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CIRCULAR ECONOMY POLICIES FOR STEEL DECARBONISATION

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Executive Summary

Circular economy approaches offer opportunities to curb emissions in the steel industry. Extending the "4R priorities" (Reduce, Reuse, Remanufacture, and Recycle) of the circular economy is key to achieving near zero emissions in steel production. These approaches impact emissions in two ways: first by lowering steel demand, and second by incentivising secondary steelmaking methods with lower emission intensity. Net-zero scenarios suggest that material efficiency strategies could help lower global steel demand, leading to an approximate 20% reduction in emissions by 2050.

Increasing scrap availability through circular economy approaches can also alleviate expected pressure on global scrap markets. Current scrap markets face regional disparities and tightening export restrictions as demonstrated by recent OECD work (OECD, 2024), hence maximising recycling, and recovery rates, will be critical to minimise competition for scrap resources. According to decarbonisation scenarios, scrap is expected to account for about half of global steelmaking production by 2050.

However, integrating circular economy approaches in steel manufacturing remains challenging. These approaches remain in the early stages with companies encountering several obstacles in their implementation. These include the lack of clear governance structures as well as the lack of lifecycle approaches in the product design phase for the reduce, remanufacture, and reuse aspects. On the recycling front, major challenges include the quality degradation of recycled steel, insufficient infrastructure for efficient scrap collection and sorting, and inadequate data on the scrap origin and composition.

From a policy perspective, circular economy approaches tend to be horizontal and focus on recycling aspects. Circular economy approaches tend to be of horizontal nature, spanning multiple sectors, and primarily focus on reducing, reusing and recycling primary materials, with limited emphasis on remanufacturing or redesign. These circular economy policies tend to be tailored to strategic downstream sectors and may not often be linked to the steel sector sufficiently.

The development of steel-specific circular economy policies could maximize their decarbonization impact. In designing such policies, it is essential to integrate circularity elements from upstream and downstream sectors to ensure that the 4Rs of the circular economy are fully realized. Currently only two countries have developed steel specific circular economy policies, while some circular economy policies target steel consuming sectors such as construction and automotive, with direct implications on scrap availability and demand for steel.

Aligning circular economy policies with decarbonisation targets can enhance their effectiveness. Many steel decarbonization strategies already include recycling, resource efficiency, and waste reduction, which overlap with the circular economy priorities of reducing and recycling. Linking decarbonisation goals with circular economy outcomes can improve policy coherence and accelerate progress towards achieving near zero emissions in steel.

Governments and companies can further advance circular economy approaches in steel through technologies like blockchain and artificial intelligence (AI). Blockchain technologies are gaining attention as tools to track, monitor and regulate the circular flows of products and raw materials including steel and scrap. AI can help address challenges in scrap sorting and collection. Leveraging these technologies strategically can help the sector achieve its circular economy and decarbonisation objectives.

1 Introduction

The Circular Economy as a building block for steel decarbonisation

The iron and steel sector accounts for nearly 8% of global emissions within the energy sector and ranks amongst the highest emitting industry sectors (around 30% of industrial carbon emissions) (OECD, 2022). Considering the large carbon footprint, decarbonising the steel sector is key to achieve climate goals.

To meet the Paris Agreement objective of limiting global warming to 1.5 °C, global CO_2 emissions must decline on an unprecedented scale, reaching net-zero in 2050 (IPCC, 2022). To comply with this goal, direct emissions of global steel production and related carbon intensity must decrease by 90% from 2020 levels by 2050 (IEA, 2021).

While a wide range of mitigation options are required to reach this objective, net-zero scenarios suggest that circular economy and ferrous scrap will play a key role in reducing global emissions in the steel sector ((IPCC, 2022), (IEA, 2021), (MPP, 2022), (E3G, 2021), (Net Zero Steel, 2021)).

Circular economy not only includes recycling with scrap, but also material efficiency considerations ("Reduce", "Remanufacture", "Reuse", see (worldsteel, 2016)). The concept of circular economy is key for reducing emissions from the steel sector globally. Indeed, it contributes to avoid some emissions that would have arisen from steel production. While access to quality scrap may be uneven across regions, the other functions such as "Reuse", "Remanufacture" or "Reduce" could be envisioned in a universal way to reduce emissions. In addition, a circular economy approach further reduces pressure on raw materials (iron ore, coal, limestone) that would be required for steel production.

Objectives, contribution, and policy questions

This paper focuses on how circular economy practices[1] may contribute to steel decarbonisation, as well as identifying the related implementation and policy challenges. The aim is to provide policy insights on how to harness the full potential of circular economy for steel decarbonisation.

This report contributes to new insights on the implications of circular economy approaches for steel decarbonisation. Circular economy and related policy aspects are usually discussed in a cross-cutting way, but not necessarily from a sectoral perspective. In addition, when focusing on steel, circular economy approaches mostly address the recycling and scrap dimension, not paying sufficient attention to the other functions of reduce, reuse, remanufacture.

