सत्यमेव जयते
NITI Aayog

EUROPEAN UNION

RESOURCE EFFICIENCY & CIRCULAR ECONOMY

Current Status And Way Forward

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FOREWORD

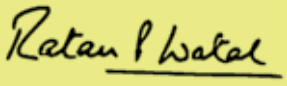
Worldwide there is a growing recognition of circular economic development approach as one of the key drivers towards achieving the 2030 Agenda for Sustainable Development and the underlined Sustainable Development Goals (SDGs). The circular economy represents a fundamental alternative to the currently predominating linear approach of development which is based on unlimited resource extraction and follows the 'take, make, dispose' model of production.

A resource efficient and circular economic development model calls for a transformation pathway towards natural resources utilization with minimization of waste, strengthening product responsibility, R&D towards dematerialization, competitiveness and enhanced job opportunities in both consumption and production processes through a range of 3R policies and measures. In recognition of this defining global trend, NITI Aayog in collaboration with EU Delegation to India has formulated a status paper on resource efficiency and circular economy.

Following up on this strategy paper, a status paper has now been prepared with four focus areas/sectors namely, Steel, Aluminium, E-waste and C&D waste. This status paper inter-alia indicates the current state of resource efficiency as well as the constraints and challenges faced in each of these sectors. It also suggests a way forward to achieve circularity and resource efficiency in these sectors with new forms of governance needed to spur innovation and sustainability in the growth process.

This status paper is based on findings from sectoral strategy papers on Steel, Aluminium, E-waste and C&D waste, prepared by concerned Departments of Government of India in consultation with NITI Aayog and other key stakeholders including EU Delegation to India. This paper brings out a comprehensive roadmap for achieving the goals of resource efficiency and sustainable development.

I would like to thank the Nodal Officers of the Nine Departments of the Government of India and the Task Force Members on RE who have been instrumental in formulating their respective sectoral strategy papers. I would like to thank Dr Prasad Modak, Executive President, Environmental Management Centre LLP and his team, who was assigned by European Union Resource Efficiency Initiative (EU-REI) Project to assist NITI Aayog in preparing this status paper. I would also like to thank Ms. Henriette Faergemann, First Counsellor of EU Delegation to India, and the EU-REI team consisting of Dr Dieter Mutz, Dr Rachna Arora, Mr Pranav Sinha and Dr Reva Prakash for their contribution in preparation of this document. I would like to especially thank Mr Satpathy, Senior Consultant, EAC-PM, and Mr Suneet Mohan, Young Professional, NITI Aayog for their support in finalisation of this document and in the implementation work related to the RE Strategy.



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List of Abbreviations

3Rs	Reduce, Reuse, Recycle
AEP	Amdavad Enviro Projects Pvt. Ltd
AHSS	Advanced High-Strength Steels
AI	Artificial Intelligence
ASSOCHAM	The Associated Chambers of Commerce and Industry of India
AUSAID	Australian Agency for International Development
B2B	Business to Business
B2C	Business to Consumer
BF-BOF	Blast Furnace-Basic Oxygen Furnace
BIS	Bureau of Indian Standards
BMTPC	Buildings Materials & Technology Promotion Council
BRE	Bureau of Resource Efficiency
C&B	Communication and Broadcasting
C&D	Construction and Demolition
CE	Circular Economy
CER	European Remanufacturing Council
CERO	A Mahindra Accelo and MSTC Venture
CLC	Cellular Light Weight Concrete
CPCB	Central Pollution Control Board
CPSE	Central Public Sector Enterprises
CPWD	Central Public Works Department
CSIR	Council of Scientific & Industrial Research
CSR	Corporate Social Responsibility
DEA	Ministry of Finance, Department of Economic Affairs
DFE	Design for Environment
DHI	Ministry of Heavy Industries and Public Enterprises, Department of Heavy Industry
DIPP	Department of Industrial Policy & Promotion
DMI&SP	Domestically Manufactured Iron and Steel Products
DRI	Direct Reduced Iron
DST	Department of Science and Technology
EAF/IF	Electric Arc Furnace/Induction Furnace
EHS	Environmental Health and Safety
EIP	Eco-Industrial Park
EITI	Extractive Industries Transparency Initiative
ELV	End-of-Life Vehicle
EMC	Electronic Manufacturing Cluster
EMS	Electronic Manufacturing Services
EPA	Environment Protection Act
EPR	Extended Producer Responsibility
ESDM	Electronic System Design & Manufacturing
ESM	Environmentally Sound Management
EU	European Union
EU-REI	European Union Resource Efficiency Initiative

FY	Financial Year
G20	Group of Twenty (countries)
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GJ	Giga Joules
GPP	Green Public Procurement
GRIHA	The Green Rating for Integrated Habitat Assessment
GST	Goods and Services Tax
ICMM	International Council on Mining and Metals
ICMQ	Institute for Certification and Quality Mark
ICT	Information and Communications Technology
IGBC	Indian Green Building Council
IIT	Indian Institute of Technology
IL&FS	Infrastructure Leasing & Financial Services
InRP	Indian Resource Panel
IRC	Indian Roads Congress
ISP	Integrated Steel Plant
IT	Information Technology
ITES	Information Technology Enabled Services
JNARDDC	Jawaharlal Nehru Aluminium Research Development and Design Centre
JSW	Jindal Group
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCA	Ministry of Consumer Affairs
MCAFPD	Ministry of Consumer Affairs, Food and Public Distribution
MCI	Ministry of Commerce and Industry
MDWS	Ministry of Drinking Water and Sanitation
MeitY	Ministry of Electronics and Information Technology
MHRD	Ministry of Human Resource Development
MLIT	Ministry of Land, Infrastructure and Transportation
MMT	Million Metric Tonnes
MNC	Multi-National Company
MNRE	Ministry of New & Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoF	Ministry of Finance
MoHI	Ministry of Heavy Industry
MoHUA	Ministry of Housing and Urban Affairs
MoIB	Ministry of Information and Broadcasting
MoM	Ministry of Mines
MoS	Ministry of Steel
MRF	Materials Recovery Facility
MSIPS	Modified Special Incentive Package Scheme
MSME	Micro Small and Medium Enterprises
MSW	Municipal Solid Waste
MT	Metric Tonnes

NALCO	National Aluminium Company Limited
NCT	National Capital Territory
NDMC	North Delhi Municipal Corporation
NDRC	National Development and Reform Commission
NEDO	New Energy and Industrial Technology Development Organization
NGO	Non-Governmental Organization
NR	Northern Railways
NSDC	National Skill Development Corporation India
OECD	Organisation for Economic Co-operation and Development
OEMs	Original Equipment Manufacturer
PCB	Printed Circuit Board
PRO	Producer Responsibility Organization
ProgRess	German Resource Efficiency Programme
PSUs	Public Sector Units
QCI	Quality Council of India
R&D	Research and Development
RCA	Recycled Concrete Aggregate
RCC	Reinforced Concrete Cement
RE	Resource Efficiency
RIC	Remanufacturing Industries Council
RWA	Resident welfare association
SAIL	Steel Authority of India
SAIL	Steel Authority of India Limited
SBM	Swacch Bharat Mission
SCBA	Sugarcane Bagasse Ash
SCM	Smart Cities Mission
SDF	Sustainable Development Framework
SDGs	Sustainable Development Goals
SEPA	State Environmental Protection Administration
SEZ	Socio-Economic Zone
SF	Silica Fume
SPCB	State Pollution Control Board
SPL	Spent Pot Lining
SPP	Sustainable Public Procurement
SRM	Secondary Raw Materials
STP	Software Technology Parks
TIFAC	Technology Information, Forecasting and Assessment Council
TPA	Tonnes Per Annum
TPD	Tonnes Per Day
TSDF	Treatment, Storage and Disposal Facility
ULBs	Urban Local Bodies
UNDP	United Nations Development Programme
WEEE	Electrical and Electronic Waste
WRRGs	Waste and Resource Recovery Groups

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Executive Summary

Circular economy (CE) represents a fundamental alternative to the currently predominant linear approach of development, that is based on uncontrolled resource extraction and follows the 'take, make, dispose' model. A circular economy is a regenerative system in which resource input and waste, emission and energy leakages are minimized by reducing, closing and narrowing material and energy loops. This is achieved through long-lasting and environmentally sensitive design, requiring lean maintenance and promoting repair, refurbishing, reuse, remanufacturing and recycling. Worldwide, there is a growing recognition of CE based development approach as one of the key strategies towards achieving the 2030 Agenda for the Sustainable Development Goals (SDGs).

With unprecedented levels of urbanization and emergence of new mega-cities, coupled with a growing population and the middle class, there has been a manifold increase in the consumption patterns in India leading to a significant demand on resources and posing a challenge to management of wastes and emissions. India needs to address its resource security by progressively adopting low carbon, resource efficient and circular economy principles in all development sectors. Recognizing this need as well as the global trend, India formulated a National Strategy on Resource Efficiency (RE) in November 2017 with a short term and medium-term action plan.[1]

Following this plan, this paper reviews the status, concerns and opportunities of four focus sectors/areas in fulfilling the goals of CE/RE. These focus areas include two key a biotic materials viz. steel and aluminium, and two waste streams viz. e-waste and construction and demolition (C&D) waste. The focus sectors/areas while contributing significantly to the GDP and employment, exert significant pressure on the resources and release significant amount of wastes and emissions. This can lead to larger economic, socio-political and environmental consequences that are often borne disproportionately by the poor and vulnerable. Promoting RE/CE in these sectors is therefore a priority.

The paper is divided into seven chapters. Chapter 1 describes the objectives, scope of this paper and the focus areas. It also highlights the inter linkages across the focus areas. Chapters 2, 3, 4 and 5 cover each of the four focus sectors/areas in more detail covering their respective lifecycle stages and material flows. For each focus sectors/area and in each lifecycle stage, key concerns and opportunities in relation to RE/CE are identified. Private sector initiatives that have already been undertaken in the context of RE/CE (both nationally and globally) are highlighted. Each chapter concludes with recommendations that are specific to the focus areas as the way forward. Chapter 6 summarizes recommendations indicating agencies who could be responsible and provides indicative time frames for implementation. The Chapter 7 contains Annexures. Annexure 1 provides the template that was used in soliciting information from various ministries. Annexures 2 to 5 have information on the four focus areas i.e. steel (Annexure 2), aluminium (Annexure 3), E-waste (Annexure 4) and C&D waste (Annexure 5). These four annexures provide graphical representations of the lifecycle stages, key stakeholders involved and highlight the key policies and programmes across relevant Ministries that reflect RE/CE considerations. Annexure 6 presents a summary of the recommendations from the focus area/sector mapped with overarching recommendations. Lastly, Annexure 7 describes RE/CE governance models adopted by Germany, Japan, China and the State of Victoria (Australia).

A brief introduction to the four focus areas, together with concerns, opportunities with key recommendations are provided in Boxes 1 to 4. More detailed descriptions of these four focus areas and findings are available

1 Strategy on Resource Efficiency, June 2017, NITI Aayog: https://eeas.europa.eu/sites/eeas/files/na_eu_restrategy_nov2017.pdf

in the strategy documents prepared by NITI Aayog and the concerned Departments of the Government of India[2].

Steel:

India is the third largest producer of steel in the world. The steel industry contributes to about 2% of Gross Domestic Product (GDP) and employs nearly 2.5 million (25 lakh) people directly and indirectly.

The National Steel Policy, 2017 projects crude steel production to reach 300 MMT by 2030-31, nearly three times the production in 2017-18. In order to reach the 2030-31 target, the efficiency of iron ore extraction and primary production has to be enhanced and the recycling rates of steel scrap need to be increased to reduce the import of scrap.

Achieving full potential of RE with steel scrap processing and by-products would require significant innovating efforts, ranging from the adoption of the state-of-the-art technologies and equipment, logistic support and new business models.

Absence of national policies for scrap generation and processing, systems for scrap collection in an organized manner between the informal sector and manufacturers, lack of standards or guidelines for recycling scrap are some of the key concerns. Formalizing and regulating the waste processing and recycling industry is a significant opportunity. Making productive use of wastes/by-products like steel slag and fly ash can help in waste utilization and reducing resource consumption.

The Strategy Paper on Resource Efficiency in Steel Sector identifies 6 key recommendations for promoting RE/CE in the steel sector. Some of the key recommendations are listed below:

i. Formulate a Comprehensive Steel Scrap Recycling Policy addressing:
   a. Efficient collection, segregation and processing of steel scrap with adequate quality control.
   b. Ensure strict adherence to necessary safety measures and use of radiation detection equipment (particularly if scrap has been sourced from laboratories/hospitals).
   c. Establish Zonal Scrap Collection and Processing Sectors in the country, so that processing is done nearer to generation centres or near the end users.
   d. Revisit the existing BIS specifications pertaining to steel scrap.
ii. Set up Scrap Processing Units near the centres/clusters of scrap consumers (i.e. EAF/IF Plants).

Box 1: Status, Concerns, Opportunities and Recommendations: Steel

Aluminium:

Aluminium is the second most used metal in the world after steel and the third most available element in the earth. India has the 7th largest bauxite reserve in the world and is the 3rd largest producer of primary aluminium. Aluminium production in India is expected to grow from 2.8 MMT in FY 2017-18 to 3.33 MMT by 2020-21 and consumption of aluminium in India is forecasted to reach 5.3 MMT by 2020-21, from 3.4 MMT in FY2017-18. Directly and indirectly, the Indian aluminium industry provides employment to more than 0.75 million (7.5 lakh) people. The secondary aluminium sector constitutes nearly 30% of the total aluminium consumed in India and has been rapidly growing. Secondary production of aluminium offers

2 Strategy on Resource Efficiency in Aluminium Sector, 2019; Strategy on Resource Efficiency in Steel Sector, 2019; Strategy on Resource Efficiency in Construction & Demolition Sector, 2019; Strategy on Resource Efficiency in Electrical and Electronic Equipment Sector, 2019.

benefits, for resource conservation and for reducing environmental impacts and energy consumption. In order to meet the forecasted demand, the efficiencies associated with the mining of bauxite ore, alumina extraction and primary production must be improved, and the recycling rates of aluminium scrap need to be increased. Sufficient availability of high-quality aluminium scrap as well as the involvement of the informal sector in the waste processing and recycling value chain are the key concerns. The production of aluminium results in several waste materials like red mud, spent pot lining (SPL) and dross. There is a significant opportunity for the industry to find productive uses of these materials.

The Strategy on Resource Efficiency in Aluminium Sector identifies 9 key recommendations for promoting RE/CE in the steel sector. Some of the key recommendations are listed below:

i. Identify Aluminium as a strategic sector for India to enable production of high-quality metal ensuring self-reliance with provision of critical infrastructure to avoid global volatility in supply and prices.

ii. Sustainability in mining of bauxite by implementation of SDF in mining sector by star rating system etc.

iii. The secondary aluminium market can aim to achieve a target of 85% recycling rate by the year 2025 and enhance job creation opportunities. The Government may consider banning the export of aluminium scrap, as indigenous supply is very poor, to encourage growth of recycling industry.

iv. Aluminium Industry produces more of waste (solid) than primary metal during its making. The waste should be converted in value added products with less efforts and resources encouraging the zero-waste concept for the industry.

v. Consider a National Strategy of utilization of Red Mud

vi. Consider zonal scrap collection/segregation/treatment facilities and recycling zones developed to address issues including transportation, pollution control etc.

Box 2: Status, Concerns, Opportunities and Recommendations: Aluminium

Electrical and Electronic Equipment:

The Indian electronics market is one of the largest in the world and is anticipated to reach US$ 400 billion by 2022. The growth in the electronic market is resulting in large volumes of e-waste being generated in the country. India, at present, is ranked as the 5th highest generator of e-waste in the world with year on year growth rates of about 30 percent. Estimates suggest that the amount of e-waste generated in India is about 2 million TPA (tonnes per annum) and will reach 5.2 million tonnes per annum by 2020. The quantity that is recycled is about 0.44 TPA primarily through the informal sector. Given the growth of the electronics market, and a largely informal recycling industry with limited capacity in the formal sector, there is pressing need to manage e-waste properly so that high value materials are recovered, toxic materials are safely managed, and recovered materials are reintroduced back in to production. Unfortunately, the recovery yield in secondary processing of e-waste is low (~10-20%), thereby losing the precious metal resources like copper besides increasing the environmental risks.

Gaps in e-waste inventorization, poor availability and access to improved technologies for recycling metals and plastics, presence of informal sector with rudimentary technology to process end of life electronics in the value chain are some of the major concerns. Leveraging on the requirement of Extended Producer Responsibility (EPR) as promulgated in the e-waste management rules will help. The SPCBs need to be equipped to understand the EPR and implement them effectively.

Strategy on Resource Efficiency in Electrical and Electronic Equipment Sector identifies 8 key recommendations for promoting RE/CE. Some of the key recommendations are listed below:

i. Formalisation, integration and capacity building of informal sector across the value chain while ensuring protection on health and safety.
ii. Set up infrastructure for collection of e-waste through local bodies
iii. Introduce standardisation for reuse and refurbishment of electronic products
iv. Support R&D for efficient recycling of e-waste
v. Develop business models that can lead to proliferation of recycling technologies

Box 3: Status, Concerns, Opportunities and Recommendations: E-Waste

Construction & Demolition (C&D) Waste:

The total quantum of waste from the construction industry in India is estimated to be 100 million tonnes per annum in 2018. While retrievable items such as bricks, wood and metal, are recycled, the concrete and masonry waste are not being adequately managed and recycled. It is estimated that only 5% of C&D waste is recovered in India. The existing practice is to dispose the waste in landfills or illegally dump in rivers and water bodies affecting the land and water resources. While disposal of C&D waste is a challenge, there is an acute shortage of naturally available aggregates, limestone and other construction materials like sand and soil. At the current growth rate, the current limestone reserves may run out by 2060. This extraction of soil, especially for brick making decreases agricultural productivity, which in turn increases food security concerns. Reduction of this demand is possible only with the utilisation of waste generated from the construction activities by producing bricks, paver blocks and construction aggregates. There is an opportunity to develop and establish standards and guidelines that create transparency and legitimacy in the reuse of C&D waste.

The Strategy on Resource Efficiency in Construction & Demolition Sector identifies 6 key recommendations for promoting RE/CE. Some of the key recommendations are listed below:

i. Carry out inventorization and characterisation of C&D waste by developing a methodology best suited for Indian context
ii. Swachh Bharat Mission (SBM) portal to be expanded to include data on C&D by ULBs
iii. Web-platform to serve as a facilitation tool to connect generators and users of C&D waste may be developed
iv. Sustainable public procurement (SPP), and other instruments to catalyse the acceptance of products manufactured from C&D waste and market penetration, especially for all non-loadbearing structures
v. Dis-incentivizing landfilling of C&D wastes by instituting high tipping fees especially for generators of bulk C&D waste

Box 4: Status, concerns, opportunities and recommendations: C&D waste

The four focus sectors/areas described above are interrelated in terms of material flows and economic linkages with various sectors. There are commonalities that can be synergized by arriving at overarching recommendations that could provide an enabling framework towards cross-sectoral promotion of RE/CE. This paper makes such recommendations keeping in view the sector specific recommendations as well as those earlier made in the national strategy paper on RE.

A total of 30 recommendations are structured in the form of categories such as policy, programmes and mainstreaming, regulations, efficient recycling, R&D & technology development and capacity development, outreach & monitoring, to emphasize a holistic approach for ensuring effective and sustained outcomes. Out of these 30 recommendations, 14 recommendations are provided in the table below as priorities for action:

#	Category	Recommendations	Implementing Agencies	Timelines
1.	Policies	**R1.1** Formulate a national policy on RE/CE for biotic and abiotic resources addressing various lifecycle stages and key stakeholders.	MoEFCC	6 months-1 year
2.		**R1.2** Formulate a national policy on Sustainable Public Procurement (SPP) with an action plan emphasizing procurement of RE & CE products.	MoF	6 months-1 year
3.	Programmes and Mainstreaming	**R2.1** Mainstream RE/CE initiatives by leveraging existing flagship programmes and schemes like Swachh Bharat Abhiyan, Smart Cities Make in India, Start-up India, Digital India and others.	MoEFCC, MoHUA, MDWS, MCI-DIPP, MeitY	6 months – I year
4.		**R2.4** Create a fund on similar lines as the National Clean Energy and Environment fund to finance infrastructure, innovative technologies and related RE/CE initiatives.	MoF,	6 months – 1 year
5.	Regulations	**R3.1** Establish a national coordinating body- Bureau of Resource Efficiency (BRE) to implement and achieve national RE/CE goals.	NITI Aayog, MoEFCC, MoCA	1-2 years
6.		**R3.4** Establish and mandate a 'Consent to Close' requirement for medium and large-scale industries in the 'RED' category to ensure that waste streams are responsibly managed and recycled after closure.	MoEFCC/CPCB	6 months – 1 year
7.		**R3.5** Rationalise tax regime on critical virgin raw materials to make secondary raw materials price competitive	MoF	6 months – 1 year
8.	Setting up a dynamic recycling industry	**R4.1** Promote the establishment of Material Recovery Facilities (MRFs) with the allocation of land in urban areas and industrial estates.	MoEFCC, MoHUA, MeitY	1-2 years
9.		**R4.5** Establish a remanufacturing council or an association to spur growth of remanufacturing industry	Industry, industrial associations	1-2 years
10.	R&D and Technology Development	**R5.1** Support R&D to develop scalable technologies for RE/CE and promote usage of Artificial Intelligence (AI) for higher efficiencies	DST, MoEFCC, MoHUA, MoA, MoS, MoM	1-2 years
11.		**R5.2** Create and manage knowledge platforms that facilitate open innovation, provide access to experts, and engage academia to support the transition towards RE/CE.	MHRD, MoEFCC	1-2 years
12.	Capacity Development, Outreach & Monitoring	**R6.2** Provide capacity development support on RE/CE for ministries/departments at the National and State levels.	NITI Aayog/ MHRD/ EU-REI[3]	6 months-1 year
13.		**R6.3** Develop and promote programmes and certifications for skill development of the informal sector	NSDC, SCGJ	1-2 years
14.		**R6.6** Develop monitoring and outcome indicators for tracking progress on RE/CE.	NITI Aayog/ MoEFCC/ State Governments	1 – 2 years

3 EU- Resource Efficiency Initiative in India

1 Introduction

1.1. Background

India is the world's sixth largest economy with GDP at 2.6 trillion USD. As one of the fastest growing economies in the world, it is expected to grow at the rate of about 7.5% and above over the next decade. India is rich in resources such as metallic minerals that include iron ore, chromite, copper, zinc, silver, gold, bauxite, tin and manganese; non-metallic minerals such as limestone and fossil fuel resources such as coal, oil and natural gas. Currently, around 97% of all materials consumed in India are extracted domestically. However, it does remain highly import dependent for critical materials such as molybdenum, copper and nickel.[4]

In India, extraction of primary raw materials increased by around 420% between 1970 and 2010. The contribution of industry sector to the GDP between 1970 and 2010 also rose steadily from 23.62% to 28.27 %. During the same period, contribution of manufacturing also increased from 12.74% to 16.17; while for mining and quarrying it only increased from 2.20% to 2.30%.[5]

The projected pace of economic development is going to put pressure on already stressed and limited resources and may lead to serious resource depletion and degradation affecting the economy, livelihoods and the quality of life. Further, the looming threat of climate change is going to pose risks to resource security. A summary report on the Global Material Resources Outlook to 2060 by OECD (2018) describes the environmental consequences of global extraction, production and material use of metals and construction materials in form of increased acidification of ecosystem, climate change, human toxicity, ozone layer depletion, photochemical oxidation, aquatic and terrestrial ecotoxicity to more than double and in some case even quadruple by 2060, in spite of ongoing efficiency improvements.[6]

It thus becomes critical and challenging for a country like India to strike a balance between the developmental needs and minimising the negative impacts associated with resource use. Building a resource efficient circular economy requires a transformative pathway which combines material availability with innovation, social and environmental responsibility. Circular economy (CE) represents a fundamental alternative to the currently predominant linear approach of development that is based on uncontrolled resource extraction and follows the 'take, make, dispose' model. Following the framework of CE, improvements and measures for resource efficiency across the value chain needs to be implemented for reducing the dependence on primary resources. This is achieved through long-lasting and environmentally sensitive design requiring lean maintenance and promoting repair, refurbishing, reuse, remanufacturing and efficient recycling.

RE/CE help to conserve resources, eliminate or minimize waste, promote use of renewable resources and reduce GHG emissions. A shift towards RE/CE is achieved not only through R&D and technology development but by increasing demand for resource efficient products as well as promoting products that utilize secondary material resources.

4 Strategy on Resource Efficiency, 2017, NITI Aayog: https://eeas.europa.eu/sites/eeas/files/na_eu_restrategy_nov2017.pdf

5 Planning Commission. (2014). Databook for PC: http://planningcommission.nic.in/data/datatable/data_2312/DatabookDec2014%202.pdf

6 Global Material Resources Outlook to 2060, 2018, OECD: https://www.oecd.org/environment/waste/highlights-global-material-resources-outlook-to-2060.pdf

1.2. Objectives and Scope

NITI Aayog published the 'Strategy Paper on Resource Efficiency'[7] in November 2017 that outlined the national vision and set the course for India's transformation in to a resource efficient and circular economy.

Building on NITI Aayog's Strategy Paper, the objectives of this Status Paper are to:

- Evaluate and summarize the status of RE in national policies and programmes with respect to four focus areas, namely:
    1. Steel
    2. Aluminium
    3. E-waste
    4. Construction & Demolition Waste
- Map existing government approaches (at the national level) addressing RE, identify opportunities for strategic interventions. The Governmental policy and program frameworks of nine stakeholder Indian Ministries (see Box 5) for each of the focus areas are mapped using a "lifecycle thinking approach".

Nine Stakeholder Indian Ministries:
(in alphabetical order)

- Ministry of Commerce and Industry, Department of Industrial Policy & Promotion (DIPP)
- Ministry of Consumer Affairs, Food and Public Distribution, Department of Consumer Affairs (DCA)
- Ministry of Electronics and Information Technology (MeitY)
- Ministry of Environment, Forest and Climate Change (MOEFCC)
- Ministry of Finance, Department of Economic Affairs (DEA)
- Ministry of Heavy Industries and Public Enterprises, Department of Heavy Industry (DHI)
- Ministry of Housing and Urban Affairs (MoHUA)
- Ministry of Mines (MoM)
- Ministry of Steel (MoS)

Box 5: Nine Stakeholder Indian Ministries

- Recommend holistic strategies which establish forward-backward linkages to increase RE practices across lifecycle stages, through cross-sectoral and cross-ministerial actions.

For the four focus sectors/areas identified, relevant policies and regulations of the nine stakeholder ministries were reviewed and instances of RE/CE considerations were compiled. The mainstreaming of RE/CE tools and instruments in the policies, regulations and programmes were also analysed. In order to assess the status, a comprehensive template (Annexure 1: Questionnaire Format for Ministries) was shared with the key stakeholder ministries for providing information on the current programmes relevant to RE/CE. NITI Aayog coordinated the information collection and conducted consultation meetings by setting up an inter-ministerial departmental group of stakeholders. In addition, an extensive research was carried out by referring to various reports and publications. For the selected sectors/areas, the inputs were drawn from the four strategy papers prepared by NITI Aayog and concerned agencies. Various drafts of the paper were reviewed

7 Strategy Paper on Resource Efficiency, November 2017, NITI Aayog: http://niti.gov.in/writereaddata/files/document_publication/StrategyOnResouceEfficiency_0.pdf

by the RE Taskforce of Subject Experts providing comments and guidance prior to the consultation meetings.

The analysis of policies and regulations, review of the past and existing programmes and concerns and opportunities in the four focus sectors/areas provided a basis for the overarching recommendations towards development of an RE/CE ecosystem in India. These recommendations were grouped into six categories viz. Policies, Programmes/Mainstreaming, Regulations, Setting up a Dynamic Recycling Industry, R&D and Technology Development, and Capacity Development, Outreach and Monitoring.

The status paper focuses primarily on RE and Box 6 provides the definition. This definition is sourced from the Strategy Paper on Resource Efficiency published by NITI Aayog in November, 2017. Two additional definitions are provided– one for Secondary Raw Materials (SRM) and another for the Circular Economy (CE). CE thinking encompasses RE and SRM and can be viewed as the overarching model or framework that any economy could aspire towards.

Resource Efficiency (RE) or resource productivity, is the ratio between a given benefit or result and the natural resource use required for it. While the term "resource efficiency" is predominantly used in business, product or material context, "resource productivity" as a term is used in an economy-wide, national context.[8]

Secondary Raw Materials (SRM) are recycled materials that can be used in manufacturing processes instead of or alongside virgin raw materials.[9]

The Circular Economy (CE) is a model of production and consumption, which retains the value of existing materials, components, products, an embedded energy for as long as possible. In practice, it implies reducing waste to a minimum. When a product reaches the end of its intended use, its materials and embedded energy are not discarded and are put to productive use within the economy as far as possible. These can be productively used again and again, thereby creating further value. The ways to implement CE principles include, but are not limited sharing, leasing, reusing, repairing, refurbishing and recycling.[10]

Box 6: Working Definitions of RE, SRM and CE

1.3. Focus Sectors/Areas

The economic contribution, environmental impact in terms of resource extraction, waste generation and the social perspectives in terms of employment and health related impacts were considered in the identification of the focus areas. This identification was built on the document Resource Efficiency and Secondary Resource Management as a Foundation for Environmental Policy in India by InRP.[11] A brief overview of the four focus areas is presented below.

Steel: India is expected to become the second largest steel producer in the world by 2018[12] and contributes around 2% to the country's GDP. The crude steel production in India reached 103 MMT in 2017-18[13]. Typically,

8 Strategy Paper on Resource Efficiency, 2017, NITI Aayog: http://niti.gov.in/writereaddata/files/document_publication/Strategy%20Paper%20on%20Resource%20Efficiency.pdf

9 Strategy for Secondary Raw Materials, 2016, European Parliament: http://www.europarl.europa.eu/legislative-train/theme-new-boost-for-jobs-growth-and-investment/file-strategy-for-secondary-raw-materials

10 Based on Circular economy: definition, importance and benefits, European Parliament: http://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

11 Resource Efficiency (RE) and Secondary Resource Management (SRM) as a Foundation for Environmental Policy in India, 2016,GIZ: http://re.urban- industrial.in/live/hrdpmp/hrdpmaster/igep/content/e64918/e64922/e67075/e67085/InRP_Draft_RE_policyanalysis_India.pdf

12 Iron & Steel Industry in India, 2018, India Brand Equity Foundation: https://www.ibef.org/industry/steel.aspx

13 Strategy on Resource Efficiency in Steel Sector, Jan 2019, NITI Aayog and Ministry of Mines, India

making 1 tonne of pig iron requires 1.6 tonnes of iron core and 450 kg of coke[14] if blast furnace technology is used. Resource efficiency in steel plays an important as it can be recycled even after its end of life into usable products and other waste or by-products like slag developed during production. Recycling of one tonne of scrap saves 1.1 tonne of iron ore, 0.6-0.7 tonne of coking coal and around 0.2-0.3 tonne of fluxes.

Aluminium: India has a production capacity of 4 million metric tonnes (MMT) of primary aluminium and production in 2016-17 stood at 2.8 MMT. Approximately 1 tonne of aluminum oxide is produced from every 4 tonnes of mined bauxite[15]. Some concerns in aluminium's lifecycle include the generation of several waste materials like red mud, spent pot lining (SPL) and dross. There is a significant opportunity for the industry to find productive uses of these materials. The sufficient availability of high-quality aluminium scrap as well as the involvement of the informal sector in the waste processing and recycling value chain are key concerns.

E-waste: E-waste is highly complex to handle due to its composition. Dumping of these wastes without proper treatment in the environment leads to irreversible effect on environment and human health. E-waste however contains a variety of valuable, precious and hazardous elements which can be recycled and recovered through proper recycling processes/ treatment. In 2016, India was the fifth largest producer of e-waste with an estimated generation of 2 MMT[16].

Construction and Demolition Waste: The total quantum of waste from the construction industry in India is estimated to be 100 million tonnes per annum in 2018. While retrievable items such as bricks, wood, metal, titles are recycled, the concrete and masonry waste are not being currently recycled in India[17]. The practice is to dispose of this waste in landfills. However, they are also illegally dump in rivers and water bodies, thus affecting the land and water resources. On one hand, the disposal of debris is a challenge, and on the other hand, there is an acute shortage of naturally available aggregates for the construction of buildings. Reduction of this demand is possible only with the reuse or recycling of waste generated from the construction activities by producing bricks, paver blocks and construction aggregates which will lead to tremendous pressure on natural resources.

1.4. Interlinkages

The utilisation of resources involves material flow from one lifecycle stage to another, beginning from extraction, followed by manufacturing, consumption and ultimately end-of-life management (disposal or recycling). The impact of each lifecycle stage can highlight the stages where maximum resource inefficiency occurs can be addressed and then measures can be developed to enhance RE.

The focus sectors/areas identified for the status paper have considerable interlinkages across the life cycle stages and in the material flows. These interlinkages require creation of cross-sectoral enabling framework for policy and market instruments that promote integration of resource efficiency as a holistic approach. This enabling framework should include strengthening of policies, mainstreaming RE/CE with existing missions and programmes, harmonizing the regulations, building programmes to foster investments and capacity building and promoting R&D and technology development. These interlinkages have been well recognized in developing recommendations for RE/CE.

Chapters 2, 3, 4 and 5 provide overview of the above focus sectors/areas. Each chapter begins with setting

14 Raw Materials, undated, World Steel Association https://www.worldsteel.org/steel-by-topic/raw-materials.html

15 What Aluminium Extraction Really Does to the Environment, 2010, RecycleNation: https://recyclenation.com/2010/11/aluminum-extraction-recycling-environment/

16 Global E-waste Monitor, 2017, UNU and ISWA: https://www.itu.int/en/ITU-D/Climate-Change/Documents/GEM%202017/Global-E-waste%20Monitor%202017%20.pdf

17 Tool Kit On Construction & Demolition Waste Management Rules 2016, 2017, National Productivity Council, : http://www.npcindia.gov.in/wp-content/uploads/2017/11/CD-Waste-Management-ToolKit-2017_R-1.pdf

the context for the respective focus area by describing the economic, environmental and social perspectives. Concerns and opportunities are identified in each lifecycle stage and the chapter concludes with way forward to address RE/CE in the focus area. Private sector initiatives towards RE/CE are also stated. More detailed description and statistics on the four focus areas is available in the strategy documents prepared by NITI Aayog, earlier cited.

Before delving into each of the focus sectors/areas, the commonalities between steel and aluminium sectors, especially on the policies are important to be recognized as these sectors are guided by the mining and metal related policies. Similarly, materials like E-waste and C&D waste are guided by the regulations set up by the Waste Management and Handling related rules of the Ministry of Environment, Forests and Climate Change (MoEFCC) under the Environmental Protection Act of 1986. Sections 1.7 and 1.8 below describe these commonalities. Figure 1 below showcases the inter-linkages between the four focus areas.

