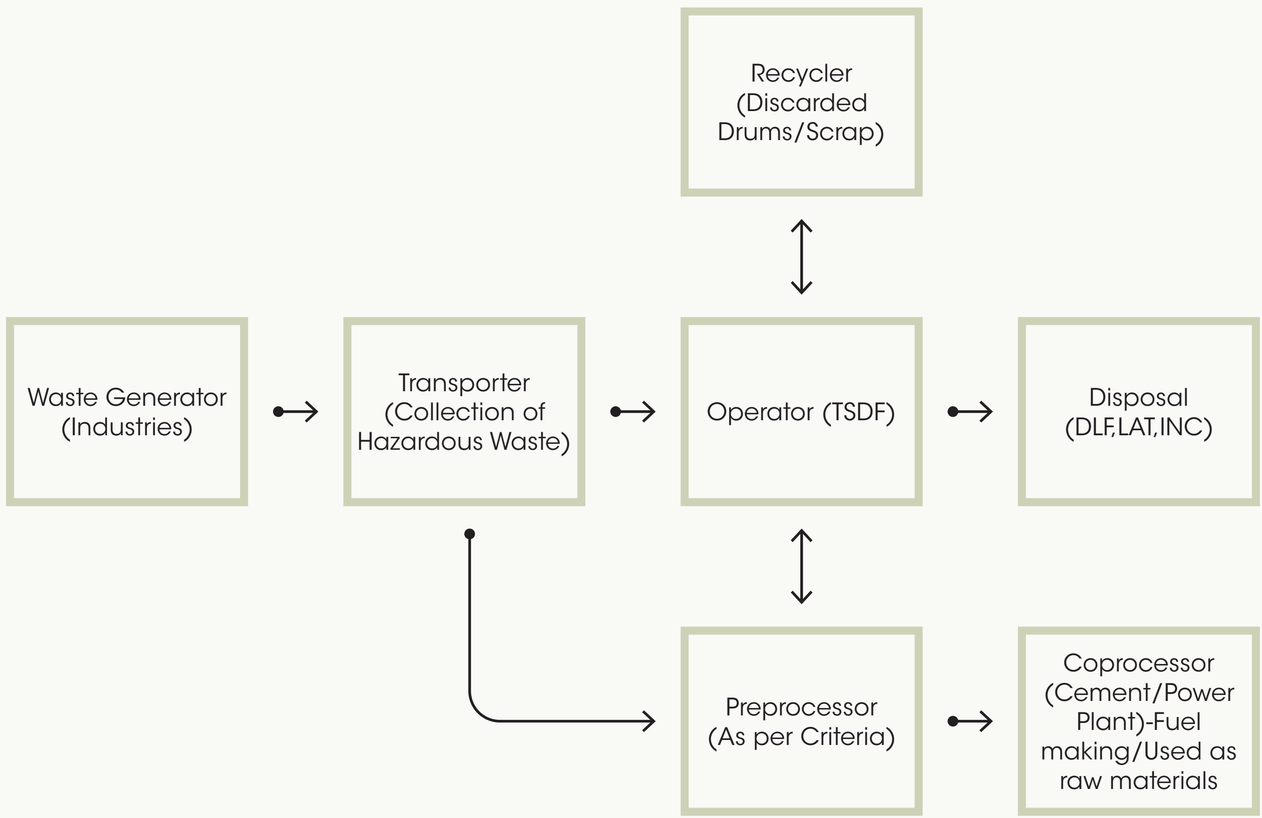
10.1. INDUSTRY OVERVIEW

10.1.1. Introduction

The waste management industry encompasses the management of various waste categories, including hazardous, biomedical, municipal solid waste (MSW), and recyclables. Industrial/hazardous waste, a significant segment within this industry, is defined under the Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016.

The global hazardous waste management market is currently valued at USD 15.4 billion and is projected to reach USD 26.1 billion by 2033. This growth highlights the increasing importance of addressing hazardous waste, a critical environmental issue with far-reaching implications for public health, ecosystems, and the planet as a whole. Proper treatment and disposal of hazardous waste is essential to prevent environmental contamination and safeguard communities. Figure 10-1 presents the typical flow of hazardous waste management, from its generation to final disposal. It highlights the key stakeholders involved in the process, including waste generators (industries), transporters, treatment, storage, and disposal facilities (TSDFs), pre-processors, recyclers, and coprocessors.

Figure 10-1: Typical Flow of Hazardous Waste Management



Waste management offers numerous benefits and plays a vital role in the circular economy. Waste is initially generated by various sources, including industries. Transporters are essential in this process, as they collect waste from generators and safely transport it to the operators, adhering to all safety regulations and guidelines, especially for hazardous materials. Operators, or waste management companies, handle the waste further through several methods, including:

1. **Recycling:**
   Discarded items like drums, oil containers, scrap materials, and plastics are recycled into new products for various uses.
2. **Pre-processing (Utilization):**
   This involves preparing waste to be used as raw material/ resource. The pre-processing stage converts waste into materials suitable for use in co-processing in cement kilns.
3. **Disposal:**
   Whatever cannot be recycled or utilised is disposed of in a scientific manner. This includes secure landfill and incineration.

This approach significantly contributes to the economy by creating job opportunities, promoting reusability and recyclability, and fostering a sustainable future for all:

- **Environmental Impacts:**
  According to research, hazardous waste production has been steadily increasing, with 15.66 million metric tons generated in FY 2022-23 (CPCB). This hazardous waste poses significant risks and improper handling or disposal can lead to contaminating air, water, and soil, emitting greenhouse gases, and harming wildlife and ecosystems. Effective waste management ensures the scientific handling of waste, helping to keep our planet clean.
- **Social Impacts:**
  Waste management also creates job opportunities and livelihoods for individuals. Sustainable practices in waste management increase these opportunities further.

10.1.2. Current and Projected Growth Rate

Hazardous waste management is currently undergoing a transformation, incorporating new technologies to enhance efficiency and stability. Both government and non-government organizations are actively working to treat hazardous waste responsibly, with a greater emphasis on reuse and recycling to promote a circular economy.

In the financial year 2022-23, approximately 15.66 million metric tons of hazardous waste was generated, while the authorized capacity stands at about 51.91 million metric tons. Of this generated waste, 42.49% is deemed utilizable, 31.74% is recyclable, 20.89% is suitable for landfill, and 4.89% is incinerable.

Since 2019, the generation of hazardous waste has been on the rise, with 12 million metric tons produced in 2022 alone. The hazardous waste management sector is projected to grow at a compound annual growth rate (CAGR) of 5.6% from 2024 to 2036.

10.2. CURRENT LEVEL OF ADOPTION OF CIRCULAR ECONOMY PRINCIPALS

Circular economy in India's hazardous waste management sector is still in its early stages, with several initiatives implemented and others under development:

- **Solvent Recovery:**
  This process aligns with circular economy principles by recovering solvents for reuse in further processes.
- **Oil Recovery:**
  Oils are extracted through methods such as pyrolysis and biodiesel production.
- **Alternative Fuel Resources (AFR):**
  AFR plays a crucial role in the circular economy, serving as an alternate fuel in cement kilns as well as an alternate raw material.
- **Plastic Recycling:**
  Reusing materials is a key principle of the circular economy, and plastic recycling has seen significant success in this context.

The above mentioned activities are a few examples of how circularity is currently embedded in the overall toxic/hazardous waste management sector but it is plagued with its own set of challenges ranging from the presence of unorganised sector, commercial viability for the organised sector & the absence of incentives to enable the end user to adopt such circular materials.

10.2.1. Overview of existing policies and incentives promoting circular economy

India has established a specific set of policies, rules and regulations to promote a circular economy in waste management. The Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016 and its further amendments are particularly significant for implementing a circular economy in hazardous waste management. These rules include various policies that align with circular economy principles.

- **Reduction of Waste Generation:**
  The Rules emphasize minimizing the production of toxic and hazardous waste within production systems.
- **Proper Segregation:**
  The Rules mandate the proper segregation of hazardous waste from non-hazardous or non-toxic waste to ensure effective management, as hazardous waste requires different treatment methods.
- **Recovery and Recycling:**
  The Rules encourage increased recycling and reuse of hazardous materials, which not only supports pre-processing but also helps reduce reliance on fossil fuels and raw materials.
- **Regulatory Compliance and Monitoring:**
  The regulations provide clear guidelines for compliance and monitoring systems to ensure that the environment is protected and not harmed.

10.2.2. Lessons from international best practices

Internationally certain best practices are being adopted to help achieve a circular economy.

The EU also has RoHS that restricts the use of certain hazardous chemicals in the manufacturing process of electronics and electrical equipment. The US has TSCA (Toxic Substance Control ACT) and California has its own legal framework called Prop 69 which includes a list of 800 chemicals and requires companies to publish a list of chemicals that are known to cause cancer, birth defects and other reproductive problems.

Some other practices include:

- **Life Cycle Assessment (LCA):**
  Implementing LCA helps industries evaluate the environmental impacts of their products from creation to disposal, encouraging them to make decisions that enhance circularity and reduce hazardous waste generation.
- **Green Chemistry:**
  Promoting the principles of green chemistry encourages the design of chemical products and processes that minimize or eliminate hazardous substances, leading to less hazardous waste generation.
- **Research and Innovation:**
  Investing in research and development for safer waste management technologies and methods is crucial. Countries that support innovation in this field often see advancements in circular waste practices.
- **Implementation and enforcement of effective regulation:**
  To minimize the use of hazardous chemicals, both virgin and recycled, in the manufacturing process.
  The EU has enforced REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) a comprehensive set of legal framework addressing chemicals in use and requiring companies marketing chemicals to present a set of test data.

10.3. GAPS AND CHALLENGES

POLICY GAPS OR REGULATORY BARRIERS:
The Indian waste management sector faces numerous challenges in handling hazardous waste, including inadequate infrastructure and unclear treatment procedures from the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB). Additionally, issues related to transboundary movement and logistical challenges complicate matters. Social and political factors can also hinder effective hazardous waste management. Many of these problems stem from a lack of financial resources, well-trained staff, and sufficient manpower.

In promoting a circular economy for hazardous waste management, one example is the practice of pre-processing and using alternative fuel resources (AFR) in cement industries. There are multiple channels through which cement industries are currently receiving waste. There is no quality control & no process in place on how to handle the waste, in case the waste received is not as per specifications.

CHALLENGES POSED BY INFORMAL SECTORS:
Informal sectors in India largely do not adhere to government regulations, leading to unmonitored waste disposal and management practices. Workers in the informal sectors often lack proper knowledge and training in waste handling, resulting in inadequate precautionary measures and the absence of protective equipment. This allows them to manage waste at lower costs than formal sectors, prompting many industries to opt for disposal through informal channels. Unfortunately, these practices can harm the environment and contribute to ineffective waste management.

Informal sectors generally have a limited understanding of hazardous waste types and treatment processes. As a result, the toxicity and hazards associated with certain waste types may go unrecognized, leading to improper handling and treatment.

CASE STUDY: AFR VALUE CHAIN

A key approach for diverting toxic and hazardous industrial wastes from landfilling or incineration is to send them to cement industries for co-processing. This process utilizes the inherent properties of these wastes as substitutes for fuel or raw materials, aligning with circular economy principles. The goal is to process the waste so it can be fully utilized in cement kilns, leaving no residues and minimizing environmental impact.

Initially, three main players were involved: the waste generator, the pre-processor, and the end user (or co-processor). Over time, two additional players—the transporter and the aggregator—have entered the chain. With five parties now involved, there has been an increase in leakages across the value chain, complicating effective waste management and accountability.

Some key reasons contributing to these issues include:

1. **Commercially Driven Decisions by Waste Generators:**
   For waste generators, waste management has become largely a commercial decision, with five options to choose from:

- TSDF Operator/Pre-processor
- Standalone Pre-processor
- Licensed Transporter (authorized by a pre-processor or co-processor)
- Aggregator
- Cement Plant/Pre-processor

This variety of options has led to aggressive rate reductions, where handling costs decrease as they get lower in the value chain. This pricing competition is further complicated by traceability gaps, making it difficult to track where and how the waste is ultimately disposed. These traceability issues have become a serious concern.

2. **Lack of Control over Input Waste and Output Resource Quality:**
   Quality control is a significant challenge, especially with smaller pre-processors that operate with minimal capabilities, or transporters and aggregators lacking proper facilities altogether. Recent issues in cement kilns using AFR (Alternative Fuels and Raw materials) waste have highlighted these risks, causing unplanned shutdowns and, in some cases, accidents. Many pre-processors lack the necessary infrastructure, including

laboratory capabilities and safety measures, leading to waste compatibility issues and increased accident risks.

3. **Quality Compliance Requirements for Cement Plants:**
   For cement plants, AFR waste must meet specific quality parameters. If waste fails to meet these standards, there must be clear protocols for managing non-compliant waste, especially for aggregators and transporters who lack facilities to safely handle such materials. Without a robust process, there is a heightened risk of operational disruptions and safety hazards.

This lack of coordination and oversight across the value chain leads to systemic challenges in safe and effective waste management.

The three major gaps identified above can be addressed through a two-step approach.

1. The first step involves implementing stricter norms and minimum requirements for pre-processors. This includes mandating in-house laboratory setups to ensure proper waste analysis and quality control, and restricting pre-processors from further delegating their licenses to transporters or aggregators, thereby preventing unregulated handling of waste. In states where Common TSDFs (Treatment, Storage, and Disposal Facilities) are established, these facilities should function as primary hubs, directly managing waste from generators. Additionally, co-processors should be encouraged to set up their own pre-processing plants, allowing them to handle waste in-house. Only if Common TSDFs or co-processor facilities face capacity constraints should standalone pre-processors be considered. This approach helps control potential leakages at the source and reduces the overall waste footprint. Furthermore, all pre-processors should be affiliated with common facilities, ensuring that in cases of waste incompatibility or rejection, the waste is safely redirected to a CHWTSDF (Common Hazardous Waste Treatment, Storage, and Disposal Facility) for proper handling.

2. The second step is to establish a comprehensive end-to-end tracking system for waste. This system would start by identifying the types of waste that each pre-processor can handle, based on their infrastructure and technical capabilities. Waste categories could include high or low calorific value (CV) materials, those with high moisture or ash content, raw materials, critical wastes, and materials with high chloride or sulfide content. Certain types of waste, such as those that are critical or unsuitable for kiln processing, should not be handled by standalone AFR (Alternative Fuels and Raw materials) facilities. Once waste is sent from a generator to a TSDF or standalone pre-processor, it should be closely tracked and tagged until it reaches a co-processor. This tracking system should include a mass balance requirement to account for the transformation of input materials into output products at the pre-processing facility, ensuring transparency and minimizing discrepancies across the waste management process.

10.4. PROPOSED FRAMEWORK FOR PROMOTING CIRCULARITY

In India, there are two primary categories of waste that can enhance circularity potential. The first category includes wastes that are already being utilized or recycled, with the main challenge being traceability and leakage to the informal sector. The second category consists of wastes managed through traditional methods like landfilling and incineration. To address these issues, action is needed on five fronts:

1. Strengthen Existing Rules & Regulations

Incorporate circularity at the core of regulations rather than merely offering superficial commitments.

2. Incentivize Waste Generators

Encourage industries to view circularity in production and waste minimization as a value-added activity, rather than a burden.

3. Enhance Traceability

Improve tracking of waste materials throughout their lifecycle.

4. Engage with the Informal Sector

Foster collaboration with informal waste handlers to improve overall management practices.

5. Promote Research

Invest in research to find alternatives to traditional waste management practices.

10.5. ENABLERS

The above mentioned five action points can be achieved through the following measures:

10.5.1. Policy Enhancement & Mandates:

- Ensure effective regulation and enforcement to minimize the use of hazardous chemicals—both virgin and recycled—in manufacturing processes.
- Define "essential use" of hazardous chemicals as necessary for health, safety, or societal functioning, in line with the Montreal Protocol, rather than for profit.
- Use REACH as a baseline to identify substances of very high concern and promote their substitution with safer alternatives.
- Regulate groups of substances collectively rather than individually.
- Require companies to commit to transparency regarding hazardous chemicals in their supply chains, both upstream and downstream.
- Establish guidelines for output materials provided by pre-processors to co-processors, specifying quality parameters.

10.5.2. Market Reorientation:

- Shift market dynamics towards resource conservation by incentivizing waste-reduction practices and penalizing those that generate excess waste. Clear price signals can encourage circular economy-friendly business models.
- Incentivize the design of products with reduced hazardous content to facilitate recycling.
- Implement the "No Data, No Market" principle, encouraging companies to disclose comprehensive lists of chemicals used in manufacturing.
- Exempt import duties on waste recycling technology and equipment.
- Develop an Extended Producer Responsibility (EPR) scheme for toxic and hazardous industrial waste.
- Offer viability gap fund for establishing Eco Parks and common hazardous waste management and recycling facilities.
- Provide incentives for industries to transition from Red to Orange and eventually Green categories as per CPCB classifications.

10.5.3. Enhance Traceability:

- Traceability of waste has become a major challenge for the Hazardous Waste Management Industry. With multiple value add partners being identified it is becoming more and more difficult to keep a track of where the waste was generated and what was its final end use. The idea of setting up of common waste management facilities was to minimize & control the footprint of the waste being generated, in terms of its end use. With multiple partners being created in the value chain this tracking has become very diluted and therefore the following needs to be encouraged.
- Establish common facilities or eco-parks that manage the entire value chain of certain products, from raw material production to recycling and final disposal, to improve quality control and traceability.
- Create common hazardous waste handling facilities with comprehensive waste management capabilities, including recycling, recovery, and final disposal, prioritizing circular practices to minimize environmental harm.
- Implement a centralized tracking system that monitors the entire production and disposal process, inventorying materials used, products manufactured, wastes generated, and value chain partners.

10.5.4. Integrate the Informal Sector:

The informal sector poses a huge risk to the circular economy principals at large as the practices undertaken harm the environment at large as well as lead to a lot of resource wastage since the activities undertaken are by and large more revenue-centric rather than circularity or environment-centric by:

- o Encouraging the lower-tier informal sector to formalize their operations through incentives.
- o Promoting partnerships between the informal and formal sectors, allowing informal entities to supply materials for the formal sector.
- o The government should act as an enforcement body, with a stringent action plan, to support the transition of the informal sector when necessary.

10.5.5. Research & Development:

- Focus on identifying cleaner manufacturing processes, starting with high-polluting industries.
- Prioritize circular economy initiatives at the government level, allocating significant resources and promoting coordinated research across departments and ministries.
- Incorporate circular economy topics into relevant academic curricula to foster research and innovation in reducing hazardous waste.
- Conduct extensive research on the limitations and long-term impacts of using hazardous waste as an alternative resource in cement industries, focusing on the materials utilized.

10.6. GOALS AND TARGETS

S.No.	Proposed Target	Target by 2030
01	**Captive Utilization of Hazardous and Other Wastes: Utilization of hazardous waste by the waste generator, over and above their current numbers (% improvement).** *[Basis for target: CPCB has prepared 100+ SOPs for utilization of different types of hazardous waste during the period 2016 to 2024]*	5%
02	**Utilization of hazardous waste as a supplementary resource: Diversion of hazardous waste to authorized utilizers by the waste generator for utilization based on CBCP's SOPs, as a percentage of total waste.** *[Basis for target: CPCB has prepared 100+ SOPs for utilization of different types of hazardous waste during the period 2016 to 2024]*	10%
03	**Thermal Substitution Rate (TSR) Target for cement industries through utilization of Hazardous Waste as AFR.** *[Basis for target: Voluntary targets set by leading cement industries to achieve about 25-30% TSR by 2030]*	15%

10.7. IMPACT POTENTIAL

The impact potential of circularity in managing hazardous and toxic waste is significant, both in terms of environmental sustainability and public health. Adopting circular economy principles for hazardous waste can help reduce the environmental burden, improve resource efficiency, and lower the risks associated with the disposal of harmful materials. Here's a detailed breakdown of the potential impacts:

- **Reduction in Environmental Contamination:**

o **Resource Recovery and Reuse:** In a circular economy, hazardous and toxic materials can be recycled, repurposed, or remanufactured rather than disposed of in landfills or incinerated. This minimizes the risk of contamination from improper disposal and ensures that hazardous substances don't leach into ecosystems.

o **Decreased Landfill Pressure:** Circularity reduces the volume of hazardous waste going to landfills, which are potential sources of soil and groundwater contamination. Proper waste treatment and recycling technologies can ensure safer handling and disposal of hazardous materials.

- **Energy Savings and Reduced Carbon Footprint**

o **Energy Efficiency:** The recycling of hazardous materials like metals, plastics, and chemicals typically requires less energy compared to the extraction of raw materials. This leads to a reduction in greenhouse gas emissions and energy consumption.

o **Lower Carbon Footprint:** Circular practices such as reusing hazardous waste materials in manufacturing or repurposing them in other industries contribute to lowering overall emissions associated with material production and disposal.

- **Economic Benefits**

o **Cost Savings:** By recycling hazardous materials and reducing the need for raw materials, industries can save money. In addition, minimizing the costs associated with hazardous waste disposal and regulatory compliance can lead to significant financial savings for companies.

o **New Business Opportunities:** Circularity in hazardous waste can lead to the creation of new business models. Companies may emerge that specialize in remanufacturing or safely recycling toxic materials, providing employment and driving innovation in waste management technologies.

- **Improved Public Health and Safety**

o **Safer Waste Handling:** Circular economy strategies focus on the safe collection, treatment, and recycling of hazardous waste, thereby minimizing human exposure to toxic substances.

o **Reduction of Toxic Exposure:** By diverting hazardous materials from incinerators or landfills, circular approaches help prevent the release of toxic substances such as dioxins, heavy metals, or persistent organic pollutants (POPs) into the environment, which can cause long-term health problems.

- **Technological Innovation**

o **New Recycling Technologies:** Circularity encourages the development of new technologies for recycling or safely treating hazardous waste. Innovations such as more efficient chemical recycling methods, solvent recovery, or bioremediation techniques can make the management of hazardous waste more sustainable.

o **Green Chemistry:** The push towards circularity may also drive research into safer, less-toxic materials and processes, resulting in the development of "green chemistry" solutions that minimize the generation of hazardous waste in the first place.

- **Compliance with Regulations and Public Expectations**

  - **Regulatory Compliance:** Strict regulations and ensuring strict compliance will help businesses for providing a pathway for safe recycling or disposal. Additionally, more stringent global regulations on waste and sustainability are pushing companies to adopt circular models.

  - **Meeting Public and Consumer Expectations:** Consumers and communities are increasingly concerned about the environmental and social impacts of waste. Companies that embrace circularity in managing hazardous waste can improve their reputation, attract customers, and respond to consumer demand for environmentally responsible practices.

- **Waste Prevention and Minimization**

  - **Design for Sustainability:** Circularity in hazardous waste management encourages manufacturers to design products with end-of-life recovery in mind. This can result in the creation of products that are easier to recycle, have fewer toxic components, or produce less hazardous waste in the first place.

  - **Extended Product Lifespan:** By focusing on repair, reuse, and recycling, products that contain hazardous materials can be kept in circulation longer, reducing the frequency of disposal and lowering the overall generation of hazardous waste.

The potential impact of circularity in hazardous waste management is profound, providing opportunities to mitigate environmental damage, enhance public health, conserve resources, and generate new economic opportunities. However, realizing this potential demands significant investment in advanced technologies, robust safety protocols, and comprehensive regulatory frameworks to ensure successful implementation. Moving forward, the key to effective circularity in hazardous waste lies in developing closed-loop systems that safely handle toxic materials, while advancing sustainability and minimizing harmful effects on both the environment and human health.

References

1. Hazardous Waste Management Market - Acumen Research and Consulting https://www.acumenresearchandconsulting.com/hazardous-waste-management-market
2. CPCB Inventory Report (2022-23) https://cpcb.nic.in/uploads/hwmd/Annual_Inventory2022-23.pdf
3. CPCB Annual Inventory 2022-23 (Section 3.5: Utilization) https://cpcb.nic.in/uploads/hwmd/Annual_Inventory2022-23.pdf#page=24

Chapter 11

CIRCULAR ECONOMY ACTION PLAN *for* USED OIL

11.1. OVERVIEW

Lubricating oils play a crucial role in both transport and industrial machinery by enhancing performance and minimizing wear. They achieve this by reducing friction between interacting surfaces, thereby extending the operational life of components. At the heart of lubricating oils is the 'base oil,' derived either from crude oil or synthetic sources, which comprises approximately 75-85% of the total oil. The remainder includes performance-enhancing additives—such as viscosity modifiers, antioxidants, and corrosion inhibitors—that contribute essential properties for protecting the moving parts of engines. These additives also ensure that engine oils meet rigorous performance specifications related to quality, stability, and longevity demanded by the automotive industry.

According to the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, used oil is defined as "any oil: (i) derived from crude oil or mixtures containing synthetic oil, including spent oil, used engine oil, gear oil, hydraulic oil, turbine oil, compressor oil, industrial gear oil, heat transfer oil, transformer oil, and their tank bottom sludges; and (ii) suitable for reprocessing if it meets the specification laid down in Part A of Schedule V, but does not include waste oil." Table 11-1 below details the common types of used oil encountered across industries.