In the context of India's G20 Presidency, the International Renewable Energy Agency (IRENA) has released a comprehensive report focusing on circularity in the steel industry (IRENA, 2023). While our report aligns with the IRENA report in exploring the circular economy's various dimensions, we further expand on these insights from the IRENA report where relevant. This includes a detailed examination of existing circular economy policies and scrap-based production practices. In addition, parallel OECD work (OECD, 2024) provides an analysis of scrap volumes and trade dynamics including export restrictions. The combination of these two OECD reports help enhance the understanding and strategies for decarbonisation in the steel sector.

Policy questions and aspects explored in this report cover the following dimensions:

- **New state of play**: How can circular economy approaches facilitate steel decarbonisation?
- **Link with industrial and decarbonisation policies**: How can policies support the industry to develop circularity in steel?
- **Link with supply chains**: How can policies related to the circular economy contribute to well-functioning steel supply chains in a decarbonisation context?

Section 2 explores how circular economy approaches can facilitate the achievement of near zero objectives and takes stock of the key barriers for implementation. Section 3 analyses the state of play for circular economy policies in the largest steelmaking jurisdictions, while section 4 provides some recommendations on what can be done to strengthen the alignment between circular economy and decarbonisation policies.

2 The Circular Economy: implications for the steel sector

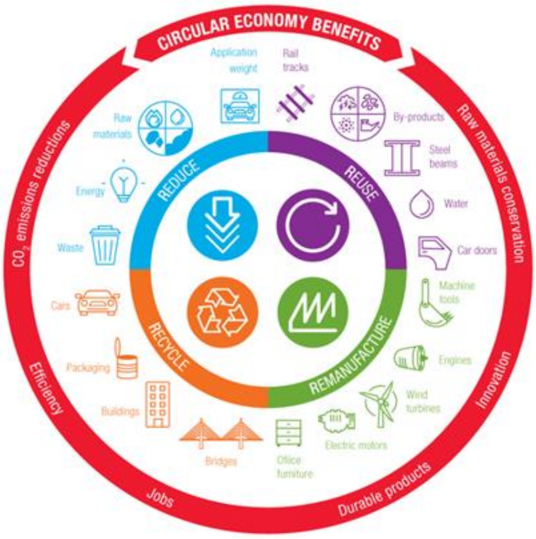
This section focuses on the circular economy as a key enabler of the low-carbon transition for the steel sector. It explores the different functions of the circular economy for steel, as well as the main barriers for implementation. In addition, examples of good practices in the steel industry are highlighted.

The different functions of the circular economy

The circular economy aims to transform existing linear economic models into circular models that reduce consumption of finite material resources. This is achieved by recovering materials from waste streams for recycling or reuse, using products longer and leveraging the potential of the sharing and services economy (OECD, 2022a). The introduction of circular economy approaches will limit the environmental impacts of material use by minimising the use of primary materials and by maximising resource efficiency.

Steel is essential to the technologies and solutions required to meet society's current needs. It will continue to remain essential for future transport systems, infrastructure, housing, manufacturing, agriculture, and energy. Steel is also a material which can be recycled repeatedly without losing its properties. In the future, the circular economy will maximise the value of raw materials by reducing the weight, minimizing losses, and increasing the recycling rates, resulting in more recycled steel to make new products (worldsteel, 2023). The circular economy model goes beyond just the recycling aspect, and the steel market should also adapt practices such as reducing, reusing and remanufacturing (Figure 2.1).

Figure 2.1. The 4Rs of the circular economy



Source: (worldsteel, 2023).

Reduce means decreasing the amount of material, energy and other resources used to create steel as well as reducing the weight of steel products used (worldsteel, 2023). Through investment in research and technology steelmakers over the past 50 years have drastically reduced the amount of raw materials and energy required to make steel (worldsteel, 2015). The steel industry continues to actively promote and develop the use of high-strength steel in many applications as less steel is needed to provide the same strength and functionality. It is estimated that there is about 15%-20% improvement potential in energy use and CO_2 emissions for many facilities in the world (worldsteel, 2021). This potential can be achieved by using the existing technology at most sites, if the industry applies to most efficient practices from the better performing sites across the industry.

Reuse involves using an object or material again, either for its original purpose or for a similar purpose, without significantly altering the physical form of the object or material (worldsteel, 2023). Reuse of steel is not limited to its original application. Rates of reuse will increase as eco-design, design for reuse and recycling, and resource efficiency become more prevalent (worldsteel, 2015). This approach would minimise the amount of waste sent to landfill, reduces emissions and preserves raw materials.

Remanufacture is the process of restoring durable steel products to a condition comparable as new (worldsteel, 2023). Remanufacturing takes the advantage of the durability of steel components and guarantees that the energy used to create the components is preserved. It differs from repair, which is a process limited to making the product operational, as opposed to thorough disassembly and restoration with the possible inclusion of new parts (worldsteel, 2015).

Recycle means melting the steel products at the end of their useful life to create new steels. Recycling alters the physical form of the steel object so that a new application can be create from recycled materials (worldsteel, 2023).