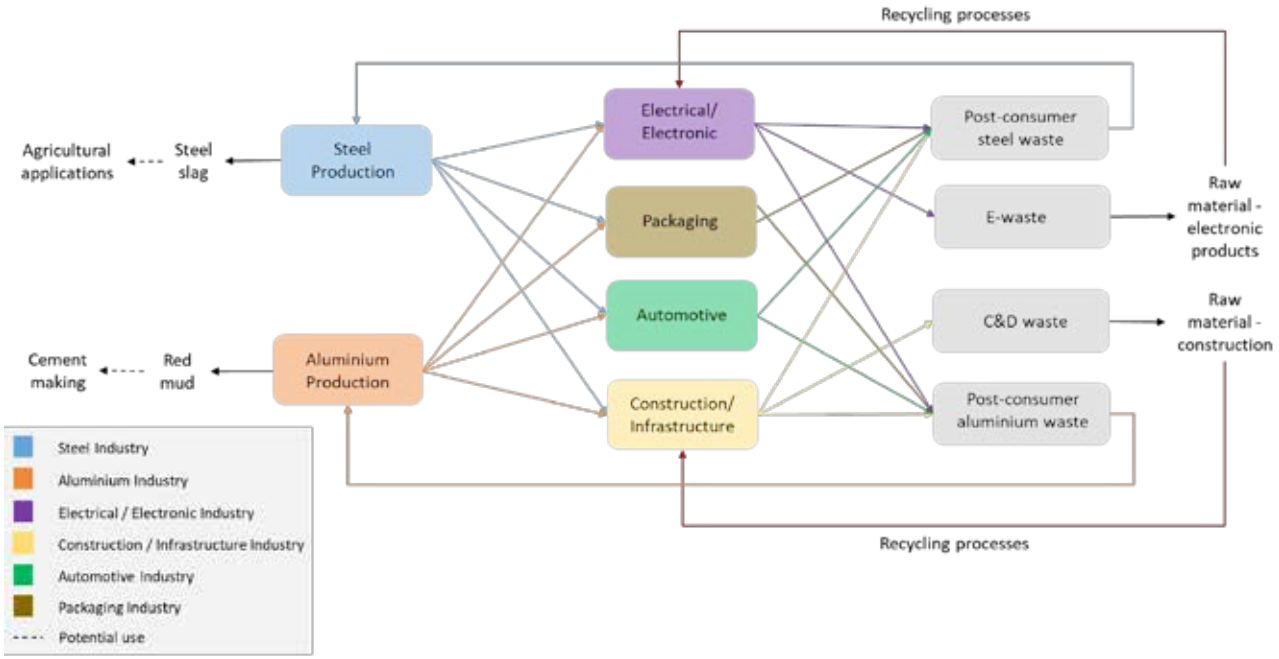

Figure 1: Interlinkages Between the Four Focus Areas

1.5. Policies Related to Mining and Metals

The **National Manufacturing Policy, 2011**[18] from the Ministry of Commerce and Industry's Department of Industrial Policy and Promotion calls for energy efficiency, optimal utilization of natural resources and restoration of damaged/degraded ecosystems, and the **National Industry Policy, 2017 - Discussion Paper**[19] calls for the establishment of circular economy, adoption of smarter technologies for energy efficiency and moving towards minimal/zero waste industrial activities.

In its action plan, the **National Design Policy, 2007**[20] discusses eco-friendliness as a key design criterion as well as mentions the need to upgrade the quality of design (engineering, machinery, process, materials, etc.) to be environmentally sound and socially and culturally relevant.

18 National Manufacturing Policy, 2011, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://meity.gov.in/writereaddata/files/National%20Manufacturing%20Policy%20(2011)%20(167%20KB).pdf

19 Industrial Policy Paper – 2017, 2017, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://pibphoto.nic.in/documents/rlink/2017/aug/p201783006.pdf

20 National Design Policy, undated, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://dipp.nic.in/sites/default/files/national_design_policy%20%20%20eng%201.pdf

While there are policies such as the National Manufacturing Policy and the Industrial Policy - 2017 in India, it is unclear to what degree these policies are effective in the context of RE/CE. In addition, no national policies appear to specifically address RE/CE in product manufacture or the recycling and remanufacturing industries in India. The recycling and remanufacturing industries do not have formal standards or guidelines in addition to being unregulated/informal. Further, the remanufacturing industry in India is very nascent.

The Ministry of Mines (MoM) has primary oversight over all types of raw material extraction in India. The Draft National Mineral Policy, 2018[21] outlines a vision for the mining industry that specifically mentions environmentally sustainable mining. Furthermore, it articulates that supply of raw materials will be augmented by developing processes for recovery of metals through recycling. It even mentions that research and development efforts will be made to improve operational efficiency and by-product recovery in mining.

The MoM has also instituted the Star Rating of Mines system[22] and the Sustainable Development Framework (SDF)[23]. The second principle of the SDF mentions the deployment of efficient machinery, as well as the reuse and recycling of mine products and wastes. However, no specific targets or indicators are provided in relation to resource efficiency.

Seven Principles outlined in the Sustainable Development Framework are:

- Incorporating environmental and social sensitivities in decisions on leases
- Strategic assessment in key mining regions
- Managing impacts at the mine level through sound management systems
- Addressing land, resettlement and other social impacts
- Community engagement, benefit sharing and contribution to socio-economic development
- Mine closer and post-closure

Box 7: Seven Principles of Sustainable Development Framework

A report released by the Material Recycling Association of India in 2015 said the Indian Metal Recycling industry was "challenged by key interlocking crises of minimal existence of a metal scrap recycling ecosystem and lack of any domestic laws and policies that assist and apply to the industry."[24]

Figure 2: Current Indian Value Scrap Chain[25]

21 Draft National Mineral Policy, 2018, Ministry of Mines: https://mines.gov.in/writereaddata/UploadFile/draftnationalmineralpolicy2018.pdf

22 Format-Evaluation Template for Star Rating of Mining Leases, undated, Indian Bureau of Mines, Ministry of Mines: https://ibm.gov.in/index.php?c=pages&m=index&id=473

23 Sustainable Development Framework (SDF) for Indian Mining Sector, 2011, Ministry of Mines: https://mines.gov.in/writereaddata/UploadFile/Sustainable_Development_Framework.pdf

24 Why Doesn't India Recycle Scrap Metal? Or Even Use Much Imported Scrap?, 2015, MetalMiner: https://agmetalminer.com/2015/09/23/why-doesnt-india-recycle-scrap-metal-or-even-use-much-imported-scrap/

25 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

The International Council on Mining and Metals (ICMM) highlights ways in which wastes from mining operations can be reused[26]. Some of these potential opportunities are described below.

- Waste rock is used as backfill, landscaping material and aggregate in road construction, or can sometimes be used as feedstock for cement and concrete or reprocessed later to extract minerals and metals.
- Manganese tailings are used in agroforestry, buildings and construction materials, coatings, resin, glass and glazes.
- Clay-rich tailings are used for making bricks, floor tiles and cement.
- Slag is often used for road construction, and in concrete and cement. It also has great potential to improve soil productivity and reduce consumption of chemical fertilizers.
- Sludge from acid rock drainage treatment, which is high in iron, is sold commercially for use in pigments.
- Smelters typically include acid plants for converting sulphur dioxide into sulphuric acid, a useful industrial chemical.

In addition, ICMM asserts that mining operations can contribute to circularity through the recycling of equipment (like tyres), remanufacturing of heavy equipment and recycling key inputs such as water and reusing chemicals.

1.6. Regulations on Management and Handling of Wastes

The e-waste and C&D waste sectors are governed by the e-waste (Management & Handling) rules and the C&D waste (Management and Handling rules) of 2016 under the Environmental Protection Act, 1986.

The objective of these rules is to protect the environment, natural resources and human health and ensure a sound management of these waste streams by specifying rules for segregation at source, collection and transportation, storage and processing for secured disposal. The enforcement of these rules is carried out by the State Pollution Control Boards, the Central Pollution Control Board as well as by the Urban Local Bodies (especially regarding the management of municipal solid waste, C&D waste and other household waste).

The 2016 amendments of these rules are now adapted reflecting the role of the informal sector and addressing various stages of the material flow. Importantly, the elements of 3Rs (Reduce, Reuse and Recycle) are introduced, stressing on waste minimization and resource recovery. For e-waste, instruments such as Extended Producer Responsibility (EPR), institutional models like the PRO (Producer Responsibility Organization) and use of fiscal instruments such as Deposit Refund Scheme (DRS) have been introduced. Targets are specified on the EPR for e-waste requiring filing of annual returns for compliance. These requirements are expected to drive RE through increased compliances. Further, private sector participation to build waste collection, processing and common recycling infrastructure is also encouraged. Many of the concerns and opportunities are therefore common across these two waste streams. Mainstreaming RE/CE in some of the policies and regulations listed above will thus greatly help in catalysing RE/CE in the focus sectors/areas. Annexures 2 to 5 provide a more detailed analyses of policies and regulations in this perspective.

26 Mining and metals and the circular economy, 2016, International Council on Mining and Metals: https://www.icmm.com/website/publications/pdfs/responsible-sourcing/icmm-circular-economy-1-.pdf

2 Steel

2.1. Preamble

Steel is a key component of infrastructure development and is one among eight core infrastructure supportive industries. Indian Steel industry is the third largest steel producer in the world and contributes around 2% of country's GDP and employs around 25 lakhs people directly or indirectly. India's steelmaking capacity will increase to 300 MTPA by 2030-31 from present level of 125 MTPA due to increased demand driven by new initiatives in various sectors such as Infrastructure, Housing, Transport, Defence, Aviation etc. under the schemes like Make in India, Smart City, Affordable Housing for all, creating significant employment opportunities.

Steel can be recycled to same quality with no downgrading. In addition, slag produced at different stages can be used in agriculture, cement and other sectors. This will reduce pressure on land resources used for virgin raw material requirement to meet growing demand as well as create additional job opportunities in the entire value chain.

In order to reach the 2030-31 target, recycling rates need to be increased in addition to increasing efficiency of iron ore extraction and primary production of steel. This chapter presents status and recommendations to maximise resource efficiency across the lifecycle stages of steel production.

Box 8: Steel Sector in India

Steel is an alloy of iron and carbon containing less than 2% carbon and 1% manganese and small amounts of silicon, phosphorus, sulphur and oxygen. Steel is one of the world's most important engineering and construction material. It is used in every aspect of our lives; in cars, cargo ships, construction materials, household appliances, utensils, and surgical tools.

2.2. Economic, Environmental and Social Context

Considering steel's contribution to the GDP[27], environmental impacts and large-scale employment, it is important to understand the economic, environmental and social context. Each of these are described in this section.

Economic: In FY18, India produced 104.98 million tonnes (MMT) of finished steel. Crude steel production during 2017-18 stood at 102.34 MMT[28]. The National Steel Policy 2017 projects crude steel production to reach 300 MMT by 2030-31, nearly three times the production in 2017-18.

According to the Ministry of Steel, in 2011 there are 13 major integrated steel plants[29], both in the public and private sector in India. In addition, there are several medium and small steel units in India which comprise of Mini Blast Furnace units, Sponge Iron units, Induction Furnace units and Rolling Mills. The total number of such units was estimated to be 3,647 based on the Joint Plant Committee survey conducted in 2009-10[30]. There are approximately 313 sponge iron producers, 42 EAFs, 1126 IFs, and around 1157 small and medium sized steel rerolling mills (SRRMs) scattered over the country. They are usually found in clusters, with each

27 Gross domestic product (GDP) is a monetary measure of the market value of all final goods and services produced in a period (quarterly or yearly) of time.

28 Indian Steel Industry Analysis, 2018, Indian Brand Equity Foundation: https://www.ibef.org/industry/steel-presentation

29 Integrated Steel Plants include covers all the steps of primary steel production starting from iron making to steel making and product rolling.

30 Number of Steel Plants in India, 2011, Press Information Bureau: http://pib.nic.in/newsite/PrintRelease.aspx?relid=77494

cluster having about 50-400 units[31]. Presently, India imports 6-7 million TPA steel scrap for secondary steel production. The domestic steel scrap industry needs to be formalized to ensure higher rates of domestic scrap recovery so that the import dependency is reduced.

Environmental[32]: The Iron and Steel Industry (involving processing from ore/scrap/integrated steel plants)[33] is included in the 17 major polluting industries in India and is classified as a "RED" Category industry (i.e. heavily polluting and covered under the Central Action Plan) by MoEFCC. Steel production has several impacts on the environment, including air emissions (CO, CO2, SOx, NOx, PM2.5 and PM10), wastewater release, and generation of solid and hazardous wastes. The major environmental impacts in integrated steel mills are from coking and iron-making. Most of the GHG emissions associated with steel production are from the emissions related to energy consumption. According to the Steel Authority of India (SAIL)[34], the steel industry accounts for about 6-7% of the total GHG in India.

Slag is a waste which is generated during manufacturing of pig iron and steel and is classified as a potential by-product by the Indian Bureau of Mines[35]. There are four types of slag which are generated from primary and secondary steel production[33]:

1. Blast Furnace Slag
2. Steel Slag (also known as Linz-Donawitz or LD slag)
3. Electric Arc Furnace (EAF) Slag
4. Induction Furnace (IF) Slag

Social: The Indian steel industry provides employment to over 2.5 million people directly and indirectly. The potential for revenue generation in steel scrap industry is of the order of 2,000 crore INR/ million tonne per annum of steel scrap processed. This will require skilling people in new trades as well as bringing focus on new innovative ideas/research in the MSME sector [33].

2.3. Status, Concerns, and Opportunities across Lifecycle Stages

The lifecycle of steel broadly involves Raw Material Extraction, Steel Production, Consumption, Reuse & Remanufacture and Steel Recycling. Annexure 2 provides a graphical representation of these lifecycle stages. Each lifecycle stage involves various stakeholders. For example, the stakeholders of the raw material extraction stage include the local communities around mines, Local, State & National governments and steel producers who source iron ore from the mines.

Annexure 2 shows the stakeholders in the various lifecycle stages of steel. From the perspective of government stakeholders across the lifecycle stages of steel, several ministries are involved. A unique feature in the Indian governance framework for steel is that a ministry (the Ministry of Steel) is dedicated for it. The Ministry of Mines has oversight over all mining activities in the country and features prominently in the Raw Material Extraction stage for both steel and aluminium.

Annexure 2 (Figure 15) provides a chronological illustration of the various government regulations, policies and programmes related to steel's lifecycle across different ministries.

31 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel

32 Steel production and environmental impact, undated, GreenSpec: http://www.greenspec.co.uk/building-design/steel-products-and-environmental-impact/

33 Classification of industries for consent management, MoEFCC: http://envfor.nic.in/legis/ucp/ucpsch8.html

34 Climate Change, undated, Steel Authority of India: https://www.sail.co.in/sites/default/files/Climate_Change.pdf

35 Indian Minerals Yearbook 2017, Indian Bureau of Mines: http://ibm.nic.in/writereaddata/files/03202018150040Slag_Iron_Steel_AR_2017.pdf

2.1.1 Lifecycle Stage – Raw Material Extraction

According to the World Steel Association, it typically takes 1.6 MT of iron ore and around 450 kg of coke to produce a tonne of pig iron, the raw iron that comes out of a blast furnace[36]. Steel scrap is also one of the industry's most important raw materials. It comes from demolished structures, end-of-life vehicles, machineries as well as from the yield losses in the steelmaking process.

2.1.2 Lifecycle Stage - Steel Production

Based on the manufacturing process, there are two key steelmaking routes globally:

a. BF-BOF (Blast Furnace-Basic Oxygen Furnace): The primary steelmaking route where steel is produced from raw materials like iron ore, coal and limestone

b. EAF/IF (Electric Arc Furnace/Induction Furnace): The secondary steelmaking route where steel is produced from steel scrap, sponge iron or Direct Reduced Iron (DRI)

Figure 3 and Figure 4 show the key by-products, emissions and resource usage from the two steelmaking routes.

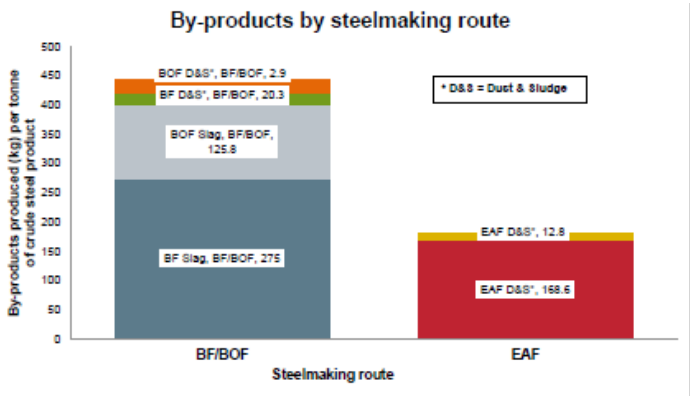

Figure 3: Key By-products of Steel making[37]

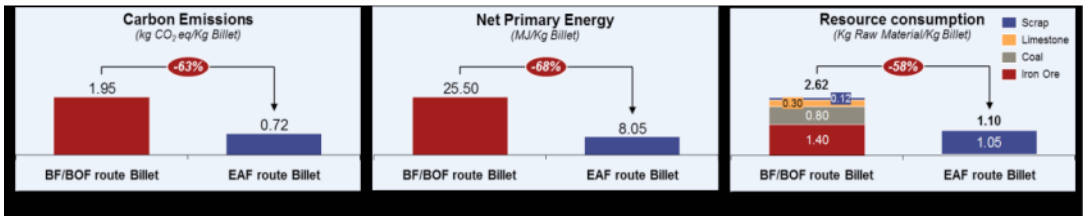

Figure 4: Comparison of Emissions and Resource Usage in Steel Making [37]

The production of crude steel from the BF-BOF route contributes to 45% of India's steelmaking capacity while 55 % is processed through the electric route. The EAF route is more environmentally efficient due to its lower carbon footprint, material efficiency and energy efficiency. The EAF-route enables steel scrap recycling, and thereby drives participation in a resource efficient circular economy. Improved efficiency in steel recycling is a critical opportunity[38].

36 Raw Materials, undated, World Steel Association: https://www.worldsteel.org/steel-by-topic/raw-materials.html

37 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

38 Also recommended by 'Strategy on Resource Efficiency in Steel Sector', 2019, NITI Aayog and Ministry of Steel.

Steel recycling provides significant environmental and economic benefits. Almost 40% of the world's steel production is made from scrap. It uses 74% less energy, 90% less virgin materials and 40% less water. It also produces 76% fewer water pollutants, 86% fewer air pollutants and 97% less mining waste.

Box 9: Benefits of Steel Recycling[39]

Promoting EAF technology through economic instruments such as tax benefits and increasing scrap recycling through a dedicated policy[40] addressing the stakeholders such as the informal sector are important elements in increasing resource efficiency and circularity in steel.

The National Steel Policy[41] put forth by the Ministry of Steel (MoS) explicitly promotes the usage of technologies that will bring down the usage of coking coal in blast furnaces. It also discusses actions to increase the availability of ferrous scrap by developing a scrap segregation (quality-wise), collection, processing and recycling policy. Furthermore, it discusses the modernization of steel plants, effective and efficient utilization of domestic resources, and articulates the vision of a zero-waste steel sector.

In addition, the Policy for Providing Preference to Domestically Manufactured Iron & Steel Products in Government Procurement, 2017[42] relates to government procurement of domestically manufactured iron and steel products and could be leveraged for the procurement of resource efficient and sustainably produced steel by the Indian government. Earlier, there was a preference to source steel from primary production for public procurement tenders. Preferences based on source (primary vs. secondary) has now been eliminated, stipulating the adherence to only the applicable BIS standards. Thus, the barrier to utilizing secondary steel has been addressed to promote scrap recycling.

The Ministry of Steel has also been issuing the Steel and Steel Products (Quality Control) Order every year pertaining to steel and steel products since 2007. The 2018[43] version of the order requires the steel and steel products manufactured to be in conformance with 52 standards issued by BIS. This order could be another mechanism by which resource efficiency standards can be introduced and enforced in the steel industry.

Economic incentives to increase the capacities of EAF and dis-incentivizing polluting technologies must be explored, along with efforts to formalize the scrap industry as the scrap supply is complex and unregulated, with much of it coming from the informal sector.

Box 10: Key Concerns and Opportunities: Steel Production

2.1.2.1 Concerns

The main concern in relation to RE/CE are[44]:

- A huge reserve of obsolete scrap is available which, if properly utilized, will lead to significant availability of scrap in the country and will boost the growth of steel manufacturing through MSME (secondary sector). However, in absence of any organized system, India is forced to import nearly 6-7 million MMT per year of steel scrap leading to drainage of large amount of foreign exchange.

39 A Brief Perspective on the Indian Metals Recycling Industry, undated, Material Recycling Association of India: https://www.mrai.org.in/site/assets/files/5259/presentation_by_arnab_kumar_hazra_director_ficci.pdf

40 A policy on scrap recycling has been recently drafted by the Ministry of Steel and is expected to be approved in the near future.

41 National Steel Policy 2017, Ministry of Steel: http://steel.gov.in/sites/default/files/draft-national-steel-policy-2017.pdf

42 Policy for Providing Preference to Domestically Manufactured Iron & Steel Products in Government Procurement – 2017, Ministry of Steel: http://steel.gov.in/policy-providing-preference-domestically-manufactured-iron-steel-products-government-procurement

43 Steel and Steel Products (Quality Control) Order - 2018. Ministry of Steel: http://steel.gov.in/sites/default/files/Steel%20and%20Steeel%20Products%20%28Quality%20Control%29%20Order%2C%202018.pdf

44 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

2.1.2.2 Opportunities

The opportunities that address the concerns are[44]:

- There is a need of clear-cut guidelines to be issued in the form of policy so that the MSME sector can grow meeting all environmental norms and adopting the best available technologies for sustainable development.
- For steel output to grow according to the plan, India's EAF output will have to rise by at least 16.85 MMT per year, which can actually be achieved by full utilization of the existing EAF and induction furnace capacities. The utilization rate in 2016 was 74%. This can be achieved by providing economic incentives to increase the capacities of EAF technology and dis-incentivization of polluting technologies through economic/policy instruments.

2.1.3 Lifecycle Stages – Consumption

More than half of the steel produced worldwide goes into steel buildings and infrastructure. Over 15% of steel produced worldwide is used to meet transportation needs. It is also essential for the construction of related infrastructure such as roads, bridges, ports, stations and airports. Advanced High-Strength Steels (AHSS) are now used for nearly every new vehicle design. Steel is needed for growing, storing and delivering our food. It is also needed in water collection, storage, purification and distribution[45]. Figure 5 shows the distribution of steel use globally across various industries.

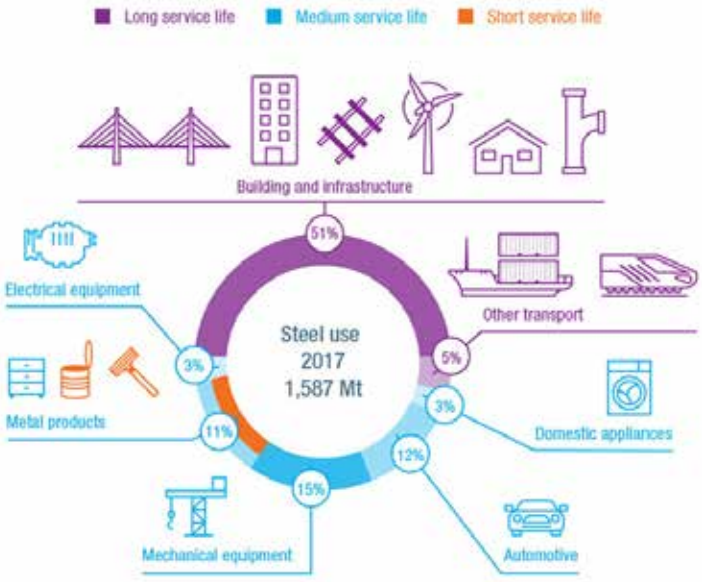

Figure 5: Global Steel Use[45]

In India, the construction and infrastructure sector are the largest consumers of steel which accounts a noteworthy share of 62% of the total finished steel consumed during 2015-16. The engineering and fabrication sector had a share of 22% of the total finished steel consumed during the year. The third largest consumer of steel was the automotive sector with a share of 10%. Other transport and packaging and others sector account for 3% each in total finished steel consumption[46]. India's steel consumption pattern is highlighted in Figure 6.

45 Steel Markets World Steel Association: https://www.worldsteel.org/steel-by-topic/steel-markets.html

46 National Steel Policy 2017, Ministry of Steel: http://steel.gov.in/sites/default/files/NATIONAL_STEEL_POLICY_2017.pdf

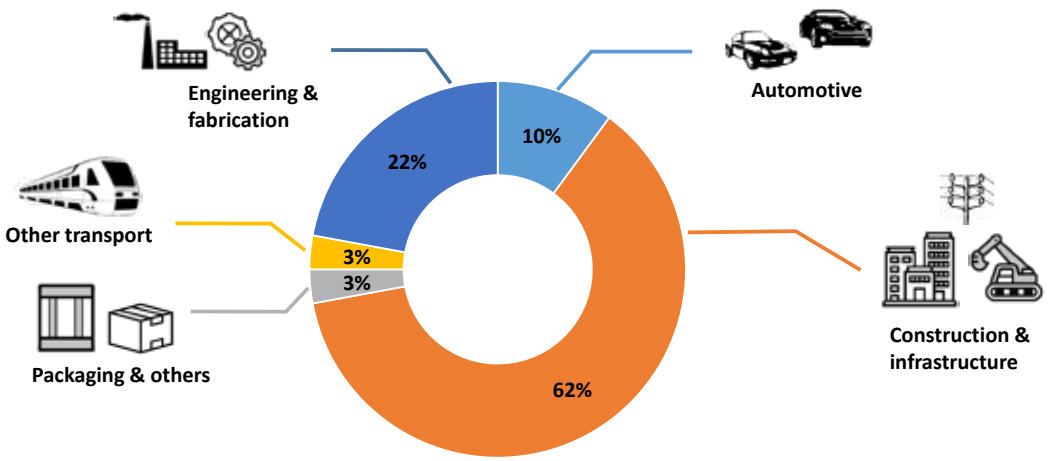

Figure 6: India's Steel Consumption (2015-16)[46]

India's steel production grew 6.2% y-o-y to 101 MT in 2017 in line with the ongoing expansion in steel making capacities and ramping of production by steel majors such as, SAIL, TATA Steel and JSW. As per World Steel Association 2018 statistics, China is the biggest steel producer, followed by Japan, and then India[47]. During 2017, steel consumption grew by around 5.2%. The steel consumption is likely to grow by an average of 6.3% and reach 140 MT by 2023. This will lead to an increase in per capita consumption of steel from 65 kg in 2017 to approximately 97 kg by 2023 and finally around 160 Kg by 2030.[46]

The benefits of efficient recycling are not well understood in India as a lot of operations are performed with obsolete technologies in the SMEs. According to the Remanufacturing Industries Council (RIC) in the US, the benefits of remanufacturing[48] include:

- Conservation of materials (of increasing importance as raw materials become scarcer and more expensive)
- Reduced energy consumption during manufacturing
- Reduced waste (and associated disposal costs)
- Lower price for comparable quality

2.1.3.1 Concerns

The concerns in relation to RE/CE are[49]:

- There is an absence of national policies for efficient collection, segregation and processing with adequate quality control.
- There is a lack of coordination between scrap collectors and steel producer, prevailing import duties and absence of a regulatory framework.
- Lack of formal standards or guidelines for RE in steel sector.

47 World Steel in Figures, 2018: https://www.worldsteel.org/media-centre/press-releases/2018/world-steel-in-figures-2018.html

48 Impacts of Remanufacturing, undated, Remanufacturing Industries Council: http://www.remancouncil.org/educate/remanufacturing-information/impacts-of-remanufacturing

49 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

2.1.3.2 Opportunities

The opportunities that address the concerns are[50]:

- Establishing a centralized authorized agency that brings together key stakeholders and promotes scrap recycling in India.
- Including production efficiency in the MoU being signed by PSUs with Government. Raw materials consumption/recycling can be parameter in the MoUs and adequate weightage can be assigned for this purpose.
- Encouraging R&D in RE in the steel sector. This is by establishing R&D programmes and allocating funds for work in RE. It is important to identify institutions (research centres and academia) for undertaking R&D on RE

2.1.4 Lifecycle Stage – Steel Recycling

The wastes generated in the production and consumption of steel include slag, fly ash and steel scrap. The metal recycling sector is largely unregulated in India. The automobile sector, especially end-of-life vehicles (ELVs) are a key source of recycled steel. From light vehicles, steel accounts for 65% of the weight of the vehicle. Therefore, their efficient recovery is of importance[51]. Currently, the ELV sector in India is largely informal and is concentrated in 5 hubs, namely, Kolkata, Chennai, Pune, Jamshedpur and Indore. A major challenge faced by ELV operators is that their capacity is hampered by their limited access to professional development and financial opportunities for business expansion and development[52]. The Guidelines for Environmentally Sound Management of End-of-Life Vehicles (ELVs) issued by the CPCB is relatively recent (2016)[53]. However, this policy needs to be strengthened with an implementation framework and financing in partnership with the private sector to achieve resource recycling for ELVs. Currently, the key concern in attaining the circular economy for steel is the existing value chain, which is unorganized and fragmented:

a. Scrap is collected from various sources at a common site where sorting, segregation and basic processing (all manual operations) are performed. These operations currently do not conform to any safety and environmental regulations.
b. The lack of processing infrastructure results in low quality scrap from domestic sources. This scrap is unclean, has low density and is high in contaminants. Scrap processing includes steps like shredding, baling, shearing, etc.
c. Hence, high quality steel scrap is imported by large players. Having a consistent domestic supply will allow for import substitution.

Formalizing the activities that are currently undertaken by the informal sector is a significant opportunity in the steel lifecycle. A draft Scrap Steel Policy has been drafted by the Ministry of Steel and is currently being reviewed for release.

50 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

51 Training Manual for Resource Efficiency in Automobile Component Manufacturing Companies in India, 2017, GIZ

52 Analysis of End of Life Vehicles (ELVs) Sector in India, 2015, Central Pollution Control Board: http://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS9MYXRlc3RfMTE0X0FuYWx5c2lzT2ZFTFZzSW5JbmRpYTFfLnBkZg

53 Guidelines for Environmentally Sound Management of End-of-Life Vehicles (ELVs), Central Pollution Control Board: http://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS9MYXRlc3RfMTEzX0RyYWZ0X0d1aWRlbGluZXNfRUxWLTFfLnBkZg

There is a concern in the existing slag management practices as slag is not being productively used. There are four types of slag generated in steel making[54]:

1. Blast Furnace Slag
2. Steel Slag (also known as Linz-Donawitz or LD slag)
3. Electric Arc Furnace (EAF) Slag
4. Induction Furnace (IF) Slag

Typical steel slag contains calcium, silicon, magnesium, phosphorous, manganese and iron.

Steel slag can be used in the following productive ways[55]:

1. Utilization in the agriculture industry for reclamation of acidic lands, especially in India's North-East and Eastern regions.
2. Utilization in the agriculture industry to substitute or reduce fertilizer consumption.
3. Granulated blast furnace slag is extensively used in the manufacture of slag cement (up to 70 % addition is permitted as per IS-455). Ground granulated BFS, is used as a substitute of cement in ready mix concrete.
4. Steel slag is traditionally used in road construction, in rail ballast and as soil stabilizer (silica and phosphorous supplement),
5. Steel slag is used as performance improver in cement making as a raw material in clinker manufacture, hence replacing limestones.

Integrated steel plants also generate huge quantity of fly ash from their captive power plants and other furnaces. This ash is generally disposed in the ash ponds along with other sludges and residues of steel making operations[56].

The productive use of fly ash should be investigated and promoted including[57] but not limited to:

1. Production of Cellular Light Weight Concrete (CLC) Blocks
2. Development of Fly Ash Based Polymer Composites as Wood Substitute
3. Substituted for cement as a blending material (up to 35%)

The sufficient availability of high-quality steel scrap due to the involvement of the unorganised business in the steel scrap as well as lack of standardisation in scrap classification processing and recycling across value chain are key concerns. Formalizing and regulating the scrap processing and recycling industry is a significant opportunity for meeting the future demand of steel and making steel industry stay competitive as virgin raw materials get scarce to source. Also, making productive use of wastes/by-products like steel slag and fly ash in construction aggregates and agriculture provides another opportunity.

Box 11: Key Concerns and Opportunities: Steel Recycling

54 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

55 Guide for the Use of Steel Slag in Agriculture and for Reclamation of Acidic Lands, undated, National Slag Association: http://www.nationalslag.org/sites/nationalslag/files/ag_guide909.pdf

56 Utilization of mixed pond ash in integrated steel plant for manufacturing superior quality bricks, 2002, Indian Academy of Sciences: https://www.ias.ac.in/article/fulltext/boms/025/05/0443-0447

57 Fly Ash Utilization in different sectors in Indian Scenario, 2011, International journal of emerging trends in Engineering and Development: https://www.researchgate.net/publication/261993642_Fly_ash_utilization_in_different_sectors_in_Indian_scenario

2.1.4.1 Concerns

The concerns in relation to RE/CE are[58]:

- The amount of LD/BoF slag generated is about 170-200kg/tonne of hot metal produced in Indian integrated steel plants. Out of this only 25% is being reused in India compared to 70-100% in other countries and especially internally for road projects, and for sintering and iron-making through recycling. It is important to find productive uses for different slags.
- With good iron ore availability in India, manufacturers may favour hot metal-based technologies for creating new capacity over scrap-based technology, if desired scrap quality, quantity, and easy availability is not assured.
- Informal/unregulated nature of steel scrap recycling industry.

2.1.4.2 Opportunities

The opportunities that address the concerns are[58]:

- Promoting and funding research to:
  - Understand and eliminate adverse side effects, if any, of use of steel slags in agriculture in order to achieve an effective and sustainable recycling. Steel slag can supply nutrients, but should not have any negative side effects on the environment and on the human, animals and plants.
  - Develop alternate uses of EAF, IF and LD slag like aggregates, sand etc., besides developing technologies for recovery of heat of slag.
- Providing economic incentives to companies to adopt scrap-intensive EAF/IF, which has a potentially lower environmental footprint.
- Establishing a comprehensive recycling strategy for monitoring and regulating the metals recycling sector in India across the value chain through formal collection, processing and recycling of scrap in an organized, safe and environmentally efficient manner

2.4. Private Sector Initiatives

In addition to policy-based initiatives, the steel industry has taken a leading role towards resource efficiency and sustainability. The World Steel Association has launched the Steel Sustainability Champions Programme[59] an industry-wide sustainability recognition programme to encourage steel companies to increase their efforts and set higher standards in relation to sustainability. The association has also launched the Global Technology Innovation Forum where companies are working together to develop breakthrough steelmaking technologies that can reduce CO_2 emissions by at least 50%. In February 2018, Tata Steel announced that it planned on establishing a scrap processing facility near Gurgaon which will supplement the company's raw material needs[60]. The company expects the scrap processing business to be of INR 10 billion in 6 to 8 years.