Table 11-1: Types of Used Oil

Type of Used Oil	Description
Used Motor Oil	Used in engines for lubrication
Used Hydraulic Oil	Used in hydraulic systems for power transmission
Used Transmission Fluid	Used in automatic transmissions for lubrication
Used Gear Oil	Used in gear systems for lubrication
Used Cutting Fluids	Used in metalworking processes for cooling and lubrication

The global lubricants market was valued at USD 119.07 billion in 2023 and is projected to reach USD 140.54 billion by 2032, with a (CAGR of 2.3% over the forecast period). The Asia-Pacific region, driven by growing demand from rapidly industrializing nations such as China, Japan, and India, leads the market, commanding a 45.26% share with a regional valuation of USD 53.89 billion in 2023. This robust demand is largely attributed to the expanding industrial and automotive sectors, with growth expected to continue as these industries develop worldwide.

Over time, lubricants are subject to degradation and contamination due to exposure to water, chlorine, particulate metals, and hazardous compounds like polychlorinated biphenyls (PCB) and polycyclic aromatic hydrocarbons (PAH). After their lifecycle, around 50% of lubricants turn into waste lubricant oil (WLO), resulting in a significant quantity of waste generated globally each year. Due to the toxic and non-biodegradable nature of these oils, improper disposal poses serious environmental threats, contaminating soil, water, and air. As a result, managing WLO has become a priority, necessitating safe handling, re-refining, energy recovery, and responsible disposal practices to mitigate environmental damage.

11.2. CURRENT STATUS

India, as one of the largest and fastest-growing lubricant markets in Asia, is an essential player in both lubricant consumption and WLO management. In 2023, India's lubricant market was valued at approximately USD 7.19 billion and is expected to grow at a CAGR of 4.4%, potentially reaching USD 9.70 billion by 2030. The automotive sector remains a dominant force, accounting for about 57% of the market. Alongside the growing demand, India generates an estimated 1.3 million tons of used oil annually. However, less than 15% of this waste oil undergoes re-refining, with a significant portion either improperly disposed of or used as fuel, raising environmental concerns.

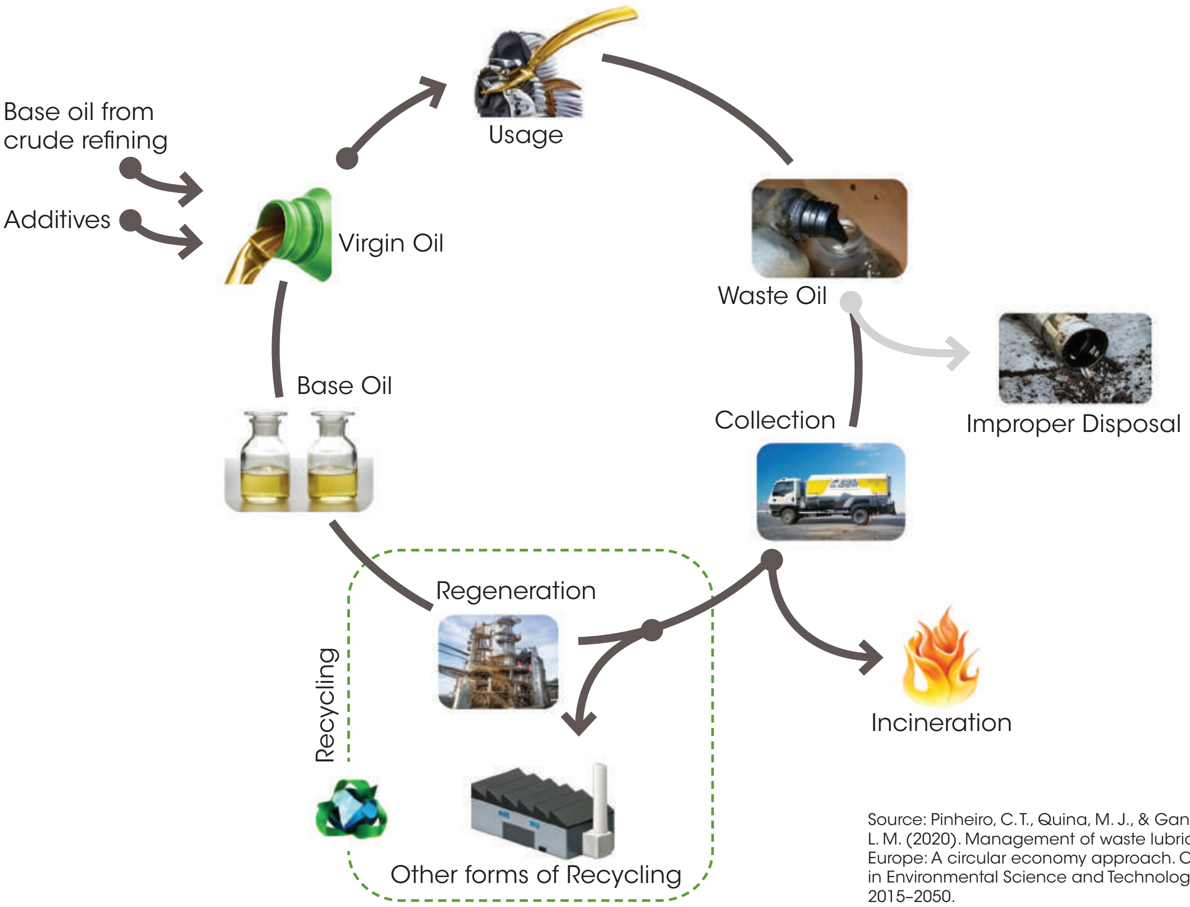
To address these challenges, India has established regulatory frameworks like the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, which provide guidelines for safe waste oil management. Additionally, companies and initiatives, such as Shell's used oil management service, aim to improve waste oil disposal systems and increase re-refining rates in the country. These initiatives align with India's broader goals of promoting sustainable industrial practices and advancing its circular economy, thereby reducing the environmental footprint of the growing lubricant sector.

Waste oil can be treated or disposed of in three general ways as mentioned below:

- Regenerated to base oil via a range of technologies such as hydro-treatment, solvent extraction and distillation.
- Converted to fuel oil via distillation.
- Incinerated in cement kilns, power plants and similar facilities for 'energy recovery'.

The following diagram shows an overview of processes required to achieve circularity in lubricant oils. However, direct disposal must be totally avoided (given in grey) since it corresponds to a negative externality.

Figure 11-1: Circular Economy Concept for Management of Used Oil



Source: Pinheiro, C. T., Quina, M. J., & Gando-Ferreira, L. M. (2020). Management of waste lubricant oil in Europe: A circular economy approach. Critical Reviews in Environmental Science and Technology, 51(18), 2015–2050.

One of the earliest methodologies of obtaining recycling base oil was carried out by UAE way back in 2002. They had utilised the process of dehydration to remove water, added sulphuric acid and diesel to remove impurities, vacuum distillation followed by cooling and filter pressing to obtain the finished product which consisted of 99% base oil. **Table 11-2** below presents the general characteristics of virgin and waste lubricant oil.

Table 11-2: General characteristics of virgin and waste lubricant oil

Property	Units	Virgin Lubricant		Recycled Used Oil	
		Min	Max	Min	Max
Density	kg/m3	817	953	851	972
Kinematic viscosity at 40°C	cSt	4	491	0.82	324
Kinematic viscosity at 100°C	cSt	1	86	ND	ND
Viscosity index	-	-13	314	ND	ND
Total acid number	mg KOH/g	<QL	5.35	0.26	4.6
Saponification number	mg KOH/g	<QL	64	2.12	21.8
Carbon Content					
Aromatics	wt. %	<QL	19.3	<QL	7.87
Paraffinics	wt. %	23.9	75.4	34.1	62.1
Naphthenics	wt. %	21.3	46.27	29.9	65.8
Water	wt. %	ND	ND	<QL	14.6
Sediments	wt. %	ND	ND	<QL	50.4
Surface tension	mN/m	ND	ND	22.4	33.2
Polychlorinated biphenyls	ppm	ND	ND	<QL	3400
Benzo[a]pyrene*	mg/L	ND	ND	0.36	62
Benzo[a]anthracene*	mg/L	ND	ND	0.87	30
Elemental Content					
P	ppm	<QL	1500	57	1220
Ca	ppm	38	8750	90	4190
Cl	ppm	9	623	<QL	6012
Cr	ppm	ND	ND	5	24
Fe	ppm	<QL	<QL	20	1210
Pb	ppm	ND	ND	3700	14000
Si	ppm	<QL	370	11	879
S	wt. %	<QL	2.2	<QL	1.1
Zn	ppm	48	1380	24	1670

In India, the re-refining of used oil is known as Re-Refined Base Oil (RRBO) which is found to have similar properties as that of Virgin Base Oils (VBOs), and thus can be blended with the latter for commercial use. As per the latest Annual Inventory report of Central Pollution Control Board, there are close to 600 used oil/waste oil registered recycling facilities spread across 19 states pointing out a huge recycling potential with a greater yield while considering the generation of used oil and waste oil from automotive sector and manufacturing industries.

The Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2023, came into force on April 1, 2024, introducing Extended Producer Responsibility (EPR) for used oil. Producers (manufacturers/importers) of base oil/lubrication oil and importers of used oil are now obligated to recycle used oil by purchasing EPR certificates from registered recyclers. This mechanism promotes environmentally sound management of used oil in India.

The Central Pollution Control Board (CPCB) released a Standard Operating Procedure (SOP) in 2021 to regulate used oil recycling. This SOP outlines the necessary steps for the pre-treatment and processing of used oil collected from service stations and hydropower plants. Notably, the procedure mandates that collected sludge be sent to a Treatment, Storage, and Disposal Facility (TSDF), while the refined oil can be repurposed for various commercial applications.

11.3. GAPS, CHALLENGES, AND LEARNINGS

Experts have identified several concerns within the current Extended Producer Responsibility (EPR) framework:

- Import of Waste Oil: Questions have been raised regarding the necessity and environmental implications of importing waste oil into India.
- Monitoring and Oversight: The effectiveness of the existing monitoring and oversight mechanisms is a major concern, impacting the transparency and accountability of the framework.

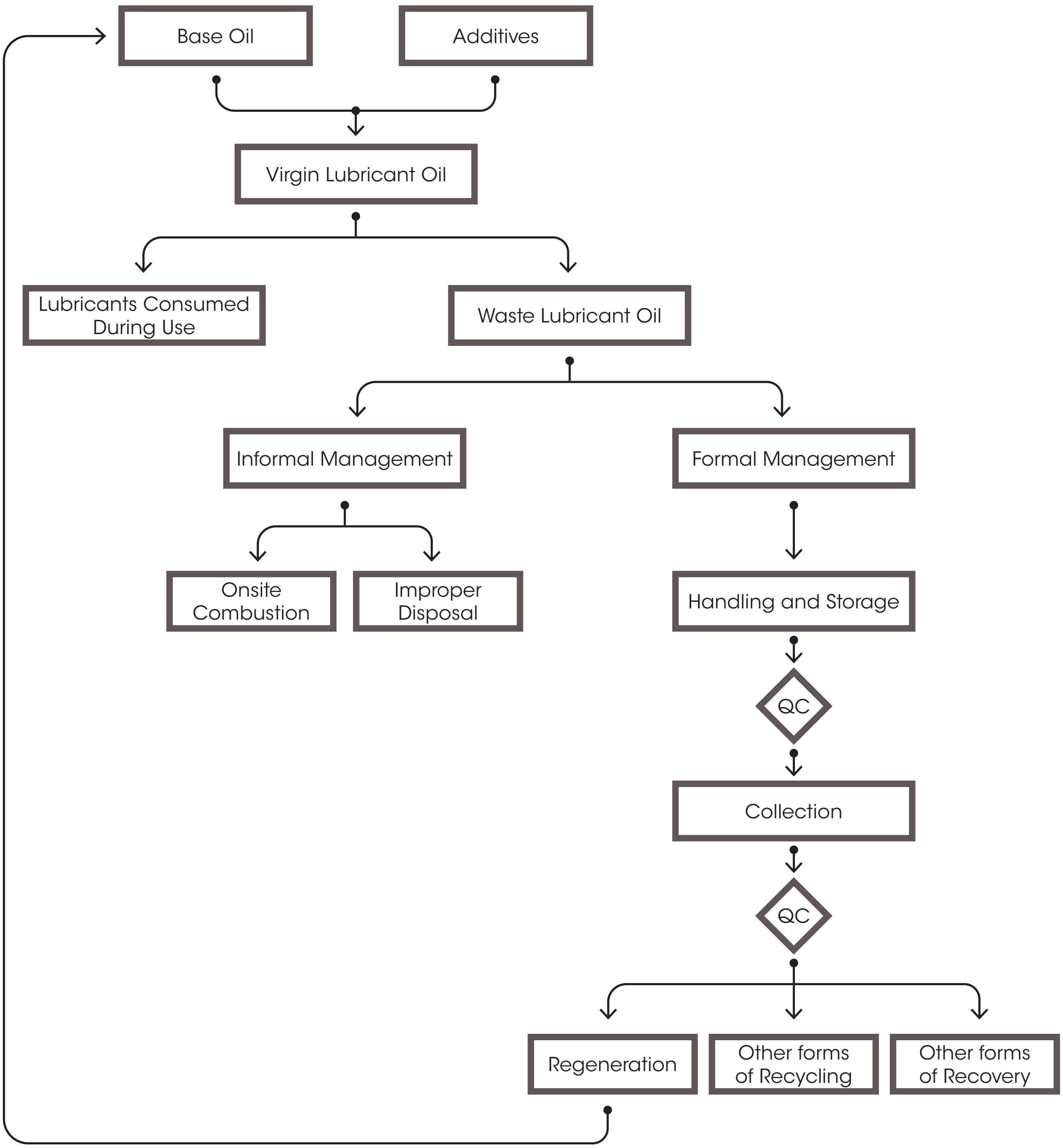
Additionally, India's waste oil management landscape is largely dominated by informal market practices, which pose significant challenges and elevate the risk profile for large-scale re-refining investments. Key issues include:

- Collection Infrastructure Efficiency: The current collection infrastructure lacks sufficient capacity and efficiency to meet the needs of large-scale re-refining.
- Fragmented and Unregulated Collection Participants: Numerous unregulated, small-scale players participate in the collection process, resulting in an unstructured market and compliance challenges.
- Stakeholder Awareness and Knowledge: Limited awareness and understanding among stakeholders further complicate adherence to safe handling and disposal practices.
- Compliance and Regulatory Uncertainty: Inconsistent regulatory implementation and enforcement create uncertainties, deterring large-scale investments in re-refining infrastructure.

To bridge these gaps and align with India's environmental objectives, experts suggest that dedicated financial support, such as a Viability Gap Funding (VGF) scheme, could be instrumental. A scheme of this nature would help support long-term investment in re-refining by enabling a structured, scalable business model for waste oil management in India, following best practices from other countries.

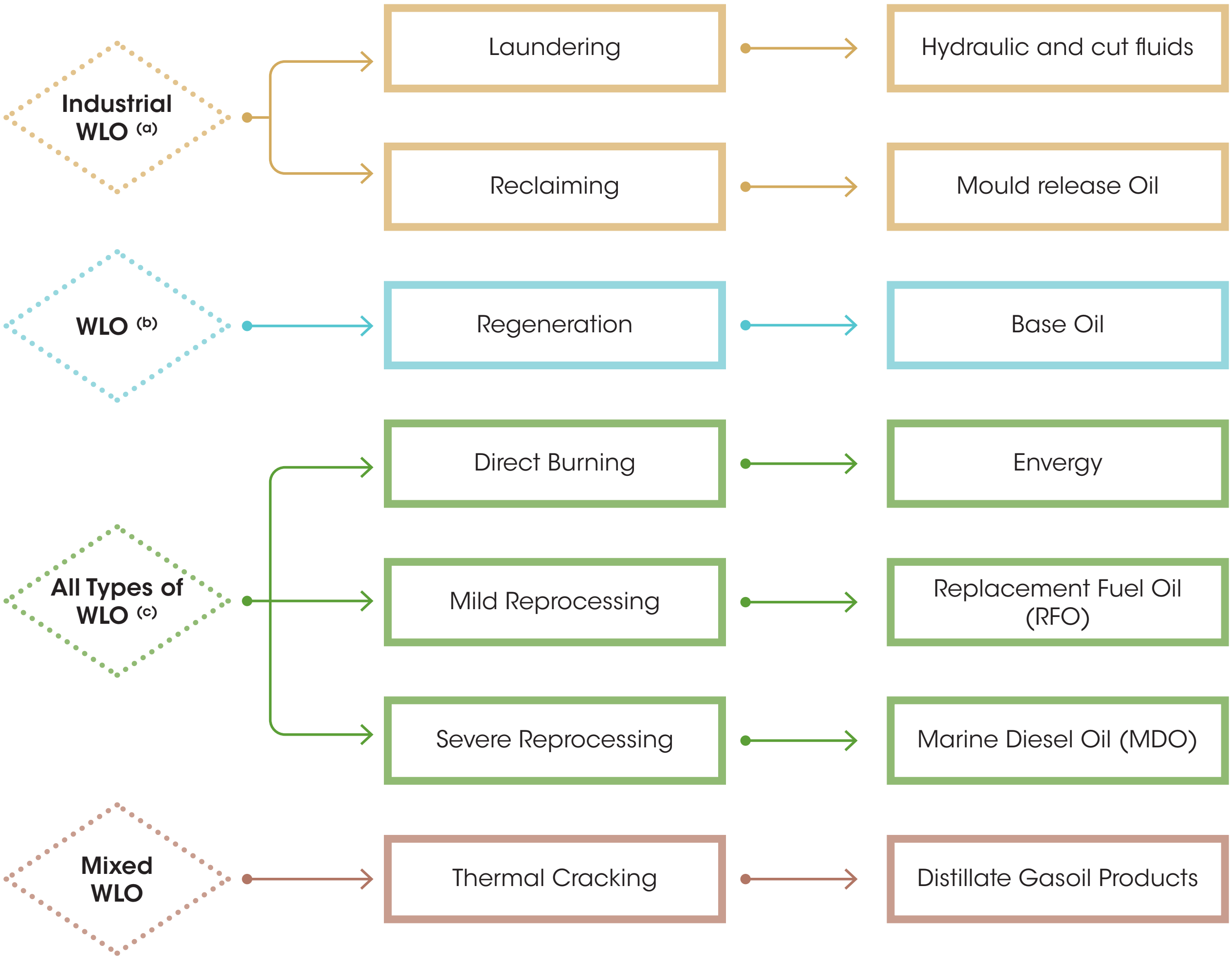
11.4. PROPOSED FRAMEWORK

In order to integrate the existing network into the formal fold, examples from the EU counterpart may be taken. The management systems in the EU countries include a network of operators that collect WLO (Waste Lubricant Oil) from generators across national territory and transport them to the treatment units as given below.



Source: Pinheiro, C. T., Quina, M. J., & Gando-Ferreira, L. M. (2020). Management of waste lubricant oil in Europe: A circular economy approach. Critical Reviews in Environmental Science and Technology, 51(18), 2015–2050.

Further, depending on the source or extent of contamination, a variety of processes may be adopted.



(a) Hydraulic and cutting fluids (b) With restrictions on chlorine, PCB and saponification number
(c) Especially heavy polluted oil

Source: Pinheiro, C.T., Quina, M. J., & Gando-Ferreira, L. M. (2020). Management of waste lubricant oil in Europe: A circular economy approach. Critical Reviews in Environmental Science and Technology, 51(18), 2015–2050.

Recent progress in the R&D of used oil recycling has opened up multiple regeneration options. **Table 11-3** below presents a quick comparison of different regeneration processes.

Table 11-3: Comparison of Regeneration Processes

Regeneration process	Energy requirements	Operating cost	Capacity (kt/year)
Acid clay process	Low	Low	Small (2~10)
Distillation process	High	Low	Medium (25)
Solvent deasphalting	High	High	Medium (25)
TFE+hydrofinishing	High	High	Large (50~80)
TFE+clay finishing	High	High	Large (100)
TFE+solvent finishing	High	High	Large (100)

11.5. GOALS AND TARGETS

The recent implementation of Extended Producer Responsibility (EPR) for used oil marks a significant advancement in promoting sustainable waste management practices. EPR incentivizes the development of formal recycling infrastructure and processes, which are essential for an effective circular economy. This mandate is expected to enhance the circularity of used oil by ensuring proper collection, treatment, and reuse, thereby minimizing environmental impact.

A key goal of this initiative is the effective implementation of EPR, with robust monitoring and evaluation mechanisms as necessary components to ensure success. Table 11-4 below summarizes the specific EPR obligations for producers of base oil or lubricating oil.

Table 11-4: Summary of EPR obligations related to used oil

EPR Obligation for the Year	Used Oil Recycling Target
2024-25	5% of the base oil or lubrication oil sold or imported in the Year 2022-2023.
2025-26	10% of the base oil or lubrication oil sold or imported in the year 2023-2024.
2026-27	20% of the base oil or lubrication oil sold or imported in the year 2024-2025
2027-28	20% of the base oil or lubrication oil sold or imported in the year 2025-2026.
2028-29	40% of the base oil or lubrication oil sold or imported in the year 2026-2027.
2029-30	40% of the base oil or lubrication oil sold or imported in the year 2027-2028.

In addition, the EPR target for oil importers in year (Y) shall be 100 % of the used oil imported in the previous year (Y-1).

To summarize, the following goals and targets are proposed:

Table 11-5: Proposed Goals and Targets

S.No.	Goal	2025	2030
1	**Recycling of base oil/lubrication oil imported in the previous year for producers (%)** *[Aligns with the Used Oil EPR targets as per Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2023].*	Minimum of 5%	Minimum of 50%
2	**Recycling of base oil/lubrication oil as per the previous year for Used Oil Importers (%)** *[Aligns with the Used Oil EPR targets as per Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2023].*	90%	100%
3	**Blending (%) of Virgin Base Oils (VBOs) with Re-refined Base Oils (RRBOs)** *[https://decarbonisationtechnology.com/article/214/indias-used-lubricating-oil-treasure-or-trash-ri-202]*	5%	10%

11.6. IMPACT POTENTIAL

Recycling used oil offers significant environmental and economic benefits by preventing improper disposal, which can lead to soil and water contamination. Unlike many resources, oil does not degrade; it becomes contaminated through use but can be purified and reused. This recycling process enables the conservation of a valuable resource and reduces the need for fresh extraction. In terms of energy efficiency, producing re-refined oil from used oil requires far less energy and raw materials than refining it from crude oil. For instance, the U.S. EPA reports that one gallon of used motor oil yields the same amount of lubricating oil as 42 gallons of crude oil, underscoring the resource efficiency of recycling.

The environmental benefits of used oil recycling are substantial. It minimizes greenhouse gas emissions, conserves natural resources, and reduces waste. By recycling used oil, we not only avoid environmental pollution but also decrease the demand for crude oil extraction, supporting climate change mitigation efforts. Recycling also curtails the volume of hazardous waste that requires management, lowering the need for new landfills or specialized disposal facilities and lessening the overall environmental impact.

Socially, used oil recycling improves public health by reducing pollution, particularly in communities near disposal sites, and fosters economic opportunities by creating jobs in collection, transport, and refining processes. Formalizing the sector can provide safer working conditions and reduce unregulated labor. Furthermore, raising awareness about proper disposal and recycling contributes to a culture of environmental responsibility and aligns with circular economy goals by promoting resource efficiency and waste reduction.

In countries reliant on oil imports, recycling used oil can reduce dependency on crude oil imports, enhancing energy security and economic resilience. By addressing both environmental and social impacts, used oil recycling not only provides a sustainable solution to waste management but also benefits ecosystems, public health, and national economies, contributing to a more sustainable and resilient future.