Recycling is currently the most developed aspect of the steel circular economy. Steel is 100% recyclable and scrap accounts for about 30% of the total metallic input to steel production globally (IEA, 2020). Going forward, as some of the existing steel stock reaches its end of life, steel scrap is expected to play a larger role in global steelmaking, with estimates suggesting that it could reach up to 50% of global steel production

((IEA, 2021); (OECD, 2023a) (OECD, 2024)) and, as a result of the lower carbon intensity of the EAF secondary route, contribute to achieving climate neutrality. However, as showed by recent OECD research (OECD, 2024), the significant presence of export restrictions hinders free scrap flows, limiting its optimal use for decarbonisation.

Contribution to steel decarbonisation

The 4Rs of the circular economy are a key driver for reaching near zero emission steel. The effects on reducing emissions are twofold: first, the circular economy can increase material efficiency in downstream sectors, lowering aggregate steel demand, and thus avoiding emissions. Second, by incentivising the scrap route, it lowers the aggregate emission intensity of the sector, as secondary steelmaking is less emission intensive than the primary route ((IEA, 2020), (MPP, 2022)).

More specifically, various global steel decarbonisation scenarios include material efficiency strategies as a key component for achieving deep emission reductions ((IEA, 2020), (IEA, 2021), (E3G, 2021), (MPP, 2022), (Net Zero Steel, 2021)). The concept of material efficiency refers to delivering goods and services using less material (IPCC, 2022), and such strategies can be applied at various stages in the life cycle of materials and products (Table 2.1). They encompass measures acting on the design (design for reducing material intensity, design for improving circularity), manufacturing (improving yields, increasing process efficiency), use (increasing the intensity of use and lifetimes, shared and service-oriented consumption modes) and end of life (improving material recovery and recycling) phases.

Table 2.1. Examples of material efficiency strategies related to steel

Product stage	Material efficiency strategies
Design	Designing for reducing material intensity, including optimised building design, light weighting vehicles, use of high strength steel Designing for circularity (longer life, reusability, repairability, ease of high-quality recycling)
Manufacture	Improved semi-manufacturing and product manufacturing yields Pushing manufacturing and fabrication process to use material and energy more efficiently and recover material wastes
Use	Increase the intensity of use and lifetimes, including direct reuse of products, repair, building lifetime extension. Shared and service-oriented consumption modes, including for building and vehicles. Vehicle reduced use
End of life	Improving the recovery at materials end of life Recycling

Source: Authors' compilation based on various sources: (IPCC, 2022), (IEA, 2020), (E3G, 2021), (MPP, 2022).

Net-zero scenarios suggest that material efficiency strategies could contribute to reducing global steel demand by around 20% in 2050, compared to a business-as-usual approach ((IEA, 2021), (E3G, 2021), (Net Zero Steel, 2021)), and up to 40% when such strategies are maximised (MPP, 2022). In terms of emission reduction, available information from scenarios highlights a contribution from material efficiency measures of around 20% in 2050 (E3G, 2021) or in 2060 (IEA, 2019).

The crucial role of material efficiency is further underlined in the Sustainable Development Scenario, by accounting for 40% of the cumulative steel direct emission reductions between 2010 and 2050 (thus being the most important mitigation lever) (IEA, 2020).

Barriers and challenges to implementation

Four main types of barriers and policy challenges can be identified in the implementation of a circular economy in the steel sector (see Table 2.2). They are economic factors, lack of policy incentives, lack of a lifecycle approach and challenges related to scrap. Economic factors refer to the costs of the secondary metals market, government support, un-priced environmental externalities. The lack of policy incentives such as the lack of a governance structure and targets for a circular economy is another barrier to a wide implementation of circularity for the steel sector. The lack of a lifecycle approach when developing a product creates challenges in the design phase and from a producer responsibility perspective. Challenges related to scrap include the downgrading of recycled steel, the necessary infrastructure and the insufficient data and tracing on scrap composition.

Table 2.2. Summary table of barriers and challenges for a circular economy in the steel sector

Group	Challenge	Description
Economic factors	Costs	State of the art technologies is currently available, but value of recycled materials is too low to justify the investment costs.
	Government support	Government support tends to disproportionally benefit primary metals sectors and lower the competitiveness of secondary metals.
	Unpriced externalities	Unpriced environmental externalities allow primary metals to compete with secondary metals.
Lack of policy incentives	Stakeholder interaction	An improved relationship between stakeholders can lead to the development of new scrap standards, investment and implementation in advanced sorting technologies, and better control over the quality of scrap.
	Lack of circular economy targets	Targets would ensure that stakeholders receive a clear message on which direction the industry is transitioning to.
Lack of lifecycle approach	Lack of eco-design	Producers tend to not consider the end-of-life of a product in the design phase.
	Lack of extended producer responsibility	Producers do not have the incentives to consider the environmental impacts and end-of life of their products. The responsibility of end of life tends to be shifted to consumers, governments, and municipalities.
Recycling barriers	Quality	Lower-quality steel scrap can only be used for a limited number of applications.
	Infrastructure	Sorting, collection and transportation infrastructures need significant investments.
	Traceability	The origin of many steel products and the properties of the steel are not always clear.