58 Strategy on Resource Efficiency in Steel Sector, 2019, NITI Aayog and Ministry of Steel.

59 Steel Sustainability Champions Programme, undated, World Steel Association: https://www.worldsteel.org/steel-by-topic/sustainability/steel-sustainability-champions.html

60 Tata Steel to foray into scrap processing with Gurgaon unit, 2018, The Economic Times: https://economictimes.indiatimes.com/tata-steel-to-foray-into-scrap-processing-with-gurgaon-unit/articleshow/62891321.cms

JSW Steel[61] has taken several steps in improving the sustainability footprint of its operations. The results include:

1. 873,635 GJ of waste heat utilized
2. 4.12 MMT of material recycled
3. 442,096 reduction in tonnes of GHG Emissions due to new projects/initiatives

Companies like CERO[62] (A Mahindra Accelo and MSTC Venture), which is India's first organized automobile recycling initiative aim to reduce environmental footprint through eco-friendly practices of recycling scrap vehicles.

2.5. Way Forward

The six key recommendations suggested in the Strategy on Resource Efficiency (RE) in the Steel sector, 2019 include:

1. Utilize capacities of existing EAFs and furnaces for planned steel output. Steel scrap economically utilized using DRI in EAFs.
2. Plan modern scrap processing facilities to source, separate, shred and process scrap as preferred input for quality steel production.
3. Develop the slag processing technologies to enable its utilization.
4. Increase establishment of scrap processing units to minimize import volumes.
5. Set up Scrap Processing Units near the centres/clusters of scrap consumers (i.e. EAF/IF Plants).
6. Formulate a Comprehensive Steel Scrap Recycling Policy addressing:
    a. Efficient collection, segregation and processing of steel scrap with adequate quality control.
    b. Ensure strict adherence to necessary safety measures and use of radiation detection equipment (particularly if scrap has been sourced from laboratories/hospitals).
    c. Establish Zonal Scrap Collection and Processing Sectors in the country, so that processing is done nearer to generation centres or near the end users.
    d. Revisit the existing BIS specifications pertaining to steel scrap.

2.6. Implementation Strategy

A centralized authorized agency may be constituted to deal with all types of ferrous, non-ferrous scrap & slag and waste. This agency will be responsible for formulating policies and guidelines, implementing, monitoring all aspects related to collection, handling, processing and recycling of all types of wastes to achieve Resource Efficiency targets. A dedicated department in the steel industry will look into all the aspects related to RE in terms of efficient technology, creation of new products and market etc.

61 Sustainability at JSW Steel, 2017, JSW Steel: http://www.jsw.in/jsw-steel-2017/sustainability.html

62 CERO Recycling: https://cerorecycling.com/

Production efficiency to be included in the MoUs being signed by PSUs with Government. Material Efficiency/ recycling can be an MoU parameter and adequate provisions can be assigned for this purpose. Data regarding R&D expenditure, ongoing efforts, identification of academic institutes undertaking R&D on RE to be sought. Faster granting of clearances for setting up Industrial units for scrap collection, processing and availability of low-cost capital. Improve skill development in steel processing technology with identified institutes.

2.7. Conclusions

The Indian Steel Industry has the potential for transformational change that can result not just in economic growth, but growth that is in harmony with human, social and natural capital. By instituting a conducive policy and regulatory framework, fostering innovation, investing in R&D and capacity building, the industry can become truly 'circular' and resource efficient. Improving the sustainability footprint of raw material extraction, adopting more efficient steel production technologies, augmenting scrap recycling and maximizing slag utilization are just some of the steps the industry can take to transform itself into a globally competitive, sustainable and cleaner industry.

3 Aluminium

3.1. Preamble

Aluminium is the most abundant metal in the Earth's crust (8.1%) but seldom found uncombined in nature. The main raw material for primary aluminium production is bauxite. Aluminum is used in a variety of applications, starting from household utensils to space vehicles due to its versatile properties such as low density, non-toxic, high thermal conductivity, resistant to corrosion and is easily malleable. Aluminium can be recycled endlessly with only 5 percent of energy and emissions needed to produce new aluminium product. India ranks 3rd in the production of primary aluminium in the world. Directly and indirectly, the Indian aluminium industry provides employment to more than 0.8 million people. The secondary aluminium sector constitutes nearly 30% of the total aluminium consumed in India and has been rapidly growing.

In order to meet the forecasted demand (which is 2 MMT higher than expected production) the efficiencies associated with the mining of bauxite ore, alumina extraction and primary production must be improved, and the recycling rates of aluminium scrap need to be increased. This chapter presents the status and makes recommendations in relation to RE, across the lifecycle stages of aluminium production.

Box 12: Aluminium Sector in India

3.2. Economic, Environmental and Social Context

Given aluminium's important role in the Indian economy, potential for large-scale employment owing to economic growth and the environmental impacts associated with aluminium production, it is important to understand the economic, environmental and social context associated with it. Each of these are described in this section.

Economic: India ranks 7th in the world in bauxite reserves with 2,908.85 MMT (as of FY 2017) based on information from the Ministry of Mines. Bauxite is the primary mineral used in aluminium production. The Indian Bureau of Mines reports that 134 out of the 152 bauxite mines in India operate in the private sector. Bauxite production in India is projected to increase from 26.1 MMT in 2017 to 49.4 MMT in 2021.

According to 2017 production numbers, India ranks 3rd in the production of primary aluminium in the world. Aluminium production in India is expected to grow from 2.8 MMT in FY 2017-18 to 3.33 MMT by 2020-21 and consumption of aluminium in India is forecasted to reach 5.3 MMT by 2020-21, from 3.4 MMT in FY2017-18[63]. Secondary aluminium accounts for about 30% of India's overall aluminium consumption of 3.3 MMT. In 2016, around 120,000 tonnes of aluminium scrap was generated in India, with the automotive and power industries accounting for 75%[64]. The Indian aluminium industry is highly concentrated with three integrated players making up the bulk of the production in the country – National Aluminium Company Limited (NALCO), Hindalco Industries Limited (Hindalco) and Vedanta Resources Plc. (Vedanta)[65].

Indian aluminium recycling industry is currently considered as unorganized, which is represented by around 5,000 Micro Small and Medium Enterprises (MSME)[65]. Currently, India imports some aluminium scrap for secondary aluminium production. The domestic aluminium scrap industry needs to be formalized to ensure higher domestic scrap recovery rates and to reduce import dependency.

63 Metals and Mining – February 2018, India Brand Equity Foundation: https://www.ibef.org/download/Metals-and-Mining-Report-Feb-2018.pdf

64 Strategy on Resource Efficiency in Aluminium Sector, 2019, NITI Aayog and Ministry of Mines.

65 Indian Aluminium Industry: Past • Present • Future, Metal Asia, Vol 19, No. 4, February 2018: http://www.isrinfomedia.com/main/publication/2

Environmental: Aluminium Smelting is included in the 17 major polluting industries in India and is classified as a "RED" Category industry (i.e. heavily polluting and covered under the Central Action Plan) by MoEFCC[66]. Producing aluminium from bauxite requires huge amounts of electricity, and the GHGs released are the highest when the source of energy is coal-based. The main wastes from bauxite mining are tailings produced by grinding and washing the bauxite. The processing of bauxite to alumina involves initial chemical processing of the bauxite. The main waste from alumina refining is the production of "red mud", a solid waste that is usually disposed in a landfill. The electrolysis of alumina to produce aluminium involves the use of aluminium fluoride, carbon anodes, and large amounts of electricity. The most significant waste products from the production of aluminium from alumina are air emissions including perfluorocarbon gases and carbon dioxide from the production of anodes and electricity[67].

In India, the smelter, refinery and mining operations are primarily powered by thermal electricity. According to accepted industry norms, up to 18 tonnes of CO2 are released (per tonne of produced aluminium) if aluminium is produced using electricity generated by burning coal. This number reduces to between 5 and 8 tonnes when gas-based electricity is used and close to 2 tonnes (per tonne of produced aluminium) when sourcing hydroelectricity [67].

Social: Directly and indirectly, the Indian aluminium industry provides employment to more than 0.75 million people[68].

3.3. Status, Concerns, and Opportunities across Lifecycle Stages

The lifecycle of aluminium broadly involves Raw Material Extraction, Aluminium Production, Reuse & Remanufacturing, Consumption and Aluminium Recycling. Annexure 3 (Figure 16) provides a graphical representation of these lifecycle stages. Each lifecycle stage involves various stakeholders. Annexure 3 (Figure 17) shows the stakeholders in the various lifecycle stages of aluminium. From the perspective of government, several stakeholder ministries are involved. Annexure 3 (Figure 19) provides a chronological illustration of the various government regulations, policies and programmes related to aluminium's lifecycle across different ministries.

3.1.1 Lifecycle Stage - Raw Material Extraction

According to the International Aluminium Institute, bauxite, a non-hazardous mineral, is the primary ore used to make aluminium. In general, around 85% of bauxite is refined into alumina (or alumina chemicals), which is then smelted into aluminium.

Besides Aluminium, strategic minerals such as Gallium and Vanadium can also be extracted from Bauxite. Depending on the ore grade, 4-6 tonnes of bauxite are required to refine 2 tonnes of alumina, which in turn are smelted to make approximately 1 tonne of aluminium metal. Most of the world's bauxite comes from surface mines in tropical and sub-tropical areas, where bauxite typically occurs in extensive, relatively thin near-surface layers. Because bauxite deposits often cover a very large area, bauxite mining involves disturbance of comparatively large land areas compared to the mining of other minerals, though for a shorter time. Only a small proportion of global bauxite is produced from underground mines[69].

66 Classification of industries for consent management, undated, MoEFCC, http://envfor.nic.in/legis/ucp/ucpsch8.html

67 OECD Global Forum on Environment Focusing on Sustainable Materials Management, undated, OECD: https://www.oecd.org/env/waste/46194971.pdf

68 Indian Aluminium Industry: Past • Present • Future, Metal Asia, Vol 19, No. 4, February 2018: http://www.isrinfomedia.com/main/publication/2

69 Sustainable Bauxite Mining Guidelines, 2018, International Aluminium Institute (IAI): http://www.world-aluminium.org/media/filer_public/2018/05/18/170518_sbmg_final.pdf

In India, Bauxite mining is carried out by opencast mining only due to shallow thickness which involves disturbance of relatively large land areas. On average one square meter of land is mined to give one tonne of Aluminium metal. Increased use of scrap will reduce pressure on land resources and preserve ecosystems and biodiversity.

Box 13: Key Concerns and Opportunities: Raw Material Extraction

3.1.1.1 Concerns

The concerns in relation to RE/CE are:

- Disturbance of a large amount of area creating a variety of environmental issues due to open cast mining as bauxite is found closer to surface in relatively shallow thickness.

3.1.1.2 Opportunities

The opportunities that address the concerns are:

- The Indian aluminium industry should consider reviewing and adopting Sustainable Bauxite Mining Guidelines.
- Aluminum recycling should be increased initially starting with replacing new capacity addition and ultimate reach a threshold rate where existing Aluminum stock get recycled again and again, preserving new land requirements for mining and its associated impacts.
- There should also be mandatory provision of a holistic mining plan that looks not only at the extraction of the primary mineral, but also at the commercial extraction of associated minor metals that often occur in association with the major metal in the mineral

3.1.2 Lifecycle Stage – Aluminium Production

Once mined, aluminium from the bauxite ore is obtained in two stages. First, the aluminium is chemically extracted into alumina – an aluminium oxide compound from bauxite. After alumina extraction, the alumina is smelted into pure aluminium metal. Primary production is the process through which new aluminium is made (versus secondary production, in which existing aluminium is recycled into pure metal)[70].

A solid waste called red mud is generated when alumina is extracted from bauxite. Producing 1 tonne of aluminium usually results in the production of approximately 2 – 3 tonnes of red mud. Highly alkaline in nature, red mud is typically made up of silica, aluminium, iron, calcium, titanium and an array of minor constituents. The disposal of red mud poses a challenge to aluminium producers[71].

Research has shown that red mud can be utilized to produce red mud bricks using fly ash and other additives. However, this has not become commercially viable yet due to transportation costs and removal of red mud from red mud ponds which are in remote areas[71]. There may also be an opportunity to use red mud in cement production.[72,73]

70 Primary Production, undated, The Aluminium Association: http://www.aluminum.org/industries/production/primary-production

71 Strategy on Resource Efficiency in Aluminium Sector, 2019, NITI Aayog and Ministry of Mines.

72 Utilization of red mud in cement production: A Review, 2011, National Center for Biotechnology Information, U.S. National Library of Medicine: https://www.ncbi.nlm.nih.gov/pubmed/21930526

73 Effect of Replacement of Cement by Red mud on the Properties of Concrete, 2015, International Journal of Scientific & Engineering Research: https://www.ijser.org/paper/Effect-of-Replacement-of-Cement-by-Red-mud-on-the-Properties-of-Concrete.html

Thus, there is a significant opportunity to investigate the economic, environmental and technical viability of utilizing red mud as a secondary raw material in safe and beneficial ways.

Aluminium is produced through the electrolysis of alumina at high temperatures in electrolysis pots. The electrolysis pots are lined with electrically conductive carbon linings which act as the cathode. Over time, the carbon lining deteriorates due to the penetration of elemental sodium and liquid bath materials into the pores of the lining. Once a pot fails, the lining is removed and is called Spent Pot Lining (SPL). SPL is classified as a hazardous waste by CPCB and must be disposed accordingly. Depending on the technology, it is estimated that 20-40 kg of SPL is produced per tonne of aluminium produced.[74]

The use of SPL in the cement industry as a fuel substitute by mixing with coal has been the most successful use of SPL[74]. However, more research needs to be done to understand the economic and environmental impacts of utilizing SPL in cement or other industries.

In the aluminium production process, a residual waste material called 'dross' is produced from when aluminium is melted in the furnace. Primary producers typically generate two types of dross – lumpy dross and fine powdery dross. The amount of dross generated by secondary producers is higher than the amount generated by primary producers.[74]

There is a need for aluminium producers (primary and secondary) to develop and institute robust dross management programmes to minimize dross generation and as well as invest in R&D for recovery of metals from dross and identify beneficial uses.[74]

The production of aluminium results in several waste materials like red mud, spent pot lining (SPL) and dross. There is a significant opportunity for the industry to find productive uses of these materials.

Box 14: Key Concerns and Opportunities: Aluminium Production

3.1.2.1 Concerns

The concern in relation to RE/CE is[74]:

- The production of aluminium results in several waste materials wastes in the form of tailings, residues, slags, ash, fumes, sludges, spent refractories, Aluminium dross and red mud etc.
- More than 50 % of the produced SPL is land filled without any special treatment.

3.1.2.2 Opportunities

The opportunities that address the concern are[74]:

- Investigate the economic, environmental and technical viability of utilizing red mud as a secondary raw material in safe and beneficial ways.
- Fund research to determine beneficial uses of SPL such as addition to cement.
- Developing and instituting robust dross management programmes to minimize dross generation at aluminium producers, invest in R&D for recovery of metals from dross and identify beneficial uses.

74 Strategy on Resource Efficiency in Aluminium Sector, 2019, NITI Aayog and Ministry of Mines.

3.1.3 Lifecycle Stages - Consumption

Globally, automobiles and transport account for 35% of aluminium consumption, followed by construction (32%), packaging (10%), electrical (17%) and other purposes (6%).[75] This is depicted in Figure 7.

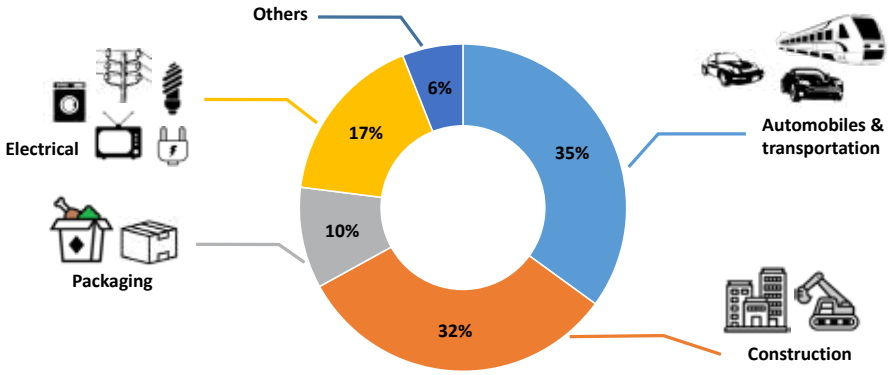

Figure 7: Global Aluminium Consumption Pattern

India consumes aluminium in sectors having typically long useful life and lower recoverability rate such as electrical (48%), transportation (15%), construction (13%), and consumer durables (7%) accounts for the major percentage of aluminium consumption[75]. This is depicted in Figure 8.

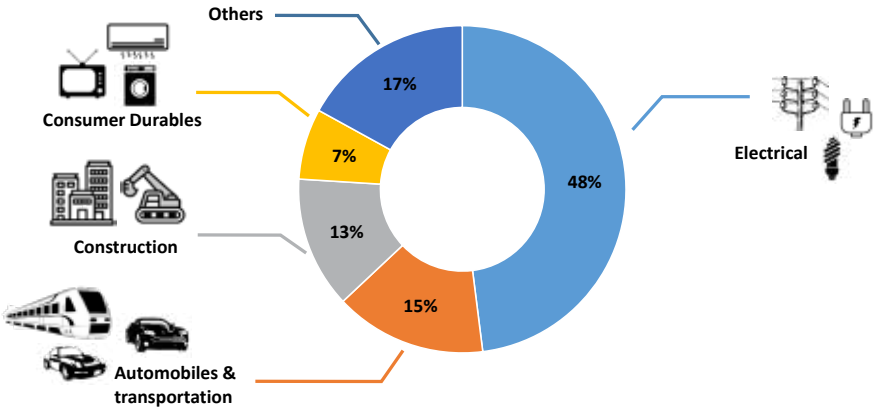

Figure 8: Present Aluminium Consumption Pattern

3.1.4 Lifecycle Stage - Aluminium Recycling

In India, activities related to aluminium scrap recovery are limited to the unorganized sector and cater mainly to the utensil and casting industries. While the proportion of recycled aluminium has been increasing in the country, there is still room for improvement. For example, recycling units use outdated or primitive technology leading to high levels of pollution and energy consumption.[75]

Secondary aluminium accounts for 30% of India's overall consumption of 3.3 MMT per year. Secondary production uses about 5% of the energy (i.e. saves up to 95%) needed for primary production. Recycling of aluminium saves 6 kg of bauxite per kg and 14kWh of electricity per kg of primary aluminium produced.[75]

75 Strategy on Resource Efficiency in Aluminium Sector, 2019, NITI Aayog and Ministry of Mines

The sufficient availability of high-quality aluminium scrap as well as the involvement of the unorganised sector in the scrap processing and recycling value chain are key concerns. As Aluminium is 100 percent recyclable without loss of natural quality with just 5 percent total energy use, recycling will help avoid new capacity additions. Formalizing and regulating the scrap processing and recycling industry is a significant opportunity. In addition, making productive use of red mud, dross and SPL from aluminium production process is another opportunity.

Box 15: Key Concerns and Opportunities: Aluminium Recycling

3.1.4.1 Concerns

The concerns in relation to RE/CE are[76]:

- Availability of good quality of bauxite for refractory.
- Informal/unregulated nature of aluminium scrap recycling industry.
- Finding productive uses for red mud, SPL and dross.

3.1.4.2 Opportunities

The opportunities that address the concerns are[76]:

- Explore methodologies for extraction of red mud from red mud ponds which are located at remote areas. Use of red mud bricks/blocks will help in saving a large amount of natural resources like clay which are primarily used for manufacture of bricks.
- The 1st cut SPL is carbon rich and should be used as a fuel. Since SPL contains cyanide, fluoride etc., it needs to be de-toxified. The process developed by JNARDDC Nagpur needs to be adopted for bulk consumption of the material, especially in power plants, cement plants and in other industries. The other potential uses of SPL are for blast furnace injection as fuel for iron-making, as flux for steelmaking or as reducing agent for slag cleaning furnaces, like copper.
- Explore technologies for recovering aluminium metal trapped in dross.

3.4. Private Sector Initiatives

- Vedanta: Red Mud Powder Plant at SSL – Lanjigarh[77]

At Vedanta's, Lanjigarh operations, a new red mud disposal system was commissioned in 2013-14 for converting the liquid red mud into solid cakes which can then be converted into useful products for cement production and pig iron production, as well as conversion into lightweight aggregates. This was established with the aim of converting the alumina plant into the world's first zero waste refinery. This led to the complete elimination of the wet red mud pond and also reduced the related risks to the environment. Additional benefits include improvement in alumina recovery and the development of by-product recovery projects for valuable resources such as titanium and iron. During 2017-18, Vedanta recycled 82% of high volume and low effect waste (fly ash, slag, red mud, gypsum) in sustainable applications.[78]

76 Strategy on Resource Efficiency in Aluminium Sector, 2019, NITI Aayog and Ministry of Mines

77 Sustainable Development Report 2013-14, Vedanta Resources plc: https://www.vedantaresources.com/SustainabilityDocs/vedanta-full-report.pdf.downloadasset.pdf

78 Sustainable Development Report 2017-18, Vedanta: https://sd.vedantaresources.com/SustainableDevelopment2017-18/pdf/VedantaSDReport2017-18.pdf

- HINDALCO: Increasing capacities of downstream aluminium recycling plants

HINDALCO's downstream manufacturing plants have dedicated aluminium recycling and remelting facilities. Their capacities have been upgraded over the years as seen in Figure 9[79].

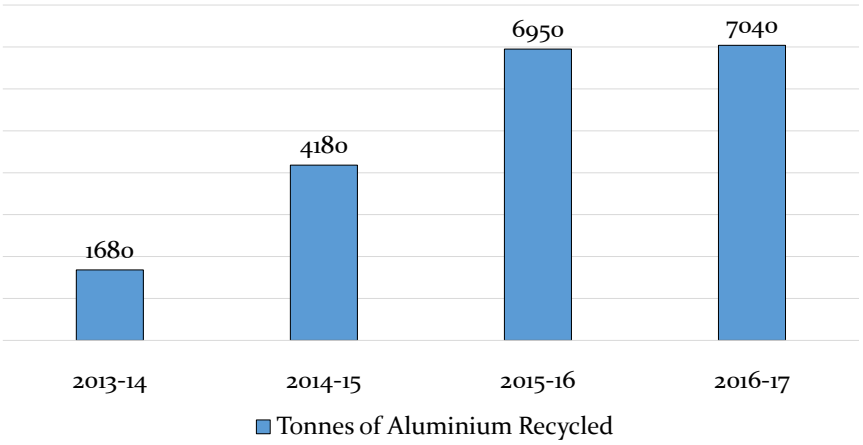

Figure 9: Downstream aluminium recycling capacities of plants of HINDALCO.

3.5. Way Forward

The nine key recommendations suggested in the Strategy on Resource Efficiency in Aluminium Sector, 2019 include:

1. Classify aluminium as a core Industry & strategic sector enabling production of high-quality metal with provision of critical infrastructure to avoid global volatility in supply and prices
2. Formulate an export policy for downstream aluminium producers towards high end product and export of value-added aluminium. Sync with the flagship programme of Make in India, with focus on development of entire value chain of aluminium production in India.
3. Develop technologies to convert waste generated during the production of aluminium with minimal resources towards a zero-waste concept for the industry.
4. Formulate a policy to encourage domestic industry to become globally competitive with appropriate duties, taxes and fiscal instruments. Consider banning export of Aluminium scrap to promote growth of domestic industry. Achieve a target of 85% recycling rate by 2025 and enhance job creation opportunities.
5. Set up zonal scrap collection/segregation/treatment facilities. Recycling zones to address issues of transportation, pollution control etc.
6. Broaden organized market for recycling scrap from Aluminium users (transport, housing & packaging sectors)
7. Recycling programmes to improve awareness pertaining to recycling and associated quality/energy/environment issues.
8. Recycled aluminium products to follow standards for better quality control & be certified
9. Introduce public awareness campaign on the quality of aluminium being recycled.

79 Sustainability Report 2016-17, Hindalco: http://www.hindalco.com/upload/pdf/hindalco-sustainability%20Report%202016-17.pdf

3.6. Implementation Strategy

A National Material Recycling Policy, aimed to provide guidance to establish an appropriate legislative, administrative and institutional framework for recycling of metals and materials needs to be formulated. A Scrap policy shall be formulated to reflect new needs, issues and opportunities with an aim to achieve a target of 85% recycling rate by the year 2025 through technical and financial support to SMEs and formalisation of informal sector in order to enhance job creation opportunities. Tax regime to be rationalised for secondary processing of Aluminium. R&D in scrap processing and recycling along with outreach needs to be carried out. Independent agencies/institutions like JNARDDC should be assigned with responsibility of certifying the products made from recycled metals.

3.7. Conclusions

The Indian aluminium industry is expected to grow due to continued demand for the metal in industries such as the automotive, power and packaging industries. The resource efficient and circular use of aluminium is going to play a critical role in decoupling economic growth and environmental impact. Bringing the activities undertaken by the informal sector into the purview of the formal sector though regulatory, technological and economic instruments is critical to maximizing the recovery of this metal. Additionally, manufacturers must be encouraged to design for easy material recovery and consumers must be educated on the environmental, economic and social value of refurbished and remanufactured products. These steps can play a transformative role in the evolution of the aluminium industry in India.

4 Electrical and Electronic Equipment

4.1. Preamble

ICTs offer great opportunities for sustainable development. At the same time, the ICT sector has enormous environmental impact during each stage of lifecycle, especially during the end- of-life disposal through the generation of e-waste. E-waste, which refers to used, broken, or obsolete electrical and electronic equipment, such as phones, laptops, sensors, and TVs, can contain hazardous substances that may pose considerable environmental and health risks, especially if treated inadequately. As technologies change at great speed, and as access to and use of electrical and electronic equipment increases, product lifecycles become shorter and many designs do not support repair or reuse. As a result, the amount of e-waste is growing rapidly throughout the world.

India, at present, is ranked as the 5th highest generator of e-waste in the world with year on year growth rates of about 30 percent. Estimates suggest that the amount of e-waste generated in India is about 2 million TPA (tonnes per annum). The quantity that is recycled is about 0.44 TPA primarily through the informal sector. Given the growth of the electronics market, and a largely informal recycling industry with limited capacity in the formal sector, there is pressing need to manage e-waste properly so that high value materials are recovered, toxic materials are safely managed, and recovered materials are reintroduced back in to production. Unfortunately, the recovery yield in secondary processing of e-waste is low (~10-20%), thereby losing the precious metal resources like copper besides increasing the environmental risks.

This chapter presents the status of e-waste in India and makes recommendations across the life cycle stages of e-waste in relation to RE.

Box 16: E-waste Sector in India

E-waste consists of end-of-life electrical and electronic equipment products. It comprises of a whole range of electrical and electronic items such as refrigerators, washing machines, computers and printers, televisions, mobiles, etc., many of which contain toxic materials. E-waste contains a wide range of heavy metals like lead, cadmium and mercury. For example, circuit boards contain lead and cadmium; cathode ray tubes (CRTs) monitors have lead oxide and cadmium. Mercury is present in the flat screen monitors and switches; cadmium in computer batteries; organic compounds such as brominate flame retardants in printed circuit boards (PCBs), plastic casings, cables, PVC cable insulations.[80]

4.2. Economic, Environmental, Social Context

The economic, environmental and social contexts in relation to the e-waste industry in India are described below.

Economic: The Indian electronics market is one of the largest in the world and is anticipated to reach US$ 400 billion by 2022 from US$ 69.6 billion in 2012.[81] Total production of electronics hardware goods in India is estimated to reach US$ 104 billion by 2020. The communication and broadcasting (C&B) equipment segment constituted the highest share (31%) of the total production of electronic goods in India in FY13-14, followed by consumer electronics at 23%. The growth in the electronic market is resulting in large volumes of e-waste being generated in the country.

80 Government of India, Rajya Sabha Secretariat, E-waste in India, Research Unit (Larrdis), 2011, Rajya Sabha Secretariat: https://rajyasabha.nic.in/rsnew/publication_electronic/E-Waste_in_india.pdf

81 Electronics, 2015, India Brand Equity Foundation: https://www.ibef.org/download/Electronics-March-2015.pdf

According to an ASSOCHAM-NEC, 2017 study on "Electricals & Electronics Manufacturing in India" the amount of e-waste generated in India is about 2 million TPA (tonnes per annum). The quantity that is recycled is about 0.44 TPA.

According to The Global E-waste Monitor, the estimated value of raw materials which can be mined from e-waste stood at 55 billion euros of which mobile phones alone was to the extent of 9.5 billion euros. Table 1 shows the resource potential which can be extracted from e-waste in the year 2016.[82]

Table 1: Potential value of raw materials in e-waste in 2016

Material	Kilo tonnes (kt)	Million €
Fe	16,283	3,582
Cu	2,164	9,524
Al	2,472	3,585
Ag	1.6	884
Au	0.5	18,840
Pd	0.2	3,369
Plastics	12,230	15,043

Printed circuit boards (PCBs) are the most valuable type of e-waste due to the presence of precious metals like gold, silver and palladium. The recovery of elements embedded in e-waste has economic value and the recovered material can be utilised as secondary raw materials for the manufacture of new products.

In addition to the domestic generation of e-waste, the import of e-waste from developed countries continues through illegal channels.

Environmental: In addition to the presence of recoverable materials of high economic value indicated in Table 1, e-waste also contains elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants. Beyond certain threshold quantities, these elements render e-waste hazardous in nature.

Thus, e-waste contains significant concentration of substances that are hazardous to human health and the environment, even a small amount of e-waste entering municipal solid waste (MSW) stream can introduce a relatively high amount of heavy metals and halogenated substances. Currently with the informal sector playing a key role in resource recovery such harmful substances pose environmental and health hazards.

Social: Around 90% of e-waste in India is managed by the unorganized sector, typically from low-income marginalized communities. Women and nearly 500,000 children are engaged in e-waste collection without adequate protection and safeguards.[83]

The contact with the chemicals used during e-waste handling/dismantling, improper ventilation and working without use of personal protection equipment lead to direct exposure to hazardous chemicals. Apart from this, workers are also exposed to other hazards leading to physical injuries and chronic ailments such as asthma, malnutrition, skin diseases, eye irritations etc. and in some cases even to long term and incurable diseases.[84]

82 The Global E-Waste Monitor 2017, 2017, UNU and ISWA: https://www.itu.int/en/ITU-D/Climate-Change/Pages/Global-E-waste-Monitor-2017.aspx

83 A Digital India Must Embrace the Circular Economy, 2018, The Royal Institute of International Affairs: https://www.chathamhouse.org/expert/comment/digital-india-must-embrace-circular-economy

84 E-Waste Recycling in India – Bridging The Gap Between The Informal And Formal Sector, 2010, International Solid Waste Association: https://www.iswa.org/uploads/tx_iswaknowledgebase/Krueger.pdf

No safety precautions are followed in the informal sector, however formal recycling operations provide personal protective equipment like gloves, masks, shoes, and caps to employees.

4.3. Status, Concerns, and Opportunities

Electronic products, whole or in part, or rejects from their manufacturing and repair process, which are intended to be discarded are termed as e-waste. The material flow of e-waste involves four broad stages – (i) producers, (ii) consumers, (iii) collectors, (iv) treatment and disposal. Annexure 4 (Figure 20) provides a graphical representation of these lifecycle stages. Each lifecycle stage involves various stakeholders. The key stakeholders in the e-waste management cycle include importers, producers/manufacturers, retailers, consumers, scrap dealers, dismantlers and recyclers. Figure 21 from Annexure 4 shows the stakeholders in the various material flow stages of e-waste. From the perspective of government stakeholders several ministries are involved. Figure 22 in Annexure 4 provides a chronological illustration of the various government regulations, policies and programmes across different ministries in relation to e-waste's material flow stages.

4.3.1 Material Flow Stage – Production

Electronic manufacturing services (EMS) are provided by organizations that design, assemble, produce, and test electronic components and printed circuit board (PCB) assemblies for original equipment manufacturers (OEMs).

The E-Waste Management Rules, 2016 & Amendment, 2018 mandates the collection of e-waste generated during manufacture of any to be channelized for recycling or disposal.

The rules direct the producers under EPR to collect and channelize e-waste of a set target to an authorised dismantler or recycler or Treatment, Storage and Disposal Facility (TSDF). Manufacturers and producers can implement EPR individually or collectively through a Producer Responsibility Organization.

EPR plan submitted to the SPCB permits producers to place products in the market. Compliance to the EPR is only through self-declaration.

SPCBs require capacity development to enable effective implementation of EPR. There is a need to inventorize e-waste data to estimate volumes and the scale of recycling infrastructure needed for resource recovery, and utilisation of secondary raw materials to feed into domestic manufacturing of EEE industry.

The SPCBs are mandated to inventorize e-waste data, however the methodology of e-waste inventorization either by sales data and equipment obsolescence rates or by tracer method is not specified. Methodologies followed by SPCBs are different, necessitating the need for harmonisation.

The Ministry of Electronics & Information Technology's Electronics and IT Goods (Requirements for Compulsory Registration) Order, 2012 specifies that manufacturers need to conform to specified Indian standards after obtaining registration from the BIS. Substandard and defective products manufactured beyond use will be disposed as scrap. However, there is no mention of how the e-waste generated is channelized into e-waste stream.

The National Information Technology Policy (2012) has no mention of any activity that considers RE/SRM aspects. The focus is on deployment of Information and Communications Technology (ICT) in all sectors of the economy making it possible for millions of citizens to access services electronically. However, does not consider the challenge of managing e-waste in the absence of collection mechanisms and recycling infrastructure.

The policy also covers Electronic System Design & Manufacturing (ESDM) which provides MSMEs with financial support to promote manufacturing. However, there is no specific mention of RE/SRM in design. Design for Environment (DFE) to minimize e-waste generation or consideration of RE/SRM in the manufacture process needs to be incorporated.

The Digital India program for Electronics Manufacturing provides incentives for Electronic Manufacturing Clusters Scheme and R&D in electronics, specifies a mandatory waste management and recycling facility but does not explicitly state whether the assistance is for an e-waste recycling facility, which is likely to constitute most of the waste from the cluster and also from users of products. Thus, special consideration should be given to e-waste recycling facilities in the program.

The Modified Special Incentive Package Scheme provides capital subsidy of 20% in SEZ for units engaged in electronics manufacturing. The SEZ policies should include RE or effective e-waste recycling.

Economic instruments as proposed in the E-waste Rules, 2016 such as the Deposit Refund Scheme for e-waste exchange to be introduced by the producers.

Restriction of Hazardous Substances (RoHS) compliance in the EPR plan is through self-declaration via the provision of detailed information on the constituents of the equipment and their components or consumables or parts or spares or through analytical test results using the methods described or referenced in EN 62321. **However, there are limited testing facilities or laboratories in India.** Adequate infrastructure dedicated to the RoHS test, skilled laboratory manpower and scientific and technical knowledge base are **rarely available and should be increased.**

There is great opportunity to strengthen national policies so that resource efficiency and secondary raw material use measures are incorporated in to the manufacture of electronics products. In addition, there is a significant need for inventorization of e-waste generated by manufacturers.