References

1. Pinheiro, Carolina T., Margarida J. Quina, and Licínio M. Gando-Ferreira. "Management of waste lubricant oil in Europe: A circular economy approach." Critical Reviews in Environmental Science and Technology 51, no. 18 (2021): 2015-2050.
2. Can Extended Producer Responsibility improve circularity in India's waste oil management https://www.downtoearth.org.in/pollution/can-extended-producer-responsibility-improve-circularity-in-india-s-waste-oil-management-89192
3. The Complete Guide To Handling Used Oil Responsibly – EPR Annual Filing Explained https://cerclex.com/blog/responsible-handling-of-used-oil-epr-annual-filing/
4. Botas, Juan A., Jovita Moreno, Juan J. Espada, David P. Serrano, and Javier Dufour. "Recycling of used lubricating oil: Evaluation of environmental and energy performance by LCA." Resources, Conservation and Recycling 125 (2017): 315-323.
5. Klenert, D., P. García-Gutiérrez, D. Tonini, H. Saveyn, and R. Marschinski. "The economics of waste oil recycling in the EU." Journal of Environmental Economics and Policy (2024): 1-22.
6. Used Oil Re-refi ning Study to Address Energy Policy Act of 2005 Section 1838 https://fossil.energy.gov/epact/used_oil_report.pdf
7. Managing, Reusing, and Recycling Used Oil https://www.epa.gov/recycle/managing-reusing-and-recycling-used-oil
8. Basel convention technical guidelines on used oil re-refining or other re-uses of previously used oil https://www.basel.int/Portals/4/Basel%20Convention/docs/meetings/sbc/workdoc/old%20docs/tech-r9.pdf
9. Hamad, Ahmad, Essam Al Zubaidy, Ahmed Aidan, Talha Hadaki, and Nasri El-Kareh. "Used oil recycling and treatment in the united Arab Emirates economical and environmental assessments." In The 6th Saudi Engineering Conference, KFUPM, Dhahran, December 2002. 2002.
10. Progress, Future Plans, and Call for Government Support https://theprint.in/ani-press-releases/avista-oil-and-ifp-petro-progress-future-plans-and-call-for-government-support/2152913/
11. Frequently Asked Questions (FAQs) on EPR for Used Oil Management https://eprusedoil.cpcb.gov.in/public/assets/images/Used_Oil_FAQ.pdf
12. Lubricants Market Size, Share & Industry Analysis https://www.fortunebusinessinsights.com/industry-reports/lubricants-market-101771
13. Selvi, P. K., Mita Sharma, and J. S. Kamyotra. "Spent oil management and its recycling potential in India inventory and issues." Procedia Environmental Sciences 18 (2013): 742-755.
14. India's used lubricating oil Treasure or trash (RI 2023) https://decarbonisationtechnology.com/article/214/indias-used-lubricating-oil-treasure-or-trash-ri-202

Chapter 12

CIRCULAR ECONOMY ACTION PLAN *for* AGRICULTURE WASTE

12.1. OVERVIEW

The agricultural waste sector plays a vital role in the global economy, driven by the need for sustainable management of biomass and the increasing demand for renewable energy sources. Agricultural waste encompasses a wide array of by-products from farming activities, such as crop residues, animal manure, and food processing waste. This sector is not only pivotal for reducing waste but also offers significant opportunities for bioenergy production, composting, and soil enhancement. As the global population grows, the emphasis on sustainable practices and circular economy principles has led to innovative approaches in managing agricultural waste. This chapter delves into the material value chain, its importance to key sectors, environmental impacts, and current market trends to illustrate the transformative potential of agricultural waste.

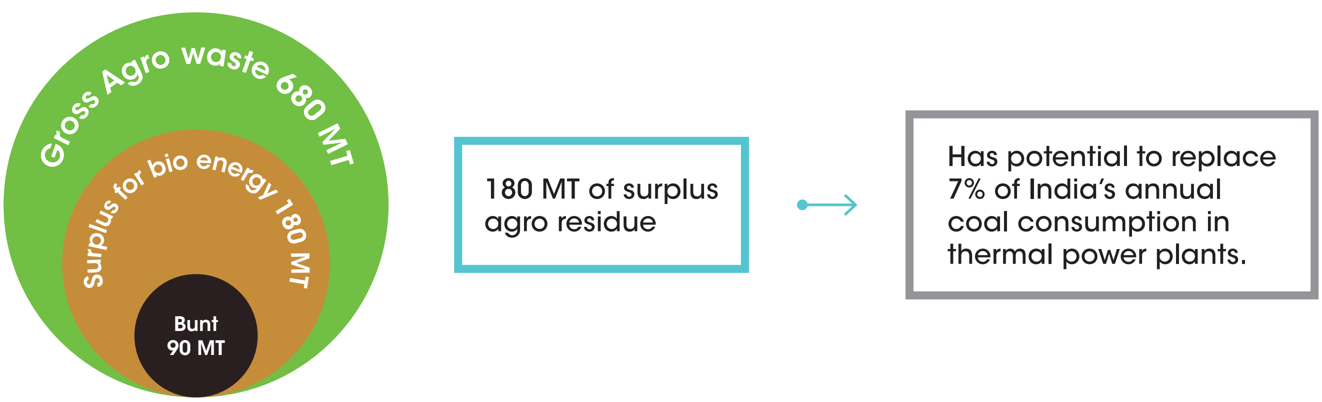
A 2018 study, "Estimation of surplus crop residue in India for biofuel production", conducted by the Indian Agricultural Research Institute (IARI) and the Technology Information Forecasting and Assessment Council (TIFAC), estimated that the country generates 680 million tonnes (MT) of gross annual crop residue.

Close to 70 percent of this residue is used in the agrarian economy as cattle fodder, soil mulch, manure, thatching. A large part of the remaining 180 million tonnes (MT) still goes unutilised. More than half of the unused agro residue is set on fire annually to clear the fields, primarily in North India, further aggravating the existing air pollution in the region.

12.1.1. Importance of Material for Key Sectors of the Economy

- **Energy Sector:** Agricultural waste serves as a crucial feedstock for bioenergy production, which is essential for achieving energy security and sustainability goals.
- **Agriculture:** Organic fertilizers derived from agricultural waste improve soil health and crop yields, supporting sustainable farming practices.
- **Paper Production:** Bagasse can be converted to paper. Wheat straw can be mixed with woodchips to make paper. There are successful public listed companies making paper and pulp from agriculture waste in India.
- **Environmental Management:** Utilizing agricultural waste mitigates the environmental impacts of waste disposal, reduces greenhouse gas emissions, and contributes to climate change mitigation efforts.
- **Economic Growth:** The agricultural waste sector presents new business opportunities, particularly in renewable energy and sustainable agricultural practices, contributing to overall economic development.

There are encouraging signs with many industries coming up in the last 5 years based on agro waste. This includes 2G ethanol plants, CBG plants and pellet / briquette co-firing in thermal power plants. With adequate support from the Central and State Government, there is hope that stubble burning will be a thing of the past.



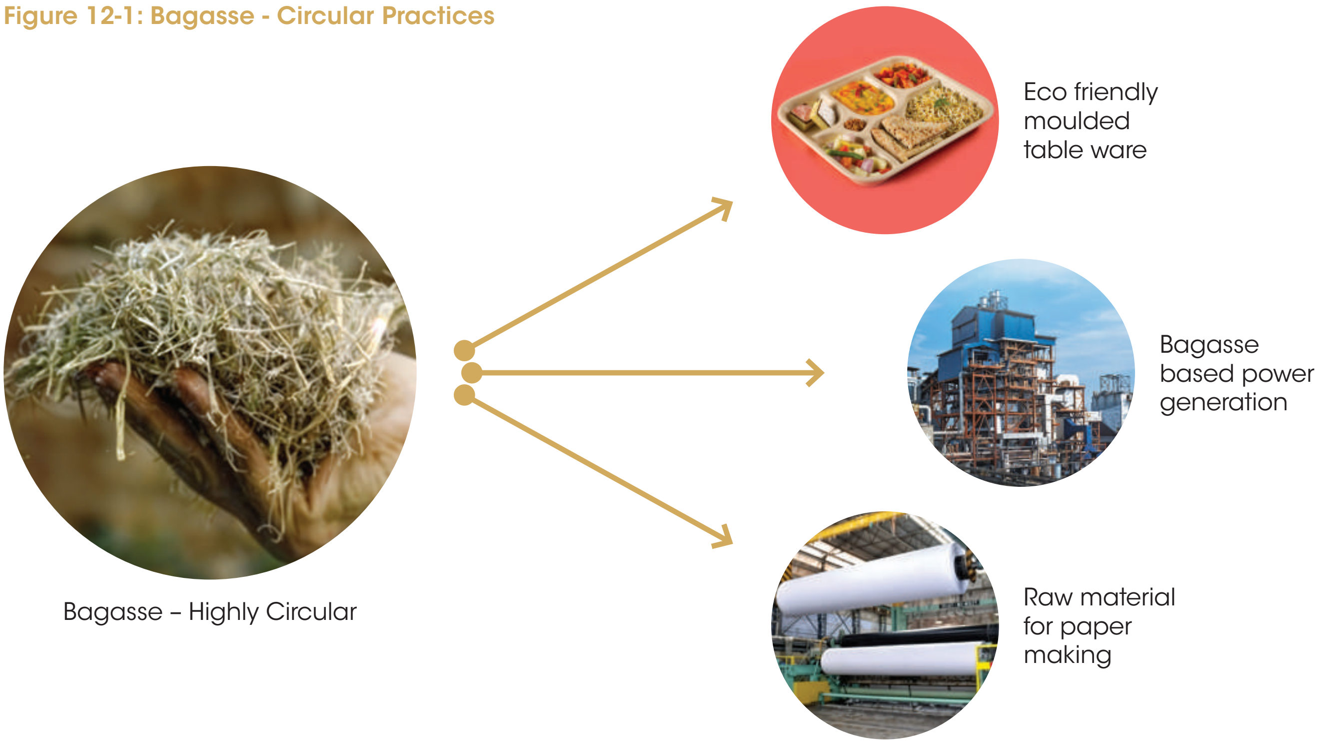
12.2. CURRENT STATUS OF CIRCULAR PRACTICES

This chapter focuses on the top 4 crop residues in India – rice straw & husk, wheat straw, sugarcane tops and bagasse. **Table 12-1** below presents the level of circularity adoption for different crop residues. Wheat and rice straw have comparatively low circularity when compared to bagasse. This is mainly due to the physical and chemical properties. High silica and alkali chlorides present in straw make them a challenging feedstock to work with for other industries like power generation and the paper industry.

Table 12-1: The level of circularity adoption for different crops residues

Crop Residue	Status	Opportunities
Bagasse	Excellent	• Highly favoured by sugar industry as a source of clean energy • Raw material in paper industry. • Recent trend of disposable tableware made from baggase is popular.
Rice husk	Good	• Good quality fuel for biomass power generation. • Additive in cement industry.
Wheat Straw	Medium	• Used as cattle fodder. • Co-firing in Power plant and CBG feedstock. • Co- feedstock in paper making
Rice straw	Medium- Poor	• High silica content makes it poor cattle fodder. • Used for Co firing in Power plant and as CBG feedstock.

Figure 12-1: Bagasse - Circular Practices



12.3. CURRENT STATUS - EXISTING POLICIES AND INCENTIVES

Government of India has given several incentives to improve circularity of agro residue in the last 5 years. With the Global Biofuels alliance unveiled in the G20 meet in Delhi in February 2023, we can expect further impetus from GoI in promoting the usage of agro residue.

Currently, policies and incentives promoting the usage of agro residue are mainly in the fuels space, namely CBG, power plant fuel and Ethanol. **Table 12-2** presents an overview of policies and incentives.

Table 12-2: Policies and Incentives

Route	Policy and incentives
CBG / Biogas route	• **Ministry of New and Renewable Energy (MNRE) –** Provides Central Financial Assistance (CFA) for the construction of Compressed Biogas (CBG) plants. • **Sustainable Alternative Towards Affordable Transportation (SATAT) Scheme –** Sets the minimum purchase price for generated CBG and offers additional incentives to support the production of CBG. • **Galvanizing Organic Bio-Agro Resources Dhan (GOBAR-Dhan) Scheme –** Offers subsidies for the installation of small-scale biogas plants, primarily targeting rural areas to promote organic waste management. • **State-Specific Incentives –** Certain states, like Uttar Pradesh (UP) and Bihar, are pioneering state-level incentives. For example, the UP government offers 100% stamp duty exemption and an incentive of INR 75 lakhs per ton of CBG produced. • **Ministry of Petroleum and Natural Gas (MoPNG) –** Proposes mandatory blending of Piped Natural Gas (PNG) with CBG from Fiscal Year 2025 onwards to promote cleaner energy. • **MoPNG –** Provides financial assistance from the GoI for developing CBG pipeline infrastructure to improve distribution networks. • **MoPNG –** Offers financial aid for the purchase of Biomass Aggregation Machinery (BAM), up to INR 90 lakhs, to support the efficient collection of biomass. • **Ministry of Finance –** Facilitates priority sector lending by Public Sector Undertaking (PSU) banks, offers a 3% interest subvention through the Ministry of Agriculture (MoA), and provides excise duty (ED) exemption for GST paid on the CBG portion within Compressed Natural Gas (CNG) blends.
Biomass Pellet route	• **Ministry of Power –** Mandatory 5 % co-firing in power plants under SAMARTH mission. • **MNRE -** Subsidy for purchase of briquette and torrefaction machines. Maximum subsidy of INR 45 Lakh for briquette machine and INR 1.5 Cr for torrefaction pellet machine. • **MNRE –** Subsidy for biomass aggregation machinery (BAM)
2G ethanol route	• **PM JI-VAN YOJANA -** Promotion of 2G ethanol based on lignocellulosic feedstock. The target is 12 commercial plants and 10 demo plants by 2029. Financial incentive of up to INR 150 crore for commercial plants and INR 15 crore for demo plants

12.4. CHALLENGES

The widespread adoption of agro waste faces several significant challenges that needs to be addressed. The major ones discussed below:

- **Collection window:**
  Biomass aggregators face challenges in collecting paddy and wheat straw in North India. Typically, the window for collection of agro-residue before the onset of stubble burning season is only 2-3 weeks. Farmers burn stubble to plant the next crop (Kharif Rabi rotation) after 3 weeks.
- **Sourcing challenge:**
  Industry buys from biomass aggregators who buy from farmers. Industry expects biomass at agreed quantity and rates which may be difficult for aggregators to commit.
- **Storage issues:**
  There are various issues associated with the storage of agro residue including biodegradation, high moisture content, fire hazards during hot weather conditions and lack of storage facilities.
- **Machinery issues:**
  No well-known domestic machinery manufacturers in the agro waste conversion space. Most of the existing players are small scale players who have challenges scaling up their product and operations.
- **Focus on bio-fuel:**
  The Government's policy and incentives for agro residue, though well meaning, seems to mainly focussed on conversion of agro residue to bio fuel. Bio Fuel however is not truly circular because fuel is eventually burnt adding to GHG emissions. Value added products like paper from agro waste, and moulded tableware would be more circular than biofuel.
- **Poor Offtake:**
  CBG gas produced in rural areas and CBG digestate currently has poor offtake.

12.5. PROPOSED FRAMEWORK

Private Industry and Government has begun to see the economic potential in agrowaste. More needs to be done because as of 2024, Northern India still faces problem of stubble burning. The following framework may be considered:

- **Beyond Biofuel:**
  Though initiatives of industry and GoI are well intended, biofuel may not be truly circular. The focus should be on keeping agro waste within the value chain as long as possible till it reaches it End of life. Preference should be given to value added products rather than biofuel. This is possible and already in practice. For example, TNPL in Tamil Nadu, the world's largest bagasse-based paper mill in the world, consumes 1.4 million tons of bagasse to make paper. Trident Paper, Punjab uses Wheat straw as a co- feedstock in paper making. Yash Packaging, a NSE listed company, makes disposable tableware from bagasse which is also exported. Conversion of agri waste to biochar is also an option as biochar is considered carbon negative and improves soil health.

- **Single Umbrella:**
  Currently different initiatives are driven by different ministries. For example, the generation of CBG gas from straw through the SATAT scheme is driven by MoPNG while co-firing of straw pellets in power plants is driven by MoP. Within the same scheme, different ministries have given their own set of targets and incentives. Ideally, a central nodal agency, preferably under the Ministry of Agriculture should be given the responsibility to increase the circularity of agricultural waste and this agency can coordinate with various stakeholders to have uniform goals.

- **Realistic Targets:**
  Though much progress has been made in bringing agro residue into the circular economy, many of the targets are unrealistic. Too much is being attempted too fast without the required infrastructure on the ground. Example: In Sep 2021, Commission of Air Quality Management (CAQM) mandated the substitution of 5-10 % coal with biomass for 11 power plants in the NCR region. As of today, less than 1 % substitution achieved as NCR power plants struggle to source biomass. SATAT scheme launched in 2018 had aimed for 5500 CBG plants by 2025. As of 2023 less than 100 CBG plants have been commissioned.

- **Biorefining Park:**
  An integrated biorefining park that contains various conversion technologies from agro waste can leverage individual synergies better. Waste /side streams from 2G ethanol plant can be used as feed in boiler and CBG plant. The boiler plant can supply electricity to all the conversion units within the park. For example, a place like Panipat has rice straw based 2G ethanol plant (IOCL), an upcoming 30 MW bagasse power plant (PCSM) and a rice straw based CBG plant (GPS renewables) in different locations within a 30 km radius. A bio-refining park containing all the three could have better synergy.

Figure 12-3: Different Pathways for Biorefining Park

Agricultural Residue

Chemical conversion -	Thermo-chemical conversion	Mechanical Conversion	Biological conversion	Value added products -
2G Ethanol	**Biomass power plants Torrefaction**	**Pellets / Briquettes**	**CBG plants**	**Paper, packaging, disposable consumer goods**

Pic: India's First 2G ethanol plant using rice straw as feedstock @ IOCL Panipat

- **Collection, transportation and storage (CTS)** of agro feedstock is the weak link in the chain. If CTS issues can be addressed, much of the problems in effective utilization of agro waste can be addressed.

12.6. ENABLERS

Table 12-3 below presents the recommendations to overcome the challenges in achieving circularity for agriculture waste.

Table 12-3: Challenges and Recommendations

Challenges	Recommendation
Short collection window Stubble Burning by Farmers	• **IEC activities** to educate farmers on the downsides of stubble burning. • **Minimum Support Price** to farmers for agro waste bales on similar lines as crop-based minimum support price (MSP)
Storage issues for Agro Residue Low Shelf life / Biodegradation	• **GoI funded Storage godowns** for agro residue, similar to Food Corporation of India godowns for grains. • **Coal India and OMC's expertise in fuel storage –** Once stored in godown, it is no longer agro waste but a solid fuel. Use Coal India / Oil India expertise in fuel storage. • **Promote Torrefaction technology** as torrefaction gives longer shelf life to biomass.
Machinery Issues Technology Gaps	• Use reputed consultants to create a minimum standard for pelleting machine / briquetting machine / Torrefaction machine. • Use relations with EU to bring **Biomass Torrefaction** technology to India. Denmark is the leader in Biomass Torrefaction Technology with much research in their universities and companies. India has experience in **RDF torrefaction** through NTPC projects but not biomass.
Beyond Biofuel - Research and Development for value added products beyond bio fuel	• Looking for alternate usage of agro waste beyond biofuel into areas like biochar, paper feedstock, other value-added chemicals like bio solvents etc. • Government needs to fund our premier research institutes and look at international research collaborations for this.
Poor offtake of biofuel and their by-products	• Central and state governments should prioritize buying biofuel for their internal consumption. **Example:** All Govt buses in rural areas should run on CBG gas generated in rural areas. Govt offices, road medians should use CBG digestate as fertilizer and soil make up.

12.7. GOALS AND TARGETS

S.No.	Proposed Goal	2027 Target	2030 Target
01	**Prioritize biomass co-firing in power plants** *[The current SAMARTH targets aim for a 7% biomass co-firing rate in power plants nationwide by 2026. However, due to limited biomass availability, the significant gap in current progress (only 1% so far), and persistent smog issues in the Indo-Gangetic plains, it is recommended to reset and realign these targets. A revised strategy should prioritize increasing biomass co-firing specifically in North India, where the impact can be maximized due to higher air pollution challenges and better access to agro-residue biomass].*	• **3%** for power plants in Punjab, Haryana, UP & Bihar • **1%** for rest of India	• **6%** for power plants in Punjab, Haryana, UP & Bihar • **3%** for rest of India
02	**Promote CBG offtake in rural areas.** *[The absence of guaranteed offtake for CBG is posing significant challenges for the CBG plant developers, particularly in rural areas utilizing paddy and wheat stubble as feedstock. This issue has been highlighted in the 17th Standing Committee Report of the Lok Sabha. To address this, the government should actively promote the utilization of CBG in rural areas, especially in sectors like public transportation, to create a stable demand and support the viability of these plants]*	• **10%** of public transport buses plying on rural highways near a CBG plant should use CBG as fuel.	**25%** of public transport buses on plying on rural highways near a CBG plant should use CBG as fuel.
03	**Promote alternative uses for agricultural waste beyond biofuel.** *[To increase circularity of agro waste, there should be focus on non bio -fuel application like paper, disposable tableware also . Currrently 8% of paper feedstock is agrowaste, as per IPMA. This should be increased and research to overcome technical challenges in using agrowaste should be encouraged.]*	• **10%** of available agro-residue utilized for non-fuel applications.	• **10%** of available agro-residue utilized for non-fuel applications.
04	**Set a Minimum Support Price (MSP) for paddy and wheat stubble.** *[Incentivizes farmers to collect and sell stubble, ensuring a consistent supply for biofuel production and other applications]*	MSP should account for the costs of stubble collection, transportation per ton, and a reasonable profit margin to ensure economic viability for farmers.	

S.No.	Proposed Goal	2027 Target	2030 Target
05	**Establish agro-residue godowns/silos.** *[Agro-residue storage infrastructure, such as godowns or silos similar to those managed by the Food Corporation of India (FCI), should be established with provisions for long-term storage. Select facilities should be equipped with torrefaction units to enhance the shelf life and quality of the biomass, ensuring its usability over extended periods.]*	• One godown within a 10 km radius in major wheat/paddy growing regions. • CAPEX incentives for entrepreneurs/ industry to set up godowns.	• One godown within a 5 km radius in major wheat/paddy growing regions. • Continue CAPEX incentives, potentially with increased support for torrefaction facilities.

12.8. IMPACT POTENTIAL

The shift towards a circular economy in agricultural waste management can deliver significant environmental, social, and economic benefits. These advantages highlight the importance of effective waste management practices in agriculture and their potential contributions to sustainable development.

- Enviromental Benefits: First benefit is Air Quality over North India can be improved in winter months. Various by products like biochar, bio digestate from CBG, ash from biomass power plants etc can improve soil health and be a natural fertiliser.
- Social Benefits: Will improve farmer income when farmers have opportunity to monetise their Agri waste. CBG plants, 2G ethanol plants etc will come up in rural areas, thereby promoting employment. Many entrepreneurial opportunities for small scale entrepreneurs also available due to biomass briquetting, aggregation, sale of biomass digestate etc.

References

1. National Policy on Biofuels – 2018 - Ministry of Petroleum and Natural Gas, Government of India
https://petroleum.nic.in/sites/default/files/biofuelpolicy2018_1.pdf
2. SATAT (Sustainable Alternative Towards Affordable Transportation) Initiative - Ministry of Petroleum and Natural Gas, Government of India
https://mopng.gov.in/en/schemes/satat
3. Status of Biomass Co-Firing in Coal Thermal Power Plants in Delhi NCR - Anubha Aggarwal, Centre for Science and Environment (CSE), 2023
https://www.cseindia.org/status-of-biomass-co-firing-in-coal-thermal-power-plants-in-delhi-ncr-11666
4. India can become sustainable fuel hub by using agri waste: Honeywell - Business Standard, June 14, 2023
https://www.business-standard.com/india-news/india-can-become-sustainable-fuel-hub-by-using-agri-waste-honeywell-123061401220_1.html
5. Modern biogas tech offers key innovative solutions for waste management, resource optimisation in agriculture: Piyush Sohani, Sistema.bio - The Economic Times, October 29, 2024. https://economictimes.indiatimes.com/topic/agricultural-waste

Chapter 13

CIRCULAR ECONOMY ACTION PLAN *for* TIRES

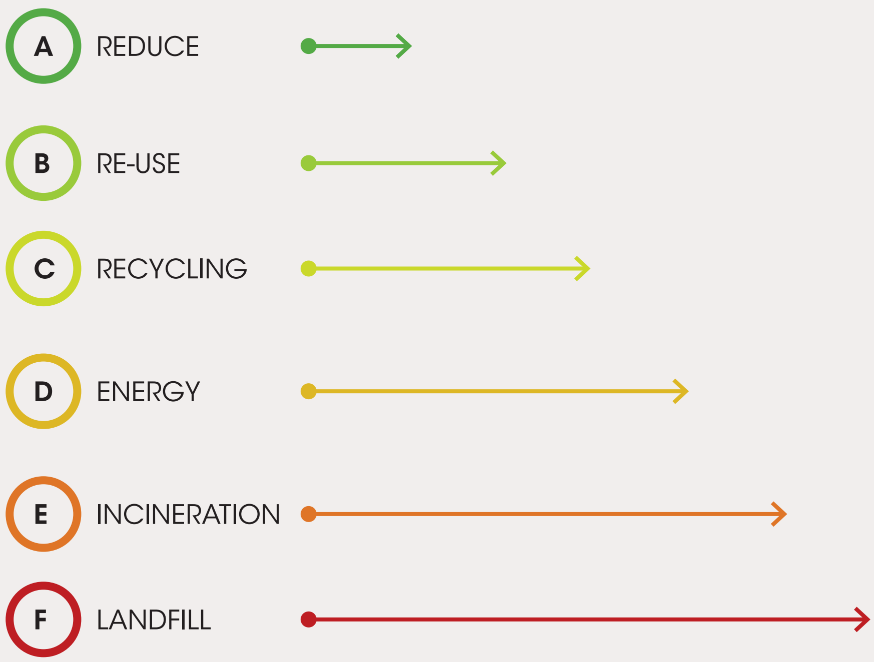
13.1. INDUSTRY OVERVIEW

13.1.1. Introduction

The tire industry plays a pivotal role in India's automotive sector, critical for daily transportation needs. With a growing population and rising standards of living, the demand for tires continues to surge, fueled by rising ownership of vehicles. Annually, approximately **240 million new tires** are produced, with about **190 million tires** consumed within the country. Replacement demand constitutes about two-thirds of this, resulting in around **2.1 million MT of end-of-life tires (ELTs)** being generated each year. Additionally, India imports around **1.4 million MT** of waste tires annually, culminating in approximately **3.5 million MT** of ELT available for material recovery.