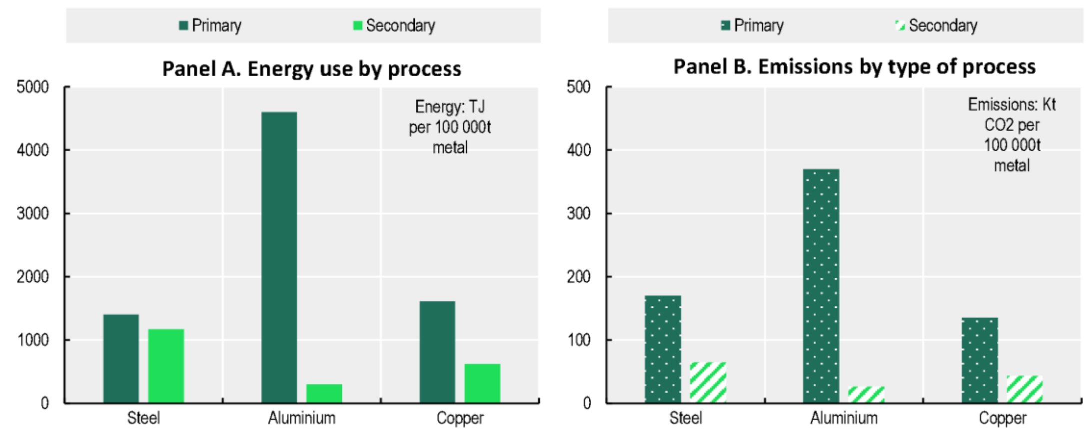
Source: Authors' compilation based on various sources: (Agora Industry, 2022) (McCarthy & Börkey, 2018) (OECD, 2022a) (Hall, Zhang, & Li, 2021) (UNEP, 2013) (Steeltrace, 2020).

Economic barriers

Currently, the economic costs facing the market for secondary metals constitutes a key barrier for the implementation of a circular economy (Agora Industry, 2022). Steel recyclers have new opportunities to invest in innovative recycling technologies to provide a high-quality secondary material. However, in practice the value of recycled materials is often too low to justify doing so. There is a need to create demand and markets for recycled materials and improve the prices of recycled materials relative to primary materials production. The importance of enabling market forces to drive price signals cannot be understated. These signals are amongst the best incentives to stimulate supplies of scrap on the market for steel producers.

Government support in the metals industry creates a less competitive secondary metals market through tax reductions or subsidies. Government support is not specific to the steel production aspect but refers to policies throughout the whole value chain, from mining to recycling. Even when government support is not specifically targeted it tends to benefit the primary metals sectors disproportionally in both absolute terms and per-unit of output terms (McCarthy & Börkey, 2018). Untargeted support reduces the cost of energy and capital which may disproportionally benefit primary metal producers due to their intensive use of inputs (Figure 2.2, (McCarthy & Börkey, 2018)). Hence, government support may reduce the competitiveness of recycled and re-used metals.

Figure 2.2. Energy use and carbon emissions, selected metals



Source: (McCarthy & Börkey, 2018).

Another factor which decreases the competitiveness of the secondary metals market are the unpriced environmental externalities (McCarthy & Börkey, 2018). Primary metals consume much more energy and produce more emissions than secondary and recycled metals (Figure 2.2). However, since these environmental externalities are largely unpriced, primary metals are able to compete with secondary metals, hence decreasing their competitiveness.

Lack of policy incentives towards circularity

Circular economy policies would facilitate the transition in the steel industry. However, the lack of a governance body and interaction with all the stakeholders' risks creating misalignment in the industry. Additionally, a lack of circular economy and recycling targets does not incentivise the industry to transition.

A challenge for the implementation of a circular economy is the lack of a governance structure in the industry. A transition to a circular economy requires collaboration on all levels. The multi-stakeholder character of the industry and its continuous development makes it necessary to continue to focus on capacity building and interactions in all concerned institutions (Government of India , 2019). Hall, Zhang, and Li also cite the existence of a misalignment in the industry, specifically between recyclers and steel scrap producers (2021). Hence, joint bodies and the involvement of all major stakeholders such as policymakers, government agencies, academics, civil society, non-profit institutions, think tanks, consumers, and technology developers would allow for better collaboration (Government of India , 2019). This would facilitate knowledge sharing, industry governance, the development of new scrap standards, investment and implementation in advanced sorting technologies, and better control over the quality of scrap, justification for the investment into new technologies and collaboration on research and development (Hall, Zhang, & Li, 2021) (Government of India , 2019).