SPCBs need to be equipped to understand the EPR and implement them effectively. Economic instruments for producers could be considered, such as the Deposit Refund Scheme for e-waste exchange. Infrastructure dedicated to the RoHS test, skilled laboratory manpower and scientific and technical knowledge should be increased.

Box 17: Key Concerns and Opportunities: Production Stage

4.3.1.1 Concerns

The concerns in relation to RE/CE are:

- Current polices on electronics manufacturing and e-waste weakly address RE/CE and SRM.
- Limited presence of testing facilities or laboratories that can provide a detailed analysis on the constituents of electronic products.
- Limited understanding of EPR by SPCBs.

4.3.1.2 Opportunities

The opportunities that address the concerns are:

- Strengthen national policies so that resource efficiency and secondary raw material utilization are incorporated in the manufacture of electronics products.
- Develop a specific methodology to inventorize e-waste.

- Investing in the establishment of testing facilities or laboratories
- Capacity building of SPCBs on monitoring of EPR plans submitted by the producers

4.3.2 Material Flow Stage – Consumption

According to the India Brand Equity Foundation, the electronics sector is split into six product segments:

1. Consumer Electronics (mobile phones, TVs, music systems)
2. Industrial Electronics (UPS systems, SCADA, PLC, AC drive systems)
3. Computers (notebooks, desktops, servers)
4. Communication and Broadcasting Equipment (Direct-To-Home – DTH, Set Top Box – STB)
5. Strategic Electronics (radars, satellite-based communication, internal security system, disaster management system)
6. Electronic components (semiconductor devices, cathode ray tubes, capacitors, picture tubes)

The consumers can be broadly classified as the bulk consumers and household consumers. Waste generated by bulk consumer electronics and computer segments may be significant contributors to the e-waste stream. According to a 2016 report[85] by the Oeko-Institut on resource efficiency in the information and communication technology (ICT) industry, there are four types of obsolescence that occur resulting in the generation of e-waste (especially in relation to mobile phones and tablets. These are:

- Material obsolescence (insufficient performance of materials and components)
- Functional obsolescence (fast changing technical and functional requirements)
- Economic obsolescence (repair and maintenance cost prohibitive)
- Psychological obsolescence (fashion trends, new technical trends)

In order to address the increase in obsolescence due to change in consumer preferences, there is a need to increase consumer awareness on the impact of electronic product manufacture as well as e-waste generation through the use of ecolabels and consumer awareness campaigns needs to be considered. Additionally, the Ministry of Environment, Forest and Climate Change's E-Waste Management Rules (2016) & Amendment 2018 lacks incentives for consumers to dispose their e-waste appropriately. The producers also need to consider EPR as a policy instrument to promote waste avoidance through design for durability, spare part availability, upgradeability and standardization to promote life extension of products.

There is a need to increase consumer awareness on the impact of electronic product manufacture as well as e-waste generation to take a critical look at consumer behaviour. Government or market-based instruments should be instituted for consumers to dispose their e-waste appropriately.

Box 18: Key Concerns and Opportunities: Consumption Stage

4.3.2.1 Concerns

The concerns in relation to RE/CE are:

- Very low consumer awareness on the impact of electronic product manufacture, and e-waste generation and management.

85 Resource efficiency in the ICT sector, 2016, Oeko-Institut e.V: https://www.oeko.de/fileadmin/oekodoc/Resource_Efficiency_ICT_LV.pdf

4.3.2.2 Opportunities

The opportunities that address the concerns are:

- Raising consumer awareness on the impact of electronic product manufacture, and e-waste generation and management.
- Establishing government or market-based incentives for consumers to dispose their e-waste appropriately.

4.3.3 Material Flow Stage – Collection

The channels for e-waste collection are through the authorised recyclers and the informal sector. However, there is no mechanism considered in the E-Waste Management Rules (2016) & Amendment 2018 Rules to include collection through the informal sector in the formal material chain. In addition, the rules state that the collector must pay the price for collecting & transporting the e-waste from households. Presently, the cost of collection is high, affecting the economics of recycling.

Informal sector and municipalities can be included for collection in the E-Waste Management Rules.

There is an opportunity and a need to formalise the e-waste collection activities undertaken by the informal sector, and support e-waste aggregators through economic incentives and capacity building.

Box 19: Key Concerns and Opportunities: Collection Stage

4.3.3.1 Concerns

The concerns in relation to RE/CE are:

- The e-waste collection activities are unregulated and primarily informal.

4.3.3.2 Opportunities

The opportunities that address the concerns are:

- Providing economic incentives and capacity development to companies in e-waste collection and mandating best practices.

4.3.4 Material Flow Stage – Dismantling

In 2016, there were 178 e-waste dismantler/recyclers registered with the Central Pollution Control Board across 14 states with an approximate capacity of 4.3 MTA.[86] Global E-Waste Monitor (2017) estimated that in 2016, India generated nearly 2 million MTA. Given the huge gap in the dismantling/recycling capacities in the formal sector and the presence of informal sector, a large volume of waste gets dismantled by the non-registered informal sector. There is a need to increase the dismantling capacity in the country in the formal sector. Opportunities and financing for recycling entrepreneurs need to be explored to enhance resource recovery and improve environmental and safety considerations.

86 List of Registered E-waste Dismantlers/Recyclers in the Country (as on 29-12-2016), 2016, Central Pollution Control Board: http://cpcb.nic.in/cpcbold/List_of_E-waste_Recycler_as_on_29.12.2016.pdf

The skills need to be upgraded for job opportunities in the manual dismantling operations in India to cater to a better resource efficient recycling in comparison to a mechanized dismantling operation.

Box 20: Key Concerns and Opportunities: Dismantlers

4.3.4.1 Concerns

The concerns in relation to RE/CE are:

- Capacity of formal dismantling units are not functional fully due to lesser collection efficiency which leads to leakages of material to be informal sector.

4.3.4.2 Opportunities

The opportunities that address the concerns are:

- Inclusion of manual operations and skilled labour will provide social, environmental and economic gains in the dismantling operation.

4.3.5 Material Flow Stage – Secondary Processing

The processing and recycling of e-waste affects the health of workers and there is a pressing need for recycling and processing standards. About 90-95% of e-waste recycling occurs in the informal sector where PCBs are treated in primitive methods to remove components and extract metals. For example, cables are burnt to recover copper, resulting in the release of toxic gases in to the surrounding. Recovery yield in secondary processing is also low (~10-20%), resulting in the loss of precious metals.

It is recommended that standards and technologies be adopted for secondary processing. For example, technologies developed for extraction of metals at pilot plants established by C-MET, Hyderabad and E-Parisaraa, Bangalore (supported by MeitY, GoI) have successfully demonstrated recovery rate of 95% of precious metals from printed circuit boards. Technology solutions like these need to be scaled up through financing and economic instruments and made available to the informal sector for their formalisation.

Recovery yield in secondary processing is low (~10-20%) resulting in the loss of precious metals. There is a need for the development and implementation of standards and promotion of best practices and technologies to be adopted for secondary processing.

Box 21: Key Concerns and Opportunities: Secondary Processing

4.3.5.1 Concerns

The concerns in relation to RE/CE are:

- There are no recycling and processing standards for e-waste.
- Recovery yield in secondary processing is low.
- Leakages of e-waste to the informal sector through the formal recyclers/ dismantlers leads to non-compliance.

4.3.5.2 Opportunities

The opportunities that address the concerns are:

- Establish recycling and processing standards for e-waste management.
- Promote best practices and innovative technologies for secondary processing.
- Expansion of recycling facilities to cover similar components extracted from end of life vehicles or other secondary resources.

4.4. Private Sector Initiatives

Manufacturing/Production

Dell: Dell uses recycled plastics recovered from old computers via the "take back" system through their Dell Reconnect Partnership with Goodwill and Asset Resale and Recycling Services in the United States. The plastics are shredded at their manufacturing facilities, melted and blended (currently 35% recycled content) and then moulded into new parts.[87] They currently use closed loop plastics for more than 90 different products. It takes approximately 6 months for the material to go from the old computer to being used in the new product.

Telangana State's e-waste Policy: The State, through its e-waste Management Policy 2017, has proposed to earmark industrial space or shed for e-waste dismantling and recycling in the existing and upcoming industrial parks, estates and industrial clusters.

Philips: Philips through their Green Innovation drive, apply Eco-design and circular economy principles in designing products and solutions.[88] Their Eco-design approach considers all aspects of product development and design including life-cycle assessment, to determine the environmental impact at each stage from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.

Apple's Trade-in and Give Back Program: Consumers can return any Apple product for an Apple Store Gift card. If it is not eligible for credit, they would recycle it for free no matter the model or condition.[89]

HP's Hardware and Recycling Program[90]*:* HP offers recycling services to small and medium business customers as well as individual consumers. HP takes back and recycles end-of-life HP branded personal computers, printers, scanners, fax machines, monitors, handheld devices, batteries and associated external components

Consumption

ITC IT e-waste Policy[91]*:* ITC has a sound policy for handling e-waste. Salient features of this policy include preferential dealing with IT vendors having sound e-waste management processes and extending the useful life of IT assets to postpone / minimize generation of e-Waste.

Collection:

Recently various Producer Responsible Organizations (PROs) have been registered with CPCB, GOI and have undertaken initiatives to engage with the informal sector for collection. E-waste exchange platforms

87 Dell - Design for Environment - Closed-Loop Recycled Content: https://www.dell.com/learn/us/en/uscorp1/corp-comm/closed-loop-recycled-content

88 Philips Sustainability- Our Green Products: https://www.philips.com/a-w/about/sustainability/sustainable-planet/green-products-and-green-innovation.html

89 Apple GiveBack: https://www.apple.com/shop/trade-in

90 HP Product Return & Recycling: http://www8.hp.com/in/en/hp-information/environment/product-recycling.html

91 ITC's IT E-waste Policy: https://www.itcportal.com/about-itc/policies/itc-it-e-waste-policy.aspx

through digitization can also help electronic & electrical product producers /manufacturers to meet EPR targets, transparency and monitoring, support bulk consumers, small medium business as well as individuals to channelize their e-waste to Government authorised e-waste recyclers for responsible recycling / reuse / upcycling.

Amazon & Re-Teck[92]: Amazon has authorised Re-Teck for collection of e-waste (Amazon devices and equipment) from consumers for further disposal of e-waste to their certified re-cycler. Amazon also allows customers to ship their devices to Re-Teck's local India facility.

Dismantling:

A number of CPCB registered dismantlers/recyclers provide an end to end integrated solution for e-waste management to many Multi-National Companies (MNC). To undertake this, they establish their own reverse logistic points across the state or nation-wide as per the consent received and also set up of pre-processing points at various locations across India. Many of these dismantlers also integrate informal sector in its network of collection & dismantling activities to share benefit of this untapped opportunity and at the same time protecting their livelihood and environment.

Reuse/Recycle:

GreenDust: Partnered with brands like Apple, Toshiba, LG, Samsung, Lenovo, Haier, Dell, Philips, Whirlpool and retailers like Croma, Homehop18 to refurbish rejected or damaged electronics. Re-selling of refurbished products is at 30% cheaper than the market price. Their main customer base is Tier II and Tier III cities. In three years, the company set-up 200 stores and 14 warehouses and repair units across the country. All the collected products undergo a 50-point quality check before re-sale with a GreenDust factory second certification.

Secondary Processing:

C-MET Hyderabad & E-Parisaraa Bangalore: Printed circuit boards processing technology was successfully developed & demonstrated by CMET and E-Parisaraa through a research and development programme of MeitY, GOI. Pilot scale project of smelting, hydro-metallurgy, electro-chemical treatment, mechanical shredding etc. to recover metals such as copper, gold, silver and palladium has been successful. The established technology handles 1 tonne of PCBs per day which can be converted into a viable business model for technology dissemination.

4.5. Way Forward

The 8 key recommendations suggested in the Strategy on Resource Efficiency in Electrical and Electronic Equipment Sector, 2019:

1. Initiating an RE and CE Scheme to drive the overall goal of achieving RE and CE through capacity building, formalisation of informal sector, Outreach and Advocacy, R&D for new technologies for improving resource efficiency, technology upgradation & proliferation with the action agenda mentioned below
2. Incorporate role of Urban Local Bodies to setup infrastructure for e-waste collection towards integrating the informal sector with in the purview of the E-waste Management Rules, 2016.
3. Conduct feasibility study for assessing resource use in the electronics manufacturing and secondary resource recovery utilization potential

92 Amazon Recycling Our Products: https://www.amazon.in/gp/help/customer/display.html?nodeId=200197550

4. Conduct awareness campaign for all stakeholders including, schools, colleges, RWAs, bulk consumers, dealers, refurbishers, producers, informal sector and government employees for behaviour change
5. Carry out capacity development measures for informal and formal actors in safe handling and disposal of e-waste
6. Develop business models for proliferation of technology adoption with informal sector towards formalization and ensuring better livelihoods.
7. Develop policies and guidelines for eco-friendly designs, and best available technologies and processes to reduce decontamination in the dismantling and recycling process.
8. Development and adoption of guidelines for use of secondary materials and standards for reuse & refurbished products

4.6. Implementation Strategy

Implementation of RE/CE in end-of-life EEE sector will require engagement and integration of multiple stakeholders in the value chain. MeitY may initiate a RE and CE scheme to drive the overall goal of achieving RE and CE through capacity building, formalisation of informal sector, outreach and advocacy, R&D for new technologies for recycling of e-waste, technology upgradation and proliferation. In support with EU-REI, MeitY would conduct a feasibility study for resource use in the electronics manufacturing and secondary resource recovery utilization potential.

MoHUA with MoEFCC may engage ULBs to set up collection infrastructure and integrate the informal sector for collection. MeitY in partnership with MoEFCC will promote business models which can lead to proliferation of technology adoption with the informal sector enabling their integration and ability to retain livelihoods.

MeitY and BIS with support from EU-REI, will develop policies and guidelines for adopting designs which are eco-friendly and processes which will reduce decontamination in the dismantling and recycling process. MeitY and BIS can also develop standardisation for refurbished and repaired products.

4.7. Conclusions

The electronics market in India is expected to grow in to the coming decade. This growth will continue to add to the challenge of managing the generated e-waste effectively. The current state of e-waste management in India is weak with most of the e-waste being managed by the informal sector and there is an urgent need for regulatory and economic instruments that can incentivize not only the effective management and recovery of materials in the e-waste stream but also influence the design of electronic products that facilitate their easy recovery and in fact, incorporate recovered materials back in to products. Also EPR should be used as an opportunity to promote upstream design changes to plan durability, and lifetime extension in products.

5 Construction & Demolition Waste

5.1. Preamble

The total quantum of waste from the construction industry in India is estimated to be 100 million tonnes per annum in 2018. While retrievable items such as bricks, wood and metal, are recycled, the concrete and masonry waste are not being adequately managed and recycled. It is estimated that only 10-30%of C&D waste is recovered in India. The existing practice in India is to dispose of this waste in landfills or illegally dump in rivers and water bodies affecting the land and water resources. While disposal of C&D Waste is a challenge, there is an acute shortage of naturally available aggregates, limestone and other of other construction materials like sand and soil.

While C&D generation estimates are uncertain, it is likely that India also has one of the highest C&D waste generation rates in the world. At the same time, it has low C&D waste utilisation rate (10-30%) for land-levelling and back-filling purposes in construction projects by private contractors. This chapter presents the status of C&D waste in India and makes recommendations across the material flow stages of C&D waste in relation to RE/CE.

Box 22: C&D Waste Generation in India

5.2. Economic, Environmental and Social Context

C&D waste refers to the waste comprising of building materials, debris and rubble resulting from construction, re-modelling, repair and demolition of any civil structure'.[93] Soil, sand and gravel (36%), brick & masonry (31%) and concrete (23%) make up most of the C&D waste in India.

To create an efficient management program for C&D waste, it is essential to understand the economic, environmental and social context of C&D waste.

Economic: A Ready reckoner on C&D Waste released by the Buildings Materials & Technology Promotion Council (BMTPC),[94] MoHUA estimates that 100 million tonnes of C&D waste is generated nationwide. The specific generation of C&D waste, based on the TIFAC Thumb Rule in is presented in Table 2.[95]

		Specific C&D waste generation
1	New Construction	50 kg/m^2
2	Renovation /Repair	45 kg/m^2
3	Demolition	400 kg/m^2

Table 2: Specific Generation of C&D Waste in India (2000)

Currently, C&D Waste in India is used in the following ways[96]:

- The recoverables of immediate secondary market value, such as metal rods, pipes and fixtures, wooden frames, etc., are salvaged by the informal sector, typically from demolition sites, leaving

93 Notification, 2016, Ministry of Environment, Forest and Climate Change: http://www.moef.gov.in/sites/default/files/C%20&D%20rules%202016.pdf

94 Utilisation of Recycled Produce of Construction & Demolition Waste: A Ready Reckoner, 2018, Building Materials & Technology Promotion Council.

95 Training Manual on Construction and Demolition Waste Management in India for Cities and Towns, 2017, GIZ and DA: http://re.urban-industrial.in/live/hrdpmp/hrdpmaster/igep/content/e64918/e64922/e67075/e67087/GIZ_CD_eTrainingManual.pdf

96 Strategy on Resource Efficiency in Construction & Demolition Sector, 2019, NITI Aayog and Ministry of Housing and Urban Affairs.

behind the "rubble" composed of bulky materials such as concrete, stones, bricks and mortar, etc.

- A small fraction of this rubble is used for back-filling in construction projects, both for private projects and public works, and the same demolition contractors arrange for its transportation to sites where it is needed.

Materials which cannot be re-used are disposed at landfill sites. However, debris consisting of concrete, brick and mortar are often indiscriminately dumped. Excavated earth is dumped illegally on roadsides, low-lying areas and river beds. This causes waste to pile up on roads, resulting in the choking of surface drains, causing traffic disruptions and causes nuisance as well as safety problems. Although directives exist for the disposal of waste to landfills, penal action against violators is not taken. Presently, the disposal of C&D waste in ULB designated dump yards only occurs in a few cities.[97, 98]

The **Construction & Demolition Waste Management Rules, 2016** from the Ministry of Environment and Forests and Climate Change the cover the application of materials made from C&D waste as well as outlines the duties of government bodies.

The **IS 383: Coarse and Fine Aggregate for Concrete – Specification, 2016** standard issued by the Bureau of India Standards specifies the extent of utilization of coarse and fine aggregates for concrete and the percentage and quality of C&D waste that can be utilized.

The **Guidelines on Environmental Management of Construction & Demolition (C&D) Wastes** by the Central Pollution Control Board discusses best practices for the utilization of recycled C&D waste.

Box 23: C&D Waste Rules, Standards and Guidelines

Environmental: C&D waste generation has several impacts on the environment, mostly through the generation of solid and hazardous wastes. The major constituents of C&D waste are concrete, soil, bricks, wood, asphalt and metal. 60% of the total waste is comprised of brick and masonry, soil, sand and gravel. While this is mostly inert material, most of them are disposed to landfills. Rajasthan has over 4,000 marble mines which produces about 95% of the entire marble produced in India. However, about 70% of marble processing waste is indiscriminately dumped in local areas. There is an environmental threat from the disposal of marble dust on the riverbeds. Flora and harvest are also affected as marble powder persists in the air and deposits on them during the dry season.[99]

Alone, C&D wastes do no directly contribute to air emissions, except for fine dust particles owing to the indiscriminate dumping of C&D wastes along roadsides which float from the movement of vehicles. Due to the movement of earthmovers, demolition and other construction activities, clouds of dust create undesirable conditions for people in the local vicinity, especially those who are suffering from respiratory diseases. Virtually all the GHG emissions associated with C&D waste generation are linked to their transportation and processing which are energy intensive processes.

C&D wastes do not create waste water releases but their indiscriminate dumping near water bodies can result in water pollution through run-offs. Noise generated from construction and demolition activities are undesirable and can create a nuisance if it is a continued activity.

97 The Impact of C&D Waste on Indian Environment: A Critical Review, 2018, Civil Engineering and Research Journal: https://juniperpublishers.com/cerj/pdf/CERJ.MS.ID.555658.pdf

98 Economic Aspects of Construction Waste Materials in terms of cost savings–A case of Indian construction Industry, 2012, International Journal of Scientific Research Publications, 2(10), 1-7.

99 Conservation of water and disposal of marble waste by using filter press, 2000, Proceedings of the National workshop on Safety & Technology in Marble Mining and Processing in new Millennium, Department of Mining Engineering.

Social: About 50% of the capital outlay in the Indian Construction Industry is towards the employment of labour and is therefore labour intensive. The construction and the real estate sectors are expected to create over 15 million jobs in the next five years with an estimation of over 67 million people working in this sector by 2022.

5.3. Status, Concerns, and Opportunities across Different Stages of Management

The different stages of management of C&D Waste broadly involves C&D Activities, C&D Waste Generation, C&D Waste Collection, C&D Waste Processing and Reuse/Recycle. Annexure 5 (Figure 24) provides a graphical representation of these lifecycle stages.

Each lifecycle stage involves various stakeholders. For example, the stakeholders of the recovery stage include the construction companies, recyclers, Local, State and National governments, informal sector, labour unions and industrial associations. Annexure 5 (Figure 25) shows the stakeholders in the various lifecycle stages of C&D Waste. From the perspective of government stakeholders across the lifecycle stages of C&D waste, only two ministries are involved. A unique feature in the Indian governance framework for C&D waste is that only the MoEFCC is dedicated to it. The MoEFCC drafted the C&D Waste Management Rules in 2016 and the CPCB drafted the Guidelines on Environmental Management of C & D Waste Management in 2017. Annexure 5 (Figure 27) provides a chronological illustration of the various government regulations, policies and programmes related to C&D waste management stages across different ministries.

5.3.1 Material Flow Stage - C&D Waste Generation

Construction and demolition activities are the primary sources of C&D waste in India. Construction activities typically include the construction of buildings (residential and commercial), industrial infrastructure and public infrastructure (like roads, bridges, etc.). Demolition activities typically involve the demolition of old structures (residential and industrial) as well as any demolition activities (due to the need for rework) that may occur during new construction projects. The typical composition of C&D waste in India is shown in Figure 10.

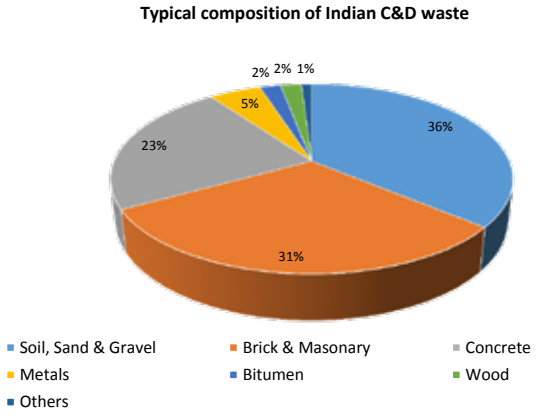

Figure 10: C&D Waste Composition[100]

Sand is one the key constituents for the manufacture of concrete and bricks. It is estimated that the annual consumption of sand in the country is around 725 MMT.[101] The rapid increase of urbanization has led to the

100 Utilization of waste from Construction Industry, 2000. TIFAC, Department of Science & Technology, New Delhi.

101 Material Consumption Patterns in India: A Baseline Study of the Automotive and Construction Sectors, 2016, GIZ, TERI and DA: http://re.urban-industrial.in/content/e64918/live/hrdpmp/hrdpmaster/igep/content/e64918/e64922/e64934/e65886/GIZBaselineEReport_compressed.pdf

exploitation of top soil for brick production. This extraction of top soil decreases agricultural productivity, which in turn increases food security concerns. Brick production has serious environmental impacts such as air pollution, and social impacts such as labour exploitation. It is estimated that soil extraction for brick manufacturing denudes 350 million cubic meter of land annually.[102] Limestone is categorized as a minor mineral when it is used for cement production. The consumption of cement grade limestone was 242 MMT. Consumption of crushed stone used as a coarse aggregate for making concrete is 2 billion tonnes annually. The total demand of cement in India is estimated to be at 297 MMT per annum.[102]

Local panchayats and other ULBs should ensure that fertile top soil is not extracted illegally for brick production. Apart from fly ash, other alternative raw materials can be explored, such as the incorporation of sugarcane bagasse ash (SCBA) and silica fume (SF) wastes into clay bricks. Reducing the domestic demand of top soil would therefore reduce the impact on agricultural productivity.

Management of C&D waste is still a challenge for urban local bodies across India due to lack of a monitoring system for the estimation of C&D waste. Due to limited knowledge on C&D waste management and logistics, it can lead to inappropriate tendering from the local body which may prevent investors from investing in a processing plant.

Despite that construction permits are usually granted, not all construction activities may be monitored. Most cities do not have formal demolition permits and developers hire local contractors for demolition. Even government agencies like PWD invite bids for demolition based on what contractors would pay for recoverables. Developing a monitoring mechanism for ensuring oversight from ULBs for achieving RE in local construction activities is required. A mechanism such as dis-incentivizing landfilling by instituting high tipping fees especially for generators of bulk C&D waste can encourage the optimal usage of construction material for projects.

The PWD, Govt. of NCT Delhi has issued an advisory to all Delhi Government departments to incorporate a clause in their tenders that mandates 2% to 10% use of recycled C&D waste products in Building and Road works respectively.[103] A major challenge regarding recycled C&D waste products is their lack of acceptance by consumers. The Green Rating for Integrated Habitat Assessment (GRIHA) online product contains all necessary information on green building products which can be incorporated for making the project GRIHA compliant.[104] There are C&D waste recycled materials which are a part of this catalogue. However, like the Ecomark scheme, an eco-labelling mechanism could be established by BIS exclusively for C&D recycled waste. This may encourage the procurement of C&D waste recycled products across various projects by both the private and public sectors. For sustainable public procurement (SPP), having incentives on procurement of recycled concrete aggregates (RCAs) or other C&D recycled waste in the form of GST rebates or relaxation may further encourage their acceptance into the market. Currently, aggregates are taxed at 5% and manufactured products are taxed at 18% making the use of recycled products economically unviable for customers. Further, the identification of all non-loadbearing structures that can maximally utilize products made from C&D recycled and SRM can enhance their market applications.

102 Resource Efficiency in the Indian Construction Sector: Market Evaluation of the Use of Secondary Raw Materials from Construction and Demolition Waste, 2015, GIZ: http://re.urban-industrial.in/live/hrdpmp/hrdpmaster/igep/content/e64918/e64922/e64934/e64952/CDMarketScan_eReport.pdf

103 Use of Recycled Products from Construction and Demolition (C&D) Waste, Office of the Director (Local Bodies), Government of NCT of Delhi, (2018), Government of NCT Delhi: https://pwddelhi.gov.in/writeread/Circular/Cir_201802161507462320.pdf

104 GRIHA Product Catalogue: http://www.grihaindia.org/?t=product_catalogue&#&Product_catalogue

The rapid increase of urbanization has led to the exploitation of top soil for brick production. This extraction of soil decreases agricultural productivity, which in turn increases food security concerns. Local panchayats and other ULBs should ensure that fertile top soil is not extracted illegally for brick production.

Alternative raw materials utilising industrial wastes, must be explored for brick production. Dis-incentivizing landfilling of C&D wastes by instituting high tipping fees especially for generators of bulk C&D waste can encourage the optimal usage of construction material for projects.

Sustainable public procurement (SPP), can catalyse the acceptance of products manufactured from C&D waste into the market. Further, the identification of all non-loadbearing structures that can maximally utilize products made from C&D wastes and SRM can enhance their market applications.

Box 24: Key Concerns and Opportunities: C&D Activities

5.3.1.1 Concerns

The concerns in relation to RE/CE are:

- Fertile top soil is extracted illegally for brick production.
- Lack of a monitoring system for the estimation of C&D waste generated.
- Low acceptance of C&D waste recycled products.

5.3.1.2 Opportunities

The opportunities that address the concerns are:

- Explore mandating the utilization of C&D waste as raw materials for brick production.
- Hauling bulky C&D waste for disposal is a substantial expense for municipal bodies which can be significantly reduced (or avoided) with an appropriately designed C&D waste management system in which generators pay for disposal.[105]
- Establish an eco-labelling mechanism (like the Ecomark scheme) for products made from recycled C&D waste.
- Promote the use of products made from recycled C&D waste through SPP. The PWD, Govt. of NCT Delhi has issued an advisory to all Delhi Government departments to incorporate a clause in their tenders that mandates 2% to 10% use of recycled C&D waste products in Building and Road works respectively.[106]

5.3.2 Material Flow Stage - C&D Waste Processing

The recoverable from C&D waste of immediate secondary market value, such as metal rods, pipes and fixtures, wooden frames, etc., are salvaged by the informal sector, from the demolition site itself. This leaves behind bulky materials such as concrete, stone, brick etc. This can be fed into crushers and reduced to smaller and smaller sizes, with size fractions separated depending on end use.

Some of the challenges related to the establishment of a C&D waste processing centres include[107]:

105 Strategy on Resource Efficiency in Construction & Demolition Sector, 2019, NITI Aayog and Ministry of Housing and Urban Affairs.

106 Use of Recycled Products from Construction and Demolition (C&D), Office of the Director (Local Bodies), Government of NCT of Delhi. (2018). Waste. Government of NCT Delhi: https://pwddelhi.gov.in/writeread/Circular/Cir_201802161507462320.pdf

107 Status and Concerns are in congruence with Strategy on Resource Efficiency in Construction & Demolition Sector, 2019, NITI Aayog and Ministry of Housing and Urban Affairs.

- **Planning Assistance for Cities**

  Implementation of C&D waste management frequently stalls after some degree of initial planning, sometimes even when capacity development efforts are conducted. "Handholding" assistance to ULBs is absolutely essential, ideally throughout the planning stages. Such assistance has to be conceived carefully since there have been instances where cities have received "guidance" from consultants that was not appropriate to their circumstances, thus resulting in stalled progress.

- **Awareness**

  There is a lack of awareness among contractors small and large alike on the C&D Waste Management Rules that they will have to comply with. It will be difficult to decide beforehand if the project would generate more than 20 tonnes of construction waste. There is no clarity on the rates for storage, collection and transportation.[108] There is no specification for applicability of penalties to generators for non-compliances. Also, there are no guidelines on the demolition permits. Since C&D waste management is a new topic, there is widespread lack of awareness in all stakeholders.

- **Land Allocation**

  Owing to the densely populated urban zones, there is a shortage of land for allocation for establishing C&D waste processing centres. Such centres require a large space to operate. Identifying land for operations within urban limits can be challenging and the only option to establish a C&D waste processing centre would be outside city limits. However, this would require collaboration between ULBs, local waste collectors and state governments (in case of establishment of C&D centres in border areas). The location should be decided in such a manner that logistics are efficient and is not cumbersome on the movement of local traffic.

  In smaller towns where the waste generated is below 100 TPD, a processing unit may not be viable. In some rare instances, it may be possible for neighbouring towns to have a joint plant provided they are close enough to each other. In most cases, a mobile crusher may be a suitable option and the recycled aggregates produced may be used by the town's own civil works, other public agencies such as PWD, or local building material manufacturers may be incentivised to use them.[107]

- **Need for Inventorization**

  Inventorization for evaluating and establishing the sizes and numbers of C&D waste recycling units that may be required. This would depend on the population density of the city or town and the numbers of buildings and other infrastructure per square kilometre.

- **Monitoring Mechanism**

  With several construction projects occurring in vast urban landscapes, it is a difficult task for local municipalities to monitor the generation of C&D waste. The TIFAC Thumb Rule, estimates C&D waste generation based on the area being constructed/demolished (50 kg/m2 for construction and 400 kg/m2 for demolition). In the absence of a more detailed methodology, municipal authorities may use this rough guide for approximate estimation. In order for ULBs to adopt this methodology for C&D waste quantification, ULBs need to know the exact area of buildings/projects that will undergo construction/demolition. It is recommended that ULBs creates easily accessible inventory from construction/demolition permits. Most cities do not have demolition permits and therefore demolition sites and practices are poorly monitored, if at all.

- **Finances for Establishment and Operation**

  Establishment of waste processing facilities are expensive, and the municipalities may not have

108 Strategy on Resource Efficiency in Construction & Demolition Sector, 2019, NITI Aayog and Ministry of Housing and Urban Affairs.

enough budgets in running recycling facilities at full capacity. A construction waste charge can be imposed on waste generators. The revenue generated from this waste charge can be utilized for extending support to the activities of authorized C&D waste recycling centres (such as payment of tipping fees to the contracted parties).

Another option can be that the local government establishes a scheme where the contractors can pay the maximal estimated fee to the ULB that would be required for processing and disposal of the estimated C&D waste to be generated from the project up front. After the end of the project, the ULB can refund the balance money or charge more money after evaluating the quantity of C&D waste that has been generated throughout the project.

It is estimated that only 5% of C&D waste is recovered in India. There is a lack of awareness among contractors on the regulations they are required to comply with. Owing to the densely populated urban zones, there is a shortage of land allocation for establishing C&D waste processing centres. Inventorization for evaluating and establishing the sizes and numbers of C&D waste recycling units that may be required. Establishment of waste recycling facilities are expensive. A construction waste charge can be imposed on waste generators. The revenue generated from this waste charge can be utilized for extending support to the activities of authorized C&D waste recycling centres.

Box 25: Key Concerns and Opportunities: C&D Processing

5.3.2.1 Concerns

The concerns in relation to RE/CE are[109]:

- C&D waste management is a relatively new topic that many municipal officials have little awareness or experience of.
- Shortage of land for the allocation for C&D waste collection centres and processing centres.
- Due to chronic financial pressures, local authorities/municipal bodies are instinctively wary of any new commitments such as establishing C&D waste processing units as they may appear to them as a new source of expenditure.

5.3.2.2 Opportunities

The opportunities that address the concerns are:

- Conducting capacity building programmes for contractors and ULBs on C&D waste management.
- Collaboration between ULBs, local waste collectors and other stakeholders for carrying out inventorization to evaluate and establish the sizes and numbers of C&D waste processing units.
- Imposing a construction waste charge on waste generators to generate revenue and extend support to the activities of authorized C&D waste processing centres.

5.3.3 Material Flow Stage - Reuse/Recycle

The generated C&D waste (reused/recycled) from projects have the following pathways:

- C&D wastes which are good quality are reused or sold by the informal sector at a discounted rate from the original value of the commodity

109 Strategy on Resource Efficiency in the Construction & Demolition Sector, 2019, NITI Aayog and Ministry of Housing and Urban Affairs.

- As filler materials in low-lying areas before new construction activities.
- Sub-base layer during the laying of roads

Since all these activities are unregulated, it is difficult to quantify these operations.

Reuse of C&D waste is unregulated. There is an opportunity to develop and establish standards and guidelines that create transparency and legitimacy in the reuse of C&D waste.

Box 26: Key Concerns and Opportunities: Reuse

5.3.3.1 Concerns

The concerns in relation to RE/CE are[110]:

- Engagement with the construction industry repeatedly demonstrates that potential buyers are hesitant about such recycled products that they perceive to be inferior in quality. Even when informed about the updated BIS standard (383) that allows recycled aggregates in many applications, potential buyers appear risk averse, pointing to their clients who seem to prefer "conventional" products.