According to Lansink's Ladder of Waste hierarchy, sustainable waste management strategies prioritize practices from most to least environmentally friendly. This hierarchy advocates for the prevention of waste generation first, followed by the reuse of products, material recycling, and energy recovery from waste. At the bottom of the hierarchy lies the disposal of materials through landfills or incineration without energy recovery, which undermines resource efficiency and circularity.

Lansink's Ladder - The Waste Hierarchy



In India, end-of-life tires (ELTs) are viewed as a valuable resource, with only **2%** ending up in landfills (98% recovery). Of the remaining ELTs, **7%** is recovered for energy, while an impressive **91%** is recycled into new materials.

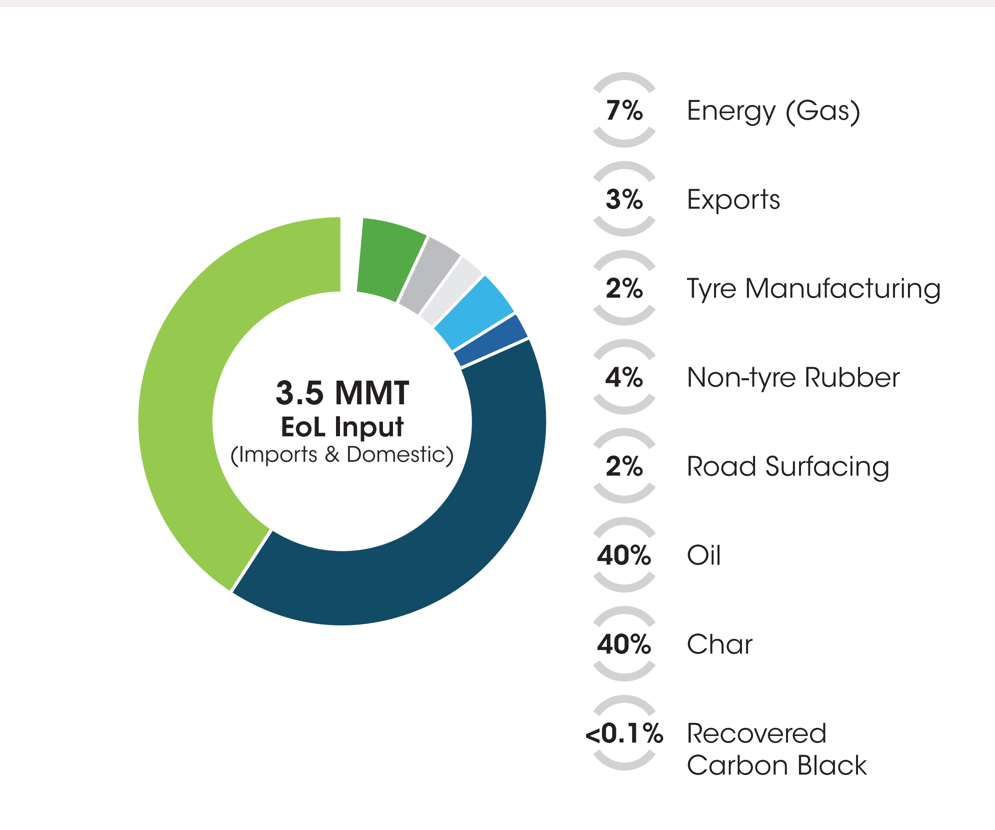
Of the **3.5 million MT** of end-of-life tires available annually in India, about 10% (0.3 million MT) is processed by the reclaim rubber industry, **2%** goes to the crumb industry, and the vast majority—**88%** (around 3 million MT)—goes to the pyrolysis sector for material recovery and energy recovery.

The value of these key materials for the economy is substantial and deserves recognition. The process of retreading, which extends the life of tires before they reach their end-of-life stage, is particularly prevalent in the commercial vehicle sector. Truck and bus tires are frequently retreaded, offering a cost-effective and resource-saving alternative to purchasing new tires. This practice not only conserves resources but also significantly reduces operational costs for fleet owners.

Recycled tire materials find diverse applications across various sectors, contributing substantially to economic growth. For instance, rubber can be devulcanized to produce reclaim rubber, which is used in both tire and non-tire applications, including tubes, conveyor belts, and automotive parts. Crumb rubber, the granulated form of rubber, is increasingly utilized in road surfacing, sports turfs, and matting. Furthermore, nylon from bias tires can be repurposed for the plastic industry, while recovered steel from used tires is reintroduced into production cycles. Pyrolysis processes yield oil and char that serve as substitutes for naphtha in chemical processes and pet coke in cement kilns, respectively. Some applications include re-designing the EoL tires for specialized applications across industries such as agriculture, landscaping etc. By capitalizing on these materials, the tire recycling industry not only minimizes waste but also bolsters the economy through job creation and resource efficiency, ultimately contributing to a more sustainable future.

13.1.2. Environmental and Social Impacts

- **Environmental Impacts:** Recycling tires has a profound environmental impact, primarily through the reduction of greenhouse gas emissions. Reclaiming rubber, for example, cuts emissions by 4-5 tons of CO_2 per ton of material recycled, through reduced energy consumption and a decreased reliance on oil. Products made from recycled rubber, such as molded items, have a carbon footprint 4-20 times smaller than those made from virgin plastics (Source: ISRI). The process also conserves resources; retreading a truck or bus tire saves 15 gallons of oil, while manufacturing a new tire demands 22 gallons (Source: TRIB). By using recycled materials like reclaim rubber and recovered carbon black (rCB), the demand for virgin resources is minimized. Additionally, the tire recycling process recovers valuable materials like rubber, steel, and carbon black, reintegrating them into production cycles. It



also mitigates pollution by preventing tires from ending up in landfills, reducing illegal burning, lowering fire risks, and minimizing harmful emissions such as VOCs and particulate matter, which protects the environment.

- **Social Impacts:**
  Traditionally, end-of-life tire collection has been managed by economically disadvantaged communities, and as the industry grows, it will help uplift these groups. The sector already supports over 250,000 jobs (Source: AIRTRA) in tire collection, distribution, and recycling across India, generating around ₹65 billion in wages. Additionally, by reducing tire waste, the industry enhances public health and safety, improving the quality of life in affected communities through better waste management and reduced environmental hazards.

13.1.3. Market Trends and Projected Growth Rate

- **Technological Advancements:**
  Advanced material separation methods and automation are significantly improving the efficiency and recovery rates of rubber, steel, and fiber from tires. Partnerships between brand owners and recyclers are driving the development of products with a lower carbon footprint. Additionally, continuous advancements in devulcanization, pyrolysis and recovered carbon black technologies are expanding the capacity to process end-of-life tires (ELTs) sustainably, enhancing circularity in the industry.
- **Focus on Sustainability and Strategic Partnerships:**
  Tire manufacturers are setting higher sustainability targets, driven by growing environmental awareness and conscious consumption, incorporating more recycled materials such as reclaim rubber, biopolymers, and pyrolysis-based polymers into their products. In line with this trend, tire companies globally are forming strategic partnerships with recyclers to integrate recycled content into their products and processes, further driving sustainability efforts.
- **Growth in Downstream Products:**
  There is growing demand for recycled products such as crumb rubber (for road construction and sports surfaces) and tire-derived fuel (TDF)
- **Current and projected growth rate:**
  The tire recycling market in India is poised for substantial growth, driven by government initiatives that promote sustainable waste management, rising environmental awareness, new applications for recycled materials, and an increasing focus from brand owners on higher substitution rates. Currently valued at around ₹3,500-4,000 crore, the market is expected to expand to ₹9,000-12,000 crore by FY30.

Categories	Current Market size in INR cr	Projected Market size in INR cr
Reclaim Rubber	1250	1800
Pyrolysis	~2500	7000
Crumb Rubber	150	200
Total	~3500-4000	~9000-12000

13.2. CURRENT STATUS

The country recycles 98% of ELTs, however, the integration of reclaim rubber or recovered carbon black back into tire manufacturing is still low, at about 5%, with most materials being downcycled rather than reused in tire production, indicating a critical need to direct efforts toward enhancing circularity rather than merely recycling.

13.2.1. Existing Policies and Regulations

- The government has introduced Extended Producer Responsibility (EPR) which requires tire manufacturers to manage end-of-life tires (ELTs) for proper recycling and waste management.
- The Central Pollution Control Board (CPCB) enforces Standard Operating Procedures (SOPs) for pyrolysis units to ensure environmental compliance.
- The Directorate General of Foreign Trade (DGFT) requires licenses for tire imports, ensuring they meet BIS standards for environmental safety.
- Export incentives, such as the Duty Drawback Scheme, provide tax refunds for exporters of recycled tire products.
- The Market Access Initiative (MAI) supports exporters particularly for statutory compliance support by funding participation in trade fairs and exploring new markets

13.2.2. Best practices and innovative approaches

Extended Producer Responsibility (EPR) implemented in India is a result of lessons learnt from global best practices for managing end-of-life (EoL) waste in an environmentally sound manner.

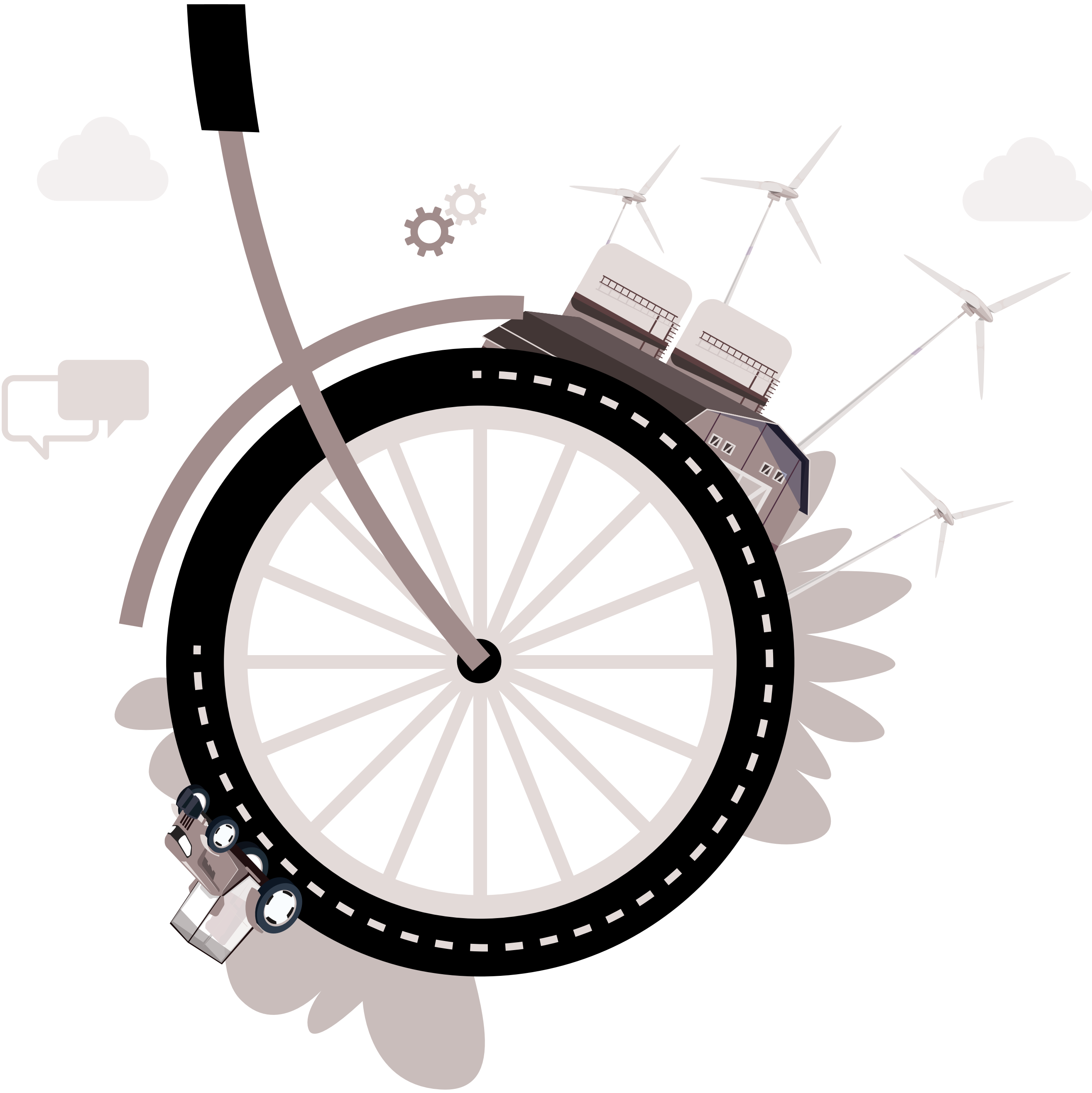
However, there remain fundamental industry challenges that need to be addressed, as outlined below. The need for innovative approaches will be crucial in overcoming these gaps and driving progress toward more sustainable practices in waste management.

THE COUNTRY RECYCLES

98%

of **ELTs**

13.3. GAPS, CHALLENGES, AND LEARNINGS



13.3.1. Gaps and Challenges

- **Product design constraints:** Existing product designs still limit the use of recycled materials, preventing broader adoption of circular materials
- **Absence of reverse logistics mechanisms:** There is a lack of a robust reverse logistics system for efficiently sourcing raw materials, which restricts the flow of end-of-life tires into recycling streams.
- **Policy gaps and regulatory barriers:** The Ministry of Environment, Forest and Climate Change (MoEFCC) grants permission for the import of waste tires based on a recycler's production capacity, GST paid, and power consumed. However, the Directorate General of Foreign Trade (DGFT) limits the

import quantity to only 40% of the average trade volume. This restriction on importing waste tires, while intended to boost domestic recycling, has inadvertently created a supply gap for quality feedstock in advanced recycling facilities.

- **Standardization issues:** The industry faces a lack of standardized norms and policies across states for set-up of new recycling units, including but not limited to pollution, tax etc. For instance, there is inconsistency in pollution norms between the State Pollution Control Boards (SPCBs) and the Central Pollution Control Board (CPCB) in classification of industry into red zone and orange zone affecting the operational capabilities of facilities.
- **Absence of product standardization:** The lack of standardized guidelines for circular products further complicates scaling efforts in the industry.
- **Financial inclusion challenges:** Waste collectors, often operating in the informal sector, face a lack of financial inclusion, limiting their ability to benefit from and contribute to a more organized recycling economy.
- **Lack of awareness, skills, or capacity:** The transition to advanced recycling technologies, such as continuous pyrolysis and devulcanization, is slowed by a shortage of trained personnel. Furthermore, the fragmented and informal collection network leads to underutilized or improperly disposed tires, reducing the potential for efficient material recovery.
- **Lack of incentives for clean technology:** The absence of adequate incentives for the adoption of economically viable clean technologies stifles innovation and progress in sustainable practices.

13.3.2. International Best practices and innovative approaches employed

Tire companies have implemented effective reverse logistics systems, such as Bridgestone, which manages tire collection through its retail locations, with 99% of its 3,500 shops partnering with processing companies to ensure proper recycling and material recovery. Innovative applications for recycled rubber are also gaining momentum, especially in Europe and the USA, where recycled rubber is being used in civil engineering, sports surfaces, and other industries, generating new demand for sustainable products. Continental has introduced tires featuring a "Contains Recycled Materials" logo on the sidewall, emphasizing their commitment to incorporating recycled content while enhancing brand recognition for sustainability. Additionally, tire manufacturers are increasingly collaborating with recyclers to establish closed-loop systems, enabling continuous recycling of end-of-life tires (ELTs) into new products, further promoting circularity within the industry.

Extended Producer Responsibility (EPR) systems are widely adopted in countries like Italy, France, Spain, Brazil, South Korea, and Russia, placing the responsibility of ELT collection on tire manufacturers and importers through eco-fees. Non-profit organizations (PROs) often oversee recovery to ensure compliance with environmental standards. In contrast, countries like Denmark and Croatia have government-managed collection systems funded by production taxes, ensuring centralized waste management. Free market systems, seen in the UK, USA, Japan, and China, do not impose eco-fees but rely on industry action plans and legislation to drive ELT collection and recycling. The eco-fees or taxes collected in these systems are used for various purposes, including grants, loans, R&D, partnerships to develop new recycling markets, subventions for unprofitable recovery routes, and public awareness initiatives.

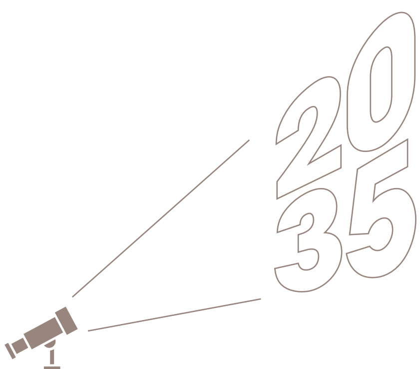
13.4. VISION FOR MATERIAL CIRCULARITY OF TIRES BY 2035

The vision is to achieve a robust, circular economy for India's tire industry by 2035, transforming every end-of-life tire (ELT) into a valuable resource that contributes to economic growth, environmental sustainability, and societal well-being. By adopting innovative design, recovery, and recycling methods, we aim to reduce waste, minimize emissions, and maximize the lifespan and reuse of materials.

The key goal here is to have much more than the current ~5% of recycled material go back into new tyres. In a country that recycled 98% of ELTs, there is much potential to avoid down cycling.

Key Strategies to achieve this vision:

1. **Material Efficiency & Circular Design:**
   Establish industry standards mandating a minimum recycled content in all new tire designs, enhancing recyclability and durability. Implement regulations that require manufacturers to prioritize recycled materials and encourage eco-friendly product design. Fast-track the standardization (BIS) of materials and processes to ensure consistent quality across the industry. Additionally, grants can facilitate research and development in recycling technologies and material recovery, driving innovation and improving the efficiency of circular practices.
2. **Green Public Procurement:**
   Mandate the use of recycled materials in the construction of roads and other public infrastructure projects. This will help create a strong market for recycled products, reduce reliance on virgin materials, and promote sustainability across government-funded projects. Public procurement policies should focus on driving demand for circular materials, ensuring a stable market for recycled products.
3. **Advanced Recovery & Recycling Facilities with robust collection systems:**
   To enable investments, implement Production-Linked Incentive (PLI) schemes, and viable gap funding to accelerate the establishment of large-scale advanced recycling plants and support the development of indigenous technologies with high-value recovery methods like devulcanization, continuous pyrolysis, and target processing of 50% of end-of-life tires (ELTs) into high-value applications—such as tire pyrolysis for use in refineries, reclaim rubber and recovered carbon black for tire production, and crumb rubber modified bitumen for infrastructure—by 2027. Mandate brand owners to contribute toward infrastructure improvements by strengthening reverse logistics systems to achieve a robust collection network. Collaborative data-sharing frameworks and industry best practices should also be fostered to support the transition to sustainable practices.
4. **Standardization & Policy Harmonization:**
   Enact uniform standards and pollution norms across the country to simplify recycling operations and ensure consistent product quality. Implement stringent audits to monitor compliance with environmental and circular economy standards. Standardize HSN codes for waste and recycled materials to ensure accurate data collection and streamline industry practices.
5. **Circular Economy Parks & Incentives:**
   Develop Circular Economy Parks and Material Recovery Facilities (MRFs) to facilitate the efficient sorting and processing of recyclables, supporting the scaling of circular practices.
6. **Consumer and Workforce Empowerment:**
   Foster public awareness through eco-labelling initiatives and consumer incentives, encouraging demand for recycled tire products. Strengthen India's recycling workforce by establishing national training programs on advanced recycling and circular economy skills in collaboration with the National Skill Development Corporation (NSDC) and academic institutions.



13.5. SUMMARY OF EXISTING EXTENDED PRODUCER RESPONSIBILITY REQUIREMENTS

Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules, 2022 dated July 21, 2022 mandates EPR for manufacturers and importers of new tyres and for the importers of waste tyres. EPR obligations for manufacturers or importers of new tyres are presented in the table below.

Table 13-1: EPR targets for manufacturers or importers of new tyres

Sl. No.	Year	Waste Tyre Recycling Target in Weight (Kilogram or Tons)
1	EPR obligation of the year 2023-2024	70% of the quantity of new manufactured or tyres imported in year 2021-2022
2	EPR obligation of the year 2024- 2025	100% of the quantity of new manufactured or tyres imported in year 2022-2023.
3	After the year 2024-2025 (year Y), the extended producer responsibility obligation shall be 100% of the quantity of new tyres manufactured or imported in the year (Y-2).	
4	Units established after the 1st April, 2022, the extended producer responsibility obligation shall start after two years (Y) and shall be 100% of the new tyres manufactured or imported in the year (Y-2).	

For waste tyre importers, the extended producer responsibility obligation for waste tyre importer in year (Y) shall be 100% of the tyre imported in year (Y-1).

13.6. GOALS AND TARGETS

Table 13-2 Proposed Goals and Targets

S.No.	Goal	Target	Year
1	**Increase recycled content in new tires.** *[Currently only ~5% of recycled End-of-Life Tires (ELTs) are used in new tire production. Increased recycled content reduces resource dependency and environmental impact.]*	**10%** recycled content in all new tires	2030
2	**Promote recycled tire-derived materials in government procured rubber products and promote recycled content in road construction projects.** *[Government guidelines (IRC, MoRTH) endorse the use of Crumb Rubber Modified Bitumen (CRMB) in road construction for its disposal and performance benefits.]*	**20%** recycled tire-derived materials in government-procured rubber products and **10%** recycled tyre content in road construction	2026
3	**Establish a nationwide ELT reverse logistics system.** *[Ensures consistent sourcing of ELTs for recycling and material recovery, building on EPR programs from other countries]*	90% ELT collection rate	2026
4	**Incentivize the creation of advanced recycling facilities.** *[Promotes high-value material recovery to create global scale and relevance.]*	50 advanced recycling facilities for high-value recovery	2027
5	**Implement and enforce national standards for tyre recycling, pollution norms, and circular product quality.** *[Aligns states with a uniform regulatory framework, ensuring consistency in recycling practices and product quality.]*	National standards implemented and enforced	2026
6	**Mandate recycled content labelling on all tires.** *[Increases consumer awareness and demand for recycled materials in tires, inspired by successful labelling programs in Europe.]*	Recycled content labelling on all tires	2027
7	**Develop Circular Economy Parks with Material Recovery Facilities (MRFs).** *[Maharashtra and Rajasthan states have proposed circular economy parks within the states and increased number of such parks across states will promote circularity]*	10 Circular Economy Parks nationwide, each with MRFs	2030
8	**Launch a national training program for advanced tire recycling.** *[Addresses the skills gap by creating a workforce for advanced recycling operations, crucial for industry growth and innovation.]*	5,000 personnel trained in advanced recycling	2028

13.7. IMPACT POTENTIAL

ENVIRONMENTAL BENEFITS

- **Greenhouse Gas (GHG) Emission Reduction:**
  Recycling tires significantly reduces greenhouse gas emissions by conserving natural resources. As per EURIC, processing 1 tonne of tires reduces CO2 emissions by 700 kg. By recycling 4.2 million MT of domestic generated end-of-life tires by 2035, it is possible to cut down 3 million tons of CO2 emissions annually.

ECONOMIC BENEFITS

- **Benefit to End Users:**
  For fleet owners, extending tire life through retreading presents substantial cost savings. Retreading costs approximately 25-30% of a new tire, allowing fleet operators to save up to ₹10,000 per tire. 1 million tires re-treaded annually, can yield savings of up to ₹1000 crores. Additionally, the utilization of recycled rubber enables OEMs to reduce their material costs, making their products more competitively priced while contributing to sustainability efforts.

- **Benefit to the Nation:**
  The oil derived from tire pyrolysis when used in refineries can help reduce India's dependence on imported crude oil, directly supporting the Atmanirbhar Bharat initiative. This shift reduces trade deficits, mitigates energy dependency, and strengthens energy security by insulating India from global oil price fluctuations.

SOCIAL BENEFITS

- **Job Creation:**
  According to Maharashtra government, the proposed 4 circular economy parks could potentially generate 4-5 million jobs. With the tire recycling industry projected to grow from ₹3500-4000 crores to ₹9000-12000 crores and assuming 10 such circular parks are created in country; an additional 1 lakh jobs could be potentially created for the sector. These roles include direct employment in facility operations, quality control, maintenance, R&D, as well as indirect positions such as trainers, support staff, and entrepreneurs etc. Employment in eco-labeling, marketing, and regulatory compliance will further enhance the socio-economic impact of the tire recycling sector.

- **Additional Socio-Economic Value:**
  This growth is expected to generate around ₹25 billion in wages, contributing significantly to the economy.

In conclusion, India's tire recycling industry stands at a transformative juncture, with the potential to drive significant environmental, economic, and social benefits, creating a sustainable, resource-efficient future through robust policies, innovation, and community engagement.