Additionally, not setting any type of material efficiency target, recycling target or minimum standard of recycled material in a product also hinders the transition to a circular economy in the steel sector. Setting a target would oblige the industry to ensure that a certain quantity of materials is recovered and recycled (UNEP, 2013). Targets would ensure that stakeholders in the recycling chains get a clear message on which direction the industry is transitioning to.

Lifecycle challenges

A challenge for the full implementation of the circular economy is the necessity to consider the whole value chain of the products. This requires a life cycle approach and the involvement of all the stakeholders along the value chain (OECD, 2022a). This relates to the design process and producer responsibility.

Currently, when designing products, most producers do not consider the whole life cycle of the product. Approximately 45% of global emissions arise when making products, and up to 80% of all product-related environmental impacts are determined during the design phase of a product (New Zealand Government, 2022). The uptake of circular models would thus further require a shift in thinking towards eco-design. This includes integrating recycling into the product, decreasing the weight of the product, using less energy in the production process, extending the product lifetime, easing reparability of the product, facilitating disassembly and ensuring that materials can be recycled ((OECD, 2022a) (UNEP, 2013)).

Additionally, the lack of a lifecycle approach means that producers currently do not have the incentives to consider the environmental impacts and end-of life of their products. The responsibility of end of life tends to be shifted to consumers, governments, and municipalities. Hence, the lack of responsibility removes incentives from producers to shift businesses models towards a more circular economy. A way to provide incentives to producers would be to consider Extended Producer Responsibility (EPR), which holds producers responsible for the costs of managing their products at the end of life (OECD, 2022a).

Recycling challenges

Currently, steel is one of the most recycled metals, and its recovery and recycling rates are approaching 75% (McCarthy & Börkey, 2018). However, the scrap market also faces challenges in the transition to a full circular economy. Some challenges include downgrading of steel, infrastructure challenges such as sorting of scrap and waste streams and the traceability of recycled steel.

Downgrading refers to the extent of impurities for steel scrap which can only be used for a limited number of applications because the recycled steel will be lower quality (Agora Industry, 2022). Currently, recyclers mix good quality scrap and poor-quality scrap, limiting the applications (Sandbag, 2022). There is little incentive to set limits on impurity levels. For example, in the United Kingdom standards on steel recycling focus on size, source, and safe practices rather than the chemical composition of scrap. This makes it unclear for recyclers and steelmakers to understand the limits of poor quality in recycled steel (Hall, Zhang, & Li, 2021). Additionally, the steel sector and recyclers would benefit from increased discussion and joint investments to ensure the best use of scrap, which could arise from an improved governance structure, as mentioned above. Furthermore, eco-design is essential to ensure that components can easily be separated from the steel scrap or that copper could be replaced with alternative in certain applications, such as aluminium, which would reduce contamination during the recycling process.

Another barrier to the implementation of the circular economy is the **sorting of scrap**. To sort the mixed scrap into grades, the scrap collectors and scrap recyclers need to invest significantly in modern scrap sorting technologies. Scrap quality control currently relies on visual inspections and sometimes aided with a spot analysis (Hall, Zhang, & Li, 2021). The lack of quality monitoring and control tools may cause disputes between suppliers and users of scrap. Additionally, any mistakes in identifying the composition of the scrap can severely downgrade the quality of the recycled steel (Hall, Zhang, & Li, 2021). Better and larger scale techniques are required to sort scrap. The technology is available to the market, but recyclers do not currently see the economic benefits of using them as there is currently little incentive to buy high quality recycled steel at a higher price (Hall, Zhang, & Li, 2021).

Another infrastructure challenge relates to the **collection** aspects of the commercial and residential recycling systems. Collection is the beginning of the recycling chain, meaning it is essential for a successful recycling supply chain. The establishment of suitable collection infrastructure still poses a great challenge, mainly from an economic point of view. The best collection method is source segregate collection, which is currently constrained by economic feasibility and the availability of physical infrastructure for dealing with separate waste streams (UNEP, 2013). From the perspective of residential recycling system, collection can be influenced by consumer behaviour (UNEP, 2013). For consumers to be able to partake in source segregation clear knowledge is necessary concerning the waste streams and guarantee convenient collection points.

This leads to another barrier which is **data and traceability** of steel products. The identification of the suitable waste stream requires data on the structure of the product. However, to date, the origin of many steel products is unknown, that means that the properties of steel are not always clear (Steeltrace, 2020). Hence, increasing the traceability and data on the origin of steel products is essential to ensure efficient use at end of life.

Examples of industry's practices

More and more companies are up taking circular economy practices in their production processes. There are examples of each of the 4 circular economy Rs (Figure 2.1) being adapted in everyday practices (Table 2.3).

An example of **recycling** is when the steelmaking company NLMK made the decision in 2018 to recycle a slag dump that had been forming next to their plant since the 1970s (worldsteel, 2023). In doing so, almost 350,000 tonnes of scrap were recovered and used to replace iron ore in blast furnace operations. Waste materials remaining after the recovery were utilised for construction projects at the plant. The environmental benefits included avoiding CO_2 emissions and reclamation of territory.