5.3.3.2 Opportunities

The opportunities that address the concerns are[110]:

- Promote utilisation of C&D waste recycled products through awareness creation. Developing an industry-oriented awareness and capacity development material and sharing them through a web-portal. Sustained outreach and engagement is required to change perceptions and entrenched business practices in the construction industry, including utilisation of recycled products. Capacity development needs to target all actors in the construction sector. Industry and professional associations may be roped in to achieve this. Such associations can adopt these capacity development initiatives through workshops, trade shows, and their own publications.
- Cities should adopt preferential procurement policy to use recycled products made from C&D waste in municipal civil works and encourages other private and public entities to do the same.

5.4. Private Sector Initiatives

The construction and demolition waste processing plant at Burari waste collection contract with Infrastructure Leasing & Financial Services (IL&FS) was approved by the North Delhi Municipal Corporation's (NDMC) Standing Committee till 2019 and sanctioned INR 230 million for the expenditure on transporting the materials to the plant. Initially, the plant was established with 500 tonnes per day (TPD) capacity and it has since been expanded to 2,000 TPD. The unit gets mixed waste from 28 designated points in three zones of the North Delhi Municipal Corporation.[111]

Amdavad Enviro Projects Pvt. Ltd. (AEP) along with Ahmedabad Municipal Corporation established a 100 tonnes per hour concrete and demolition waste recycling facility in Ahmedabad in 2013. Under the brand of 'NuEarth', the plant manufactures recycled products for construction such as paver blocks (strength of M30 and above), hollow blocks (strength of M10 and above), solid blocks (strength of M10 and above) and kerbstones (strength of M25 and above)[112].

110 Strategy on Resource Efficiency in Construction & Demolition Sector, 2019, NITI Aayog and Ministry of Housing and Urban Affairs.

111 Waste to Wealth, 2017, Ministry of Housing and Urban Affairs, Government of India: http://164.100.228.143:8080/sbm/content/writereaddata/Waste%20to%20Wealth_2%20Oct.pdf

112 Amdavad Enviro Projects Pvt. Ltd. Website: http://amdavadenviro.com/

While maintaining quality, AEP achieved a cost reduction of 10% in manufacturing of M30 grade paver blocks. Also, an M50 grade paver block was developed at the cost of an M30 grade paver block. For the C&D waste-based products made by AEP, Institute for Certification and Quality Mark (ICMQ) (accredited by the European Union (EU) for third-party certification of a wide range of green products, buildings, management systems) was engaged for product audit[113]. The M30 paver block obtained the GRIHA certification for building material with recycled content and added to the GRIHA product catalogue[114].

5.5. Way forward

The 6 key recommendations suggested in the Strategy on Resource Efficiency in the Construction & Demolition Sector, 2019:

1. Develop/augment construction/demolition permits consolidated to an easily accessible inventory and link them with project approvals.
2. Inventorize and characterise C&D waste by
    a. Select quantum estimation method best suited for Indian context
    b. Use this method to estimate nationwide generation
    c. Prepare simple standardised method for cities to estimate and characterise waste
    d. SBM portal to be expanded to include data on C&D by ULBs
    e. Centralised web-platform to serve as a facilitation tool to connect generators and users of C&D waste
3. Provide planning assistance (handholding) for cities by
    a. Empanelling consultants to provide assistance to cities on developing detailed management plan, financial model and implementation strategy
    b. Disseminating best practices and C&D management models along with development of toolkits covering technical aspects, management models, business case, tendering documents, etc.
    c. Appointing appropriate consultants and expert agencies, to conduct capacity development workshops for ULBs
    d. Develop/augment construction/demolition permits consolidated into an easily accessible inventory and linking them with project approvals
    e. Frame by-laws on C&D waste management incorporating appropriate levels of fees and penalties for generators
4. State-level facilitation and recognition of efforts in C&D waste management.
5. Promote awareness in construction industry
    a. Industry associations to conduct sustained outreach covering all types of industry actors using capacity development manuals/toolkits on “deconstruction”, recycling and reutilisation
    b. Special emphasis to be placed on technical standards (e.g., BIS) as well as “green” marketing and certification through BMTPC/GRIHA/IGBC

113 Circular Economy: A Business Imperative for India, 2018, YES BANK Ltd. and TERI: http://www.teriin.org/sites/default/files/2018-03/TERI-YES_BANK_Circular_Economy_Report.pdf

114 GRIHA Product Catalogue: http://www.grihaindia.org/?t=product_catalogue&#&Product_catalogue

6. Promote utilization of C&D waste recycled products:
    a. ULBs and State agencies to adopt public procurement in a time-bound manner
    b. CPWD/IRC to promote increased adoption of C&D waste products
    c. BIS to promote standards and inclusion in National Building Code
    d. MoF to consider GST rebates
    e. MoEFCC to adopt Ecomark label
    f. MoHUA may facilitate states/UTs to make arrangements for quality checks of recycled products
    g. Mandating all Govt. projects to incorporate deconstruction and in-situ utilization

5.6. Implementation Strategy

Ministry of Housing and Urban Affairs (MoHUA) would take the lead role in driving forward the C&D Waste RE/CE Strategy. MoEFCC will continue to play a regulatory role in compliance. MoHUA may constitute an ad hoc expert task force comprising of reputed expert institutions for inventorization and characterization of C&D waste. MoHUA may consider developing a web-platform as a facilitation tool to connect generators, recyclers and potential users for various applications of C&D waste and derived products based on location for prompt utilisation. Expert consultants/agencies may be empanelled to provide handholding of ULBs in disseminating best practices, development of toolkits for C&D waste management. Cities may engage with MoHUA empanelled experts through their respective state agencies according to their needs and applicable protocol.

Engagement with professional and industry associations for outreach to the wider construction industry will be established. MoHUA may guide state agencies such as PWD, Housing Board, etc. to adopt Preferential Public Procurement policies, and may write to Ministry of Consumer Affairs to direct BIS for increased inclusion of recycled products made from C&D waste into future revisions of the National Building Code as well as further development/amendment of standards and prospects for ISI certification of several categories of products made from C&D waste. MoHUA may write to Ministry of Road Transport to include C&D waste products in Indian Roads Congress codes. MoHUA to continue engagement with Ministry of Finance for continued GST rebates on recycled product categories as and when they become available in the market. MoHUA to engage with green building rating schemes such as GRIHA and IGBC for inclusion of a greater range of products made from C&D waste into their certification schemes.

5.7. Conclusions

The Indian construction sector has the potential for reinventing itself and growing in a sustainable manner. By instituting a conducive policy and regulatory framework, fostering innovation, investing in R&D and capacity building, the industry can become truly ‘circular’ and resource efficient. Improving the practices of construction activities, adopting the use of recycled C&D wastes, preventing indiscriminate dumping and landfilling are just some of the steps the industry can take to transform itself into a sustainable and cleaner industry.

6 Way Forward

Based on the analysis of four strategy papers, this chapter develops 30 cross-cutting recommendations in the form of an overarching framework.

The framework consists of following six categories that serve like pillars to support the overall canvas of RE/CE.

1. Policies
2. Programmes/Mainstreaming
3. Regulations
4. Setting up a Dynamic Recycling Industry
5. R&D and Technology Development
6. Capacity Development, Outreach and Monitoring

The above categories address needs and interests of diverse sectors and material flows as well as the key stakeholders for the promotion of RE/CE.

Each of these categories and their relevance are briefly described below.

Policies: The focus sectors/areas studied in the strategy papers show the importance of policy and regulatory framework in the promotion of RE/CE. While there are already provisions made to promote RE/CE in some of the national policies, in many cases these policy elements are implicit and need to be explicitly stated.

It is necessary therefore that a harmonized overarching national policy on RE/CE is evolved building upon the existing policies to address multiple sectors. Such a policy framework should address various life cycle stages and the material flows to ensure closing of the loop and involvement of the key stakeholders. The national policy should be supported by studies such as identification and prioritization of nationally relevant resources or sectors (biotic and abiotic) that could benefit from RE/CE interventions. The analyses presented in Annexures 2 to 5 of this report emphasizes such a need.

One of the major cross cutting policies supporting the national policy on RE/CE can be on Sustainable Public Procurement (SPP). This will help minimize consumption of resources, reduce waste generation and GHG emissions, as well as contribute to innovation in materials and technology in the space of RE/CE. SPP will essentially help to introduce RE/CE in India's production and consumption patterns. Many of the recommendations arising from the strategy papers on recycled products will be addressed through SPP. SPP will also lead to reduction of GHG emissions resulting from various life cycle stages of products.

Strengthening of policies and the existing sectoral programmes of Ministry of Mines by incorporating RE/CE principles is going to play a critical role. Updation of the Sustainable Development Framework (SDF) to include RE/CE, encouraging procurement of raw materials from 4 or 5 Star Rated mines and possibilities to join the Extractive Industries Transparency Initiative (EITI) can make the mining industry both sustainable as well as resource efficient.

Management of End-of-Life Vehicles (ELVs) has been identified as one of major challenges in the waste management sector. ELVs are in fact a major repository of resources that needs to be tapped efficiently and in an environmentally sound manner. Establishment of common recycling infrastructure with resource efficient, safe technologies and integrating with the informal sector will address issues related to resource availability, waste management and employment.

India has introduced several waste management related policies and rules led by MoEFCC under the Environmental Protection Act, 1986. Some of the waste streams such as e-waste and C&D waste enjoy a significant resource recovery potential. Further extractive sectors such as Steel and Aluminium generate scrap, slag, red mud etc. that have a great potential for recycle, recovery and reuse. A harmonized Waste to Resource Management Directive will therefore help. In harmonizing the existing waste regulations, it will be important to explore integration with the hazardous substance management rules following a lifecycle approach. This consideration will help in improving circularity of the waste streams at higher efficiency, lower costs and low environmental risks. The Directive should address relevant stakeholders, especially the informal sector, focus on RE/CE and introduce economic instruments.

Programmes/Mainstreaming: India is implementing several flagship programmes such as Swachh Bharat Abhiyan, Make in India and Smart Cities. These programmes provide a great opportunity to mainstream RE/CE and reap economic, environmental and social benefits on a scale. Apart from the flagship programmes, new and innovative programmes will need to evolve in each of the focus sectors. The programmes could include setting up of financing schemes. The strategy paper on e-waste suggests that for informal sector integration, there is a need for development of business models that may enable proliferation of indigenously developed recycling technology to the informal sector towards formalisation to ensure safe and environment friendly recovery of resources from the WEEE. The strategy paper on steel recommends programmes on zonal scrap collection and processing programmes under the steel scrap recycling policy.

Recently introduced Corporate Social Responsibility (CSR), Corporate Environmental Responsibility (CER) and Extended Producer Responsibility (EPR) have now mandated the business to commit to environmental protection and livelihoods of the communities. These obligations could be leveraged to promote RE/CE. Under CSR, industries can impart skilling to the informal sector engaged in waste segregation, collection and recycling as it will provide market for the recycled products. Environmental action plans conceived and implemented under CER could be encouraged to introduce RE/CE in their projects. Under EPR, product manufactures could improve product design and packaging so as increase take back and recycling rates across the life cycle.

Chemicals used in products when not environmentally sound pose difficulties in waste recycling, increase costs and raise risks to the human health and environment. A National Chemical Management Plan that is being drafted by MoEFCC may help to develop a strategy, framework and guidelines for the safe and circular management of chemicals. This plan may also explore opportunities for R&D in chemicals that will allow increased utilization of wastes with low risks.

Programs for financing on RE/CE will play an important role. A fund on similar lines as the National Clean Energy and Environment Fund could be used to finance recycling infrastructure, clean technologies and related RE/CE initiatives. A special fund may also be considered to support innovations/pilots that can help in R&D and technology development in green products and recycling technologies. Introduction of economic instruments and rationalization of taxes will be useful to reduce wastes being sent to the landfills. The revenues so generated may be directed to the RE/CE related funds.

Regulations: Modernization of regulations and their enforcement is important to put the RE/CE related policies into practice. As earlier brought out, harmonization of the waste related regulations under the Environmental Protection Act (EPA), 1986 emphasizing RE/CE could be an opportunity. Strict enforcement of Environmental Statements for large, highly consumptive and RED category industries can help in building databases on the resource consumption. Such databases can help to develop monitoring and reporting indicators.

Strengthening regulations can include developing standards for green products and revamp schemes such as Ecomark. Standards for recycled products will ensure a level playing field with the products made from virgin materials. All the four strategy papers make a reference to such a need.

India needs to make more use of economic instruments to promote RE/CE. This may be done by rationalizing tax regime on extraction of critical virgin raw materials[115] to make secondary raw materials price-competitive and for businesses entering remanufacturing, refurbishing and recycling sectors.

To address these reforms in the regulations, there is a need to establish a national coordinating body- Bureau of Resource Efficiency (BRE). This body may coordinate and drive all activities of RE/CE. To support the BRE, RE/CE cells may be established within each concerned ministry. The MoEFCC has already established such as cell. In addition, a Waste to Resource Management Board may be established for monitoring and oversight. Establishing State Level coordinating bodies to identify, implement and achieve State- level RE/CE goals will ensure implementation of RE/CE interventions customized to the State.

Setting up a Dynamic Recycling Industry: Given the opportunities in waste recycling, it is critical that India develops a dynamic and mature waste recycling industry. Until recently, China was a large importer of recyclable materials, accepting more than 30 million tonnes of waste from all over the world every year. At the start of January 2018, however, China began to stringently enforce restrictions on the import of recycled materials under its National Sword policy[116]. India should therefore consider strengthening of its waste recycling infrastructure to increase the domestic material recycling rates.

All the strategy papers have underscored the need of promoting recycling. Recycling could include repair, refurbishing and remanufacturing. For sectors such as steel and aluminium, increase in scrap recycling rate is going to be critical to reduce extraction from the mines, reduce imports and increase utilization of technologies like EAF in steel making. Recycling of the C&D waste will help in reducing extraction of virgin materials, reduce waste to the landfills and provide alternate materials and products in the market. E-waste recycling is critical to recover precious metal resources, reduce imports and lower the environmental risks given the steep increase expected in the e-waste generation. Industries in Europe and the United States greatly benefited by establishment a remanufacturing council or association[117]. A constitution of such a council may be considered especially for the steel and aluminium sector.

There is a need to develop recycling related technologies, build infrastructures such as MRFs, develop eco-industrial parks, develop schemes and come up with innovative business models. Both centralized and decentralized solutions of waste recycling will need to be supported. Setting up zonal/regional recycling centres and promoting waste exchange platforms are other possibilities as expressed in the strategy papers.

Most of the municipal solid waste is today disposed in dump sites, in India. This practice has resulted into serious environmental degradation, generation of GHGs and a lost opportunity to recover resources. In order to address these challenges, urban mining may be promoted by giving assistance to the ULBs. Indigenous technical expertise will need to be developed that can help process waste and economically recycle. Innovative business models are required with the private sector who could undertake urban mining in partnership with ULBs and create secure landfills. Putting urban mining as one of the priority agendas in missions like Swatch Bharat Abhiyan will certainly boost these activities.

Employment generation will be one of the major benefits of boosting the recycling industry. Given the role of the informal sector (as echoed by all the strategy papers), their strengthening (skilling), formalization and

115 Federal Acquisition Regulation: https://www.govinfo.gov/content/pkg/CFR-2011-title48-vol1/pdf/CFR-2011-title48-vol1-sec2-101.pdf

116 China's National Sword policy and its future ban on certain types of plastic scrap are affecting global markets - can be accessed at: https://www.recyclingtoday.com/article/national-sword-china-plastics-recycling/

117 European Remanufacturing Council: http://www.remancouncil.eu/

integration will be important. Assuring a safe working environment for the informal sector is also necessary.

R&D and Technology Development: Inventorization of the waste streams to assess the magnitude and resource recovery potential still remains a challenge. There is need to develop practical and reliable methodologies to carry out inventorization and characterisation of major waste streams such as e-waste and C&D waste.

Emphasis on product redesign and recycling will require R&D and technology development. The strategy papers make specific recommendations on improving technologies in the areas such as scrap and slag utilization, metal recycling from e-waste and making products from C&D waste. For promoting recycling, efficient and economical solutions are required at both small scale (decentralized) and large scale (centralized) scales. This will require focused R&D and technology development. Further technologies like Artificial Intelligence (AI), robotics, blockchain etc. may be considered for R&D for the recycling industry

Institutions of national importance such as IITs, research institutions and laboratories set up under CSIR will need to undertake joint R&D projects with the industry and set up incubation and accelerator programmes on RE/CE for the start-ups. Experience in Europe has shown that knowledge platforms play a significant role in the promotion of RE/CE. Knowledge platforms may therefore bet set up to facilitate open innovation, provide access to experts, and engage academia to support the transition towards RE/CE.

Capacity Development, Outreach and Monitoring: To achieve all of the above, awareness programmes, training of professionals and capacity building of key institutions will be necessary. Stakeholder analyses conducted in this study indicates that capacity development (including leadership) is required at the ULBs, PCBs, stakeholder ministries and implementing agencies involved in various national flagship programmes. Only when adequate capacities are built in these institutions, the effective enforcement of regulations will take place.

Academia and training institutions will need to hold series of continuing education programmes on policies, regulations, technologies and business models focusing on RE/CE. Industry associations will need to play a key role in the outreach of RE/CE concepts and expertise by holding seminars, workshops and exhibitions. The outreach related activities may not be limited to national level but include global outreach programmes. Consumer interest organizations will be important in raising awareness of communities on sustainable consumption, waste segregation and recycling. Building skills and introducing certification of the waste pickers and processors in the informal sector as well as of operators of recycling facilities will also be essential.

Finally, indicators will be required to track progress i.e. monitoring for the purpose of reporting. These indicators could include number of green products introduced, number of recycling infrastructure facilities established, sector specific material and energy consumption, recycling rates etc. The indicator framework may follow a tiered approach such as core common, sectoral and regional indicators.

It may be observed that all the six categories described above are in fact interrelated and present an “ecosystem” approach (see Figure 11). Any intervention towards transition to CE will require policy support, enforcement of regulations and a programmatic approach following mainstreaming. Financing, technology and capacity development will ensure the effectiveness and sustainability of the outcomes. Considering these interrelationships in the framework, thirty (30) recommendations covering the six categories are evolved as the way forward. Potential agencies who can take lead in the addressing these recommendations are stated along with indicative timelines.

In developing these recommendations, following inputs have been considered.

- Thirty (30) recommendations as made by the strategy papers as summarized in Chapters 2 to 5[118] building on the commonalities
- Research and analyses carried out in this study (refer Annexures 2 to 5)
- Concerns & opportunities and key stakeholders identified across life cycle stages and material flows in the four focus sectors/areas (as reflected in Chapters 2 to 5)
- International experience (refer Annexure 7)
- Recommendations earlier made in the National RE Strategy by NITI Aayog[119]

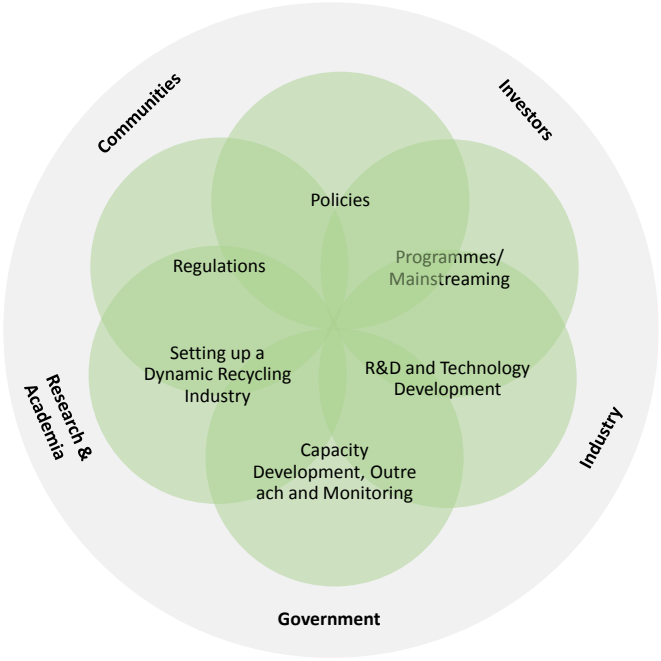

Figure 11: Enabling Framework for Promotion of RE/CE

Specific recommendations under each of the above categories are described below along with the action points.

6.1. Policies

Recommendations	Implementation agency	Timeline
R1.1 Formulate a national policy on RE/CE for biotic, and abiotic resources addressing various lifecycle stages and key stakeholders.	MoEFCC	6 months-1 year
	Action points	
	• Review existing policies across the nine ministries with RE/CE considerations • Follow a lifecycle thinking approach and address key stakeholders while achieving harmonization • Identify and prioritize nationally relevant resources or sectors (biotic and abiotic) that could benefit from RE/CE interventions	

118 Strategy on Resource Efficiency in Aluminium Sector, 2019; Strategy on Resource Efficiency in Steel,2019; Strategy on Resource Efficiency in Electrical and Electronic Equipment Sector, 2019; Strategy on Resource Efficiency in Construction & Demolition Sector, 2109.

119 Strategy on Resource Efficiency, 2017, NITI Aayog and EU Delegation to India: https://www.niti.gov.in/writereaddata/files/document_publication/StrategyOnResouceEfficiency_0.pdf

	• Carry out risk analyses on the identified resources from an economic, environmental and social perspective • Reflect the attendant policy/ guidelines on the global value chain of the recycling industry and evaluate opportunities and threats	
R1.2 Formulate a national policy on Sustainable Public Procurement (SPP) with an action plan emphasizing procurement of RE & CE products.	MoEFCC	6 months-1 year
	Action points	
	• Establish and promote green product labels/certifications program by revamping the earlier ECOMARK scheme • Introduce low carbon considerations • Create standards, for remanufactured /refurbished/recycled products addressing quality, environmental, health and safety related considerations • Develop guidelines on testing methodologies, product specifications and codes of practices on certifying products • Establish a model of partnership of innovation on SPP • Prepare training materials and toolkits for capacity building of procurement officers • Develop and launch consumer awareness programmes • Incentivize eco-labelled products for price competitiveness and promoting consumers purchase • Develop and launch pilot programmes at PSUs like the Indian Railways and Smart Cities programmes	
R1.3 Strengthen existing sectoral policies and programmes Ministry of Mines by incorporating RE/CE principles.	MoM, MoEFCC	1 -2 years
	Action points	
	• Update the Sustainable Development Framework (SDF) to include RE/CE and actions to be taken for resource efficient mining • Encourage procurement of raw materials from 4 or 5 Star Rated mines • Quantify recyclable materials generated at mines and encourage recycling of these materials to reduce the burden on raw material extraction • Consider to join the Extractive Industries Transparency Initiative (EITI) and elicit compliance from mining companies	
R1.4 Formulate a national policy for End-of-Life Vehicles (ELVs).	MoEFCC	1 -2 years
	Action points	
	• Enhance resource recovery of secondary materials from ELVs through common recycling centres • Develop an implementation framework for efficient and environmentally sound management practices addressing the informal sector and increasing the involvement of vehicle manufacturers	

R 1.5 Formulate a Waste to Resource Management Directive based on existing waste and hazardous substance management rules/ regulations following a lifecycle approach targeting relevant stakeholders and focusing on RE/CE.	MoEFCC	1-2 years
	Action points	
	• Integrate and harmonize various waste management rules currently enforced under the Environmental Protection Act, 1986 • Consolidate rules in the form of a Waste and Resource Management Directive (i.e. setting targets) in consultation with relevant ministries • Follow the lifecycle stages and emphasize the elements of RE/CE, while ensuring environmental health and safety (EHS) compliance • Provide guidance on engaging all the stakeholders including the informal and private sector. • Link rules of hazardous waste and substances to achieve circularity with reduced environmental risks	

6.2. Programmes and Mainstreaming

Recommendations	Implementation agency	Timeline
R2.1 Mainstream RE/CE initiatives by leveraging existing flagships programmes and schemes like Swachh Bharat Abhiyan, Smart Cities Make in India, Start up India, Digital India and others.	MoEFCC, MoHUA, MDWS, MCI-DIPP, MeitY	6 months-1 year
	Action points	
	• Harmonize and strengthen existing Government flagship programmes in the interest of RE/CE • RE/CE Initiatives lead to reduced waste generation and disposal augmenting the ongoing programme of Swachh Bharat Abhiyan • Smart Cities programme envisages development of efficient urban infrastructure with smart solutions providing opportunity for a resource efficient procurement, transition and replication	
R2.2 Industry may leverage Corporate Social Responsibility (CSR) Corporate Environmental Responsibility (CER) and Extended Producer Responsibility (EPR) for RE/CE initiatives.	MCA, MoEFCC	6 months-1 year
	Action points	
	• CSR- Industries can engage in informal sector skill training on waste segregation, collection and recycling as well as provide market for the recycled products. • CER- Greenfield Resource intensive industries may be guided to introduce RE/CE in their environmental action plans. • EPR- Product manufactures improve product design and packaging to increase take back and recycling rates across life cycle. PROs use the network of informal sectors in e-waste collection and recovery	
R2.3 Build on the National Chemical Management Plan being drafted by MoEFCC to develop a strategy, framework and guidelines for the safe and circular management of chemicals.	MoEFCC	1 -2 years
	Action points	
	• National Action Plan for Chemicals (NAPC) being drafted by MoEFCC may reflect RE/CE considerations for the sound management of chemicals and wastes • Explore opportunities for R&D in manufacture of innovative products from chemicals and waste that can be reused and recycled with low risks	

R2.4 Create a fund on the similar lines as the National Clean Energy and Environment Fund to finance infrastructure, clean technologies and related RE/CE initiatives.	MoF	6 months – 1 year
	Action points	
	• Make existing funds on clean energy and environmental protection available for investments in RE/CE such as recycling infrastructure • Consider establishing a special fund to support innovations/pilots that can help in R&D and technology development in green products and recycling technologies. • Introduce economic instruments and rationalize taxes to reduce wastes sent to the landfills. Redirect the revenue flows so generated to the RE/CE related funds	

6.3. Regulations

Recommendations	Implementation agency	Timeline
R3.1 Establish a national coordinating body- Bureau of Resource Efficiency (BRE) to identify, implement and achieve national RE/CE goals.	NITI Aayog, MoEFCC, MoCA	1-2 years
	Action points	
	• Create an apex coordinating body – BRE to coordinate and drive all activities of RE/CE • RE/CE cells to be established within each concerned ministry • BRE to roll out and implement measures in coordination with the RE/CE cells • Constitute a Waste to Resource Management Board for oversight	
R3.2 Establish State Level coordinating bodies to identify, implement and achieve State- level RE/CE goals.	NITI Aayog, MoEFCC, State Governments	1-2 years
	Action points	
	• Recommendations from State level RE/CE plans (e.g. Goa, Telangana & Odisha) to be harmonized with the recommendations in the Status paper • State level coordinating bodies to identify, implement and achieve RE/CE goals in coordination with BRE	
R3.3 Large and resource intensive industries generating bulk waste may be mandated to file the Resource Use and Efficiency Statement.	MoEFCC/CPCB	1-2 years
	Action points	
	• Strict enforcement of an Environmental Statement[120] to the concerned State Pollution Control Board will be an effective method of monitoring resource use and waste generation in critical industries • Support a database creation for industries to report resource use and waste generation • Establish benchmarks on production-resource consumption and track progress in RE initiatives • Develop/augment C&D waste permits for bulk waste generators by consolidating them to an inventory and linking them with project approvals	

120 Environmental Statement, Environmental Laws of India: http://www.environmentallawsofindia.com/environmental-statement.html

R3.4 Establish and mandate a 'Consent to Close' requirement for medium and large industries in the 'RED' category to ensure that waste streams are responsibly managed and recycled before closure.	MoEFCC/CPCB	6 months – 1 year
	Action points	
	• Ensure waste streams are responsibly managed and recycled for completing the closure formalities of medium and large industries in the RED Category • Introduce requirement of "consent to close" for medium and large industries in RED category, especially in the environmentally sensitive areas • Mandate independent closure audits with site assessments as a requirement to permit closure	
R3.5 Rationalise tax regime on critical virgin raw materials to make secondary raw materials price competitive.	MoF	6 months – 1 year
	Action points	
	• Engineer circular material flows with a rationalized tax regime on extraction of critical virgin raw materials[121] to make secondary raw materials price-competitive • Rationalize tax regime for businesses entering remanufacturing, refurbishing and recycling, making their products and services price competitive • Incentivize use of remanufactured/refurbished/ recycled products and related services through appropriate fiscal instruments. • Dis-incentivize landfilling by instituting high tipping fees for bulk waste generators • Higher tipping fees and penalties for bulk waste generators to encourage reduced waste generation, optimal reuse and redirection of waste into appropriate channels for recovery	

6.4. Setting up a Dynamic Recycling Industry

Recommendations	Implementation agency	Timeline
R4.1 Promote the establishment of Material Recovery Facilities (MRFs) with the allocation of land in urban areas and industrial estates.	NITI Aayog, MoEFCC, MoCA	1-2 years
	Action points	
	• MRFs[122] (including those for scraps) to create high quality and high value recyclable streams to be used as raw materials by industries • MRFs may be set up on zonal/regional basis or as part of the infrastructure of waste intensive industrial estates • Develop eco-industrial parks	
R4.2 Facilitate ULBs to undertake urban mining and create secure landfills.	MoHUA, MoEFCC	1-2 years
	Action points	
	• Support finance, technology, ULB capacity and indigenous expertise in extracting and processing wastes which have been previously stocked • Promote innovative business models to undertake urban mining and create secure landfills	

121 https://www.govinfo.gov/content/pkg/CFR-2011-title48-vol1/pdf/CFR-2011-title48-vol1-sec2-101.pdf

122 Materials recovery facility, Encyclopaedia Britannica: https://www.britannica.com/technology/materials-recovery-facility

R4.3 Facilitate the establishment of Producer Responsibility Organizations (PRO) for waste recycling and for engagement with the informal sector.	MoEFCC	2-3 years
	Action points	
	• Facilitate establishment of PROs, to enable EPR compliance by bridging the gap between producers/manufactures and the informal sector	
R4.4 Facilitate innovation to enhance resource recovery and improve working conditions by integrating the informal sector into the waste value chain. [123]	MoEFCC	1-2 years
	Action points	
	• Recognize informal sector as collectors in the waste management related rules and scrap processing units • Promote innovative models in PPP mode to formally integrate the informal sector into the waste value chain • Ensure safe working conditions during sorting and processing for the informal sector	
R4.5 Establish a remanufacturing council or association to catalyse the growth of the remanufacturing industry.[124]	Industrial associations	1-2 years
	Action points	
	• Promote benefits of remanufacturing • Provide insight and evidence to relevant Ministries in policy making • Promote the procurement of remanufactured and refurbished products by the public and profit-sector • Identify areas of common interest, both amongst corporations and policy makers • Network with experts from International Associations such as the European Remanufacturing Council (CER) and Remanufacturing Industries Council (RIC), USA	
R4.6 Establish and manage platforms for waste exchange by expanding the SBM portal.	Industrial associations	1-2 years
	Action points	
	• Encourage industrial estates and industry associations to set up a B2B waste exchange platform • Reflect waste exchange adequately in the waste related regulations addressing waste transportation and tracking • Ensure that PCBs are involved in the oversight of the platform operations	

6.5. R&D and Technology Development

Recommendations	Implementation agency	Timeline
R5.1 R5.1 Support R&D to develop scalable technologies for RE/CE and promote usage of Artificial Intelligence (AI) for higher efficiencies.	DST, MoEFCC, MoHUA, MoA, MoS, MoM	1-2 years
	Action points	
	• Develop practical and reliable methodologies to carry out inventorization and characterisation of major waste streams such as e-waste and C&D waste • Promote R&D related to enhanced material and energy recovery at both small scale (decentralized) and large scale (centralized) operations	

123 Also recommended by 'Strategy Paper on Resource Efficiency in the Steel Sector', 2019, NITI Aayog and Ministry of Steel.

124 European Remanufacturing Council: http://www.remancouncil.eu/

	• Conduct feasibility studies to make productive use industrials wastes and by-products (red mud, fly ash, slag, etc.) • Support technology start-ups related to material recovery and help with up-scaling of relevant technologies by engaging with industry	
R5.2 Create and manage knowledge platforms that facilitate open innovation, provide access to experts, and engage academia to support the transition towards RE/CE.	MHRD, MoEFCC	1-2 years
	Action points	
	• Establish a RE/CE focussed national level knowledge network with resources such as case studies, experts, learning content and academia	
R5.3 Leverage technologies like Artificial Intelligence (AI), robotics, blockchain etc. for the recycling industry.	MoEFCC, MeitY	2-3 years
	Action points	
	• Use of technologies such as Artificial Intelligence (AI) for higher separation efficiency in recycling • Technologies such as blockchain help in creating platforms to track material flows, develop indicators and participation of stakeholders with transparency	

6.6. Capacity Development, Outreach & Monitoring

Recommendations	Implementation agency	Timeline
R6.1 Facilitate creation of accredited laboratories that could conduct testing (especially for recycled products) as well as provide advisory services.	MoEFCC, Quality Council of India (QCI)	2 -3 years
	Action points	
	• QCI-accredited laboratories can be used exclusively for testing of remanufactured/refurbished/recycled products • Accredited Laboratories will assist in certification of remanufactured/ refurbished/recycled products and establishing national level benchmarks for tested and certified products	
R6.2 Provide capacity development support on RE/CE for ministries/ departments at the National and State levels.	NITI Aayog/ MHRD/ EU-REI [125]	6 months-1 year
	Action points	
	• Capacity development of key actors responsible for undertaking or overseeing RE/CE strategies (e.g. policy makers and regulators, ULBs and industrial estate authorities) • Raising awareness on the need and benefits of RE/CE (especially on themes like collaborative consumption, green products and services)	
R6.3 Develop and promote programmes and certifications for informal sector skill development of the informal sector.	NSDC, SCGJ	1years
	Action points	
	• Conduct certification programmes for waste sorting, disassembly, refurbishing and waste recycling to enhance RE/CE, reduce risks and generate employment of the informal sector • Impart training to the informal sector for value creation, especially in upcycling of waste	

125 EU- Resource Efficiency Initiative in India

R6.4 Develop and launch citizen awareness programmes on CE/RE.	MoEFCC/ EU-REI/ NITI Aayog/ MIB	1-2 years
	Action points	
	• Address general perception of recycled products as one of inferior quality • Demonstrate projects and outreach to sensitise potential buyers, both in the B2B and B2C spaces • Awareness campaigns across different media, involving multiple stakeholder groups • Consumer awareness campaigns to educate and inform RE/CE benefits, adopting resource efficient behaviours and purchasing resource efficient products/services by design	
R6.5 Foster inter-governmental collaboration and knowledge exchange with the G20, RE dialogue and other bodies like International Resource Panel and other national and international forums.	NITI Aayog, MoEFCC	1-2 years
	Action points	
	• Host delegations from foreign governments for conducting dialogues on experience sharing, knowledge transfer and governance models • Creation of opportunities for enabling partnerships in RE/CE • Engage with the global partners to share India's experience and best practices/knowledge	
R6.6 Develop monitoring and outcome indicators for tracking progress on RE/CE.	NITI Aayog, MoEFCC, State Governments	1-2 years
	Action points	
	• Formulate a core set of RE/CE indicators to track the implementation and effectiveness of RE/CE plans at the state and national level in consultation with BRE and ministries	
R6.7 Establish and mandate the certification for operators managing waste-to-resource recycling centres to ensure safe, efficient, and net positive operations.	MoEFCC, MoS	1-2 years
	Action points	
	• Establish training programmes for certifying operators qualified for managing recycling centres • Build a network of institutions to provide such training and certification • Mandate employment of certified operators at the recycling centres	

Annexure 6 shows a mapping of these 30 recommendations with the 30 recommendations made in the strategy papers with the linkages.