References

1. Rubber Statistics - Rubber Board, Ministry of Commerce and Industry, India
https://rubberboard.gov.in/rbfilereader?fileid=1078

2. Benefits of Recycled Rubber - Recycled Rubber Facts
https://www.recycledrubberfacts.org/wp-content/uploads/2016/03/Benefits_of_Recycled_Rubber.pdf

3. Environmental Benefits of Retreading - Tire Retread & Repair Information Bureau
https://www.retread.org/environmental-benefits-of-retreading

4. Air Transport Rubber Association (AIRTRA)
https://airtra.org/

5. End-of-Life Tire Management - State of Knowledge Report - World Business Council for Sustainable Development (WBCSD)
https://docs.wbcsd.org/2018/02/TIP/WBCSD_ELT_management_State_of_Knowledge_Report.pdf

6. Government of India Press Release on Waste Management Initiatives - Press Information Bureau, Government of India
https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1777240

7. Sustainability Roadmap - Apollo Tyres
https://corporate.apollotyres.com/press-and-media/news/corporate/sustainability-roadmap/

8. Mechanical Tire Recycling Fact Sheet - European Recycling Industries' Confederation (EuRIC)
https://euric-aisbl.eu/images/Brochures/EuRIC_MTR_mechanical_tyre_recycling_Fact_sheet.pdf

9. Maharashtra to Set Up Four Circular Economy Parks for Major Industries - Economic Times
https://economictimes.indiatimes.com/news/economy/policy/maharashtra-to-set-up-four-circular-economy-parks-for-major-industries/articleshow/97622242.cms?from=mdr

10. Continental Launches ContiRe.Tex Technology for Tire Recycling - Continental Press Release
https://www.continental.com/en/press/press-releases/20220405-contire-tex/

11. Tire Recycling and Resource Conservation Initiatives - Bridgestone
https://www.bridgestone.com/responsibilities/environment/resources/tire_recycle/

Chapter 14

CIRCULAR ECONOMY ACTION PLAN *for* END-OF-LIFE VEHICLES

14.1. OVERVIEW

The automotive industry is a vital pillar of India's economy, driving growth through strong backward and forward linkages. Policy liberalization and strategic interventions have led to a competitive market landscape, encouraging new players, expanding production capacity, and generating significant employment. The sector's contribution to the national GDP has increased to 7.1% now compared to 2.77% in 1992-93, providing direct and indirect employment to over 19 million people.

In FY 2023-24, India's automotive industry saw robust production growth across two-wheelers, passenger vehicles, and commercial vehicles. Exports continued to rise, highlighting India's role as a key global manufacturing hub, while imports were primarily focused on specialized components and high-end vehicles.

Table 14-1: Production and Imports/Exports of Automobiles (FY 2023-24)

	Production	Domestic Sales	Exports
Category	**2023-24**	**2023-24**	**2023-24**
Passenger Vehicles	49,01,844	42 18,746	6,72,105
Commercial Vehicles	10.66,429	9,67,878	65,816
Three Wheelers	9,92,936	6,91,749	2,99,977
Two Wheelers	2,14,68,527	1,79,74,365	34,58,416
Quadricycles	5,006	725	4,178
Grand Total	**2,84,34,742**	**2,38,53,463**	**45,00,492**

Source : https://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=15

In the Indian automobile market, two-wheelers and passenger cars dominate, accounting for 77% and 18% of the market share respectively in 2021-22. The sector has seen significant export growth, with a positive increase of 35.9%. Globally, India ranks as the second-largest manufacturer of two-wheelers, the sixth-largest in passenger vehicles, and the largest in tractors, demonstrating its prominence on the global stage. Over the last decade, India has become a preferred location for manufacturing high-quality automotive components and vehicles, catching up with established international markets.

Material Composition in Vehicles: The automobile market is closely linked to the availability of key resources such as steel, aluminum, copper, and plastics, which are the primary materials used in vehicle manufacturing. Vehicles also contain smaller amounts of textiles, glass, wood, and precious metals. These resources are crucial, directly or indirectly, to the automotive industry.

Typical material composition of a vehicle includes:

- Ferrous Metals: 68%
- Aluminum: 7%
- Copper: 1%
- Plastics: 10%
- Glass: 3%
- Tires: 5%
- Precious Metals: 0.1%
- Other Materials: 3%
- Batteries: 1%
- Fluids: 2%

In FY 2023-24, India's ferrous metals industry showed strong production levels in both crude and finished steel. Despite this, the country remained a net importer of finished steel due to high domestic demand. Key sectors like construction, automotive, and infrastructure continued to drive consumption, while exports saw steady performance, reinforcing India's position as one of the top steel producers globally.

Typical Lifecycle of Vehicles: Typical lifecycle of a vehicle consists of three phases:

1. **Active Life (0-7 years):**
   During this phase, the vehicle operates at peak efficiency, delivering optimal performance and functionality.
2. **Passive Life (7-12 years):**
   The vehicle begins to show signs of wear and tear, requiring more frequent repairs and part replacements. Its efficiency declines, leading to higher maintenance costs.
3. **Storage Life (12-15 years):**
   At this stage, the vehicle is no longer economically viable to operate. It is typically decommissioned, marking the end-of-life phase where it becomes suitable for scrapping or recycling.

Current Status of End-of-Life Vehicles:

By 2025, India is projected to have approximately **22.5 million End-of-Life Vehicles (ELVs)** and the details are presented in **Table 14-2** below. The ELV market was valued at $3,474 million in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 17.2% from 2020 to 2030. Properly managed scrapping facilities can help recover valuable materials, potentially generating around five million tonnes of steel scrap, 1.2 million tonnes of aluminum, and 0.2 million tonnes of copper. These recycled materials are crucial for supporting sectors like construction, automotive, and infrastructure, reducing reliance on raw material imports and promoting a circular economy.

Table 14-2: Estimated Number of ELVs by 2025

SN	Category	Estimated No. of ELVs
1	Two Wheelers	17,723,951
2	Private Cars	2,809,996
3	Commercial Goods Vehicles	1,188,833
4	Three Wheelers	757,932
5	Commercial Passenger Vehicles	94,757
	Total ELVs	**22,575,469**

In the recycling process, both ferrous and non-ferrous metals are recovered and redirected for reuse. It is estimated that passenger cars are composed of approximately 70% steel and 7-8% aluminum, with the remaining 20-25% consisting of plastic, rubber, glass, and other recyclable materials. Recycling one ton of steel conserves about 1,134 kg of iron ore, 635 kg of coal, and 54.4 kg of limestone (Sakai et al., 2013; Steel Recycling Institute, 2014).

68%
Ferrous Metals

7%
Aluminum

1%
Copper

10%
Plastics

3%
Glass

5%
Tires

0.1%
Precious Metals

3%
Other Materials

1%
Batteries

2%
Fluids

14.2. CURRENT STATUS OF ADOPTION OF CIRCULAR ECONOMY FOR ELVs

14.2.1. Current Level of Adoption of Circular Economy Principles

The concept of a circular economy—which emphasizes the reuse, repair, refurbishment, and recycling of materials to extend product life cycles—has only recently started gaining traction in India's ELV recycling sector. While the traditional recycling practices in India have focused primarily on scrapping metals, the comprehensive adoption of circular economy principles is still in its infancy.

- **Reuse and Life Extension:** In India, there is a long-standing culture of extending vehicle life through repair and refurbishment. Vehicles, particularly in the commercial sector, are often kept on the road well beyond their optimal operational life through frequent repairs and part replacements. However, there is limited emphasis on the reuse of components in a more structured or systematic manner.
- **Recycling:** India's ELV recycling sector has been largely informal, with a focus on metal recovery (steel, aluminum, copper) while other materials, like plastics, rubber, and electronic components, are often discarded. The country has not yet fully adopted advanced recycling processes, such as upcycling (turning waste materials into higher-value products) or closed-loop recycling (where materials are fully recovered and reused without loss of quality).
- **Upcycling and Component Refurbishment:** The idea of upcycling ELV components (such as repurposing tires into products like rubberized roads or playground surfaces) is still nascent in India. Some initiatives exist for refurbishing parts like engines or transmissions, but this remains largely unregulated and informal.

India is yet to adopt a widespread design-for-recycling approach in the automotive sector. Design for disassembly—which allows for easier dismantling of vehicles for recycling or reusing parts—has not been fully embraced by automakers operating in the country.

- **Design for Life Extension:** Many vehicle manufacturers in India focus more on selling new models than on encouraging life extension of vehicles. While repair services are common, the concept of remanufacturing parts and components to give them a second life (as seen in other countries) is not widely implemented.
- **Design for Recycling:** Indian automakers have not yet adopted the global best practices for designing vehicles with recyclability in mind. Many vehicles still contain complex materials and components that are difficult to dismantle or recycle. While global brands in India may follow international standards, local manufacturers are yet to embrace design for easy recycling.
- **Reuse and Repair Markets:** The reuse market is robust in India due to the informal sector's dominance in dismantling and salvaging vehicle parts. However, this is largely unregulated and lacks environmental and safety standards. Repair is also a strong market segment, with an emphasis on keeping vehicles operational for extended periods.

14.2.2. Overview of Existing Policies and Incentives Promoting Circular Economy

India has recently begun making policy strides to promote circular economy principles in the ELV recycling industry:

- **Vehicle Scrappage Policy (2021):** This is a major step forward in India's ELV recycling sector. The Vehicle Scrappage Policy incentivizes the removal of old, polluting vehicles from the road by offering financial incentives for scrapping vehicles older than 15 years for personal vehicles and 10 years for commercial vehicles. This policy seeks to increase material recovery and improve environmental outcomes by diverting ELVs from illegal or informal disposal methods.

- **National Material Recycling Policy:**
  The National Material Recycling Policy (2019) outlines broad strategies for increasing recycling in various sectors, including the automotive sector. It encourages the adoption of circular economy principles, although specific regulations for ELV recycling are still evolving.
- **Hazardous Waste Management Rules (2016) and its amendments:**
  While not specific to ELVs, these rules govern the safe handling and disposal of hazardous materials found in vehicles, such as engine oils, batteries, and air conditioning refrigerants. Enforcement, however, remains a challenge.
- **State-Level Initiatives:**
  States, like Gujarat, Maharashtra and few others, have launched their own initiatives to promote vehicle scrapping and recycling. These state policies focus on creating hubs for formal scrapping and recycling infrastructure.
- **Incentives for EV and Battery Recycling:**
  As the electric vehicle (EV) market grows, the government is considering policies and incentives for the recycling of EV batteries under the FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) II policy. This aims to ensure the safe disposal and recycling of EV batteries and the recovery of valuable materials like lithium and cobalt.

14.2.3. Best Practices and Innovative Approaches Employed in India

Despite the challenges, some best practices and innovative approaches are emerging in India's ELV recycling industry:

- **Formal ELV Recycling Centers:**
  India's Vehicle Scrappage Policy has led to the establishment of formal vehicle recycling centers, such as the Maruti Suzuki-Toyota Tsusho Recycling Plant in Noida and Re Sustainability's ELV Recycling Facility in Jhajjar, Haryana. These centers follow global best practices for dismantling, material recovery, and recycling, providing an environmentally friendly alternative to the informal sector.
- **Automation and Robotics:**
  There is growing interest in adopting robotic dismantling technologies to improve material recovery and recycling efficiency. These technologies are particularly valuable in recovering rare earth metals and complex vehicle components like engines, transmissions, and electronics.
- **Public-Private Partnerships (PPPs):**
  Partnerships between the government and private companies are being promoted to develop modern, environmentally friendly recycling infrastructure. These partnerships aim to bring in global expertise, advanced technologies, and better environmental compliance to the ELV recycling sector.
- **Battery Recycling Initiatives:**
  Companies like Attero Recycling are focusing on lithium-ion battery recycling, crucial for the upcoming surge in EVs. Attero and other players are building the capacity to extract valuable metals from EV batteries, reducing India's dependency on raw material imports for future EV production.
- **Scrap Certification and Incentive Programs:**
  The government has introduced scrap certification programs, where vehicle owners receive incentives for scrapping old vehicles in certified centers. This is designed to encourage formal scrapping and prevent illegal vehicle dismantling.

14.3. GAPS AND CHALLENGES

14.3.1. Policy Gaps or Regulatory Barriers in India's ELV Recycling:

While India has begun to address End-of-Life Vehicle (ELV) recycling through initiatives such as the Vehicle Scrappage Policy (2021), there remain significant policy gaps and regulatory barriers:

- **EPR Mandates for Automakers:** Currently, India does not have EPR mandates for the automobile manufacturers. However, this will change soon. India's upcoming EPR mandate for automakers, effective April 2025 under the Draft End-of-Life Vehicles (Management) Rules, 2024, is a positive step towards environmentally sound vehicle disposal.
- **Lack of Specific Rules for Electric Vehicles (EVs):** India's EV market is growing rapidly, but there is a lack of clear regulatory guidelines for handling end-of-life EVs, particularly in relation to battery recycling. EV batteries, which contain hazardous materials like lithium and cobalt, need specific disposal and recycling protocols that are still underdeveloped in India.

14.3.2. Infrastructure and Technology Gaps

India faces significant infrastructure and technology challenges that limit efficient ELV recycling:

- **Insufficient Formal Recycling Infrastructure:** The majority of ELVs in India are handled by the informal sector, where dismantling and recycling facilities lack modern technology and operate with minimal environmental controls. The country lacks sufficient certified and technologically advanced ELV processing facilities that can safely dismantle vehicles, recover materials, and recycle valuable components like metals and plastics.
- **Limited Adoption of Advanced Recycling Technology:** India's ELV recycling largely relies on manual dismantling, leading to low recovery rates for certain materials like plastics, electronic components, and rare earth metals. Advanced technologies such as robotic dismantling systems, chemical recycling of plastics, and closed-loop systems for EV batteries are either absent or in their nascent stages.
- **Challenges with Modern Vehicle Materials:** With the rise of electric vehicles and more complex material compositions in modern vehicles (e.g., lightweight composites, advanced polymers), existing infrastructure is ill-equipped to handle these materials. This leads to difficulties in extracting valuable components and higher rates of landfill waste.
- **Lack of Battery Recycling Infrastructure for EVs:** India's EV battery recycling infrastructure is still underdeveloped. Efficient recycling processes for extracting valuable metals like lithium, cobalt, and nickel from EV batteries are not widely available, leading to a gap in sustainable management of this growing waste stream.

14.3.3. Lack of Awareness, Skills, or Capacity

A major challenge in India's ELV recycling landscape is the lack of awareness and skill gaps throughout the value chain:

- **Low Consumer Awareness:** Many vehicle owners in India are unaware of proper ELV disposal methods or the environmental risks associated with illegal scrapping. This results in a majority of end-of-life vehicles being handled by the informal sector, which lacks safe practices.

- **Skill Deficiencies in Dismantling and Recycling:** The majority of India's ELV recycling workforce is unskilled or semi-skilled, relying on traditional methods that are inefficient and environmentally harmful. There is a significant need for training programs and capacity-building initiatives to improve the technical skills required for safe and efficient dismantling, recovery, and recycling processes.
- **Limited Formal Education or Certifications in Recycling Technologies:** India lacks formal education programs or certifications specifically focused on ELV recycling technologies, materials recovery, and hazardous waste management. This limits the availability of skilled professionals who can manage advanced recycling operations.

14.3.4. Challenges Posed by Informal Sector and Potential Solutions

- **Inadequate Equipment and Industry Compliance** Some organized players in the Registered Vehicle Scrapping Facility (RVSF) sector are operating with inadequate equipment that does not fully comply with industry standards. This can reduce operational costs but may compromise quality, impacting both large companies and the overall sector reputation.
- **Revenue Generation Difficulties** Operating on a capital-intensive service model, RVSFs face challenges in generating consistent revenue due to competitive pricing and fluctuating scrap market values, which affect profitability.
- **Reuse of Defective Parts** Defective parts from dismantled vehicles continue to be used in operational vehicles less than 10 years old, potentially contributing to pollution levels comparable to end-of-life vehicles.
- **Wastage of Reusable Materials** Valuable reusable materials often end up scrapped, missing out on opportunities to conserve resources and add market value through refurbishment.

14.4. PROPOSED FRAMEWORK

14.4.1. Potential Solutions:

Potential solutions for implementing circular economy for end-of-life vehicles include:

- **Enforce Equipment and Technology Standards:** CPCB, SPCB, and MoRTH may consider mandating infrastructure and technology standards within RVSFs to improve compliance, ensure consistency, and maintain quality across the sector. Standardized requirements can also provide clarity on operational expectations, enhancing sectoral growth.
- **Establish a Credit-Based Revenue System:** Interlinking RVSFs with OEMs and other industries through a credit-based system, such as Extended Producer Responsibility (EPR) credits and carbon credits, may offer additional revenue channels and promote sustainability. Involving CPCB, SPCB, MoRTH, and MoEFCC in this initiative can support the integration and wider adoption of credit-based ecosystems within the RVSF sector.
- **Mandatory Testing for Defective Parts:** Implementing mandatory testing even for vehicles under 10 years old can help reduce pollution by minimizing the circulation of defective components. CPCB, SPCB, and MoRTH may play a role in developing guidelines and standards for this testing process to improve vehicle safety and environmental impact.
- **Promote Refurbishment and Resource Conservation:** The Ministry of Micro, Small, and Medium Enterprises can encourage the refurbishment and remanufacturing of reusable materials to shift the market towards more organized and structured operations. Promoting organized refurbishment may improve consumer confidence in refurbished products and support sustainable resource management by reducing waste.

14.4.2. Lessons from International Best Practices:

India can learn valuable lessons from countries with advanced ELV recycling systems:

- **European Union's ELV Directive:** The EU's End-of-Life Vehicle Directive sets a global benchmark, requiring 95% of a vehicle's weight to be recycled, reused, or recovered. India could adopt similar regulations that mandate higher recycling rates and impose Extended Producer Responsibility (EPR) on automakers, incentivizing them to design vehicles with recyclability in mind and ensuring the safe disposal of ELVs.
- **Japan's Comprehensive ELV Management System:** Japan's Automobile Recycling Law enforces a highly efficient system for ELV recycling, with a strong focus on recycling airbag systems, fluorocarbons, and vehicle shredder residue. Japan's high level of collaboration between automakers, recyclers, and the government ensures better compliance and more efficient resource recovery. India can adapt similar public-private partnerships to improve its ELV recycling system.

14.5. GOALS AND TARGETS

The Ministry of Environment, Forest and Climate Change of India (MoEF&CC) announced the **draft End-of-Life Vehicles (Management) Rules, 2024.** The draft Rules will establish an **Extended Producer Responsibility (EPR)** system for automobile manufacturers (producer of vehicles) starting in April 2025 to promote the environmentally appropriate disposal of End-of-Life Vehicles (ELVs). The recycling of End-of-Life Vehicles means recycling of steel from End-of-Life Vehicles.

Companies that qualify as producers are required to achieve steel recycling targets, register on a dedicated portal, and submit annual reports. While guidelines for ELV processors and recyclers have been promulgated in the past, this draft Rules will be the first full-fledged EPR regulation targeting automobile manufacturers. It also covers electric vehicles (EVs), including e-rickshaws and e-carts. The EPR targets for various transports are given below:

For Private Vehicles

EPR target year (Xth year)	EPR target in Xth year	Annual EPR target from (X+1)th year (2nd year) to (X+14)th year (15th year)
2025-2030	Min 10% of the steel used in vehicles placed in market in (X-20)th year	Min 3% of the steel used in vehicles placed in market in (X-20)th year
2030-2035	Min 20% of the steel used in vehicles placed in market in (X-20)th year	
2035-2040	Min 30% of the steel used in vehicles placed in market in (X-20)th year	

For Commercial Vehicles

EPR target year (Xth year)	EPR target in Xth year	Annual EPR target from (X+1)th year (2nd year) to (X+14)th year (15th year)
2025-2030	Min 10% of the steel used in vehicles placed in market in (X-12)th year	Min 3% of the steel used in vehicles placed in market in (X-12)th year
2030-2035	Min 20% of the steel used in vehicles placed in market in (X-12)th year	

In addition to the above EPR targets, India's End-of-Life Vehicle (ELV) Recycling industry needs clear and actionable targets to create a sustainable, resource-efficient, and circular economy for vehicle disposal. The proposed goals and targets are presented in **Table 14-3** below:

Table 14-3: Proposed Goals and Targets

Goal & Basis	2030 Target
Number of RVSFs in India *[Based on the projected ELV load (FY24 – 1.2Cr to FY30 – 1.5Cr), current RVSFs (73 with ~12,000 pa capacity) at 20% utilisation and based on the assumption of 80% utilisation)]*	180
Cumulative Capacity of RVSFs in India (No. of passenger car equivalent per day) *[In line with the projected ELV load and based on a survey of operational RVSFs across the country, on-site visits, CPCB authorization(s) etc.]*	6,000
% of Pre BS, BSI, BSII vehicles recycled as ELVs in RVSFs *[Assumption based on quotes from MoRTH Secretary in the public domain, court order for similar action in Delhi NCR, introduction of BS VII in the next 5 years]*	100%
Monthly processing run-rate for RVSFs *(No. of passenger car equivalent processed by RVSFs per month)*	110,000
Share of formal channels in total vehicles scrapped/recycled *[Assumption based on current conversion rate of informal scrappers into RVSFs and ongoing efforts by GoI to formalize them]*	80%
Import substitution of scrap steel (tons/annum) *[Based on the number of ELVs proposed to be processed at RVSFs and the average estimate of steel in a vehicle i.e., ~850kg based on average kerb weight and 90% recovery rate]*	1 Million

Monitoring and Evaluation (M&E) is crucial to track progress toward these targets, identify challenges, and adapt to evolving circumstances. A robust M&E framework can ensure that India remains on track to meet its ELV recycling goals while making necessary adjustments along the way.

1. Data Collection and Reporting

- Establish a national ELV recycling database to track vehicle disposal rates, material recovery, and waste reduction.
- Require certified recyclers and dismantlers to submit annual reports detailing the volume of ELVs processed, materials recovered, and environmental compliance.

2. Third-Party Audits

- Introduce mandatory third-party audits for ELV recycling centers to ensure compliance with environmental and safety standards.
- Regular audits will help track progress, address compliance issues, and highlight areas for improvement.

3. Performance Reviews

- Conduct periodic performance reviews at regional and national levels to assess progress toward recycling targets.
- These reviews should involve all key stakeholders, including government agencies, manufacturers, recyclers, and representatives from the informal sector.

4. Adaptive Policies

- o Use data from M&E activities to inform policy changes, update targets, and seize emerging opportunities in the ELV recycling industry.
- o Flexible and adaptive policies will allow for the integration of new technologies, address unforeseen challenges, and respond to market dynamics.

5. Stakeholder Engagement

- o Engage with key stakeholders, including vehicle manufacturers, recyclers, informal sector workers, and consumers, to ensure that their feedback is incorporated into the M&E process.
- o This will enable the government to address industry concerns and ensure that targets are relevant and achievable.

References

1. Statistics Document: https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/feb/doc2023217160601.pdf
2. Invest India Website: https://www.investindia.gov.in/sector/automobile
3. MORTH Annual Report 2023-24: https://morth.nic.in/sites/default/files/AR-MoRTH_Annual%20Report_2023-24_English.pdf
4. SIAM Production Report: https://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=15

Chapter 15

CIRCULAR ECONOMY ACTION PLAN *for* PLASTICS

15.1. INDUSTRY OVERVIEW

The plastic market is a dynamic and rapidly growing industry, driven by factors such as increasing population, urbanization, and rising disposable incomes. The global plastic market is projected to experience significant growth in the coming years. Market studies project the global plastic market size to grow at a compound annual growth rate (CAGR) of around 4.2 % during the 2024-2030 (Grand View Research). While the overall plastic market is expected to grow, the growth rate may vary depending on specific regions, product types, and market conditions.

The Indian plastic market is currently USD 46.48 billion with a CAGR of greater than 6.5%, expected to be USD 52.72 billion by 2029. It is the third largest consumer of plastic after China and the U.S. Plastics comes in several shapes and forms (Circular Economy Plastics Roadmap, TERI).