Table 2.3. Circular economy practices in the steel sector

Group	Company	Title
Recycle	NLMK	Processing of a 5 mmt metallurgical slag dump and reclamation of the adjacent territory
Reduce, Recycle	Tenaris	Smart furnace for scrap use optimization based on mathematical models and data science
Reduce	Tata Steel	PACI – a tool to support innovation and customer engagement through life cycle thinking in the steel

		value chain
	HBIS	Using LCA to promote the carbon emission reduction in the whole value chain of hydrogen-based DRI projects
	ArcelorMittal	Carbon footprint of cold stamping and how stamping components
		CO_2 reduction by means of coke oven gas co-injection in blast furnace
		HISTAR steel accounts for 30% of materials savings
	Ansteel	The R&D of digitization and networking energy management system at the Bayuquan site
	Hyundai Steel	Development of 1.5 GPa hot stamping steel in conjunction with high toughness performance
	POSCO	Recycling shell waste for sustainable steelmaking
		Roll stamping technologies for automotive giga steel
		Using LCA to assist automakers in recognizing the benefits of steel
	JFE	Green beverage can with unique Cr plated steel sheet
	JSW	Development of construction sand from waste steel slag
Reuse	POSCO	Slag upcycling for negative emissions
		Triton sea forestation project
	BSRM	Using 100% induction furnace slag to replace clay bricks and stone chips
	Ternium	Carbon capture and utilisation
Remanufacture	LRPI Remanufacturing	Automotive parts remanufacturing
	Renewable Parts Ltd	Remanufacturing of wind turbines components

Source: (worldsteel, 2023) (worldsteel, 2016).

POSCO **reused** steel slag by developing artificial reefs to transform damaged coastal areas into sea forests (worldsteel, 2023). Slag is a co-product of steel making with high calcium and iron content, which promotes growth and photosynthesis of marine algae. The sea forests also sequester and store significant amount of CO_2.

ArcelorMittal developed the HISTAR range of steels for construction. HISTAR is an example of **reduction** because compared to conventional structural steel it exhibits significant weight and material cost savings (worldsteel, 2016). It accounts to around 30% materials savings while meeting the demands of architects and designers for materials which enable them to create light and economic structures.

An example of **remanufacturing** is Renewable Parts Ltd which specializes in hydromechanical wind turbine components (worldsteel, 2023). All components have a high steel content. In 2018, it expanded into the process of remanufacturing and by 2022 had diverted 111 tonnes of waste from landfill.

3 Policy aspects

This section addresses in what way policymakers can effectively tackle the challenges surrounding the application of circular economy principles. It provides a comprehensive review of key findings from a policy mapping exercise conducted across major steel-producing countries, highlighting the existing policy frameworks that support the circular economy and steel scrap utilization.

Circular economy policies in steel-producing countries

Objective

The objective of the policy mapping is: i) to provide concrete insights on how steel producing countries are approaching the transition to a circular economy through the existing legal and policy frameworks, and ii) explore whether circular economy policies sufficiently take into account the specificities of the steel sector.

The policy analysis also aims to assess the potential complementarity between circular economy policy and steel decarbonisation policies. On the one hand, circular economy policies may be part of a wider (steel) decarbonisation strategy, as some governments may set circular economy objectives as part of their decarbonisation targets. On the other hand, industrial policies and resource efficiency policies could encompass circular economy aspects.

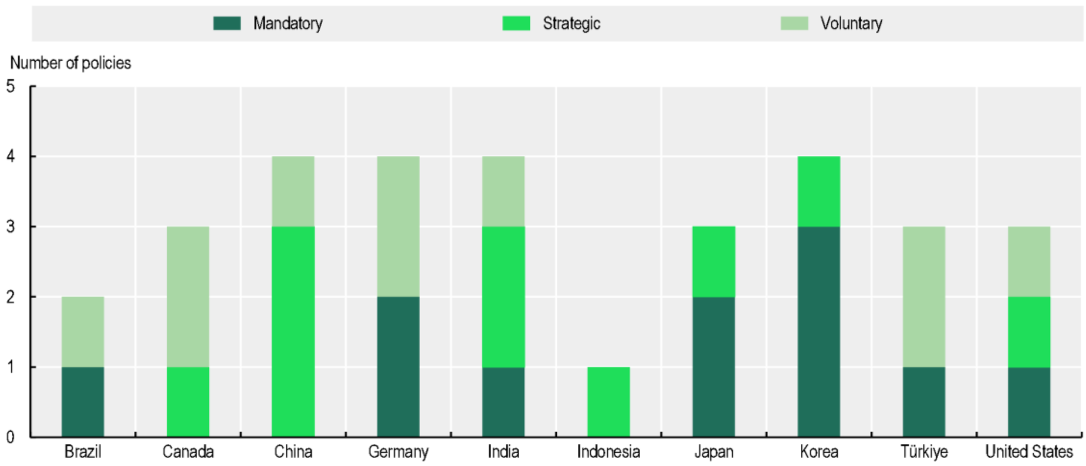
Comparison of Circular Economy approaches from a steel perspective

This section compares circular economy approaches in the ten focus countries[2]. It focuses on several key aspects including the type of policy, main circular economy priorities, the strategic importance of the steel sector and downstream sectors.