6.7. Expected Outcomes of RE/CE Implementation

Key benefits of implementing the above recommendations are listed in the Box below:

- Achieve resource efficient and environmentally sound production
- Achieve sustainable and scientific mining to increase recovery of extraction of primary and associated minerals
- Achieve higher recycling rates
- Creation of new industries in recycling
- Reduced import of critical resources such as minerals
- Improve competitiveness and profitability of the business

- Generate employment and improve livelihoods, especially through integration of the informal sector
- Enhance private sector participation
- Foster innovation
- Achieve reduction in GHG emissions along the lifecycle of products
- Improve resource security

Box 27: Key Benefits of Implementing the Overarching RE/CE Recommendations

Mainstreaming RE/CE is thus going to lead India to a competitive advantage, improve its resource security and achieve inclusive growth while advancing towards the Sustainable Development Goals. This will usher in a new paradigm of development by generating wealth from waste and giving a flip to the recycling industry.

7 Annexures

7.1. Annexure 1: Questionnaire Format for Ministries

Name of Officer: _____

Name of Ministry: _____

1. Mapping Regulatory Framework related to Resource Efficiency (RE) and Circular Economy (CE):

#	Policies/Materials	Relevant Details relating to RE

2. Mapping of the Policies related to RE & CE

#	Policies/Materials	Relevant Details relating to RE

3. Mapping of the Existing Guidelines related to RE & CE:

#	Policies/Materials	Relevant Details relating to RE

4. Mapping of the Project Approval Guidelines related to RE & CE:

#	Policies/Materials	Relevant Details relating to RE

5. Mapping of the GoI Programmes, Schemes, Missions and Projects related to RE & CE:

#	Policies/Materials	Relevant Details relating to RE

7.2. Annexure 2: Steel

7.2.1 Steel Lifecycle Stages and Stakeholders

The lifecycle of steel broadly involves Raw Material Extraction, Steel Production, Manufacture, Consumption, Reuse and remanufacture and Steel Recycling. Figure 12 provides a graphical representation of these lifecycle stages. In this paper, steel is looked at broadly without considering specific types of steel.

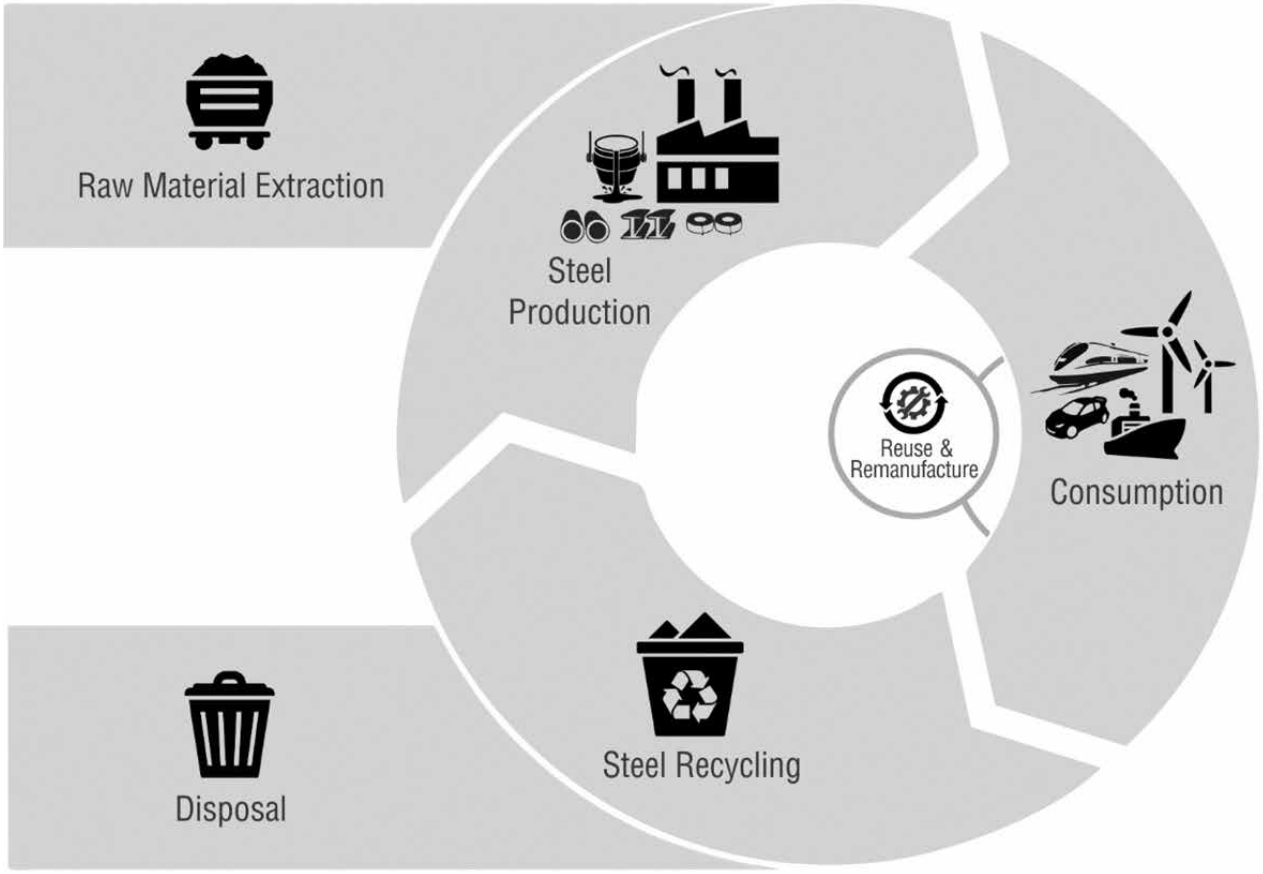

Figure 12: Steel Lifecycle Stages

7.2.1.1 Stakeholders

Each lifecycle stage involves various stakeholders. For example, the stakeholders of mining companies include the local communities around mines, Local, State and National governments, as well as steel producers who source iron ore from the mines. Figure 13 shows the stakeholders in the various lifecycle stages of steel. Common stakeholders include the government (local, state and national) as well as industry associations while the informal sector is unique to the Waste Processing and Recycling stage.

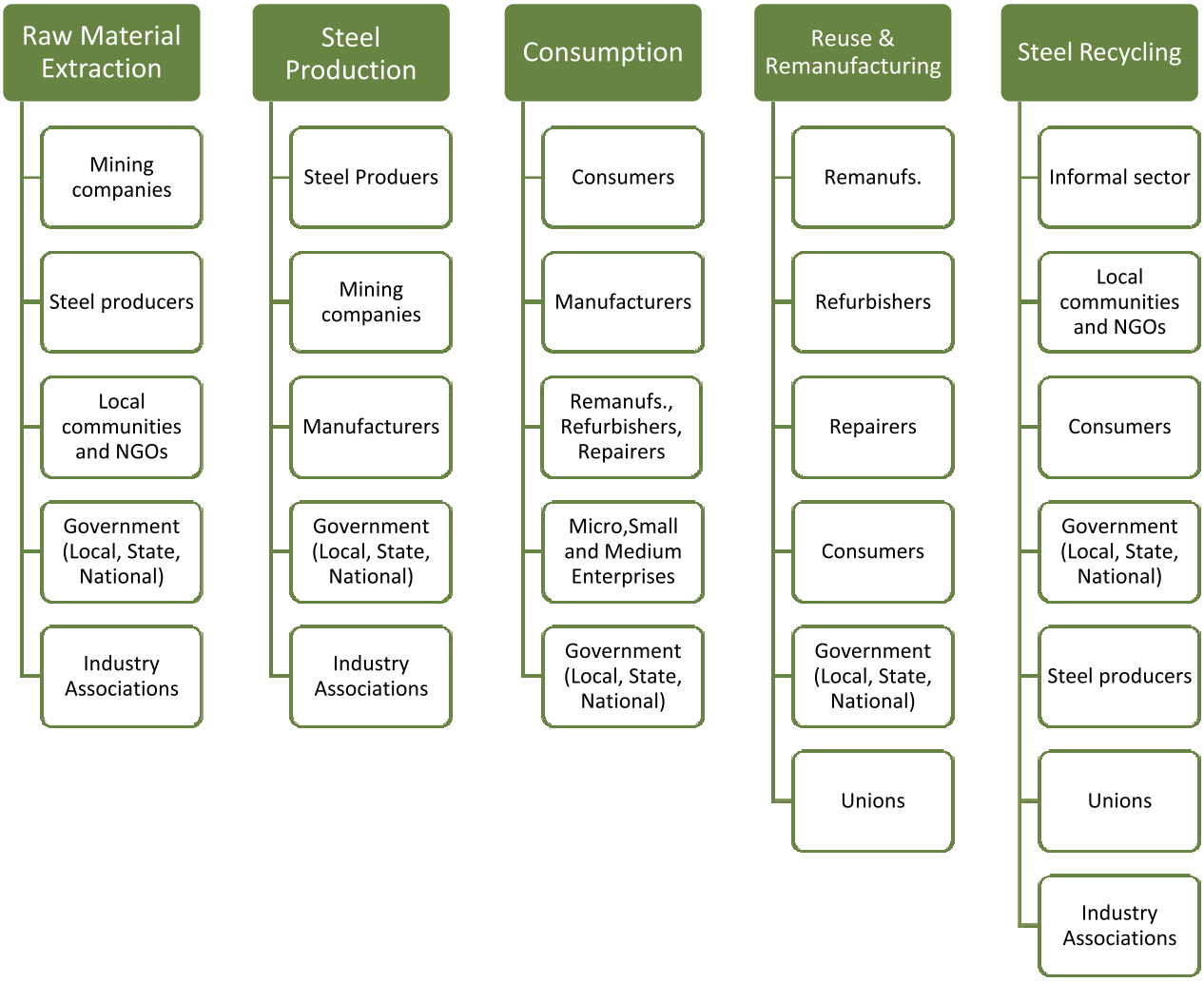

Figure 13: Mapping of Stakeholders relevant to the Steel Sector

7.2.1.2 Ministries Involved

Across the lifecycle stages of steel, several ministries are involved, as shown below. A unique feature in the Indian governance framework for steel is that an entire ministry (the Ministry of Steel) is dedicated to it and is well positioned to take the lead in championing and implementing RE and related policies. The Ministry of Mines has oversight over all mining activities in the country and features prominently in the Raw Material Extraction stage for both Steel and Aluminium. There is a significant opportunity at the policy level to catalyse the recycling and remanufacturing industries as well as promote reuse and repair of products.

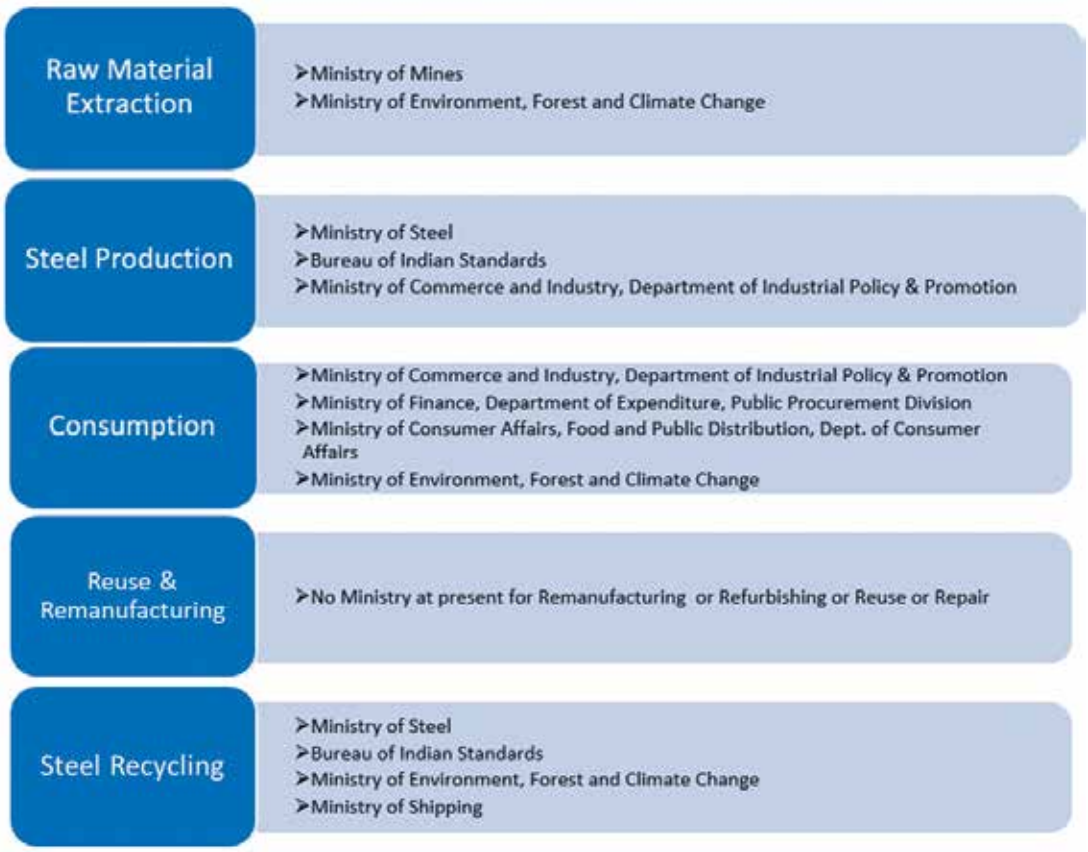

Figure 14: Stakeholder Ministries involved in Steel Sector

7.2.2 Review of Policies

1. National Steel Policy, 2017[126]

   1.1. "The Ministry will promote cluster-based consortium approach for optimum land use, easy availability of raw materials and economies of scale" – Chapter 4.2 Steel capacity, Point 4.2.7, Pg. 10

   1.2. "Necessary policy environment will also be provided to promote gas-based steel plants, electric/ induction furnaces and other technologies which will bring down usage of coking coal in blast furnaces" – Chapter 4.2 Steel capacity, Point 4.2.8, Pg. 10

   1.3. "…actions will be initiated to increase availability of ferrous scrap. Options will also be evaluated in coordination with other concerned ministries to develop a scrap segregation (quality-wise), collection, processing and recycling policy" – Chapter 4.3.9, Ferrous Scrap, Point 4.3.9.1, Pg. 13

   1.4. "...there has been a major thrust by the Government on reduction of discharge from the steel plants which will require innovative solutions and techniques to effectively recycle treated waste water" – Chapter 4.4 Land, Water & Power, Point 4.4.4, Pg. 14

   1.5. "Ministry of Steel will facilitate the use of waste heat recovery in Steel plants in consultation with other ministries" – Chapter 4.4 Land, Water & Power, Point 4.4.6, Pg. 15

   1.6. "…are conducive to effective & efficient utilization of domestic resources". –Chapter 4.7 Technological Efficiency, Point 4.7.1.1, Pg. 17

126 National Steel Policy 2017, Ministry of Steel: http://steel.gov.in/sites/default/files/draft-national-steel-policy-2017.pdf

1.7. “Optimize resource utilization and facilitate modernization of the steel industry”. – Chapter 4.7 Technological Efficiency, Point 4.7.1.3, Pg. 17

1.8. “Adoption of energy efficient technologies in the MSME steel sector will be encouraged”. – Chapter 4.8. MSME Steel Sector, Point 4.8.3.3, Pg. 18

1.9. “…and clusters for optimal utilization of land and reach economies of scale”. –Chapter 4.8. MSME Steel Sector, Point 4.8.3.3, Pg. 18

1.10. “...such as NEDO model projects in CPSEs and UNDP-AUSAID-MOS steel project in steel re-rolling mills to facilitate improvement in energy efficiency”. –Chapter 4.10. Environment Management, Point 4.10.3, Pg. 19

1.11. “Considering all waste materials as an economic asset, Ministry will encourage the steel companies to develop a Waste Management Plan for additional impetus on zero-waste or complete waste recycling. Concrete efforts will further be made by Ministry to promote use of iron & steel slag in alternate uses like road making, rail ballast, construction material, soil conditioner etc. Simultaneously, steel plants will be pursued to implement steel making slag weathering/ steam ageing plants to enable them to supply processed/ sized steel making slag for road making, rail ballast etc.” – Chapter 4.10. Environment Management, Point 4.10.4, Pg. 19

2. Policy for Providing Preference to Domestically Manufactured Iron & Steel Products in Government Procurement, 2017 [127]

2.1. “This policy provides preference to Domestically Manufactured Iron and Steel Products (DMI&SP) in Government procurement”. - 1. Background, 1.1, Pg., 6

2.2. “The policy is applicable to iron & steel products as provided in Appendix A, produced in compliance to prescribed quality standards, as applicable”. - 1. Background, 1.2, Pg., 6

2.3. “The policy is applicable to every Ministry or Department of Government and all agencies/ entities under their administrative control for purchase of iron & steel products for government projects and not with a view to commercial resale or with a view to use in the production of goods for commercial sale”. - 1. Background, 1.3, Pg. 6

3. Steel and Steel Products (Quality Control) Order, 2018 [128]

3.1. 4. Conformity to Standards - Every steel and steel products shall conform to the corresponding Indian Standard specified in column (2) of the Schedule with effect from the corresponding date specified in column (5) thereof.

3.2. 5. Compulsory use of Standard Mark - Every steel and steel product shall bear the Standard Mark under a licence issued by the Bureau of Indian Standards (BIS).

3.3. 6. Certification and Enforcement Authority - The Bureau of Indian Standards shall be the certifying and enforcing authority in respect of the steel and steel products.

4. Draft National Mineral Policy, 2018 [129]

4.1. Mining needs to be carried out in an environmentally sustainable manner keeping stakeholder’s interest in mind. - Vision, Pg. 1

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127. Policy for Providing Preference to Domestically Manufactured Iron & Steel Products in Government Procurement – 2017, Ministry of Steel: http://steel.gov.in/policy-providing-preference-domestically-manufactured-iron-steel-products-government-procurement

128. Steel and Steel Products (Quality Control) Order - 2018. Ministry of Steel: http://steel.gov.in/sites/default/files/Steel%20and%20Steeel%20Products%20%28Quality%20Control%29%20Order%2C%202018.pdf

129. Draft National Mineral Policy, Ministry of Mines: https://mines.gov.in/writereaddata/UploadFile/draftnationalmineralpolicy2018.pdf

4.2. "...efforts shall be made to augment supply by developing processes for recovery of metal through recycling..." - Chapter 6, Mining and mineral development, section 6.1, General Strategies, Pg. 5

4.3. "There shall be an adequate and effective legal and constitutional framework mandating zero waste mining as the ultimate goal and a commitment to prevent sub-optimal and unscientific mining". - Conservation and Mineral Development, Pg. 5

4.4. "...mining conditions shall be such as to favourably predispose the leased areas to systematic, scientific, optimum, and complete extraction of minerals..." - Chapter 6, Mining and mineral development, section 6.3, Scientific methods of mining, Pg. 6

4.5. "All mining shall be undertaken within the parameters of Sustainable Development Framework…The guiding principle shall be that a miner shall leave the mining area in an ecological shape which is as good as it was before the commencement of mining or better...". - Chapter 6, Mining and mineral development, section 6.10, Protection of the Environment, Pg. 9

4.6. "Environment, economic and social considerations must be taken into account as early as possible in the decision- making process, to ensure sustainable development in the mining sector...uses mineral resources optimally and ensures sustainable post-closure land uses". - Chapter 6, Mining and mineral development, section 6.11, Sustainable Development in the Mining Sector Pg. 10

4.7. "It will be an endeavour of the government to design fiscal measures within the context of… including beneficiation and other forms of product refinement". -Chapter 8, Fiscal Aspects, Pg. 14

4.8. "Research and development efforts shall be made to improve efficiency in process, operations, and also the recovery of by-products and reduction in specification and consumption norms." - Chapter 9, Research and Development, section 9.2, Research in Mining Methods, Pg. 15

5. National Manufacturing Policy, 2011 [130]

5.1. "Ensure sustainability of growth, particularly with regard to the environment including energy efficiency, optimal utilization of natural resources and restoration of damaged/ degraded eco-systems"- Chapter 1 Point 1.9.6, Pg. 4

5.2. "Mandatory treatment of waste-water by every industry as per CPCB and PCB norms" - Chapter 4. Technology Acquisition and Development, Point 4.3.3, Waste water treatment Pg. 15

6. National Industry Policy, 2017 - Discussion Paper [131]

6.1. "Establishment of a circular economy" - Chapter 5.5, Ensuring sustainability and responsible industrialisation, Point 5.5.3 Illustrative outcomes and trigger questions - Long term Pg. 13

6.2. "Improvements in energy use efficiency through large scale adoption of smarter technologies" - Chapter 5.5, Ensuring sustainability and responsible industrialisation, Point 5.5.3 Illustrative outcomes and trigger questions - Medium term Pg. 13

130. National Manufacturing Policy, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://meity.gov.in/writereaddata/files/National%20Manufacturing%20Policy%20(2011)%20(167%20KB).pdf

131. Industrial Policy Paper – 2017, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://pibphoto.nic.in/documents/rlink/2017/aug/p201783006.pdf

6.3. "What are the measures to ensure minimal/zero waste from industrial activities?" - Chapter 5.5, Ensuring sustainability and responsible industrialisation, Point 5.5.3 Illustrative outcomes and trigger questions - Sustainability Pg. 13

7. National Design Policy, 2007[132]

7.1. "..designs which satisfy key design criteria like originality, innovation, aesthetic appeal, user-centricity, ergonomic features, safety and eco-friendliness." - Chapter 4 Action Plan Point 4, Pg. 3

7.2. "Upgrading quality of engineering design, machinery design, process design, design materials, environmentally sound and socially and culturally relevant designs." - Chapter 4 Action Plan Point 10, Pg. 4

7.2.3 Timeline of Policies

Figure 15 shows a timeline of the various policies and programmes related to steel's lifecycle across different ministries.

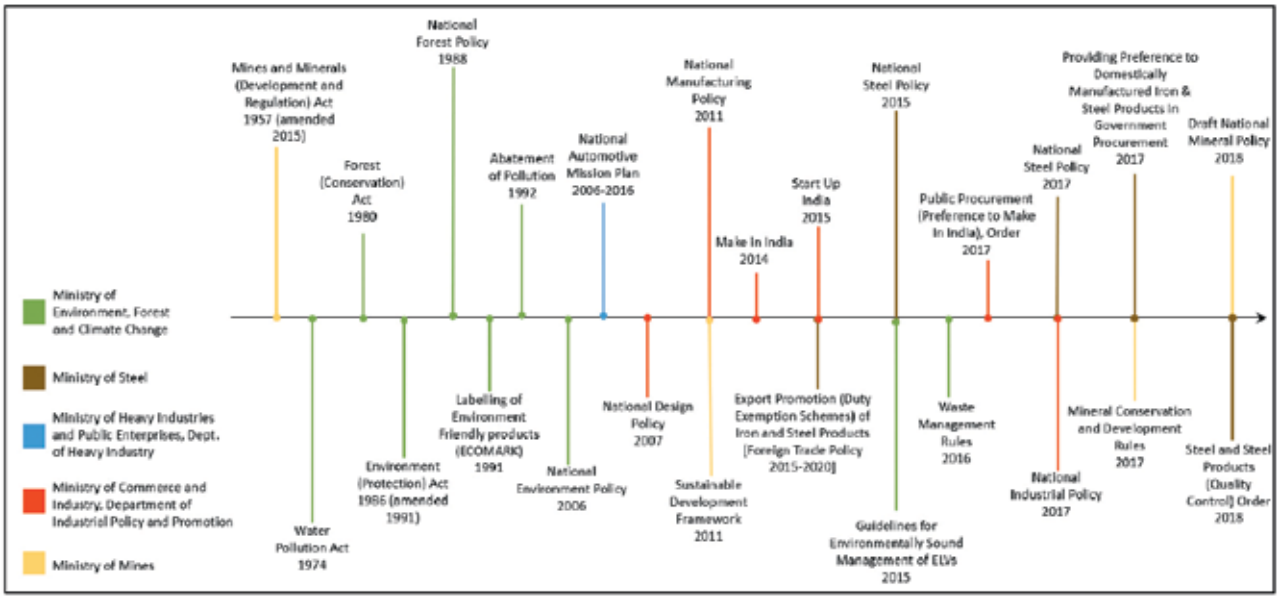

Figure 15: Timeline of various policies and programmes related to steel

132. National Design Policy, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://dipp.nic.in/sites/default/files/national_design_policy%20%20%20eng%201.pdf

7.3. Annexure 3: Aluminium

7.3.1 Aluminium Lifecycle Stages and Stakeholders

The lifecycle of aluminium broadly involves Raw Material Extraction, Aluminium Production, Manufacture, Consumption, Remanufacture/Refurbish/Repair/Reuse and Waste Processing and Recycling. Figure 16 provides a graphical representation of these lifecycle stages. In this paper, aluminium is looked at broadly without considering specific types of steel.

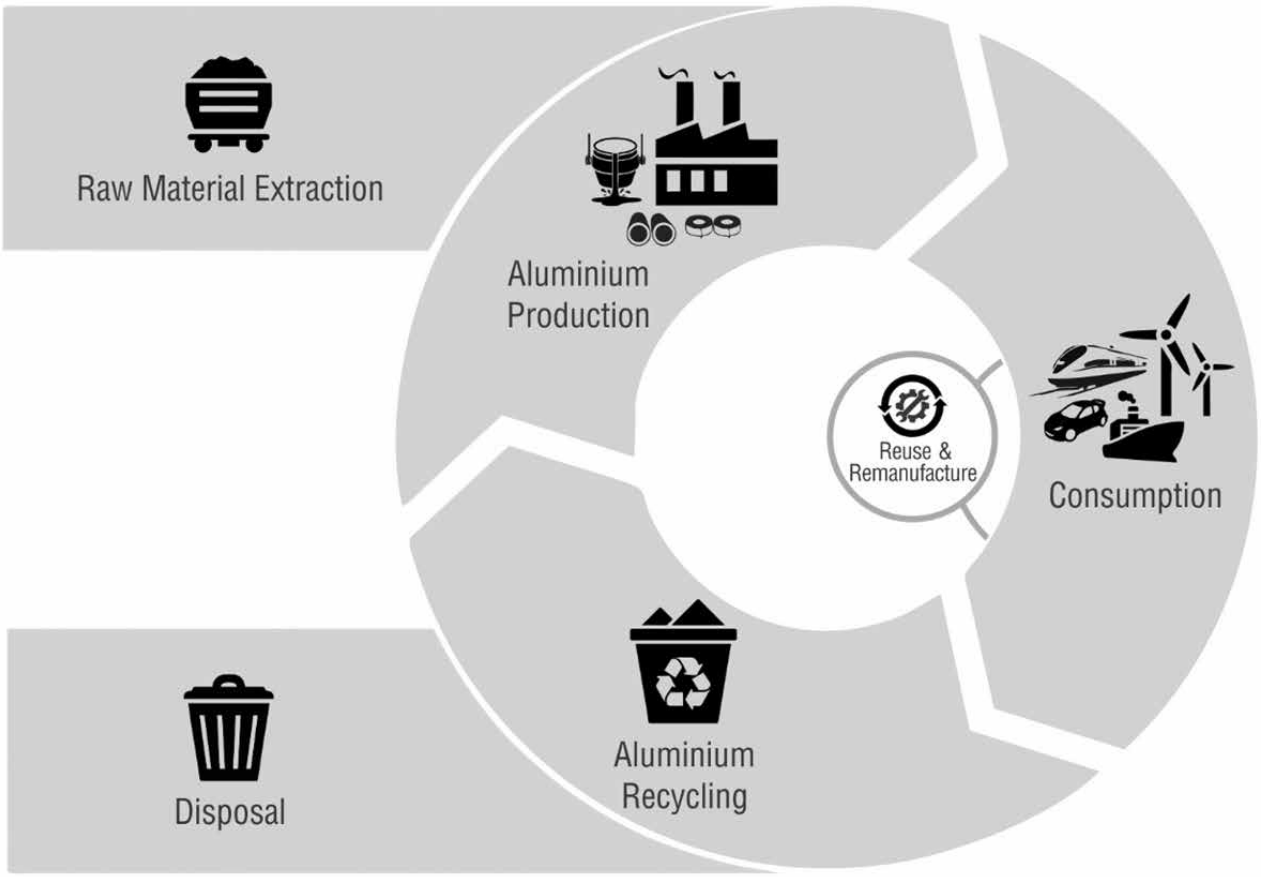

Figure 16: Aluminium Lifecycle Stages

7.3.1.1 Stakeholders

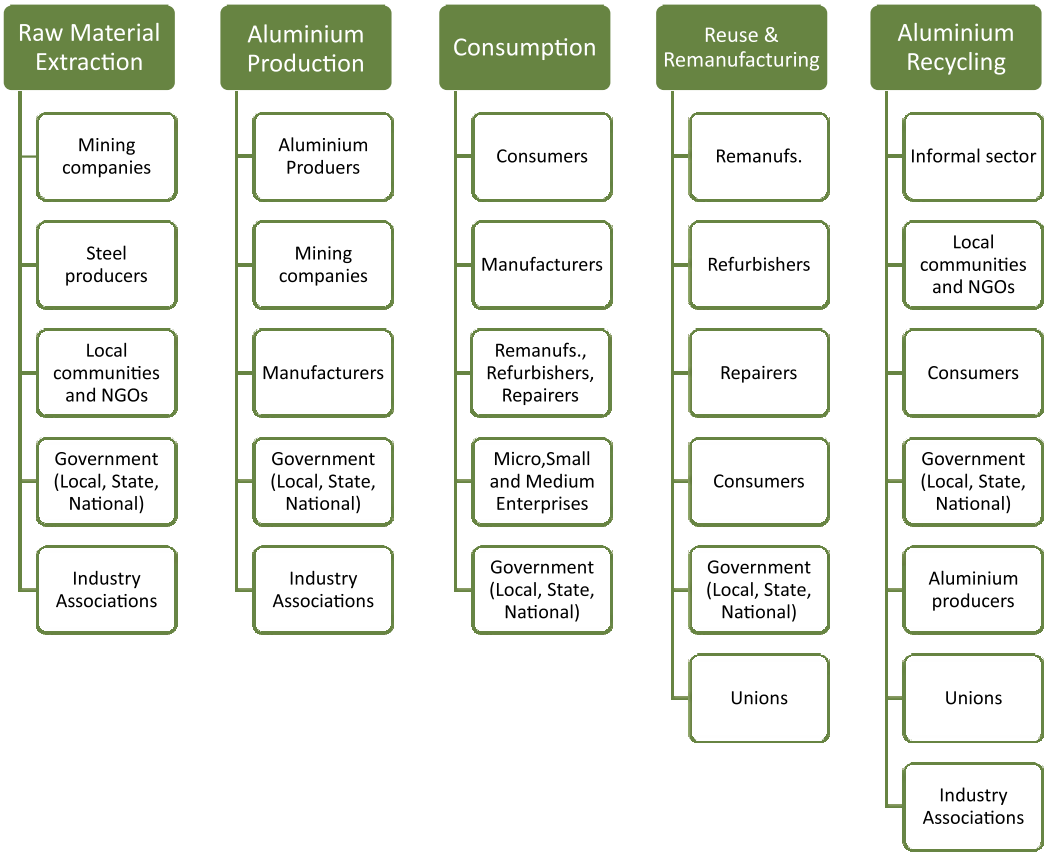

Figure 17: Mapping of Stakeholders relevant to the Aluminium Sector

7.3.1.2 Ministries Involved

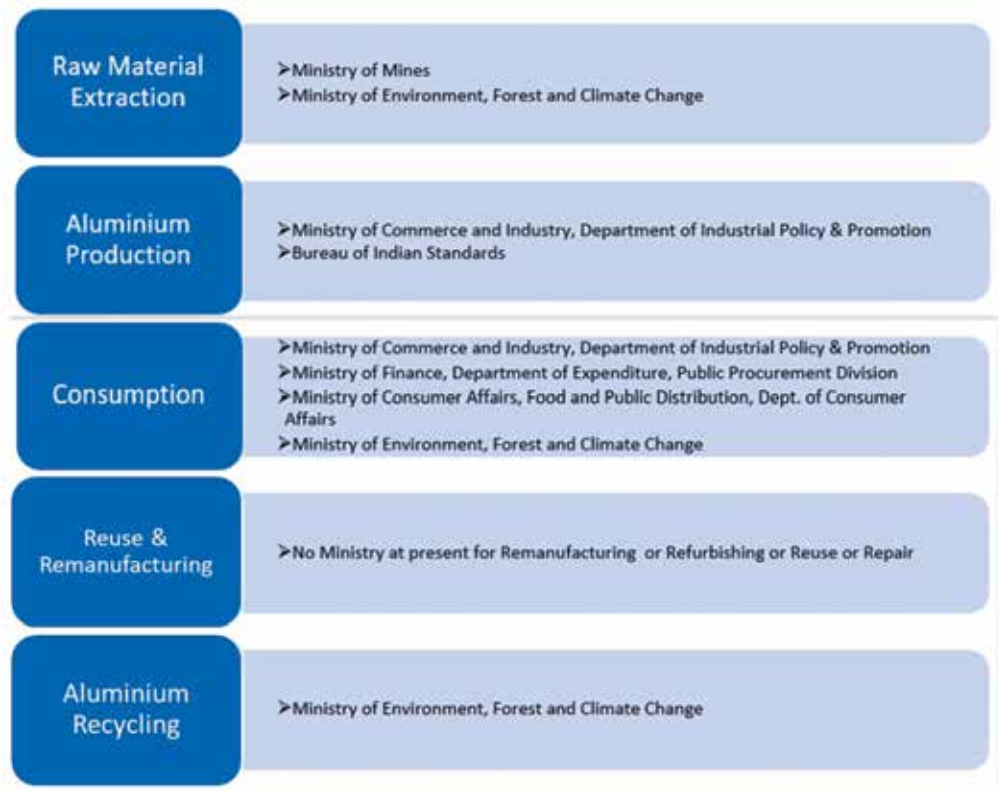

Figure 18: Stakeholder Ministries involved in Aluminium Sector

7.3.2 Review Policies to examine support to RE/CE

8. Draft National Mineral Policy, 2018 [133]

8.1. Mining needs to be carried out in an environmentally sustainable manner keeping stakeholder's interest in mind. - Vision, Pg. 1