Table 15-1: Usage and Recycling Status of Different Polymers

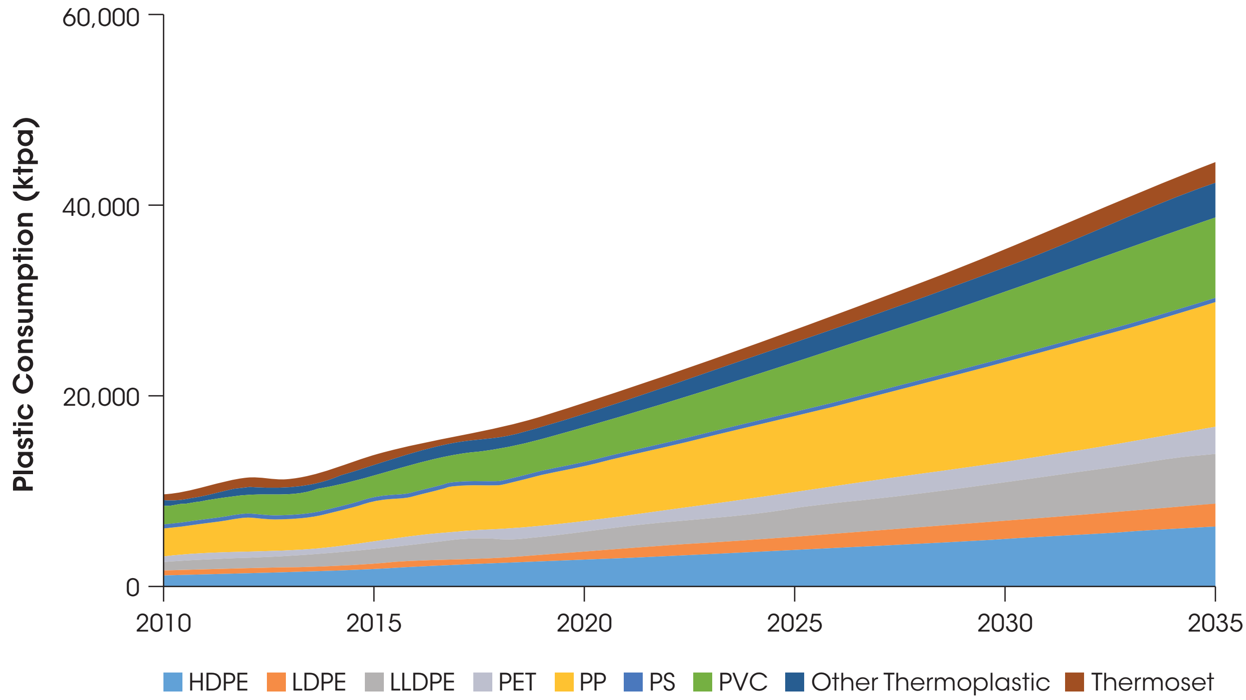
S/No	Resin Code	Polymer Type	Usage share in India	Status of Recycling
1	1	Polyethylene terephthalate (PET)	38%	Very commonly Recycled
2	2	High-density polyethylene (HDPE)	14%	
3	3	Polyvinyl chloride (PVC)	10%	Commonly Recycled
4	5	Polypropylene (PP)	38%	
5	4	Low-density polyethylene (LDPE)	2%	Sometimes Recycled
6	4	Linear LDPE	11%	
7	6	Polystyrene (PS)	2%	Typically Not recycled
8	7	Others - Thermoset, MLPs, Nylon, Melamine, ABS, PUF Bakelite, Polycarbonate.	10%	

Source: Kapur-Bakshi, S., Kaur, M., and Gautam, S., 2021. Circular Economy for Plastics in India: A Roadmap. New Delhi: The Energy and Resources Institute

India is one of the largest consumers of plastics accounting for 81% of the entire South Asian region and with a consumption rate that grows almost 10% per year (Fortune India). India's per capita plastic waste generation has more than doubled over the past 5 years to 15.09 Kg/ capita/year. Imports and domestic production currently stand at 31,830 KT/ year (World Bank report); while the national collection rate is nearly 90%, the recycling rate is only 40.6% leaving a huge gap and opportunity.

It is also noteworthy that marine-bound plastics can be significantly reduced if India plugs the leakages via major river systems and transitions into a circular economy. Due to its population, India has a significant role in moving towards a circular plastic economy by syncing government policies and private sector capabilities through targeted laws and mandates. Figure 15-1 presents the consumption trends projected till 2035 without (L) and with ban (R) on Single Use Plastics (SUP) and Figure 15-2 presents the overall material flows of Plastic in India, depicted in a Sankey Diagram.

Figure 15-1: Plastics Consumption Trend Projected till 2035 (with and without ban on SUP)



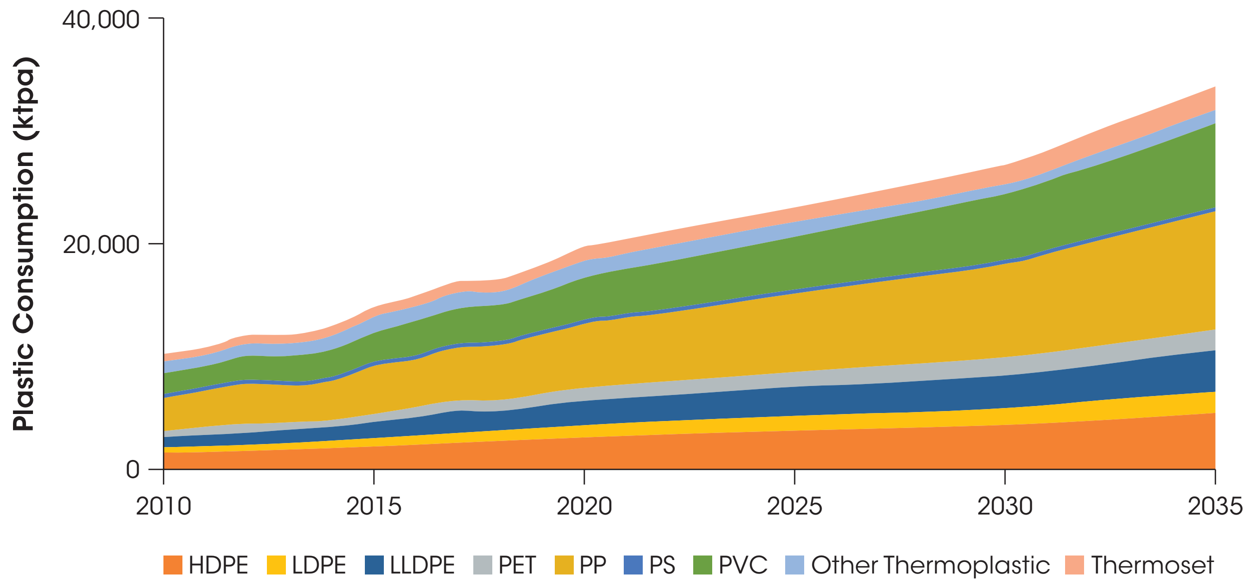


Image Source: Kapur-Bakshi, S., Kaur, M., and Gautam, S., 2021. Circular Economy for Plastics in India: A Roadmap. New Delhi: The Energy and Resources Institute

Figure 15-2: Overall Material Flows of Plastic in India

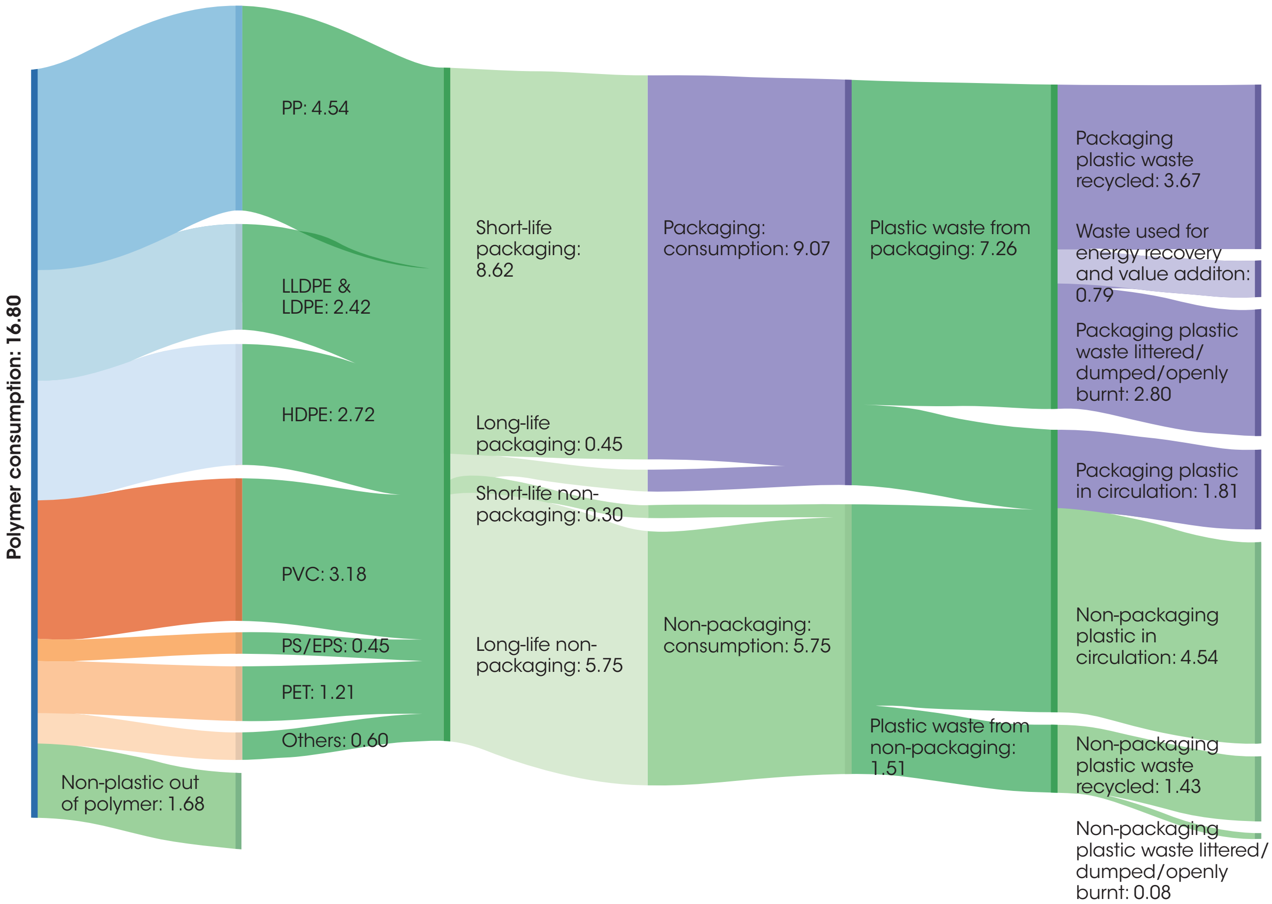


Image Source: Kapur-Bakshi, S., Kaur, M., and Gautam, S., 2021. Circular Economy for Plastics in India: A Roadmap. New Delhi: The Energy and Resources Institute

The plastic value chain faces significant challenges, including plastic pollution, limited recycling rates, and dependence on fossil fuels. However, there are also opportunities for innovation and sustainable practices to address these issues and create a more circular economy for plastics. The plastic economy encompasses a wide range of sectors, each playing a crucial role in the production, distribution, and consumption of plastic products. Here are some of the key sectors:

1. Petrochemical Industry (Raw Material Extraction & Chemical Processing)
2. Plastic resin manufacturing (Polymerization)
3. Waste Management, Recycling, and End-of-life Treatment (Waste Collection, Recycling and co-processing Facilities)
4. Research & Development (Material Science & Technology)

These sectors are interconnected and interdependent, forming a complex value chain that drives the plastic economy. Understanding these key sectors is essential for addressing the challenges and opportunities associated with plastic production, consumption, and waste management.

The plastic economy has significant Environmental impacts (Pollution of land and water bodies, GHG emissions, Resource depletion, Micro-plastics, Marine litter) and Social impacts (Health Risks, Challenges in waste management, Economic disparities, Social justice issues, etc.)

ECONOMIC FOOTPRINT:

a. **Clean-up Costs:**
   The government and various organizations incur substantial costs for cleaning up plastic waste from public spaces, rivers, and oceans. These resources could be better utilized for other essential services.

b. **Health Costs:**
   The health costs associated with plastic pollution are significant. Pollution from burning plastic and exposure to harmful chemicals can lead to health issues, increasing the economic burden on the healthcare system.

c. **Tourism Impact:**
   The unsightly plastic pollution can negatively affect India's tourism industry. Reduced tourist inflow can result in economic losses for communities and businesses that depend on tourism.

d. **Impact on Agriculture:**
   Plastic pollution can impact agricultural lands, affecting crop productivity. The presence of microplastics in soil and water can lead to reduced soil fertility and damage to the agricultural sector.

e. **Loss of Biodiversity:**
   The environmental impacts of plastic pollution can lead to a loss of biodiversity, which can affect various economic sectors, including fisheries, forestry, and agriculture.

f. **Economic Opportunities Lost:**
   Inefficient plastic waste management means the country misses opportunities in recycling, waste-to-energy technologies, and the production of eco-friendly alternatives to plastic. Developing a Circular Economy for plastics could create jobs and stimulate economic growth.

15.2. CURRENT STATUS

15.2.1. Initiatives for Plastics Circularity in India

In 2021, India became the first Asian country to launch a Plastics Pact with targets of making 100% plastic packaging reusable or recyclable and recycling 50% of plastic packaging by 2030. The India Plastics Pact, a collaboration model amongst stakeholders across the value chain, is to promote circularity of plastics by reducing, redesigning, fostering collaboration and enabling a fair transition to circularity. A CII initiative, it is the first Plastics Pact in Asia and part of the Plastics Pact network by the Ellen McArthur Foundation & WRAP. It provides a roadmap to achieve the 2030 goals, with investments required, stakeholders involved and potential challenges to be addressed. It currently has 54 signatories.

The Wealth to Waste mission was established in 2021 with the goal to create a circular economy that was financially feasible. The amendments made to the Plastic Waste Management Rules in 2022 include targets to increase the use of recycled content in packaging and eliminate single use plastics. Amendments have been made to EPR guidelines to drive demand for quality recycled material. The Swachh Bharat Abhiyan (Clean India Mission) is another initiative contributing to improved management of plastic waste.

TERI (The Energy & Resources Institute) has provided the below guidance on achieving circularity for Plastics:

Table 15-2: TERI's Guidance on Achieving Circularity for Plastics

OBJECTIVE 1 - Adopting sustainable material solutions-use of bio-based polymers, substitution of virgin polymer with recycled polymer, and dematerialization of plastic products		
R&D around sustainable material solutions	Green Procurement	Technology based solution
Targets (voluntary & mandatory) for adoption of sustainable material solutions	Incentivizing sustainable material use	Awareness generation
Circular designs on plastic products (including packaging)	Knowledge creation	Business development support programme
OBJECTIVE 2 - Increase supply of good quality secondary plastics feedstock (recycled plastics)		
Informal sector integration with formal sector	Infrastructure for waste recycling	Awareness generation
Capacity Building	Incentivize supply of quality recycled plastics	Knowledge creation
OBJECTIVE 3 - Invent, innovate, and encourage alternative uses of diffi¬cult to recycle plastic waste		
Expanding reutilization	Infrastructure for existing and new uses	Industry collaboration and partnership
R&D to ¬find economically viable alternative new uses	Business development support programme	

15.2.2. Other Best Practices/ Innovations in achieving circularity of Plastics:

- **Chemical Recycling:**
  Chemical recycling is an advanced recycling process that breaks down polymers to their building blocks – hence producing recycled plastic with similar properties as virgin plastic. This enables recycled plastic to be used in industries with strict regulations eg. Food, pharmaceuticals. It also enables recycling of plastics like films and laminates, which are challenging to recycle through mechanical recycling, hence ending up in landfills.
- **Bio-based Plastics:**
  Bio-plastics are commercially viable plastics made from bio-based, renewable sources. 100% bio-based plastics are produced at a capacity of 2 million tons/year globally. Depending on the source, they can offer a lower carbon footprint, improved material properties and bio-degradation as an end of life option.
- **Elimination/Ban of micro plastics:**
  When plastics break down into microplastics, they become challenging to capture and recycle. By eliminating microplastics, recycling systems can more effectively recover and process whole plastics, improving the efficiency of material recovery and reuse. Additionally, focusing on microplastic elimination encourages companies to design products that do not fragment easily, promoting durable and high-quality materials. This design innovation supports circularity by reducing waste and creating products that last longer and retain value.
- **Re-use and return programs for customers:**
  Providing reuse and return options for plastic packaging is a powerful approach to fostering a circular economy, enabling customers to actively participate in reducing plastic waste. In this system, companies offer durable, reusable packaging that customers can return after use, allowing it to be cleaned, refilled, or repurposed instead of discarding it. This shift not only reduces single-use plastic consumption but also lowers production costs and minimizes environmental impact. Reuse and return programs can be implemented in various forms, from refill stations for household products to deposit-return schemes for beverage bottles. By incentivizing customers through discounts or rewards, companies can encourage higher participation.
- **Advanced sorting & recycling technologies:**
  AI-based and advanced sorting technologies are revolutionizing the circular economy for plastics by enhancing recycling efficiency and material recovery quality. These systems use machine learning and computer vision to identify, sort, and separate plastics more accurately than traditional methods, increasing the volume of high-quality recycled material. One leading technology is near-infrared (NIR) spectroscopy, which can detect different types of plastics based on their molecular composition, even in mixed waste streams. Combined with AI, these systems can recognize complex packaging formats and multiple resin types, directing them to the correct recycling paths. Robotic arms equipped with AI-driven sensors can precisely pick and place items, further improving sorting accuracy and speed. High-speed cameras, laser-based detection, and X-ray technology are also used to detect foreign objects and multi-layer materials, making it possible to recycle previously challenging items. With these cutting-edge technologies, recycling facilities can achieve higher purity levels in recovered plastics, allowing for a broader range of applications and strengthening the circular economy by ensuring that more plastics are reused and less ends up as waste.

15.3. GAPS, CHALLENGES AND LEARNINGS

The global plastic crisis is a pressing environmental issue, with significant implications for ecosystems, human health, and the economy. Despite numerous efforts to address this problem, several policy gaps persist, hindering effective solutions. Here are some key areas where policy interventions are needed:

1. While some international agreements address plastic pollution, a comprehensive global treaty is still lacking.
2. The current EPR implementation is more like CSR activity. The EPR laws are in place, but enforcement is often lax, leading to inadequate waste management and recycling.
3. More funding is needed to develop sustainable alternatives to plastic, such as biodegradable materials and innovative recycling technologies
4. Research into circular economy models can help reduce plastic waste and promote reuse and recycling.
5. Recycling is hindered by contamination from other materials, making it difficult to process and reuse plastic effectively.
6. Accurate data on plastic production, consumption, and waste generation is crucial for effective policymaking.
7. Brands must design for recycling so as to ease the process of collection, segregation and recycling back into packaging products.

Despite advancements in plastic recycling technologies, significant infrastructure and technology gaps persist, hindering the effective recovery and reuse of plastic waste. Here are some key areas where improvements are needed:

1. Lack of proper segregation at source hinders efficient sorting and recycling.
2. Many regions lack adequate waste collection and sorting infrastructure, especially in rural areas.
3. Existing recycling facilities may have limited capacity, unable to handle the volume of plastic waste generated
4. Some recycling technologies may be outdated or inefficient, limiting their ability to process certain types of plastic.
5. Scaling up chemical recycling facilities to meet demand can be challenging due to technical and economic factors
6. Lack of standardized quality control measures can make it difficult to ensure the consistency and reliability of recycled plastic.
7. More research and development are needed to improve recycling technologies as the current market is difficult for recycled plastics as the brands have stringent physical and chemical requirements and are unwilling to pay a fair price for recycled plastics.

Despite the growing concern about plastic pollution, a significant lack of awareness about plastic recycling persists among the general public. This lack of awareness can have a detrimental impact on recycling efforts, leading to improper disposal, contamination, and reduced recycling rates.

15.4. VISION FOR A CIRCULAR ECONOMY

India envisions a plastic circular economy that continuously reuses, recycles, and recovers plastic waste, transforming it into a valuable resource while minimizing environmental impact. This transition away from a linear "produce-use-discard" model emphasizes a sustainable, resource-efficient approach. Key aspects include designing recyclable or reusable plastic products, enhancing durability to reduce waste, and replacing single-use plastics with alternatives where possible. By investing in advanced sorting technologies and setting minimum standards for recycled polymers, such as those for rPET, India can improve material quality and promote safety across industries.

Scaling chemical and mechanical recycling technologies will ensure a broader range of plastics are reprocessed, expanding their applications and conserving resources. Additionally, reducing dependency on fossil fuels and creating jobs within recycling, manufacturing, and waste management sectors will drive economic growth and social equity. Trade regulations that incentivize recycled plastic use and discourage waste dumping will strengthen India's circular economy, while uplifting standards in the informal waste sector will enhance traceability, remuneration, and resilience in reverse value chains.

Strategies for promoting circularity of plastics:

Promoting a Circular Economy in plastics is crucial for reducing waste, conserving resources, and minimizing environmental impacts. Here are some key strategies to promote a Circular Economy in plastics:

1. **Design for Recyclability:** Encourage the design of plastic products and packaging that are easy to recycle. This includes using mono-materials and avoiding complex, mixed materials that are difficult to separate and recycle. For example, Coke currently uses HDPE material for PET bottle caps while Pepsi uses PP material. Standardizing the cap material would simplify PET bottle recycling and eliminate the need for polymer sorting to separate PP and HDPE. As other example, decomposable material may be used as a wrapper on the water bottles instead of PVC film.
2. **Extended Producer Responsibility (EPR):** India has taken a lead among developing countries in implementing EPR for plastic waste. With a country of the size of India, it is important to monitor the implementation of EPR continuously and closely.
3. **Recycling Infrastructure:** Invest in and expand recycling infrastructure, including collection systems, sorting facilities, and recycling plants. This ensures that plastics collected for recycling can be effectively processed and turned into new products.
4. **Bottle-To-Bottle Recycling:** Promote the use of recycled plastics in manufacturing new products. This helps create a closed-loop system, reducing the need for virgin plastic production.
5. **Consumer Education:** Raise awareness and educate consumers about the importance of recycling and proper disposal of plastics. Make recycling easy and accessible to the public.
6. **Innovative Recycling Technologies:** Support research and development of innovative recycling technologies, such as chemical recycling and advanced sorting techniques, to improve plastic recycling efficiency.
7. **Plastic Bans and Regulations:** Enact regulations and bans on single-use plastics or non-recyclable plastics to reduce their production and use. Use of alternate materials must also be promoted at the same time to change user behaviour patterns.
8. **Market Demand:** Encourage businesses and industries to use recycled plastics in their products. The Government of India has created such incentives under the EPR scheme. This must be followed through religiously by all stakeholders.
9. **Circular Business Models:** Encourage businesses to adopt circular business models, such as leasing or take-back programs, which promote reuse and recycling of products rather than disposal.
10. **Collaboration:** Foster collaboration among central government, state governments, producers, recyclers, and waste management organizations to create a unified approach to tackling plastic waste. This includes setting common recycling and sustainability goals.
11. **Consumer Behaviour Change:** Promote behaviour changes among consumers to reduce plastic consumption, opt for reusable alternatives, and make sustainable choices.

15.5. EXTENDED PRODUCER RESPONSIBILITY

Plastic Waste Management (Amendment) Rules, 2022 mandate EPR for plastic packaging. This means producers, importers, and brand owners are responsible for managing plastic packaging waste. The plastic categories covered under the Extended Producer Responsibility (EPR) include rigid plastic packaging (Category I), flexible plastic packaging of single layer or multilayer (Category II), multi-layered plastic packaging (Category III), plastic sheets and packaging made from compostable plastics (Category IV), and this amendment establishes recycling targets for these packaging materials on producers, importers and brand owners.

The minimum level of recycling (excluding End-of-Life disposal) of plastic packaging waste (% of EPR) for the Producers, Importers and Brand Owners (PIBOs) are given below:

Plastic packaging category	2024-25	2025-26	2026-27	2027-28 and onwards
Category I	50	60	70	80
Category II	30	40	50	60
Category III	30	40	50	60
Category IV	50	60	70	80

The Mandatory use of recycled plastic in plastic packaging (% of manufactured/imported plastic for the year)

Plastic packaging category	2024-25	2025-26	2026-27	2027-28 and onwards
Category I	30	40	50	60
Category II	10	10	20	20
Category III	5	5	10	10

15.6. GOALS AND TARGETS

Plastic pollution remains a significant challenge in India. However, a paradigm shift towards a circular economy for plastics presents a promising opportunity to address this issue. This action plan outlines ambitious yet achievable goals and targets, aiming to transform the way plastics are produced, consumed, and managed in India. By focusing on key areas like reducing virgin plastic use, expanding single-use plastic bans, and enhancing recycling rates, a more sustainable future can be created for plastic in India. Here's a breakdown of our proposed goals and targets:

Table 15-3: Proposed Goals and Targets

S.No.	Proposed goals and targets	Timeline for Achievement	
		2025	2030
1	**Reduction in utilization of virgin plastics (%) compared to 2022**	5	10
2	**Expand the list of SUP materials banned to enhance the percentage of total plastic waste covered under SUP ban (%)** *[Basis for target: The share of plastic used for the banned single-use plastic products is less than 2%-3% of the total plastic waste generated in India, the industry estimates. https://scroll.in/article/1034134/three-months-in-indias-ban-on-single-use-plastic-has-flopped]*	6	10
3	**Percentage of plastic packaging to be effectively recycled (%)** *[Basis for target: The proposed target is in line with the India Plastics Pact targets to 2030.]*	20	30
4	**Increase the collection and recycling of plastic waste (% of plastic waste generated)** *[Basis for target: India recycles only 30 per cent of 3.4 MT plastic waste generated annually https://economictimes.indiatimes.com/news/india/india-recycles-only-30-per-cent-of-3-4-mt-plastic-waste-generated-annually-report/articleshow/96918352.cms]*	75	90
5	**Increased consumption of plastics in construction as a substitute to conventional construction materials (%)**	2	4
6	**Average recycled content across all plastics packaging (%).** *[Basis for target: The proposed target is in line with the India Plastics Pact targets to 2030].*	15	25
7	**Percentage of plastic packaging to be reusable, recyclable, or compostable (%)** *[Basis for target: The proposed target is in line with the India Plastics Pact targets to 2030].*	50	100

For effective monitoring and evaluation (M&E), to track the progress of plastic recycling targets and ensure that initiatives are on track, some of the key strategies to consider include:

1. Enroll third-party auditors to ensure the quality and claims of recyclers under the EPR system.
2. Publish names of non-compliant recyclers and brand owners to ensure higher compliance.
3. Enroll PROs to take accountability on behalf of brand owners.
4. Require customers of recycled plastics to audit the entire plastic value chain ensuring the movement of waste plastic from collection to recycling
5. Ensure timely and regular data upload of EPR compliance, minimum level of recycling achieved, and volume of recycled content used in packaging to monitor progress.