What types of policies are dedicated for the circular economy?

Governments in major steel-producing countries are working to strengthen their circular economy frameworks. The policy mapping identifies various government's approaches using a mix of mandatory, strategic, or voluntary initiatives (Figure 3.1). Germany, Japan, and Korea have increasingly used mandatory policies, representing over half policies in place (7 out of the 11 mandatory policies). Almost all countries have adopted a circular economy strategy or have drafts under preparation since 2024 (for example, in Indonesia and Türkiye).

Figure 3.1. Overview of the circular economy policies by type and country



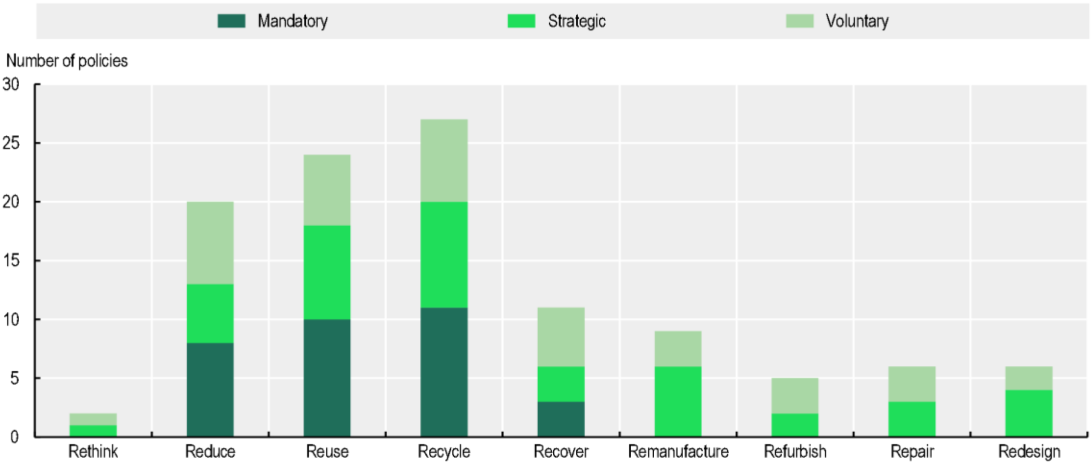
Source: Authors' calculations based on Steel Decarbonisation Policy dataset (OECD, 2024).

All policies emphasise the critical importance of resource efficiency, waste resource and management, sustainable production and consumption. Mandatory policies provide, for example, legal definitions of waste (Germany). Strategic policies target the shifts from linear to circular economic models, the definition of circular economy objectives, the identification of key sectors and products with high-circularity potential, as well as the considerations of policy instruments in achieving the transition. Voluntary policies provide awareness and the recognition of the importance of the circular economy.

How do steel-producing countries define and approach the circular economy?

Steel-producing countries have defined a set of circularity priorities in achieving their transition. Recycling is identified as a top policy priority for the circular economy in major steel producers. Over two-third (27) policies are dedicated to promoting or regulating recycling activities (see Figure 3.2). Reducing, reusing, and recovering solutions are also a key part of the circular economy policies in place, with more than 10 policies dedicated to these priority areas.

Figure 3.2. Circularity priorities by type of policy



Note: The mapping exercise considers the policies based on whether they explicitly mention one of the circularity priorities. It includes both horizontal and sectoral policies.
Source: Authors' calculations based on Steel Decarbonisation Policy dataset (OECD, 2024).

Few existing policies address all four core circular economy priorities (Reduce, Reuse, Remanufacture and Recycle) in steel producing countries. The way governments incorporate these priorities into policy varies widely. Mandatory policies tend to focus on the key goals of reducing the consumption of virgin materials and enhance the recovery, reuse, and recycling of end-of-life products. By contrast, policies that include other circularity priorities such as "Remanufacture", "Refurbish" or "Redesign" tend to be of strategic or voluntary nature and lack formal regulation.

The principles of the circular economy, especially the "Reduce", "Reuse", "Recycle" (the "3Rs"), are becoming more common in the policy landscape of major steel producers. Out of the ten focus countries, eight have implemented policies that relate to these 3Rs. (see Table 3.1). Only a few countries have policies that cover a broader range of circular priorities, referred to as the 9Rs: "Rethink", "Reduce", "Reuse", "Recycle", "Recover", "Remanufacture", "Repair", "Refurbish", "Redesign".

Germany and India are notable examples, each with at least one policy that address all 9Rs, showing a more advanced approach to circularity.