8.2. "...efforts shall be made to augment supply by developing processes for recovery of metal through recycling..." - Chapter 6, Mining and mineral development, section 6.1, General Strategies, Pg. 5

8.3. "There shall be an adequate and effective legal and constitutional framework mandating zero waste mining as the ultimate goal and a commitment to prevent sub-optimal and unscientific mining". - Conservation and Mineral Development, Pg. 5

8.4. "...mining conditions shall be such as to favourably predispose the leased areas to systematic, scientific, optimum, and complete extraction of minerals..." - Chapter 6, Mining and mineral development, section 6.3, Scientific methods of mining, Pg. 6

8.5. "All mining shall be undertaken within the parameters of Sustainable Development Framework…The guiding principle shall be that a miner shall leave the mining area in an ecological shape which is as good as it was before the commencement of mining or better...". - Chapter 6, Mining and mineral development, section 6.10, Protection of the Environment, Pg. 9

8.6. "Environment, economic and social considerations must be taken into account as early as possible in the decision- making process, to ensure sustainable development in the mining sector...uses mineral resources optimally and ensures sustainable post-closure land uses". - Chapter 6, Mining and mineral development, section 6.11, Sustainable Development in the Mining Sector Pg. 10

8.7. "It will be an endeavour of the government to design fiscal measures within the context of… including beneficiation and other forms of product refinement". -Chapter 8, Fiscal Aspects, Pg. 14

8.8. "Research and development efforts shall be made to improve efficiency in process, operations, and also the recovery of by-products and reduction in specification and consumption norms." - Chapter 9, Research and Development, section 9.2, Research in Mining Methods, Pg. 15

9. National Manufacturing Policy, 2011 [134]

9.1. "Ensure sustainability of growth, particularly with regard to the environment including energy efficiency, optimal utilization of natural resources and restoration of damaged/ degraded eco-systems"- Chapter 1 Point 1.9.6, Pg. 4

9.2. "Mandatory treatment of waste-water by every industry as per CPCB and PCB norms" - Chapter 4. Technology Acquisition and Development, Point 4.3.3, Waste water treatment Pg. 15

133. Draft National Mineral Policy, Ministry of Mines: https://mines.gov.in/writereaddata/UploadFile/draftnationalmineralpolicy2018.pdf

134. National Manufacturing Policy, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://meity.gov.in/writereaddata/files/National%20Manufacturing%20Policy%20(2011)%20(167%20KB).pdf

10. National Industry Policy, 2017 - Discussion Paper [135]

10.1. "Establishment of a circular economy" - Chapter 5.5, Ensuring sustainability and responsible industrialisation, Point 5.5.3 Illustrative outcomes and trigger questions - Long term Pg. 13

10.2. "Improvements in energy use efficiency through large scale adoption of smarter technologies" - Chapter 5.5, Ensuring sustainability and responsible industrialisation, Point 5.5.3 Illustrative outcomes and trigger questions - Medium term Pg. 13

10.3. "What are the measures to ensure minimal/zero waste from industrial activities?" - Chapter 5.5, Ensuring sustainability and responsible industrialisation, Point 5.5.3 Illustrative outcomes and trigger questions - Sustainability Pg. 13

11. National Design Policy, 2007 [136]

11.1. "..designs which satisfy key design criteria like originality, innovation, aesthetic appeal, user-centricity, ergonomic features, safety and eco-friendliness." - Chapter 4 Action Plan Point 4, Pg. 3

11.2. "Upgrading quality of engineering design, machinery design, process design, design materials, environmentally sound and socially and culturally relevant designs." - Chapter 4 Action Plan Point 10, Pg. 4

7.3.3 Timeline of Policies

Figure 19 shows a timeline of the various policies and programmes related to aluminium's lifecycle across different ministries

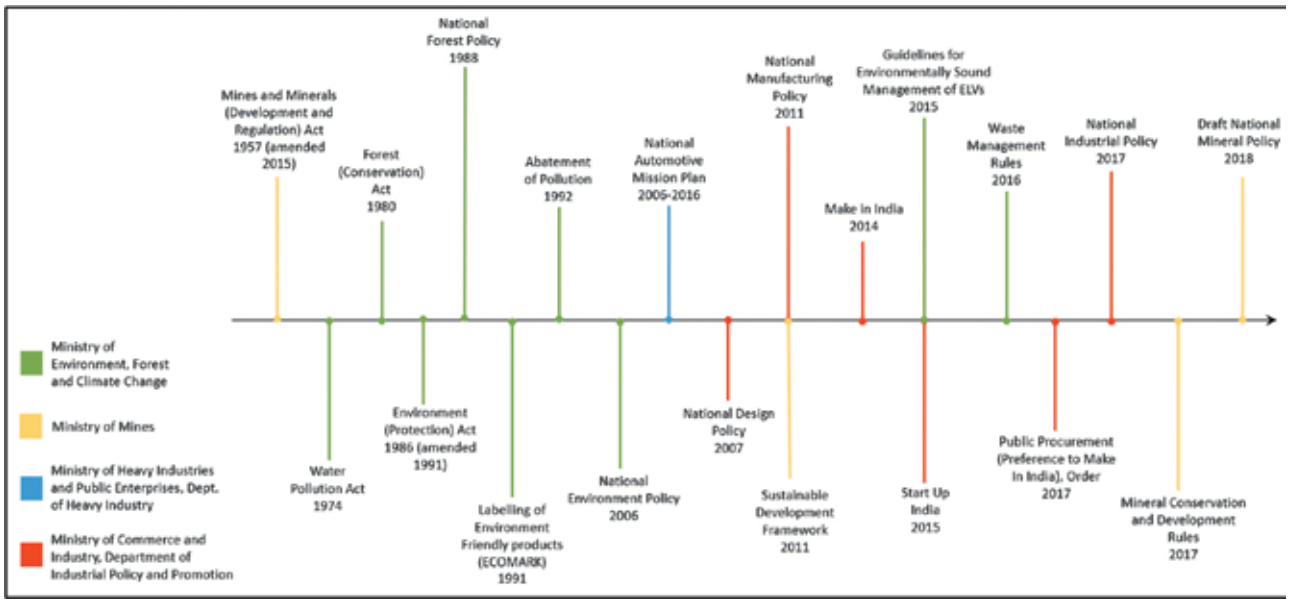

Figure 19: Timeline of various policies and programmes related to aluminium

135. Industrial Policy Paper – 2017, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://pibphoto.nic.in/documents/rlink/2017/aug/p201783006.pdf

136. National Design Policy, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry: http://dipp.nic.in/sites/default/files/national_design_policy%20%20%20eng%201.pdf

7.4. Annexure 4: E-waste

7.4.1 E-waste Material Flow Stages and Stakeholders

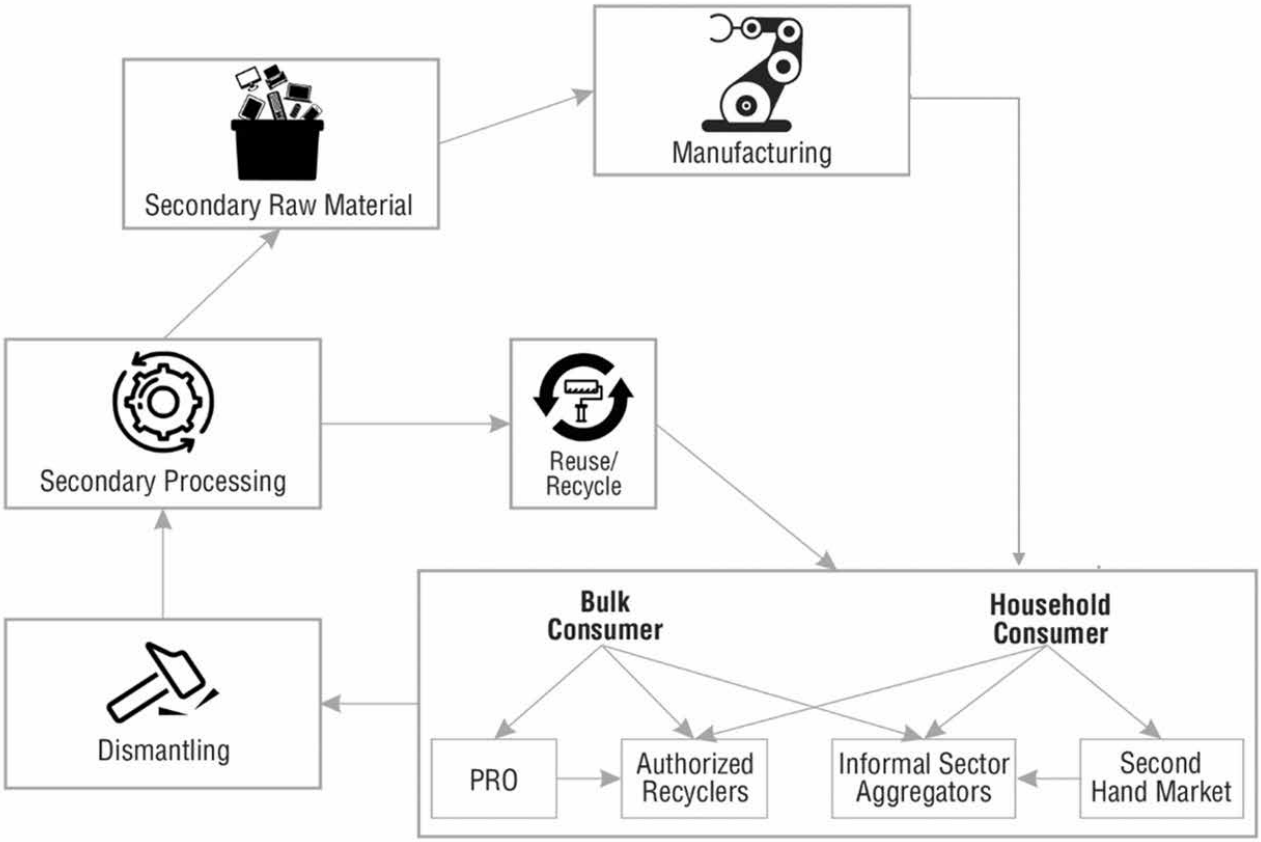

Figure 20: E-waste material flow stages

7.4.1.1 E-waste Stakeholders

Electronic products, at the end of their lives become e-waste. The material flow stages of e-waste (which is a subset of the lifecycle of electronic products) involves four broad stages – (i) manufacturing and producers, (ii) consumption, (iii) collection (iv) dismantling & secondary processing. Each lifecycle stage involves various stakeholders. The key stakeholders in the e-waste lifecycle include importers, producers/manufacturers, retailers, consumers, scrap dealers, dismantlers and recyclers.

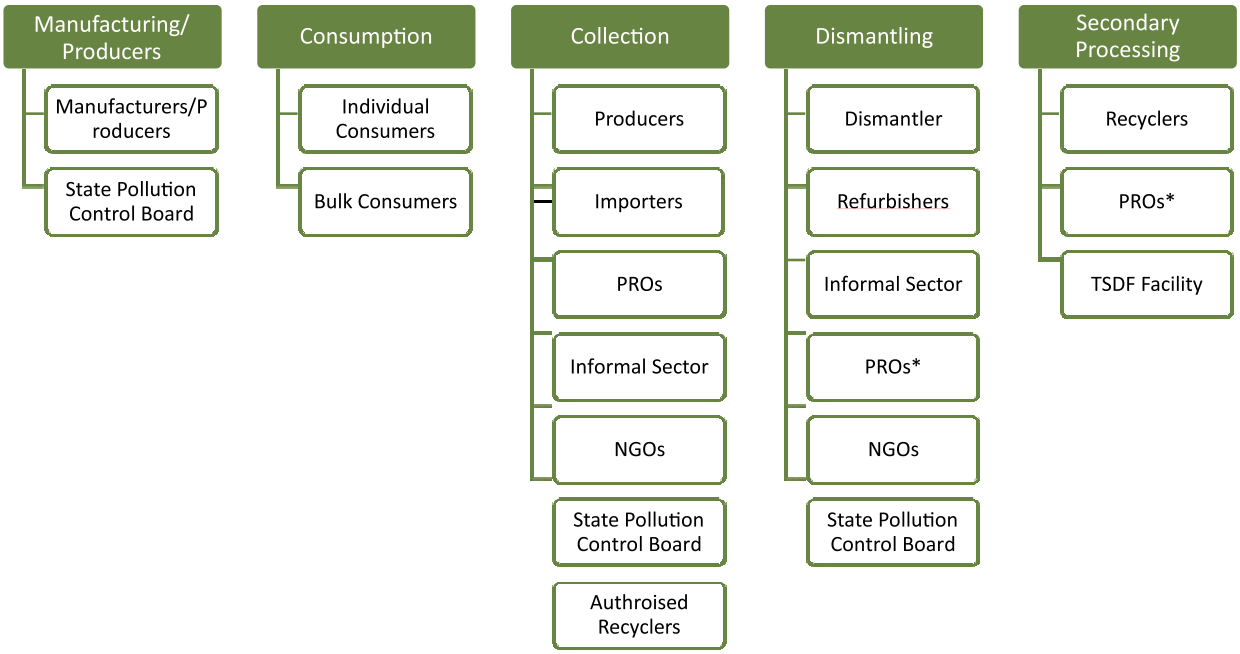

Figure 21: Mapping of stakeholders relevant to e-waste

7.4.1.2 Ministries Involved

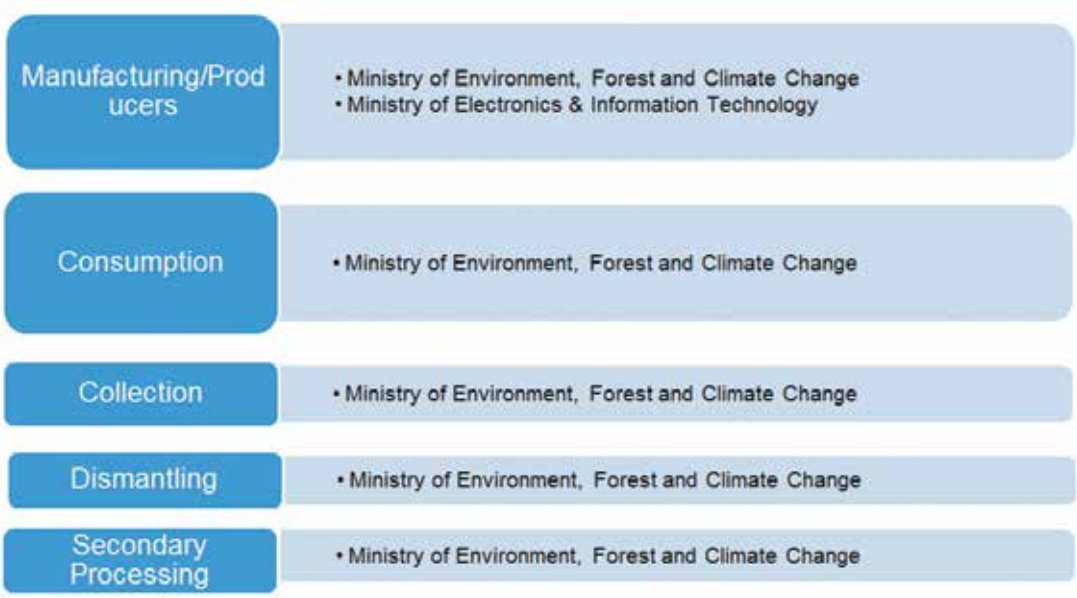

Figure 22: Ministries involved in e-waste management

7.4.2 Review Policies to examine support to RE/CE

1. E-Waste Management Rules (2016) & Amendment 2018 [137]

   1.1. "Collect e-waste generated during the manufacture of any electrical and electronic equipment and channelize it for recycling or disposal" - Chapter 2, 4. (1) Responsibilities of the manufacturer, Pg. 5

137. E-waste Management Rules- Ministry Of Environment, Forest And Climate Change : http://www.moef.gov.in/sites/default/files/EWM%20Rules%202016%20english%2023.03.2016.pdf

1.2. "Maintain records of the e-waste generated, handled and disposed in Form-2 and make such records available for scrutiny by the concerned State Pollution Control Board" - Chapter 2, 4. (4) Responsibilities of the manufacturer, Pg. 5

1.3. "Implementing the Extended Producers Responsibility with the following frameworks, namely:- (a) collection and channelization of e-waste generated from the 'end-of-life' of their products or 'end-of-life' products with same electrical and electronic equipment code and historical waste available on the date" - Chapter 2, 5. (1) (a) Responsibilities of the producer, Pg. 5

1.4. "…… the mechanism used for channelization of e-waste from 'end-of-life' products including those from their service centres to authorised dismantler or recycler shall be in accordance with the Extended Producer Responsibility" - Chapter 2, 5. (1) (b) Responsibilities of the producer, Pg. 5

1.5. "…… or disposal in Treatment, Storage and Disposal Facility, a pre-treatment is necessary to immobilise the mercury and reduce the volume of waste to be disposed off" - Chapter 2, 5. (1) (c) Responsibilities of the producer, Pg. 5

1.6. "…… Authorisation should comprise of general scheme for collection of waste Electrical and Electronic Equipment from the Electrical and Electronic Equipment placed on the market earlier, such as through dealer, collection centres, Producer Responsibility Organisation, through buy-back arrangement, exchange scheme, Deposit Refund System, etc. whether directly or through any authorised agency and channelizing the items so collected to authorised recyclers" - Chapter 2, 5. (1) (d) Responsibilities of the producer, Pg. 5

1.7. "the import of electrical and electronic equipment shall be allowed only to producers having Extended Producer Responsibility authorisation" - Chapter 2, 5. (3) Responsibilities of the producer, Pg. 6

1.8. "Consumers or bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that e-waste generated by them is channelized through collection centre or dealer of authorised producer or dismantler or recycler or through the designated take back service provider of the producer to authorised dismantler or recycler" - Chapter 2, 9 (1) Responsibilities of consumer or bulk consumer, Pg. 8

1.9. "collect e-waste on behalf of producer or dismantler or recycler or refurbisher including those arising from orphaned products; Provided the collection centres established by producer can also collect e-waste on behalf of dismantler, refurbisher and recycler including those arising from orphaned products" - Chapter 2, 6 (1) Responsibilities of collection centers, Pg. 7

1.10. "ensure that the facilities are in accordance with the standards or guidelines issued by Central Pollution Control Board from time to time" - Chapter 2, 6 (2) Responsibilities of collection centers, Pg. 7

1.11. "maintain records in Form-2 of the e-waste handled as per the guidelines of Central Pollution Control Board and make such records available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board as and when asked for" - Chapter 2, 6 (5) Responsibilities of collection centers, Pg. 7

1.12. "in the case the dealer has been given the responsibility of collection on behalf of the producer, the dealer shall collect the e-waste by providing the consumer a box, bin or a

demarcated area to deposit e-waste, or through take back system and send the e-waste so collected to collection centre or dismantler or recycler as designated by producer" - Chapter 2, 7 (1) Responsibilities of dealers, Pg. 7

1.13. "the dealer or retailer or e-retailer shall refund the amount as per take back system or Deposit Refund Scheme of the producer to the depositor of e-waste" - Chapter 2, 7 (2) Responsibilities of dealers, Pg. 7

1.14. "collect e-waste generated during the process of refurbishing and channelize the waste to authorised dismantler or recycler through its collection centre" - Chapter 2, 8 (1) Responsibilities of refurbisher, Pg. 7

1.15. "ensure that the facility and dismantling processes are in accordance with the standards or guidelines prescribed by Central Pollution Control Board from time to time" - Chapter 2, 10 (1) Responsibilities of dismantler, Pg. 8

1.16. "ensure that dismantled e-wastes are segregated and sent to the authorised recycling facilities for recovery of materials" - Chapter 2, 10 (5) Responsibilities of dismantler, Pg. 8

1.17. "ensure that non-recyclable or non-recoverable components are sent to authorised treatment storage and disposal facilities" - Chapter 2, 10 (6) Responsibilities of dismantler, Pg. 8

1.18. "not process any e-waste for recovery or refining of materials, unless he is authorised with concerned State Pollution Control Board as a recycler for refining and recovery of materials" - Chapter 2, 10 (9) Responsibilities of dismantler, Pg. 8

1.19. "shall ensure that the facility and recycling processes are in accordance with the standards or guidelines prescribed by the Central Pollution Control Board from time to time" - Chapter 2, 11 (1) Responsibilities of recycler, Pg. 9

1.20. "ensure that the fractions or material not recycled in its facility is sent to the respective authorised recyclers" - Chapter 2, 11 (6) Responsibilities of recycler, Pg. 9

1.21. "ensure that residue generated during recycling process is disposed of in an authorised treatment storage disposal facility" - Chapter 2, 11 (7) Responsibilities of recycler, Pg. 9

1.22. "may accept waste electrical and electronic equipment or components not listed in Schedule I for recycling provided that they do not contain any radioactive material and same shall be indicated while taking the authorisation from concerned State Pollution Control Board" - Chapter 2, 11 (10) Responsibilities of recycler, Pg. 9

1.23. "Department of Industry in State or any other government agency authorised in this regard by the State Government, to ensure earmarking or allocation of industrial space or shed for e-waste dismantling and recycling in the existing and upcoming industrial park, estate and industrial clusters" - Chapter 2, 12 (1) Responsibilities of State Government for environmentally sound management of E-waste, Pg. 9

1.24. "Department of Labour in the State or any other government agency authorised in this regard by the State Government shall: a. ensure recognition and registration of workers involved in dismantling and recycling; b. assist formation of groups of such workers to facilitate setting up dismantling facilities; c. undertake industrial skill development activities for the workers involved in dismantling and recycling; d. undertake annual monitoring and to ensure safety

& health of workers involved in dismantling and recycling" - Chapter 2, 12 (2) Responsibilities of Responsibilities of State Government for environmentally sound management of E-waste, Pg. 9

1.25. "Every manufacturer, producer, bulk consumer, collection centre, dealer, refurbisher, dismantler and recycler may store the e-waste for a period not exceeding one hundred and eighty days and shall maintain a record of collection, sale, transfer and storage of wastes and make these records available for inspection" - Chapter 4, 15. Procedure for storage of e-waste. Pg. 14

1.26. Chapter 5, 16, Reduction In The Use Of Hazardous Substances In The Manufacture Of Electrical And Electronic Equipment And Their Components Or Consumables Or Parts Or Spares, Pg. 14

1.27. "The transportation of e-waste shall be carried out as per the manifest system whereby the transporter shall be required to carry a document (three copies) prepared by the sender, giving the details as per Form-6: Provided that the transportation of waste generated from manufacturing or recycling destined for final disposal to a treatment, storage and disposal facility shall follow the provisions under Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008." - Chapter 6, 19, Transportation of e-waste. Pg. 15

1.28. "The manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler shall be liable for all damages caused to the environment or third party due to improper handling and management of the e-waste" - Chapter 6, 21 (1). Liability of manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler, Pg. 16

2. Electronics and IT Goods (Requirements for Compulsory Registration) Order, 2012 [138]

2.1. "Substandard and defective products will be deformed beyond use and disposed off as scrap." - 3 (2) - Prohibition regarding manufacture, storage, sale and distribution of Goods, Pg 9

3. National Policy on Information Technology 2012 [139]

3.1 "To formulate policies to provide fiscal benefits to SMEs and Start-ups in the key industrial sectors for adoption of IT in value creation" - 4 (1) Strategies- Creating ecosystem for a globally competitive IT/ITES Industry, Pg. 5,

4. Digital India [140]

Program Pillar- Electronics Manufacturing–"This pillar focuses on promoting electronics manufacturing in the country with the target of NET ZERO Imports by 2020 as a striking demonstration of intent. This ambitious goal requires coordinated action on many fronts, such as: Taxation, incentives, Economies of scale, eliminating cost disadvantages ; Focus areas – Big Ticket Items, Incubators, clusters , Skill development, Enhancing PhDs , Government procurement, Safety Standards – Compulsory registration, Support for Labs and MSMEs, National Award, Marketing, Brand Building, National Centres – Flexible Electronics, Security Forces, R & D in electronics"

138. "Electronics and Information Technology Goods (Requirement for Compulsory Registration) Order, 2012: https://crsbis.in/BIS/app_srv/tdc/gl/docs/gazette_notification_2012_10_03.pdf

139. National Policy on Information Technology http://meity.gov.in/writereaddata/files/National_20IT_20Policyt%20_20.pdf

140. Digital India Electronics Manufacturing - http://digitalindia.gov.in/content/electronics-manufacturing

5. National Policy on Electronics 2012 [141]

5.1. "… the Government has decided to offer financial support for the development of EMCs. It is expected that these EMCs would aid the growth of the Electronic System Design & Manufacturing sector" - 1.1 Electronic Manufacturing Clusters Scheme- Background & Objectives Pg. 6

5.2. "The scheme provides capital subsidy of 20% in SEZ (25% in non-SEZ) for units engaged in electronics manufacturing." - Modified Special Incentive Package Scheme (M-SIPS)[142]

6. Software Technology Parks Scheme [143]

6.1. "The Software Technology Park (STP) Scheme is a 100 percent Export Oriented Scheme for the development and export of computer software, including export of professional services using communication links or physical media.

6.2. Scheme Benefits & Highlights - "All the imports of Hardware & Software in the STP units are completely duty free, import of second hand capital goods also permitted."

6.3. Scheme Benefits & Highlights - "The items like computers and computers peripherals can be donated to recognized non-commercial educational institutions, registered charitable hospitals, public libraries, public funded research and development establishments, organizations of Govt. of India, or Govt. of a State or Union Territory without payment of any duties after two years of their import."

7.4.3 Timeline of Policies

Figure 23 shows a timeline of the various policies and programmes related to e-waste's lifecycle across the different ministries.

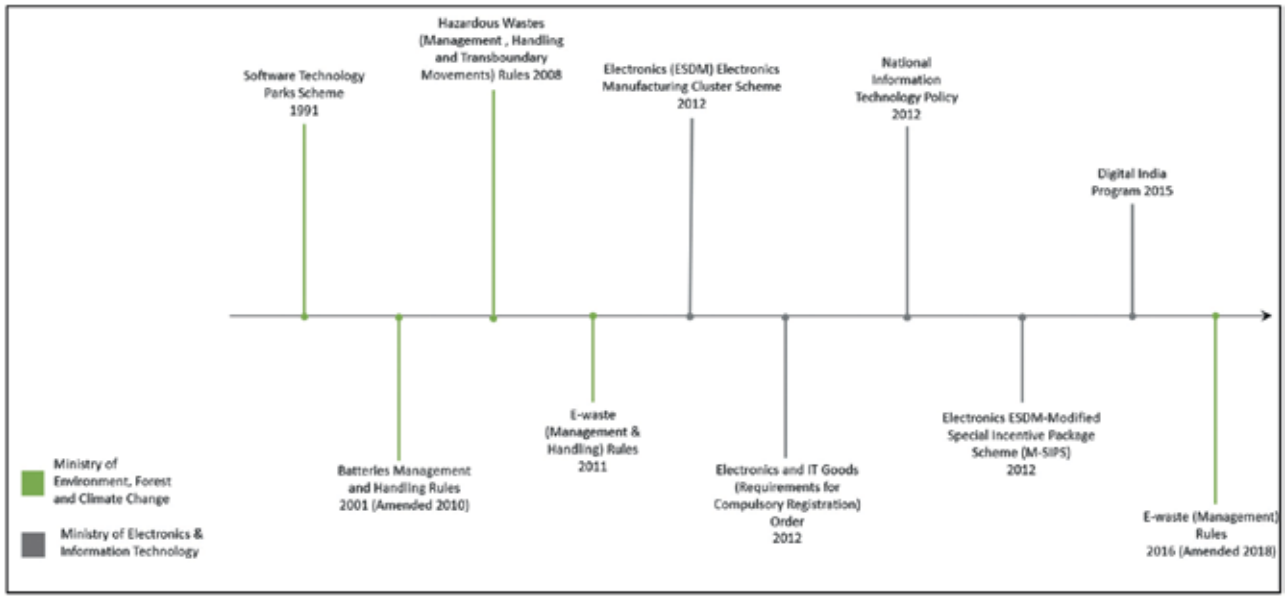

Figure 23: Timeline of various policies and programmes related to e-waste

141. National Policy on Electronics - Electronic System Design & Manufacturing- Electronic Manufacturing Clusters http://meity.gov.in/writereaddata/files/Notification-EMC-Gazette.pdf

142. Electronic System Design & Manufacturing - Incentive Schemes- Modified Special Incentive Package Scheme http://meity.gov.in/writereaddata/files/Special%20Incentive%20Package%20Scheme-%20Guidelines%20for%20Operation%20of%20the%20Scheme%20(2007)%20(247%20KB).pdf

143. Software Technology Park Scheme, Ministry of Electronics & Information Technology: https://www.stpi.in/11025

7.5. Annexure 5: C&D waste

7.5.1 C&D Waste Stages of Management and Stakeholders

The different stages of management C&D Waste broadly involves C&D Activities, C&D Waste Generation, Collection Points, C&D Waste Processing, and Reuse/Recycle. Figure 24 provides a graphical representation of these lifecycle stages.

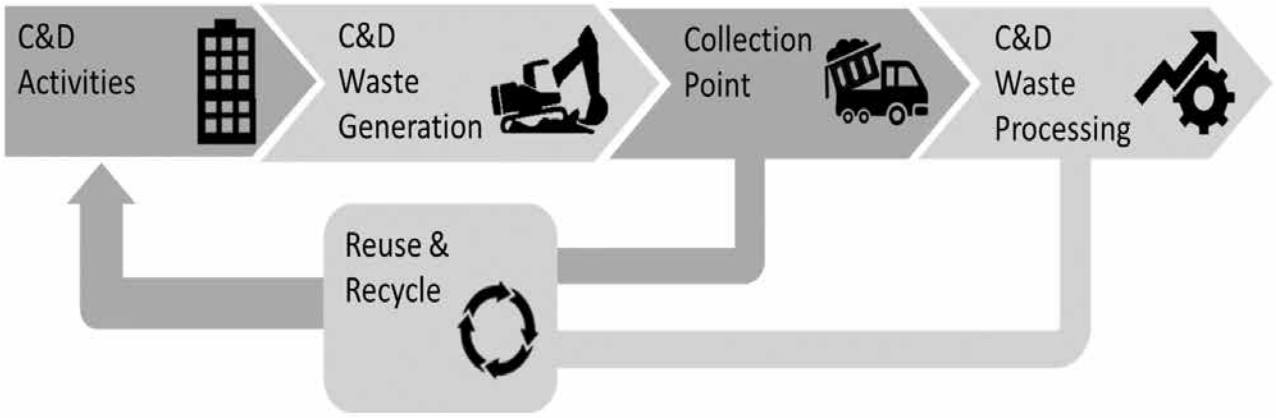

Figure 24: C&D Waste Stages of Management

7.5.1.1 Stakeholders

Each lifecycle stage involves various stakeholders. For example, some of the stakeholders in the C&D activities include construction companies, local, State and National governments, shareholders, unions and industry associations. Figure 25 shows the stakeholders in the various lifecycle stages of C&D waste.

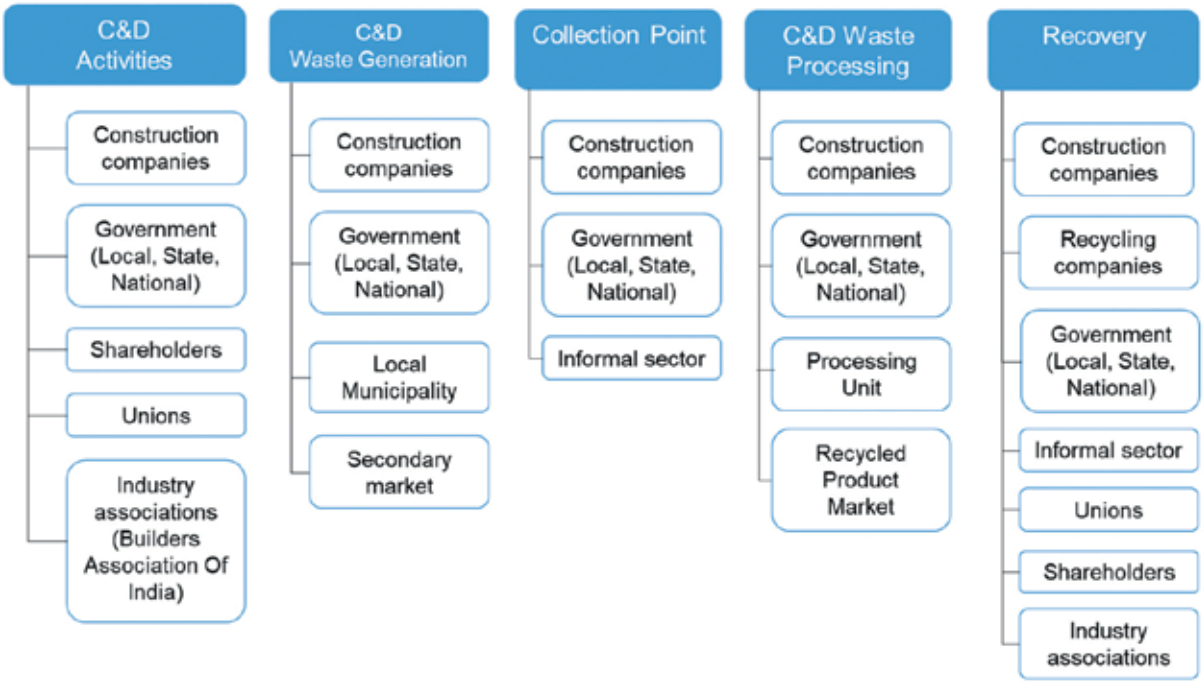

Figure 25: Mapping of stakeholders relevant to C&D waste

7.5.1.2 Ministries Involved

Across the lifecycle stages of C&D waste, several ministries are involved. Figure 26 shows the various ministries related to C&D waste's lifecycle.