By implementing effective monitoring and evaluation strategies, organizations can track the progress of plastic recycling targets, identify areas for improvement, and ensure that initiatives are delivering the desired outcomes.

15.7. IMPACT POTENTIAL

Achieving a circular economy for plastics offers transformative benefits across environmental, economic, and social dimensions:

Environmental Sustainability:

- **Waste Reduction:** Diverts plastic from landfills, reducing pollution and preserving soil and water quality.
- **Resource Conservation:** Reduces reliance on virgin resources like crude oil, conserving natural reserves and protecting ecosystems.
- **Pollution Prevention:** Limits plastic waste entering natural habitats, protecting wildlife and biodiversity from contamination.
- **Lower Greenhouse Gas Emissions:** Recycling plastic typically requires less energy than manufacturing new plastic, decreasing GHG emissions and mitigating climate change.
- **Reduced Incineration Impact:** Minimizes the need for plastic incineration, which releases pollutants and GHGs into the atmosphere.

Economic Growth:

- **Job Creation:** Supports employment in recycling, sorting, processing, and manufacturing sectors, building a green economy.
- **New Market Opportunities:** Encourages innovation in recycled products, fostering growth in industries like construction, automotive, and consumer goods.
- **Cost Savings:** Reduces costs associated with raw material extraction, manufacturing, and waste disposal, benefiting businesses and economies.
- **Economic Resilience:** Reduces dependency on imported fossil fuels, stabilizing economies against price fluctuations and supply risks.

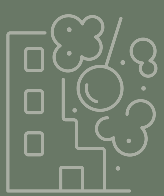
Social and Community Benefits:

- **Enhanced Public Health:** Reduces plastic-related pollution in communities, lowering health risks associated with plastic exposure.
- **Social Equity:** Drives sustainable development in marginalized communities through job creation and better waste management practices.

A circular economy for plastics maximizes resource value, reduces environmental impact, and promotes economic and social resilience, paving the way for a sustainable and inclusive future.

References

1. India's plastic recycling market and innovation landscape - Innovate UK Business Connect
   https://iuk-business-connect.org.uk/perspectives/indias-plastic-recycling-market-and-innovation-landscape/#:~=In%202021%2C%20India%20has%20become,of%20plastic%20packaging%20by%202030.
2. India Plastic Industry Market Size - Mordor Intelligence
   https://www.mordorintelligence.com/industry-reports/analysis-of-plastic-industry-in-india/market-size
3. India Plastics Pact
   https://www.indiaplasticspact.org
4. Chemical recycling - Plastics Europe
   https://plasticseurope.org/sustainability/circularity/recycling/chemical-recycling/#:~=Chemical%20recycling%20is%20the%20process,of%20plastics%20or%20other%20products
5. Bioplastics for a circular economy - Nature Reviews Materials
   https://www.nature.com/articles/s41578-021-00407-8
6. A snapshot of Marine Plastic Pollution in South Asia - World Bank, 2024
   https://documents1.worldbank.org/curated/en/099933108202431142/pdf/IDU18e0bbc271c078143281a4e016dc43e77b919.pdf
7. CPCB Annual Report 2020-21 on Implementation of Plastic Waste Management Rules, 2016
   https://cpcb.nic.in/uploads/plasticwaste/Annual_Report_2020-21_PWM.pdf
8. Circular Economy for Plastics in India: A Roadmap - TERI, 2021
   https://www.teriin.org/sites/default/files/2021-12/Circular-Economy-Plastics-India-Roadmap.pdf



Chapter 16

CIRCULAR ECONOMY ACTION PLAN *for* CONSTRUCTION *and* DEMOLITION WASTE

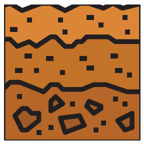
16.1. INDUSTRY OVERVIEW

Construction sector is the second largest employer in India contributing to 9% GDP and is poised to become world's third largest construction market by 2025 with a market valuation of 1.4 Trillion USD and CAGR of 6.6% especially with the ambitious government missions like Smart Cities, Housing for all, Industrial Corridors, data centers, etc., and fast pace of development.

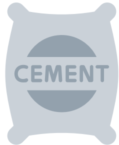
Construction accounts for nearly 65% of the total investment in infrastructure and the trend is increasing. Over 51 million people are involved in this sector directly or indirectly. It is estimated that almost 70% of buildings supposed to exist by 2030 are yet to be built which involves mined and quarried materials like sand, soil, stone and limestone. India is currently undergoing a rapid transition towards urbanization, where the urban population is expected to become half of the total population by 2050. However, to fulfil the overwhelming housing requirements of the burgeoning urban population, India needs to construct around 170 million houses by 2030. India is therefore expected to join the United States and China as one of the leading nations in the global construction sector by 2030.

Estimated annual consumption of construction materials in India

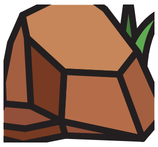
SAND -
750 million
TONNES



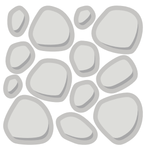
SOIL -
350 million
CUBIC METERS



CEMENT -
297 million
TONNES



STONE (AGGREGATE) -
2 billion
TONNES

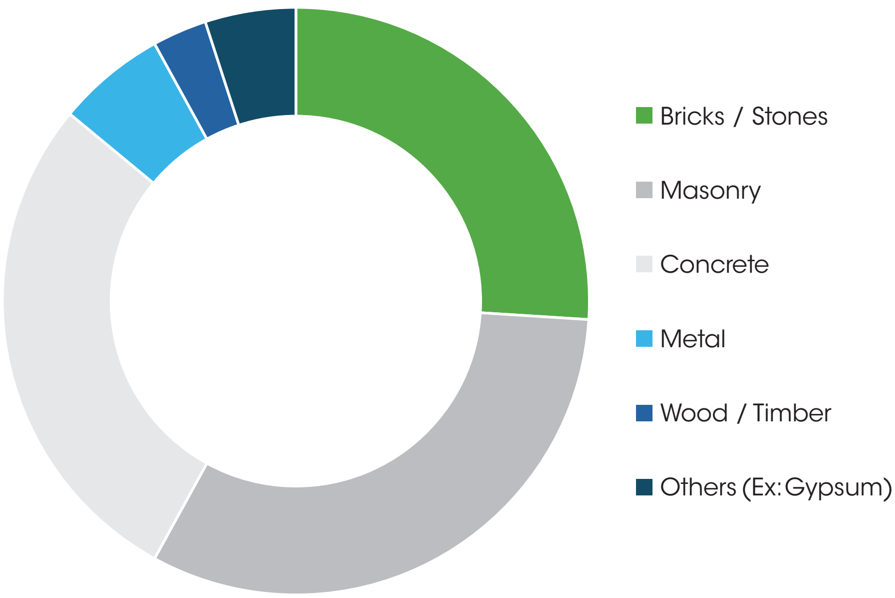


LIMESTONE -
242 million
TONNES

16.2. CURRENT STATUS

Expansion of the construction sector strains the environment twofold: it generates a pressing demand for natural aggregates and necessitates the management of construction waste of new structures & demolition waste from existing structures. Projections for building materials in India, indicated a demand of 400 million cubic meters of aggregates for the year 2021–22. Recycling and reusing C&D wastes can ease the growing pressure on natural resources. The key characteristics of C&D wastes in India consists of Bricks (26%), Masonry - soil, sand & gravel (32%), Concretes (28%), Metal (6%), Wood (3%), and others (5%). In fact, excavations, concrete, masonry and wood together constitute over 90% of all C&D waste.

Indian C&DW characteristics



Source: CPCB Guidelines on dust mitigation measures in handling construction material and C&D wastes
Note : Also the numbers (%) are missing in this donut graph

Depending upon the population size, the share of C&D wastes in solid wastes is estimated as per the table given below:

Table 16-1: Share of C&D Waste in Solid Waste

S/No	Urban Population Categories	C&D waste generation (as % of total solid wastes)
1	More than 10 million	~25%
2	(1-10) million	(20-25)%
3	(0.5-1) million	(15-20)%
4	Less than 0.5 million	10%

Source : Circular Economy in Municipal Solid and Liquid Waste (MoHUA)

India has a much lower recycling rate at (20-25) % as compared to Europe (70 %), and Japan (90%). Construction and demolition waste (C&DW) comprises the largest waste stream in India, with cities like NCR, Noida, Hyderabad having C&D recycling plants with remarkable recovery rates of high grade aggregates which are reused in bound applications and these cities are well on the path of making a circular construction sector. A few other Indian cities also have C&D plants however a close scrutiny of waste management practices reveals that C&DW recovered material is majorly based in backfilling operations and low-grade recovery, such as using recycled aggregates in road sub-bases.

Discussions are on how to make aggregate of better quality in the existing plants. And for non-attainment cities wherein spillage, safety and dust are identified as key operational challenges and a need for stronger mandate for using recycled product and better economics for wet processing technology have been felt. This paper examines how circular economy-inspired actions can help achieve waste policy objectives, namely waste prevention and increase both the quantity and the quality of recycling for C&DW while reducing contaminant materials in the waste.

There are two main ways in which recycled aggregate is reused:

- Substituted for mined aggregate in lower grades of new concrete
- Substituted in unbound applications such as road construction and earthworks.

The choice of application is based on the optimum balance of sustainability, local availability and long-term technical performance.

A third route for recycling concrete under development is the use of the fine particles from crushed concrete as a secondary raw material in clinker and cement production (EN 197-6).

16.3. CHALLENGES AND ROADBLOCKS

The two primary issues that need addressing are:

1. The lack of efficient sorting and collection of Construction & Demolition Waste (C&DW).
2. Insufficient demand due to limited confidence in the technical quality of recycled aggregate materials.

A potential third challenge is the distance to new construction sites, where long transport distances make it difficult to reach potential clients cost-effectively.

Challenges and roadblocks at Municipal bodies / Local authorities level:

- C&D waste is often mixed with other solid waste, especially from legacy dumps, complicating management.
- Municipal bodies lack adequate monitoring capacity and experience in managing C&D waste.
- Limited land availability at city peripheries affects project feasibility.
- Data gaps in waste quantification hinder effective management and require guidance.
- Many cities lack dedicated helplines and MIS for handling collection requests and grievances.
- SOPs and MIS frameworks are often insufficient for efficient waste management.
- The informal sector handling collection and processing is poorly integrated into formal systems.
- Numerous cities, particularly non-attainment and large cities, have yet to establish C&D waste bye-laws.
- Recycling newer materials like plastics, asbestos, and insulation presents technical challenges.
- Waste from major infrastructure projects, such as metro rail construction, requires specialized management.

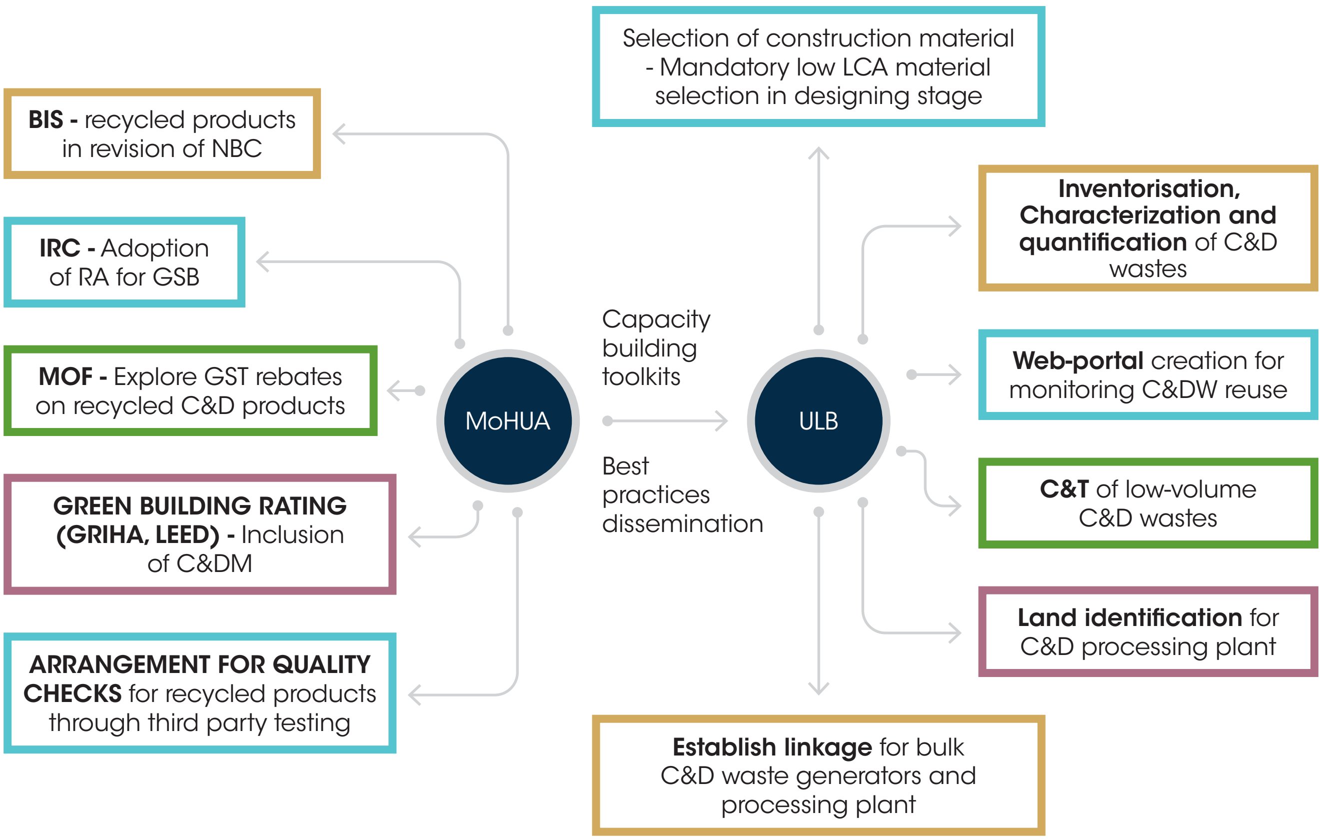
Challenges and roadblocks at the level of waste generators / operators and recyclers:

- Despite IRC-121:2017 standards, market uptake of C&D waste-based products remains low due to limited buyer confidence.
- General lack of awareness and concern hampers adoption of recycled materials.
- The demolition sector is dominated by unorganized players, impacting recycling efforts.
- Buyers exhibit low confidence in the quality of recycled products.
- Processing and recycling facilities are still in early stages and need strong process guidance for effective scaling.

16.4. PROPOSED CIRCULAR FRAMEWORK

Though the roles of stakeholders are defined clearly in the Construction and Demolition Waste Management Rules, the onus of monitoring & evaluation lies majorly with ULBs and Circular Economy adoption with MoHUA as mentioned in Figure 16-1 below.

Figure 16-1: Roles of MoHUA and ULBs



The Draft Construction and Demolition Waste Management Rules, 2024, outline mandates for waste utilization, EPR, environmental compliance standards with penalties, and IEC activities. However, field studies indicate that several specific, relevant, and achievable bottlenecks still need to be addressed to enhance implementation. Key areas for improvement include:

- Expedite the framing and notification of C&D waste bye-laws, particularly for all cities with populations over a million.
- Urban Local Bodies (ULBs) should identify and notify secondary collection points and transfer stations for C&D waste.
- To promote market uptake of recycled C&D waste products, government and private entities could consider preferential buy-back policies, as well as eco-labeling and green certification of products.
- In smaller towns with lower C&D waste generation, mobile crushing units can be a practical solution, addressing both processing needs and land scarcity.
- Swachh Survekshan should include new ranking

benchmarks that capture data on C&D waste collection and processing.

- ULBs should adopt dynamic user charges and establish a funding stream dedicated to legacy waste management.
- Address air pollution from construction sites by enforcing dust control measures and penalties for non-compliance; ensure compliance with CPCB guidelines on dust mitigation during on-site activities, transportation, and storage of C&D materials.
- ULBs should implement comprehensive awareness, capacity building, and enforcement initiatives. Examples include Pimpri-Chinchwad, Nagpur, and Gurugram, which have reduced illegal dumping by 60% by deploying dedicated flying squads and outsourcing surveillance for regular inspections and enforcement.

Source: C&D waste: Closing the waste loop for sustainability (Centre for Science & Environment)

Strategies to Achieve Circularity with C&D Waste:

- **Data on Waste Generation:**
  Accurate estimates of C&D waste volumes are essential for planning future infrastructure, recycling capacity, and incentives. Currently, C&D waste from building projects can be projected using built-up area data from the RERA portal, combined with TIFAC estimates (e.g., 50 kg of construction waste per m² of built-up area, 300-500 kg of demolition waste per m² demolished). Many ULBs have set up recycling plants with conservative capacities, but these must be expanded to account for untracked waste.
- **Collection Systems for Small Generators:**
  While bulk generators often transport waste to designated sites, collection systems for smaller generators are also needed. In the Building Permission-Linked Model, builders pay a C&D waste fee when obtaining permits, as in Delhi, with waste sent to designated points. The On-Demand Door-to-Door Model uses helplines for pickup requests, as seen in Pune and Gurugram. In the GPS and RFID-Enabled Tipping Fee Model, tagged skip bins allow efficient waste tracking and transport to disposal sites.
- **Creating By-Laws:**
  Effective C&D waste management requires clear, enforceable by-laws outlining generator responsibilities, agency roles, and compliance requirements, including penalties. Detailed by-laws should specify each agency's duties to prevent overlap and improve coordination. An overarching body to oversee implementation could further streamline processes and resolve administrative challenges.
- **Establishing User Charges:**
  Once recycling plants are operational, generators should transport new C&D waste there and pay user fees. Since managing legacy waste is costly for ULBs, an additional funding mechanism from generators could help cover these expenses.
- **Enforcement:**
  Effective C&D waste compliance requires robust enforcement, including a penalty system and on-ground inspection teams to monitor adherence to regulations.
- **Public Awareness & Capacity Building:**
  Public awareness is being raised in some cities through newspaper ads, local TV, and self-help groups. Standard procedures and training for collection teams are essential, and additional tools like posters, jingles, and campaigns with resident associations and civil groups can further educate the public and enhance compliance efforts.

16.5. ENABLERS

There have already been several guidelines issued by statutory bodies on reusing and uptake of the C&D waste materials:

- IRC (Indian Road Congress IRC:121 - 2017) suggests usage of Recycled Aggregates (RA) and Recycled Concrete Aggregates (RCA), for all categories of roads – State, National Highways and Major District Roads. Also in form of embankments, Flexible pavements, Concrete pavements, Paving Blocks and Kerb stone.
- Indian Standards (IS 383) Revised IS 383 permits use of (RA) up to 25% in plain concrete, 20% in reinforced concrete of M-25 or lower grade and up to 100% in lean concretes of grade less than M-15.
- National Building Code (NBC – CED 46) of India 2005 recommends usage of RCA to replace (30 - 50) % of natural crushed coarse aggregates depending on compression-specific usages.

On July 29, 2024, the Ministry of Environment, Forest and Climate Change (MoEF&CC) notified the draft "Construction and Demolition Waste Management Rules, 2024," which will come into force on April 1, 2025. This comprehensive revision of the existing regulations strengthens measures for waste management and utilization, aligning them with circular economy principles. Key additions include EPR, environmental compensation, and a centralized online monitoring system for improved compliance assessment. Responsibility of stakeholders as per these rules are given in the table below:

Table 16-2: Responsibilities of Stakeholders as per C&D Waste Management Rules, 2024

Bulk Waste Generator / Producer • **Segregate wastes on site –** (a) Concrete (b) Soil (c) Bricks (d) Steel (e) Wood (f) Plastics • **Demolition as per "IS 4130:** Safety code for demolition of buildings" • **Implement sustainable building practices as per "IS 15883: 2021 –** Guidelines for construction project mgmt. (Part-11)"	**Central Government** • **MoHUA –** Progressively update schedule of rates • **MoRTH –** Promote utilization of C&DW in road construction, guidance manuals for such usage • **Mo Commerce & Industry –** Listing of processed fractions in GeM • **MoF –** Fiscal measures to increase competitiveness of recycled C&DW • **MoRD, MoJS, Ministry of Panchayati Raj –** IES activities in rural areas
Recycler / Operators of Intermediate waste storage facility • Registration on the portal, and payment of registration and other fee as may be prescribed under these rules • Following SOPs prescribed by CPCB or SPCB / PCC • Disposal of rejects after recycling to nearest SLF as per CPCB SOP	**CPCB** • Maintenance of EPR portal and monitoring compliance • **Detailed guidelines & SOPs –** EPR implementation, waste utilization framework • Action against violations and non-compliance • **Training programs for capacity building –** SPCBs, ULBs, State Gov, etc.,
BIS / IRC • Preparation of codes and practices for use of recycled C&DW in construction activities and road constructions	**State government / ULB / UT / SPCBs** • Inventory of wastes including legacy wastes to be prepared. • Supporting local authorities in identification and setting up of intermediate waste storage facilities & processing sites on local / regional / cluster basis • Levy compensation against non-complaint construction activities

16.6. GOALS AND TARGETS

The Construction and Demolition Waste Management Rules, 2024 has clearly laid out timely targets for EPR framework as well as mandated minimum waste utilization for both building and road construction.

Table 16-3: Targets for Recycling of Waste as per EPR Framework

Year	Re-construction Projects	Demolition Projects
2025-26	50%	50%
2026-27 onwards	100%	100%

Table 16-4: Minimum targets for utilisation of waste in construction / re-construction and road construction activities

Year	Waste utilization mandate for construction & reconstruction	Waste utilisation mandate for road construction
2026-27	5%	5%
2027-28	10%	5%
2028-29	15%	10%
2029-30	20%	10%
2030-31 and onwards	25%	15%

Apart from the recycling targets as per EPR framework and the targets for utilization mentioned above, the following targets may be considered:

S.No.	Proposed Target	Timeline for Achievement	
		2025	2030
1	**Reduction (%) in the generation of C&D waste by promoting more sustainable construction practices.** *[Aligns with IGBC-CII 'Net Zero Waste Rating System for Buildings and Built environment']*	5	10
2	**Increase (%) in collection & recycling of C&D waste.** *[CSE study 'Another Brick of the wall: Improving C&D waste management in Indian cities' (https://www.cseindia.org/another-brick-off-the-wall-10325)]*	20	40
3	**Sustainable procurement for government agencies and large corporations (as % of the total cost)** *[In line in IGBC-CII 'Net Zero Waste Rating System for Buildings and Built environment']*	10	20
4	**Use of processed C&DW in construction and reconstruction** *[In line with EPR targets under C&DW rules, 2024]*	5%	25%
5	**Use of processed C&DW in road construction** *[In line with EPR targets under C&DW rules, 2024]*	5%	15%

16.7. IMPACT POTENTIAL

- Recycled aggregate (RA) can reduce the environmental cost of concrete. Cost saving in recycled C&D waste products as per a project estimate is:

Precast Products	% Saving
Bricks, Solid block, Paving block	25
Lean Concrete	30
Concrete Mixes upto M30	15
Dry Mortar Mix	35

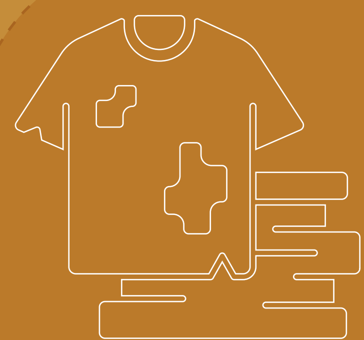
- Eliminates the waste that ends up in river and lake beds, thus conserving natural resources. Natural resources are essential for our survival. Land, forests, water, fisheries, minerals, and air—these are all important to sustain life.
- Additionally, national GHG emissions from the construction industry is estimated to be about 30 % out of which 97 % is attributed to indirect emissions resulting from construction material production such as steel, cement, lime, brick etc., and services required for construction operations. For India, it is estimated that about 80 % of construction sector's GHG emissions comes from materials likes cement, bricks, steel and lime. Thus recycling also reduces GHG emissions and energy consumption since it requires less energy to produce recycled aggregate than mine virgin aggregate.