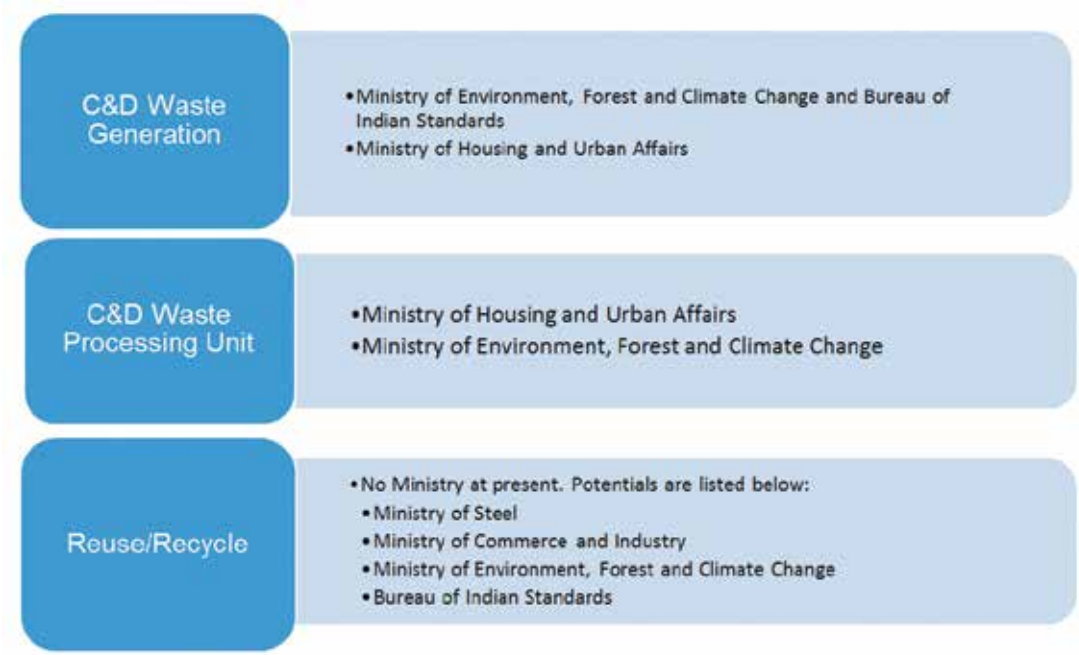

Figure 26: Ministries involved in C&D waste

7.5.2 Review of policies to examine support to RE/CE

1. C&D Rules, 2016

   1.1. "Application of materials made from construction and demolition waste and its products." - Schedule II, Pg. 8

   1.2. Duties of local authority:

   - "shall device appropriate measures in consultation with expert institutions for management of construction and demolition waste generated including processing facility and for using the recycled products in the best possible manner" – 6 (9), Pg. 4
   - "shall make provision for giving incentives for use of material made out of construction and demolition waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads" – 6 (11), Pg. 4

   1.3. Duties of State Government or Union Territory Administration-

   - "Procurement of materials made from construction and demolition waste shall be made mandatory to a certain percentage (say 10-20%) in municipal and Government contracts subject to strict quality control." – 9 (4), Pg. 5

   1.4. Duties of Bureau of Indian Standards and Indian Roads Congress – "The Bureau of Indian Standards and Indian Roads Congress shall be responsible for preparation of code of practices and standards for use of recycled materials and products of construction and demolition waste in respect of construction activities and the role of Indian Road Congress shall be specific to the standards and practices pertaining to construction of roads." – 11, Pg. 5

2. IS 383 (2016): Coarse and Fine Aggregate for Concrete – Specification

   2.1. Extent of utilization of coarse and fine aggregates – Pg. 2, Clause 4.2.1

   2.2. Construction and Demolition (C&D) Waste – Pg. 10, A3

3. CPWD Guidelines for Sustainable Habitat: Part IV Guidelines on Reuse & Recycling of Construction & Demolition Waste

   3.1. "Reusing of Construction and Demolition waste: "Reusing of construction and Demolition waste is different from Recycling. It does not require any further processing to convert into a useful product. The items which are usable directly are screened out from the debris and put into the intended use without further processing or the application of any further energy for conversion into the useful product. Thus, reusing a waste item is a better service to the environment and the environment is saved from further impacts due to recycling activities. For example, full bricks can be screened out of the demolition debris and used as it is for building a partition wall. Otherwise same would have been converted into smaller pieces for using it as an aggregate or brick bats for plinth protection etc. Since the reusing of C&D waste is always more advantageous, it is essential that to have more and more reusable materials in debris. This is possible, if sufficient precautions are taken while a building is demolished. There should be an effective deconstruction plan instead of just converting the standing structure into debris within minutes. Useful products like doors and windows, bricks, reinforcement, from RCC components, structural steel can be taken out with little extra efforts and put into reuse without much processing." – 3 (3.1), Pg. 28

   3.2. Recycling of Construction and Demolition waste: "Once the waste generated from Construction and demolition waste has been segregated and reusable items are taken out, the leftover waste is now available for recycling. Recycling of this waste into useful products to extend the service to environment is a challenge." – 3 (3.2), Pg. 29

7.5.3 Timeline of Policies

Figure 27 shows a timeline of the various policies and programmes related to C&D waste's lifecycle across the different ministries.

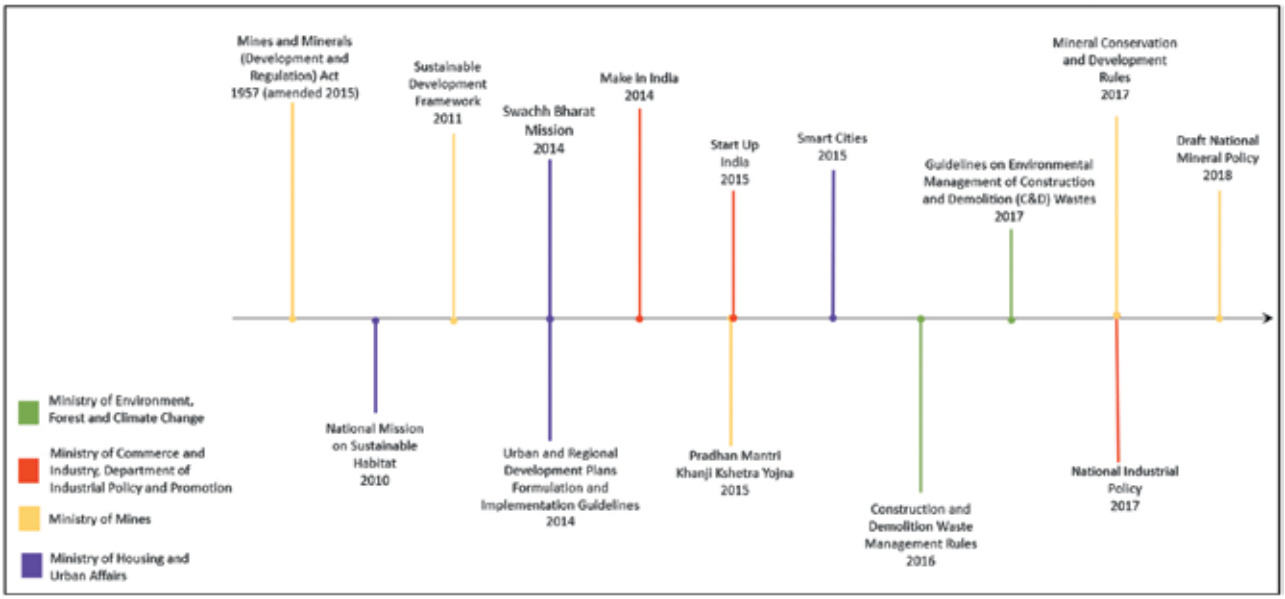

Figure 27: Timeline of various policies and programmes related to C&D waste

7.6. Annexure 6: Recommendations from the Strategy Papers as Mapped to the Overarching Recommendations and Action Points

The recommendations from the Strategy Papers have been mapped with the overarching recommendations presented in Table 3.

Categories	Recommendations from the Strategy Papers	Mapping to Overarching Recommendations and Action Points
Policies	Formulate a Comprehensive Steel Scrap Recycling Policy addressing: 1. Efficient collection, segregation and processing of steel scrap with adequate quality control. 2. Strict adherence to necessary safety measures and use of radiation detection equipment (particularly if scrap has been sourced from laboratories/hospitals). 3. Establishment of Zonal Scrap Collection and Processing Sectors in the country, ensuring processing is nearer to generation centres or near the end users. 4. Revisit of the existing BIS specifications pertaining to steel scrap.	R1.1 Formulate a national policy on RE/CE for all types of resources (biotic, abiotic) addressing various lifecycle stages and key stakeholders. • Follow a lifecycle thinking approach and address key stakeholders while achieving harmonization • Carry out risk analyses on the identified resources from an economic, environmental and social perspective • Reflect the attendant policy/ guidelines on the global value chain of the recycling industry and evaluate opportunities and threats
	Classify aluminium as a Core Industry & strategic sector enabling production of high-quality metal with provision of critical infrastructure to avoid global volatility in supply and prices	R1.1 Formulate a national policy on RE/CE for all types of resources (biotic, abiotic) addressing various lifecycle stages and key stakeholders. • Identify and prioritize nationally relevant resources or sectors (biotic and abiotic) that could benefit from RE/CE interventions
		• Reflect the attendant policy/ guidelines on the global value chain of the recycling industry and evaluate opportunities and threats
	Formulate an export policy for downstream aluminium producers towards high end product and export of value added aluminium. Sync with the flagship programme of Make in India, with focus on development of entire value chain of aluminium production in India.	R1.3 Strengthen existing sectoral policies and programmes Ministry of Mines by incorporating RE/CE principles • Update the Sustainable Development Framework (SDF) to include RE/CE and actions to be taken for resource efficient mining • Encourage procurement of raw materials from 4 or 5 Star Rated mines
	Formulate a policy to encourage domestic industry to become globally competitive with appropriate duties, taxes and fiscal instruments. Consider banning export of Aluminium scrap to promote growth of domestic industry. Achieve a target of 85% recycling rate by 2025 and enhance job creation opportunities.	R1.1 Formulate a national policy on RE/CE for all types of resources (biotic, abiotic) addressing various lifecycle stages and key stakeholders. • Carry out risk analyses on the identified resources from an economic, environmental and social perspective • Follow a lifecycle thinking approach and address key stakeholders while achieving harmonization • Reflect the attendant policy/ guidelines on the global value chain of the recycling industry and evaluate opportunities and threats

	Recycled aluminium products to follow standards for better quality control & be certified	R1.2 Formulate a national policy on Sustainable Public Procurement (SPP) with an action plan emphasizing procurement of RE & CE products. • Create standards, for remanufactured / refurbished/recycled products addressing quality, environmental, health and safety related considerations
	Development and adoption of guidelines for use of secondary materials and standards for reuse & refurbished products	R1.2 Formulate a national policy on Sustainable Public Procurement (SPP) with an action plan emphasizing procurement of RE & CE products. • Develop guidelines on testing methodologies, product specifications and codes of practices on certifying products
	Develop policies and guidelines for eco-friendly designs, and best available technologies and processes to reduce decontamination in the dismantling and recycling process.	R1.2 Formulate a national policy on Sustainable Public Procurement (SPP) with an action plan emphasizing procurement of RE & CE products. • Develop guidelines on testing methodologies, product specifications and codes of practices on certifying products
	Promote utilization of C&D waste recycled products: 1. ULBs and State agencies to adopt public procurement in a time-bound manner 2. CPWD/IRC to promote increased adoption of C&D waste products 3. BIS to promote standards and inclusion in National Building Code 4. MoF to consider GST rebates 5. MoEFCC to adopt Ecomark label 6. MoHUA to make arrangements for quality checks for recycled products through third-party testing 7. Mandating all Govt. projects to incorporate deconstruction and in-situ utilization	R1.2 Formulate a national policy on Sustainable Public Procurement (SPP) with an action plan emphasizing procurement of RE & CE products • Incentivize eco-labelled products for price competitiveness and promoting consumers purchase • Establish and promote green product labels/ certifications program by revamping the earlier ECOMARK scheme • Develop and launch pilot programmes at PSUs like the Indian Railways and Smart Cities programmes.
Programmes/ Mainstreaming	Utilize capacities of existing EAFs and furnaces for planned steel output. Steel scrap economically utilized using DRI in EAFs	R2.1 Mainstream RE/CE initiatives by leveraging existing flagships programmes and schemes like Swachh Bharat Abhiyan, Smart Cities Make in India, Start-up India, Digital India and others • Harmonize and strengthen existing Government flagship programmes in the interest of RE/CE
	Incorporate role of Urban Local Bodies to setup infrastructure for e-waste collection towards integrating the informal sector	R2.1 Mainstream RE/CE initiatives by leveraging existing flagships programmes and schemes like Swachh Bharat Abhiyan, Smart Cities Make in India, Start-up India, Digital India and others • Harmonize and strengthen existing Government flagship programmes in the interest of RE/CE • RE/CE Initiatives lead to reduced waste generation and disposal augmenting the ongoing programme of Swachh Bharat Abhiyan
	Develop business models for proliferation of technology adoption with informal sector towards formalization and ensuring better livelihoods.	R2.1 Mainstream RE/CE initiatives by leveraging existing flagships programmes and schemes like Swachh Bharat Abhiyan, Smart Cities Make in India, Start-up India, Digital India and others • Harmonize and strengthen existing Government flagship programmes in the interest of RE/CE

	Identify business models to be adopted by C-MET and the changes required for technology proliferation	R2.1 Mainstream RE/CE initiatives by leveraging existing flagships programmes and schemes like Swachh Bharat Abhiyan, Smart Cities Make in India, Start-up India, Digital India and others • Harmonize and strengthen existing Government flagship programmes in the interest of RE/CE
Regulations	Develop/augment construction/demolition permits consolidated to an easily accessible inventory and link them with project approvals.	R3.2 Establish State Level coordinating bodies to identify, implement and achieve State- level RE/CE goals • State level coordinating bodies to identify, implement and achieve RE/CE goals in coordination with BRE
	State-level facilitation and recognition of efforts in C&D waste management	R3.2 Establish State Level coordinating bodies to identify, implement and achieve State- level RE/CE goals • Recommendations from State level RE/CE plans to be harmonized with the recommendations in the Status paper
	Frame by-laws on C&D waste management incorporating appropriate levels of fees and penalties for generators	R3.5 Rationalise tax regime on critical virgin raw materials to make secondary raw materials price competitive • Higher tipping fees for bulk waste generators to encourage reduced generation, optimal reuse and redirection of waste into appropriate channels for recovery • Higher penalties may be introduced for non-compliance
Setting up a Dynamic Recycling Industry	Plan modern scrap processing facilities to source, separate, shred and process scrap as preferred input for quality steel production.	R4.1 Promote the establishment of Material Recovery Facilities (MRFs) with the allocation of land in urban areas and industrial estates • MRFs (including those for scraps) to create high quality and high value recyclable streams to be used as raw materials by industries
	Increase establishment of scrap processing units to minimize import volumes.	R4.1 Promote the establishment of Material Recovery Facilities (MRFs) with the allocation of land in urban areas and industrial estates. • MRFs may be set up on zonal/regional basis or as part of the infrastructure of waste intensive industrial estates.
	Set up Scrap Processing Units near the centres/clusters of scrap consumers (i.e. EAF/ IF Plants).	R4.1 Promote the establishment of Material Recovery Facilities (MRFs) with the allocation of land in urban areas and industrial estates. • MRFs (including those for scraps) to create high quality and high value recyclable streams to be used as raw materials by industries
	Set up zonal scrap collection/segregation/ treatment facilities. Recycling zones to address issues of transportation, pollution control etc.	R4.1 Promote the establishment of Material Recovery Facilities (MRFs) with the allocation of land in urban areas and industrial estates. • MRFs (including those for scraps) to create high quality and high value recyclable streams to be used as raw materials by industries

	SBM portal to be expanded to include data on C&D by ULBs. Centralised web-platform to serve as a facilitation tool to connect generators and users to be developed	R4.6 Establish and manage platforms for waste exchange • Reflect waste exchange adequately in the waste related regulations addressing waste transportation and tracking • Ensure that PCBs are involved in the oversight of the platform operations
R&D Technology & Development	Develop the slag processing technologies to enable its utilization.	R5.1 Support R&D to develop scalable technologies for RE/CE • Conduct feasibility studies to make productive use industrials wastes and by-products (red mud, fly ash, slag, etc.) • Promote R&D related to enhanced material and energy recovery
	Develop technologies to convert waste generated during the production of aluminium with minimal resources towards a zero-waste concept for the industry.	R5.1 Support R&D to develop scalable technologies for RE/CE • Promote R&D related to enhanced material and energy recovery
	Conduct feasibility study for assessing secondary resource recovery and utilization potential for electronics manufacturing	R5.1 Support R&D to develop scalable technologies for RE/CE • Conduct feasibility studies to make productive use industrials wastes and by-products (red mud, fly ash, slag, etc.)
	Inventorize and characterise C&D waste by 1. Select quantum estimation method best suited for Indian context 2. Use this method to estimate nationwide generation 3. Prepare simple standardised method for cities to estimate and characterise waste	R5.1 Support R&D to develop scalable technologies for RE • R&D to address small scale (decentralized) and large scale (centralized) operations • Support technology start-ups related to material recovery and help with up-scaling of relevant technologies • Partnerships to foster innovation, pilot testing and promotion of wastes and by-products as sustainable alternatives • Carry out inventorization and characterisation of e-waste and C&D waste
Capacity Development, Outreach and Monitoring	Recycling programmes to improve awareness pertaining to recycling and associated quality/ energy/environment issues.	R6.4 Develop and launch citizen awareness programmes on CE/RE • Address general perception of recycled products as one of inferior quality • Demonstrate projects and outreach to sensitise potential buyers, both in the B2B and B2C spaces

	Conduct awareness campaign for all stakeholders including, schools, colleges, RWAs, bulk consumers, dealers, refurbishers, producers, informal sector and government employees.	R6.2 Provide capacity development support on RE/CE for ministries/departments at the National and State levels. • Capacity development of key actors responsible for undertaking or overseeing RE/CE strategies (e.g. policy makers and regulators, ULBs and industrial estate authorities) R6.3 Develop and promote programmes and certifications for informal sector skill development in RE/CE. • Impart training to the informal sector for value creation, especially in upcycling of waste. R6.4 Develop and launch citizen awareness programmes on CE/RE • Consumer awareness campaigns to educate and inform RE/CE benefits, adopting resource efficient behaviours and purchasing resource efficient products/services by design
	Carry out capacity development of informal and formal actors in safe handling and disposal of e-waste and associates	R6.3 Develop and promote programmes and certifications for informal sector skill development in RE/CE. • Conduct certification programmes for waste sorting, disassembly, refurbishing and waste recycling to enhance RE/CE, reduce risks and generate employment of the informal sector
	Provide planning assistance (handholding) for cities by 1. Empanelling consultants to provide assistance to cities on developing detailed management plan, financial model and implementation strategy 2. Disseminating best practices and C&D management models along with development of toolkits covering technical aspects, management models, business case, tendering documents, etc. 3. Appointing appropriate consultants and expert agencies, to conduct capacity development workshops for ULBs	R6.2 Provide capacity development support on RE/CE for ministries/departments at the National and State levels • Capacity development of key actors responsible for undertaking or overseeing RE/CE strategies (e.g. policy makers and regulators, ULBs and industrial estate authorities)
	Promote awareness in construction industry 1. Industry associations to conduct sustained outreach covering all types of industry actors using capacity development manuals/toolkits on “deconstruction”, recycling and reutilisation 2. Special emphasis to be placed on technical standards (e.g., BIS) as well as “green” marketing and certification through BMTPC/GRIHA/IGBC	R6.2 Provide capacity development support on RE/CE for ministries/departments at the National and State levels • Raising awareness on the need and benefits of RE/CE (especially on themes like collaborative consumption, green products and services)

Table 3: Sectoral Recommendations mapped to overarching recommendations

7.7. Annexure 7: Governance Models for Promoting RE

Production and consumption practices in an economy rest on governance structures, systems and policies that are enabling in nature. Governance plays an important role by setting the course for greater resource efficiency in an economy and its transition to a circular one. Additionally, transitioning to a circular economy calls for integrated and coordinated approaches between ministries and governing bodies. This section discusses governance models and related factors that can enable a resource efficient and circular economy to flourish.

The resource efficiency and circular economy governance models of three countries are closely analysed – Germany, Japan and China – and the impacts of their respective policies are discussed. Potential context to Indian situation is also highlighted. For each country indicators for setting targets and tracking are also presented.

The Government of India based on this analysis may take an appropriate decision on the implementation of the proposed national action plan on RE.

7.7.1 Governance in Germany

Germany is a pioneer in Resource Efficiency in the Europe. Owing to the remarkable industrial performance and thrust on innovation, the nation adopted RE policies in the early 2000s. The principle of sustainable development became a guiding principle of federal environmental policy in Germany in the twenty first century. This has been manifested in the national sustainable development strategy from 2002 "Perspectives for Germany". This strategy sets the main course on resource efficiency policy in terms of sustainable development and intergeneration equity. It places defined targets on raw material productivity (doubling to 2020 with base year 1994) and energy productivity (doubling to 2020 with base year 1990).

Another main driver for increasing resource efficiency is the German waste policy. Waste policy focused on the prevention of hazards at the beginning, but it now mainly deals with closing the material flows and recycling raw materials. The various waste related rules promulgated by the MoEFCC in India could be bundled into a national waste policy focusing on all the life cycle stages of production and consumption. The third imperative of Germany's resource efficiency policy is resource efficiency as a strategic topic for innovation, growth and improving competitiveness of the German economy. In this context, the proposed emphasis on R&D and fostering innovation Resource Efficiency fits

As early as 2002, it set a target in the National Sustainable Development Strategy of doubling Germany's raw material productivity by 2020 relative to 1994. To promote resource efficiency as a main driver for future growth, the Federal Ministry of Economy and Technology funded the German Material Efficiency Agency in 2006. The German Resource Efficiency Programme (ProgRess) of 2012 was directed towards achieving this target.

The overarching goal of the German Resource Efficiency Programme is 'to make the extraction and use of natural resources more sustainable and in doing so, live up to our responsibility to future generations and contribute to securing the natural foundations of life in the long term'. With this aim, the first phase of ProgRess was adopted in 2012 and the second phase followed in 2016. The focus of the program is not only on enhancing resource efficiency, but also on showing how in many cases the use of raw materials such as in environmental technologies can conserve natural resources.

The following are the dimensions in ProgRess II[144] . It may be observed that many of the perspectives of ProgRess II have been captured in proposed action plan on RE in India.

144 Germany's national and international policies for resource efficiency, The Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, Germany: https://www.unece.org/fileadmin/DAM/ceci/documents/2017/ICP/TOS-ICP/Presentations/Session2/Session_2.1_Mues.pdf

Figure 28: International dimensions in ProgRess II

Resource efficiency is an overall policy objective of the Federal Government of Germany, but also of the Federal States (Bundesländer), with many cross-cutting linkages to various policy fields. Therefore, resource efficiency policies are formulated and introduced by various Federal Ministries, covering different issues and aspects of the resource efficiency agenda, like:

- Federal Ministry of Economy and Technology (BMWi)
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
- Federal Ministry of Education and Research (BMBF)
- Federal Ministry of Food, Agriculture and Consumer Protection (BMELV)
- Federal Ministry of Economic Development and Cooperation (BMZ)

The above institutional arrangements are relevant for India given the need for inter-ministerial coordination for improving Resource Efficiency.

A significant distinguishing feature of the policy of Germany is the public consultation component. It was a component of ProgRess I and the theme of public dialogue for ProgRess II was resource-efficient living. Such an approach will be appropriate for developing and implementing RE action plan for India.

7.7.2 Governance in Japan

The environmental protection measures started in Japan in the late 1960s. The Basic Law for Environmental Pollution Control was enacted in 1967 and the Environment Agency was established in 1971. The first law that brought resource efficiency to the centre stage in Japan was the 'Basic Act for Establishing a Sound Material-Cycle Society'. This law was enacted in 2000. Several laws and policies in the domains of RE/CE followed this Basic act of 2000, pertaining to material-cycle society.

"Sound material-cycle society" is defined under the Fundamental Law for Sound Material-Cycle Society as "a society in which the consumption of natural resources is minimised, and the environmental load is reduced as much as possible by preventing products, etc., from becoming wastes, etc., promoting appropriate recycling

of products, etc., when they have become recyclable resources, and securing appropriate disposal (as wastes) those recyclable resources that are not recycled[145]."

The first Fundamental Plan was established in 2003 as a 10-year program to accelerate the transition away from unsustainable patterns of production and consumption[146]. The plan discussed about ways to create a SMC society which is also a low carbon society. It addressed global warming and emphasised on the 3Rs for tackling environmental issues.

The linkage between RE and low carbon living is worth to consider while planning national action plan for RE in India. Addressing this perspective explicitly could help India meet the commitments made in the IDNC.

The Second "Fundamental Plan for Establishing a Sound Material-Cycle Society (approved by a Cabinet decision in March 2008) has set additional goals for the indices concerning the "Inlet", "Outlet" and "Cycle" of materials to the earlier plan. This refers to the three sections of the material flow (meaning the flow of materials and goods), where appropriate and balanced measures for reduction, reuse, recycling and disposal of resources are required. It also set goals for effort indices to measure the progress of efforts toward the establishment of a Sound Material-Cycle Society. The Third Fundamental Plan for Establishing a Sound Material-Cycle Society (approved in 2013) provides guidelines for future initiatives, along with numerical targets for FY2020, to align government institutions towards establishing a sound material-cycle society. It furthermore, revised certain indicators and these are explicated in the subsequent section.

The implementation of the laws was through the coordination among different ministries and agencies. The Ministry of the Environment (MoE), is responsible for the Basic Law, and therefore responsible for realizing sound material cycles. The responsibility of managing the municipal waste lies with the MoE, and the efficient use of materials and promoting recycling in private enterprises is the responsibility of the Ministry of Economy, Trade and Industry (METI) (Indian equivalent - MoC). The flow of bio-material comes under the jurisdiction of Ministry of Agriculture (MoA), Forestry and Fisheries (MAFF), whereas the Ministry of Land, Infrastructure and Transportation (MLIT) is responsible for construction material related matters. The above multi-institutional arrangements could provide a guidance for proposing governance on RE in India.

Japan has had considerable investments for environmental protection and capacity-building. Figure 29 shows the environmental expenditure of Japan for 1990-2006 period[147]. The country sets aside significant amount for environmental protection from the national budget.

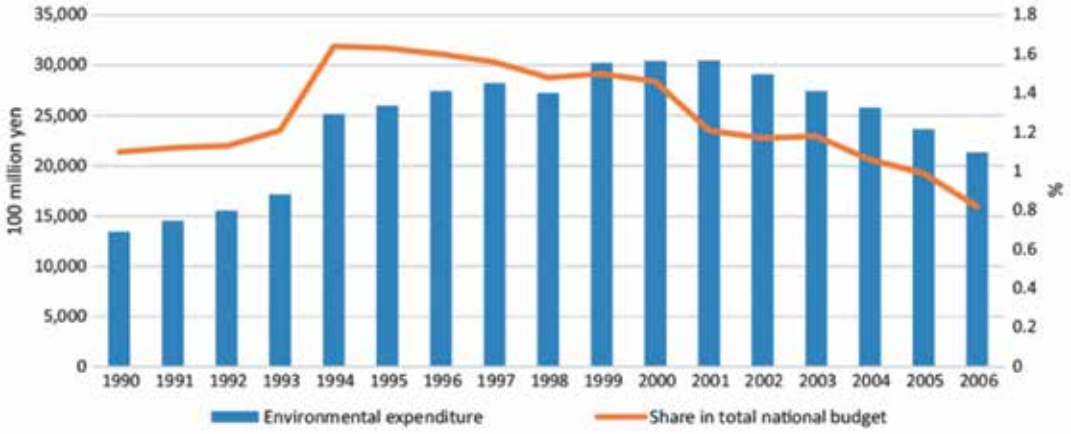

Figure 29: Environmental expenditure in Japan

145. The Basic Act for Establishing a Sound Material-Cycle Society (Act No.110 of 2000), Government of Japan: http://www.env.go.jp/en/laws/recycle/12.pdf
146. Fundamental Plan for Establishing a Sound Material-Cycle Society, Government of Japan: https://www.env.go.jp/en/recycle/smcs/2nd-f_plan.pdf
147. China's future investments in environmental protection and control of manufacturing industry: lessons from developed countries, Natural Hazards: https://www.researchgate.net/figure/Environmental-expenditure-and-its-share-in-Japans-total-national-budget-1990-2006_fig3_277604632

The multi-level governance system of Japan is very conducive to the successful implementation of the resource efficiency and material recovery policies. The policies are collectively implemented at different levels of governance, i.e. from Central Government to prefectures to municipalities. These are the three levels at which material cycle society policies are implemented.

7.7.3 Governance in China

People's Republic of China is a pioneer in circular economy governance. The concept of CE in China was introduced in the 1990s. It had origins in cleaner production, industrial ecology, and ecological modernization thinking and was inspired by examples of implementation in Europe, the United States, and Japan.[148] The concept of a CE was formally accepted in 2002 by the central government as a new development strategy. China's main national-level framework for pursuing CE is the Circular Economy Promotion Law, which came into force in 2009. China has circular economy practices in three levels- micro, meso and macro levels. The micro level initiatives are often associated with firms or companies. The meso level CE implementation is mainly in Eco-Industrial Parks and similar eco-parks. The macro level initiatives are intended for circular regions and eco-cities. Table 4 gives a snapshot of the structure of CE practices in China.

	Micro	Meso	Macro
Production Area	Cleaner Production Eco-design	Eco-industrial park Eco-agricultural system	Network of eco-industrial parks
Consumption Area	Green Purchase and Consumption	Eco-living park	Renting service
Waste Management Area	Product Recycle System	Waste trade market	Regional circular industry
Other support areas	Policies and laws, NGOs		

Table 4: Structure of CE practices in China

Chinese government regulates the implementation of CE through two agencies, the 8 State Environmental Protection Administration (SEPA) and the National Development and Reform Commission (NDRC). The former one oversees the National Pilot Eco-Industrial Park Program while the latter one oversees the National Pilot Circular Economy Zone Program in cooperation with SEPA and other 4 related ministries. Both programmes collaborated to build eco-industrial parks (EIP). All together 60 industrial parks have received approval to be developed into national pilot EIPs[149]. Along with the central government policies, there are also certain local regulations pertaining to circular economy. For e.g. Guangdong province has regulations and actions in CE. Despite the long experience on CE in China, recent assessments show a mixed bag of results. Some of the challenges faced include complexity and overlaps in the implementation, poor leadership, difficulties in accessing frontier technologies and low awareness.

Understanding these challenges is very relevant while preparing and implementing national action plan on RE in India. The proposed emphasis on strengthening and mainstreaming of the informal sector and capacity building (addressing awareness, leadership and education) is extremely relevant in this context.

Given the federal setup of Governance in India, it may be worth to review the models for State level governance on CE. Section 7.1.16 illustrates the Governance in the State of Victoria in Australia.

148. China Council for International Cooperation on Environment and Development (CCICED), 2005. www.cciced.net/encciced/policyresearch/report/201205/t20120529_230487.html

149. A Review of the Circular Economy in China: Moving from Rhetoric to Implementation, The Association of Korean Economic Studies: http://www.akes.or.kr/eng/papers(2012)/7.full.pdf

7.7.4 Governance in Victoria, Australia

In Australia, the State of Victoria is one of the leading States that focuses on waste and resource recovery. With the combined efforts of the Victorian community, local government, business, the resource recovery industry and the manufacturing sector, nearly 8 million tonnes of valuable materials are diverted from the landfills on annual basis. This corresponds to equate to a recovery rate of 70%.[150]

In 2014 the Victorian Waste and Resource Recovery Infrastructure Planning Framework was established after the legislative amendments to the Environment Protection Act 1970 were made. The framework provides the structure for strategic planning for waste and resource recovery that integrates planning at the state level with planning for local and regional communities.

The State infrastructure plan is a 30-year long term vision and roadmap to guide future planning for resource recovery infrastructure for Victoria. The State infrastructure plan guides the regional implementation plans, which in turn identify local waste and resource recovery infrastructure requirement each of the seven Victorian Waste and Resource Recovery Groups (WRRGs), over a 10-year timeframe. This experience may be useful in India's context while planning common CE infrastructure. For support of the infrastructure plan's vision, the following are the initiatives as presented from Victorian Market Development Strategy for Recovered Resources (2016) :[151]

- "leading targeted waste education to facilitate reduced waste generation, improve resource recovery and increase the community's participation and understanding of waste management and resource recovery infrastructure and services"
- "stimulating and supporting markets for products made from recovered resources (the role of this Strategy)"
- "improving the recovery of organic material to reduce the community, environment and public health impacts of organic waste"
- "facilitating collaborative procurement of waste and resource recovery services and infrastructure for local governments"
- "facilitating industry and local government investment in new waste and resource recovery infrastructure"
- "improving the quality, timeliness and accessibility of waste and resource recovery data."

For assigning priority for market development of recovered materials and products, a prioritization methodology was developed to support decision making to inform market development program planning and interventions for the future. Figure 30 summarizes the prioritisation methodology for market development of recovered resources. Pathway 1 highlights that government policy commitments has top most prioritization. Pathway 2 assess other products and materials.

150. Victorian Recycling Industries Annual Survey 2013 - 14, Sustainability Victoria, 2015: http://www.sustainability.vic.gov.au/-/media/resources/documents/publications-and-research/research/recycling-in-victoria/victorian-recycling-industries-annual-survey-2013-14/victorian-recycling-industries-annual-survey-2013-14-pdf.pdf?la=en

151. Victorian Market Development Strategy for Recovered Resources, Sustainability Victoria. 2016: http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Victorian-market-development-strategy-for-recovered-resources

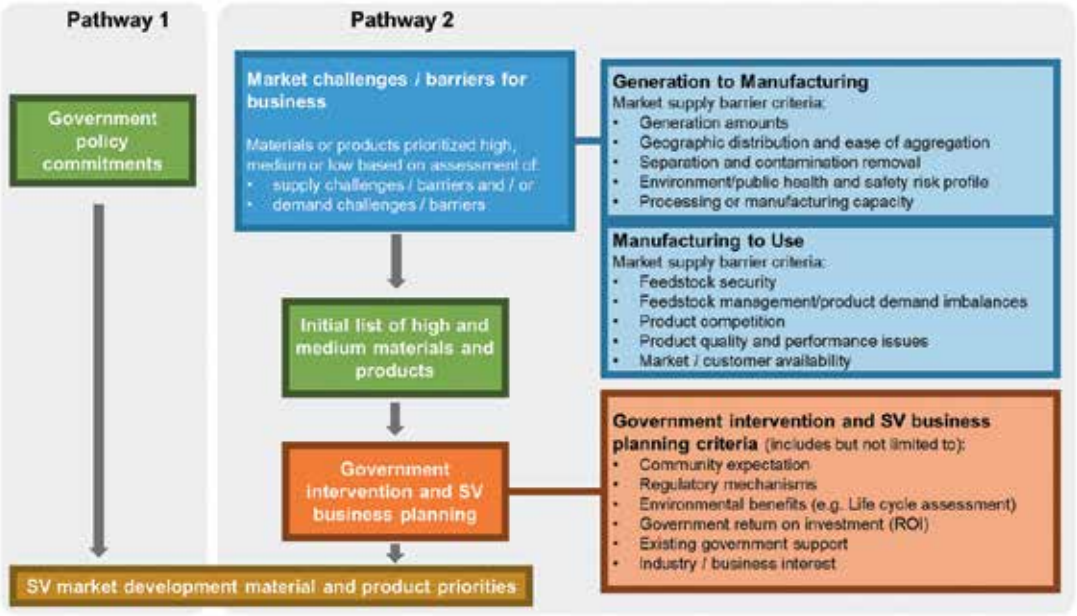

Figure 30: Prioritisation methodology for market development of recovered resources [152]

152. Adapted from Victorian Market Development Strategy for Recovered Resources, Sustainability Victoria. 2016: http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Victorian-market-development-strategy-for-recovered-resources

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https://www.niti.gov.in/

EU Delegation to India
https://eeas.europa.eu/delegations/india_en

European Union's Resource Efficiency Initiative
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