References

1. Invest India: Construction Sector https://www.investindia.gov.in/sector/construction
2. CSE Report: Another Brick of the wall: Improving C&D waste management in Indian cities (Centre for Science & Environment) (https://www.cseindia.org/another-brick-off-the-wall-10325)
3. CPCB guidelines on environmental management of Construction and Demolition (C&D) wastes https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvNTUyXzE1MTEyNjQwMTVfbWVkaWFwaG90bzQ2OTAucGRm
4. Strategy for Promoting Processing of Construction and Demolition (C&D) Waste and Utilisation of Recycled Products (NITI Aayog – MoHUA Draft) https://www.niti.gov.in/sites/default/files/2019-03/CDW_Strategy_Draft%20Final_011118.pdf
5. Global Powers of Construction 2023 (Deloitte) https://www.deloitte.com/global/en/Industries/energy/perspectives/deloitte-global-powers-of-construction.html
6. Global construction prospects (Aecom) https://publications.aecom.com/MEH/report/global-construction-prospects-2024
7. CPCB Guidelines on dust mitigation measures in handling construction material and C&D wastes (https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvNTYxXzE1MTE5MzMzNzJfbWVkaWFwaG90bzEyNjcxLnBkZg==)
8. Circular Economy in Municipal Solid and Liquid Waste (MoHUA) (https://mohua.gov.in/pdf/627b8318adf18Circular-Economy-in-waste-management-FINAL.pdf)
9. Guidelines for use of construction & Demolition waste in road sector (IRC:121-2017) (https://law.resource.org/pub/in/bis/irc/irc.gov.in.121.2017.pdf)
10. C&D waste: Closing the waste loop for sustainability (Centre for Science & Environment) (https://www.cseindia.org/construction-and-demolition-waste-11992)
11. Utilisation of Recycled Produce of Construction & Demolition Waste: A ready reckoner (BMTPC 2018) (https://www.bmtpc.org/DataFiles/CMS/file/PDF_Files/C&D_Ready_Reckoner_BMTPC_web.pdf)
12. Construction and Demolition waste factsheet (Centre for Science & Environment) (https://cdn.cseindia.org/attachments/0.49371000_1560337022_Construction-demolition(C&D)-WasteFactsheet.pdf)
13. Indian Standard: Coarse and Fine Aggregate for Concrete - Specification (IS 383: 2016) (https://icikbc.org/docs/IS383-2016.pdf)
14. National Building Code of India 2005 (Bureau of Indian Standards) https://nmc.gov.in/assets/admin/upload/download/National_Bild_CODE.pdf
15. Construction and Demolition Waste Management Rules, 2024. https://moef.gov.in/storage/tender/1725617021.pdf

Chapter 17

CIRCULAR ECONOMY ACTION PLAN *for* TEXTILES WASTE



17.1. INDUSTRY OVERVIEW

India is one of the largest textile and apparel-sourcing regions in the world, with processing infrastructure and a skilled workforce for almost all activities ranging from spinning to apparel production, making it a key competitive sourcing destination for most global brands. The textile and apparel industry contributes to 2% of the country's GDP, 7% of industry output in value terms and 11.4% of total exports. With 11% YoY growth in RMG (Ready Made Garments) of all textiles exports, India's textiles sector to grow to USD 350 Billion by 2030. Recently, GoI has identified 'Technical Textiles' as a thrust segment with application areas across all key sectors in India.

India's domestic consumer market is worth USD 75 billion which is also growing at a CAGR of 10%. Both the production and consumption trends lead to a significant amount of textile waste generation. Nevertheless, despite the absence of extensive technologies, India established its recycling industry back in the 1990s and today has a stronghold in mechanical recycling with a well networked value chain for the management of textile waste.

The global technical textiles market is estimated at USD212 billion in 2022 and is expected to reach USD274 billion by 2027, growing at a CAGR of 5.2 per cent during 2022-27. It is estimated that 92 million tons of textile wastes are produced every year globally which is expected to reach 134 million tons by 2030. At present, meagre amount of 20% of clothing is collected for reuse or recycling out of which less than 1% is being recycled. The textile wastes ending up in landfills amounts to 18.6 million tons annually which is projected to touch 150 million by 2050 under BAU scenario.

17.2. CURRENT STATUS

The textile industry all over the world leads to substantial waste generation during the production and consumption of textiles and apparel. This waste can be classified across three waste streams: pre-consumer (42%) which includes cut-outs and yarn scraps, domestic post-consumer (51%) and imported post-consumer waste (7%). Import of re-wearable clothing is forbidden in India. Therefore, clothes are mutilated (slashed) upon arrival. However, it was noticed that non-mutilated imported clothing was sorted in Panipat and sold to second-hand market retailers.

At present, nearly 61% of the total waste generated in India is cotton-rich material. However, there has been a considerable increase in the quantity of synthetic textile (especially polyester) waste over the last five years. The current end use and application of different textile wastes are highlighted in Table 17-1.

Table 17-1: Current end use and application of different textile wastes

Waste Type	End Use	Waste	Application
Fibre Waste	Downcycle & Repurpose	Cotton sweep waste and waste from OE spinning mills	As raw material for allied industries
	Recycle	Comber and Pneumafil waste	As coarser yarn for denim
Yarn Waste	Downcycle & Repurpose	Denim yarn, End bits of Beam	Used to make ropes
	Recycle	Sized yarn	Shredded into fibres
Fabric waste	Downcycle & Repurpose	Blended and mixed colour fibres	Bags
	Recycle	Knitted and woven white and solids cotton cut waste	White and coloured recycled yarn
	Reuse	Clean bigger and medium cut piece	Apparel
	Disposal	Soiled small cut waste	Worn clothes are sent to landfill
	Incineration	Polyester cut waste	As boiler fuel
Overproduction & Deadstock	Reuse	Garments from overproduction	Stock lot sale
Post-Consumer Waste	Downcycle & Repurpose	Blended and mixed colour clothes	Bags, filler for mattress and cushion
	Recycle	Knitted and woven white and solids cotton clothes	White and coloured recycled yarn
	Reuse	Outsized clothes	Second-hand apparel
	Disposal	Wipes made from clothes	Sent to landfill
	Incineration	Soiled clothes	Municipal incineration plant

Source: Approaches for Circular Textile and Apparel Industry in India: Baseline Assessment Report

As per estimates, approximately 7,793 kilo tons, or 8.5% of global textile waste, is accumulated in India every year. About 59% of this waste finds its way back into the textile industry through reuse and recycling but only a fraction of this makes it back into the global supply chain due to quality and visibility challenges. The remaining 41% is downcycled (19%), incinerated (5%) or ends up in a landfill (17%).

Figure 17-1: End-Use and Destination of Textile Waste in India

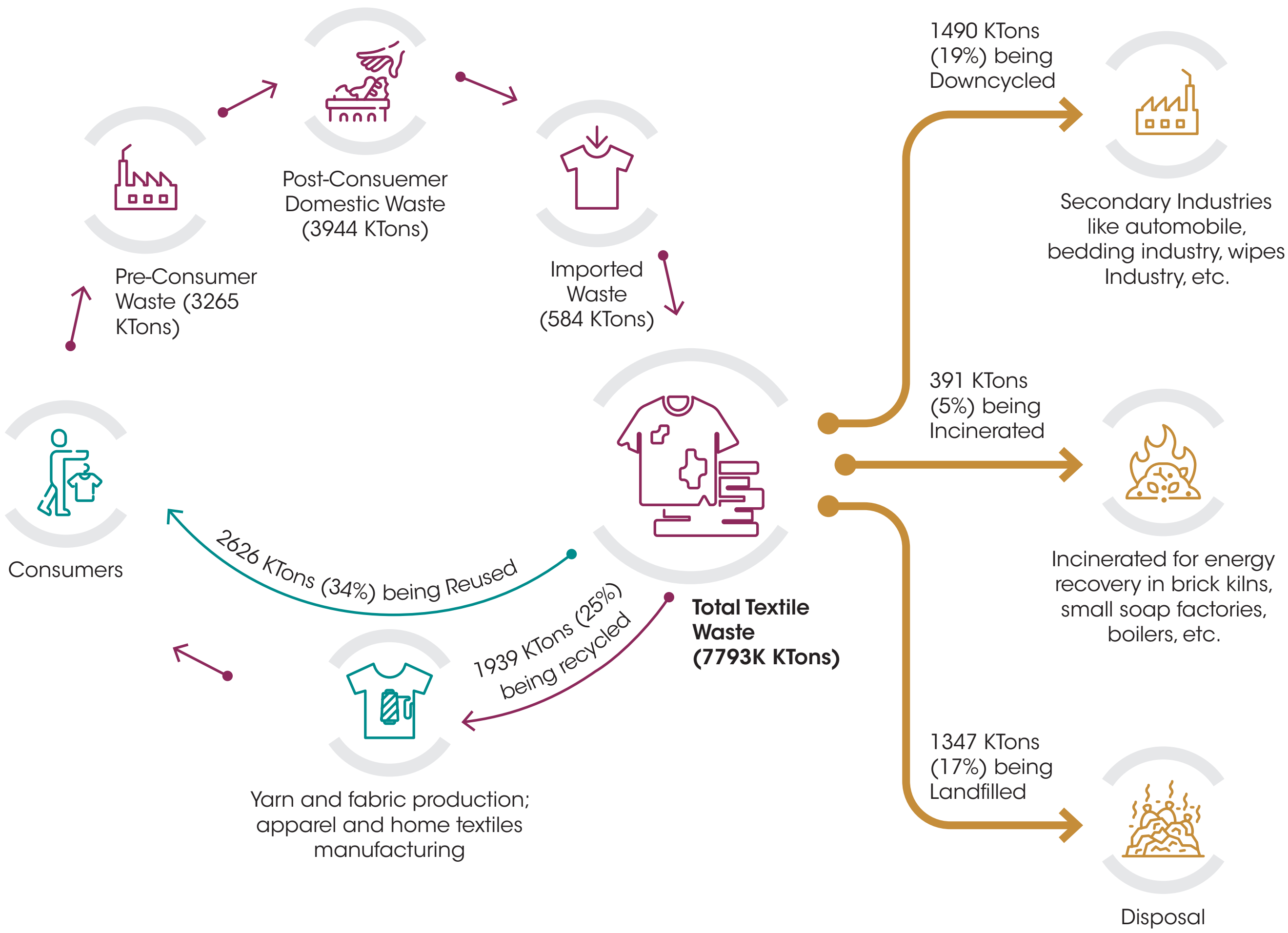


Image Source: Wealth in Waste Report - India's potential to bring textile waste back into the supply chain

Recycling hubs such as Tirupur in South and Panipat in North India continue to act as converging points for majority of the domestic and imported textile wastes. In addition, some medium and small scale recycling facilities are prominent in Amroha and parts of Rajasthan, Madhya Pradesh, Punjab and Gujarat. The history of the recycling in the textile sector is given below:

Figure 17-2: Timeline of textile and textile waste management industry in India

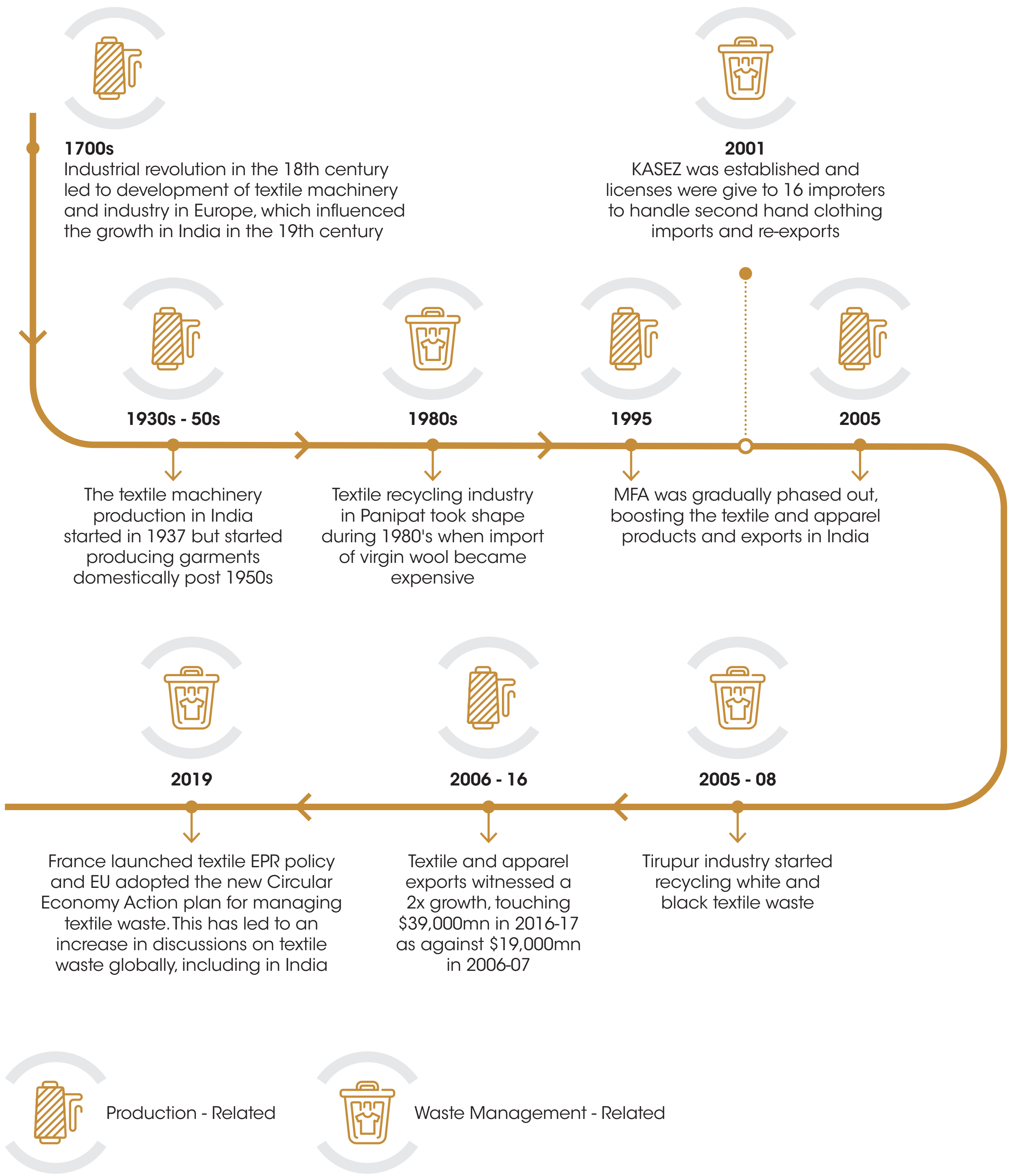


Image Source: Wealth in Waste Report - India's potential to bring textile waste back into the supply chain

17.3. GAPS AND CHALLENGES

Baseline study conducted by `Fashion for Good' highlights the key challenges:

1. Ineffective Textile Waste Management Systems

a. Lack of traceability and visibility of the waste value chain

b. High contamination rates of manually sorted materials

c. Low economic realization of fabric deadstock

d. Lack of standards to identify and sort waste across waste streams

e. Lack of regulations for domestic post-consumer waste

f. Rural areas are excluded from most of the waste management programmes of domestic post-consumer waste that are specifically designed for urban areas

2. Unorganised and informal textile waste value chains

a. Leakages of waste in the system and importing of second hand clothing

b. Procurement challenges faced by recyclers which impact the potential to valourise textile waste suitably

c. Major communication gaps between industry players in all waste streams

d. High transport costs and non-availability of transporters

3. Inefficient realisation of textile waste potential

a. Low quality of recycled yarn

b. Polyester and blends in fabric make the material unsuitable for recycling

c. Low recyclability of domestic post-consumer waste due to wear and tear

Challenges faced by Textile and Apparel Manufacturers:

- There is a lack of recognition for waste trade in the ecosystem
- In house recycling facilities unfeasible due to limited supply of waste and demand for recycled products
- Difficulties in cost and extent of sorting prevents scaling up the practice

Challenges faced by waste handlers:

- Sourcing and Procurement challenges which depends on cost and availability of the raw material
- Lack of established use-cases for handling the waste
- Economic challenges with transportation and storage of waste
- Limitations of existing rules, policies and monitoring mechanisms for waste handlers.
- Constraints with scaling of operations as nearly 30% goods are unsaleable

17.4. PROPOSED CIRCULAR FRAMEWORK

The immediate steps proposed to bring textile wastes back to the supply chain include:

1. Enabling visibility and access to waste

a. Generating less or better quality waste

b. Sorting and segregation of pre-consumer waste at factory floor

c. Sorting and segregation on post-consumer waste

d. Real time waste mapping and supply chain transparency

2. Harnessing recycling potential of India

a. Upgradation of existing mechanical recycling facilities

b. Investments in innovative chemical and mechanical recycling technologies

c. Re-evaluate and standardize minimum prices offered by brands and manufacturers for recycled Yarns

3. Establish systems, infrastructure and regulations of textile management

a. Formalize textile waste value chain, ensuring worker well-being and high value returns for all stakeholders

b. Material identification and sorting standards:

c. Extended Producer Responsibility (EPR) for textile waste

17.5. ENABLERS/STRATEGIES TO ACHIEVE CIRCULARITY FOR TEXTILE WASTES

1. **Embracing the 6R concept**
   - By decreasing waste and pollution, saving resources, and promoting economic viability, the 6Rs methodology [Refuse, Reduce, Reuse, Remanufacture, Recycle, and Regenerate (decompose)] can lead the Indian textile sector towards a sustainable and circular future.

2. **Reverse Logistics Technology**
   - Industries must enhance, accelerate (shorten) reverse logistics and supply chain capabilities by integrating digital technology in resource tracking and tracing. To boost the collection rate of old apparel, customers can be incentivized on future purchases with the same brand.

3. **Value Chain Stakeholder Education and Awareness**
   It is critical to delegate awareness, knowledge, tools, and training to all supply chain stakeholders to ensure long-term success in the circular economy implementation and stimulate innovation.

4. **Policy Instruments**
   Government policies to achieve textile circularity, such as extended producer responsibility (EPR) and product take-back programmes are required. Startup capital grants may be provided for circular business models working in the fields of collection, repair, and recycling.

5. **Research & Development**
   There is a lack of commercial cost-effective technology for recycling various fiber types and composite products which requires technological innovations. On the other hand, there are also some research being attempted to limit the negative effects of production process and reduce resource usage which includes developing cellulose-bed fibres, waterless dye processes, digital printing technologies, ZLD, etc.,

6. **Consumer Engagement**
   There must be a significant effort to alter consumption patterns toward sharing, extended usage, and reusing. New ideas, such as sharing platforms, may require significant marketing, public awareness campaigns, and retailer dedication to attract customers.

India's Readiness in Textile EPR

- India has a positive consumer behavior towards garment reuse in India, which is less common in developed countries.
- Drawing lessons from European counterparts, it is essential to design EPR schemes to include incentives for reuse, repurposing, and recycling, while not disincentivising existing charitable activities.
- To make the EPR Strategy effective, brands in India should be incentivised to implement strong collection and take-back mechanisms, promoting reuse.
- While sorting for textile recycling is still relatively new, informal recyclers have been seasoned and in the recent years, significant advancements have been made. However, the transition to the formal recycling requires extensive sorting technology to handle larger volumes and varied qualities of textiles.
- The global nature of the textile industry necessitates alignment between international and local EPR directives; Synchronizing India's EPR policy with the EU's forthcoming directives could facilitate a seamless value chain integration.
- India has a unique opportunity to develop a comprehensive recycling infrastructure due to its position as a major textile manufacturing hub, which could facilitate the easier transition from a linear to a circular economy.

17.6. CASE STUDIES

- Textiles 2030 is the UK's leading voluntary initiative supporting businesses and organisations within the fashion and textiles industry to transition to more sustainable and circular practices by the end of the decade.
- H&M's waste cloth collection centres - Offer discount coupons to customers depositing post-consumer waste
- Jeanologia's G2 technology uses ozone to create colour degradation effects before being transformed back into oxygen. These reportedly saves 95% of water, 100% chemicals, 80% energy, and 40% of carbon emissions during the fabric finishing process.
- MuddleArt collects all kinds of pre-consumer textile waste from brands and manufacturers and then sorting it based on the specifications of the end users/recyclers all the while ensuring that material reaches destination without contamination.
- Doodlage Retail LLP based in New Delhi, recycles post-consumer waste and post cutting scraps into new fabrics to create season-less well finished garments made for longevity. Waste is segregated and converted into accessories, soft furnishing products.

17.7. GOALS AND TARGETS

Based on the experiences of Netherlands and Sweden in setting EPR targets, the following goals are proposed taking into considerations of the existing informal recycling.

Proposed EPR Targets

Year	EPR Target for Producers
2025	20%
2028	30%
2030	40%

Additional targets

Target	2030
Compliance with Extended Producer Responsibility (EPR) regulations (%): Introduce EPR program for textile producers, manufacturers and brand owners *[Basis: Textile EPR targets of Netherlands and Sweden were referred. Other EPR frameworks issued by MoEFCC were referred]*	40
Increase transparency and traceability in textile recycling *[Basis: IDH / Sattva report on 'Unveils India's Textile Waste Landscape']*	100
Sustainable Product design standards for the textile products (%) *[Basis: Fashion For Good Report 'Wealth in Waste: India's Potential to bring textile waste back into the supply chain']*	50
Increase consumer recycling participation (%) by conducting awareness campaigns *[Basis: CEE Report 'Approaches for Circular Textile and Apparel Industry in India']*	30
Establish formal regional recycling hubs (number) with enhanced mechanical and chemical recycling	10

17.8. IMPACT POTENTIAL

- **Environmental Benefits:**
  As per World Economic Forum study, fast fashion contributes to 10% of the global emissions which is more than maritime and aviation transport emissions combined. Fibre Production consumes lot of water and pesticides diminishing the self-regeneration capacity while the dyeing and finishing processes include use of chemicals and heavy metals for every virgin material production. As per an estimate, the total textile industry has a water footprint of 93 billion cubic meters of water. By reducing textiles waste, we can conserve natural resources and reduce the environmental impact of textile production, including the use of water, energy, chemicals and other inputs.

- **Social Benefits:**
  Textile wastes can bring huge opportunities for artisans and handicraft workers which can lift the people out of poverty and improve their standard of living.

- **Economic Benefits:**
  Sustainable textile recycling can be a cost-effective way to create new products, particularly when compared to the production of new textiles from virgin materials. Recycled textile product can appeal to increasing environmentally conscious customers boosting sales and profitability.

References

1. Unveiling India's Textile Waste Landscape: A Cost Analysis (2023) - IDH Sustainable Trade
   https://www.idhsustainabletrade.com/uploaded/2023/09/IDH_textile-waste-cost-analysis_2023.pdf
2. Textiles & Apparel - Invest India
   https://www.investindia.gov.in/sector/textiles-apparel
3. India 2047 – Vision and Strategic Roadmap for Technical Textiles (2023) - KPMG
   https://texmin.gov.in/sites/default/files/India%202047_Vision%20%26%20Strategic%20Roadmap%20for%20Technical%20Textiles%20in%20India_KPMG.pdf
4. Wealth in Waste: India's Potential to Bring Textile Waste Back into the Supply Chain (2022) - Fashion for Good
   https://reports.fashionforgood.com/wp-content/uploads/2022/07/Sorting-for-Circularity-Wealth-in-Waste.pdf
5. Textile Recycling Unraveled: Exploring Post- and Pre-Consumer Textile Recycling Value Chains in Panipat, India - Arisa
   https://arisa.nl/wp-content/uploads/TextileRecyclingUnravelled.pdf
6. Approaches for a Circular Textile and Apparel Industry in India: Baseline Assessment Report (2023) - CEE India
   https://www.ceeindia.org/pdf_files/Baseline%20Assessment%20Report%20(Digital%20Version).pdf
7. Assessing India's Readiness in EPR for Textile Waste - Waste & Recycling Magazine
   https://www.wasterecyclingmag.com/news/assessing-india-s-readiness-in-epr-for-textile-waste
8. Ellen MacArthur Foundation - Circular Examples in Textiles
   https://www.ellenmacarthurfoundation.org/topics/biodiversity/circular-examples
9. Textiles Extended Producer Responsibility - Asia Garment Hub (2024)
   https://asiagarmenthub.net/resources/2024/wrap-textiles-epr-status-report-january-2024-v2.pdf
10. Textiles 2030 - WRAP
    https://www.wrap.ngo/taking-action/textiles/initiatives/textiles-2030
11. Crafting Sustainable Products from Textile Scraps - RSA, Textiles Committee, Ministry of Textiles, Government of India
    https://textilescommittee.nic.in/sites/default/files/publications/CSPFTS_compressed_0.pdf

Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, with around 9,000 members from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 365,000 enterprises from 294 national and regional sectoral industry bodies.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness, and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Through its dedicated Centres of Excellence and Industry competitiveness initiatives, promotion of innovation and technology adoption, and partnerships for sustainability, CII plays a transformative part in shaping the future of the nation. Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes across diverse domains including affirmative action, livelihoods, diversity management, skill development, empowerment of women, and sustainable development, to name a few.

For 2024-25, CII has identified "Globally Competitive India: Partnerships for Sustainable and Inclusive Growth" as its Theme, prioritizing 5 key pillars. During the year, it would align its initiatives and activities to facilitate strategic actions for driving India's global competitiveness and growth through a robust and resilient Indian industry.

With 70 offices, including 12 Centres of Excellence, in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with about 300 counterpart organizations in almost 100 countries, CII serves as a reference point for Indian industry and the international business community.

Confederation of Indian Industry
The Mantosh Sondhi Centre
23, Institutional Area, Lodi Road, New Delhi – 110 003 (India)
T : +91-11-45771000 | E : info@cii.in | W : www.cii.in