Table 3.1. Governments' approach for circular economy practices

Country	Rethink	Reduce	Reuse	Recycle	Recover	Remanufacture	Refurbish	Repair	Redesign
Brazil				✓	✓				
Canada		✓	✓	✓	✓	✓	✓	✓	
China		✓	✓	✓		✓			
Germany	✓	✓	✓	✓	✓	✓	✓	✓	✓
India	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indonesia			✓	✓					
Japan		✓	✓	✓					
Korea		✓	✓	✓		✓			
Türkiye		✓	✓	✓	✓	✓	✓	✓	✓

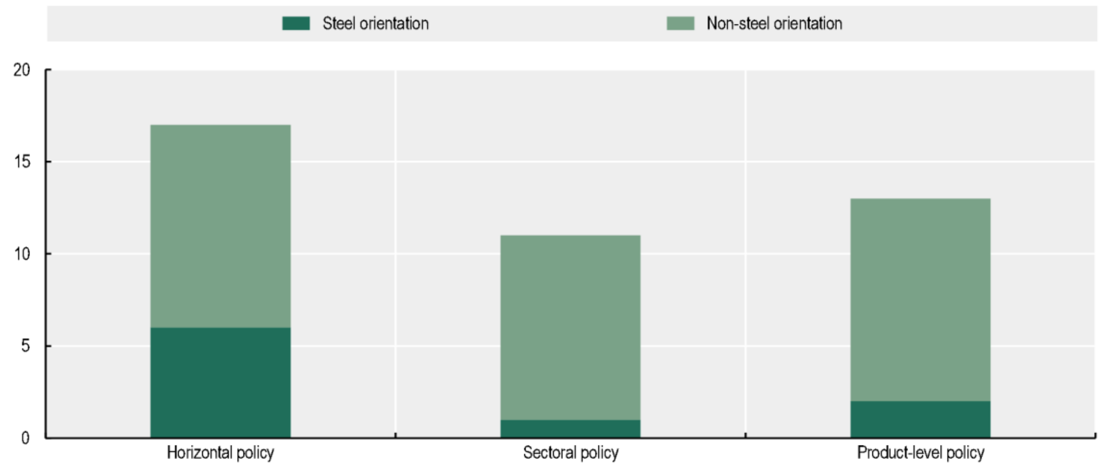
United States		✓	✓	✓	✓	✓			✓

Note: The mapping exercise considers the policies based on whether they explicitly mention one of the circularity priorities.
Source: Authors' compilation based on Steel Decarbonisation Policy dataset (OECD, 2024).

On which sectors do circular economy policies focus?

Horizontal circular economy policies are the preferred approach among major steel-producing countries. Over half (17) of circular economy policies are horizontal (Figure 3.3), focusing on deeper structural transformations of the whole production system. In some cases, policies have a sectoral focus, targeting one or several industries that have been identified as having high circularity potential. These include steel, construction and buildings products, automobile, and the renewable energy sector. Some policies target a specific product (plastics, steel scrap) or a group of products (e-waste) to strengthen their circularity.

Figure 3.3. Number of circular economy policy, by type of integration and steel-specific



Note: Each policy document identified in the policy mapping (see Annex A) was scanned with keywords "steel" to identify policy status.
Source: Authors' calculations based on Steel Decarbonisation Policy dataset (OECD, 2024).

Many horizontal policies mention steel as a key example of sectors with high circularity potential. However, only, two sectoral policies are dedicated especially to consider the specificities of the steel sector. Similarly, recycling policies broadly focus on the recovery and valorisation of wastes, but few product-level policies take the importance of steel scrap explicitly into consideration.

While Asian countries and Germany have in general a cross-sectoral approach on the circularity of the steel industry (Table 3.2), establishing some complementarities with the circularity of downstream sectors, only India has put in place a recycling policy centred on steel scrap.

Table 3.2. Examples of sectoral policy on circular economy

Country	Policy name	Steel	Automobile	Construction	Shipbuilding	Renewable energy
Brazil	National Policy for Regional Development			✓		
Canada	National Guidelines for Whole-Building Life Cycle Assessment			✓		
	National Vehicle Scrappage Programme		✓			
China	Circular Economy promotion Law	✓	✓	✓		✓
	Swap the Old for Remanufacturing		✓			
Germany	Circular Economy Act		✓	✓	✓	✓
	Resource efficiency program Phase III	✓	✓	✓		✓
	National program of Sustainable Consumption					✓
India	Steel Scrap Recycling Policy	✓				
	Recycling of Ships Act				✓	
	Vehicle Scrappage Policy		✓			
Indonesia	Roadmap to waste reduction by producer			✓		
Japan	Circular Economy Vision 2020	✓		✓		
	Construction recycling act			✓		
	Automobile recycling act		✓			
Korea	Framework Act on Resource Circulation			✓		
	Circular economy 9 Projects	✓	✓	✓		✓
Türkiye	Scrapping Scheme Programme for Old Vehicles		✓			
	Mediterranean Sustainable Consumption and Production Regional Action Plan			✓		
United States	National Recycling Strategy			✓		✓
	Clean Shipping Act				✓	

Note: Each policy document identified in the policy mapping (Annex A) was scanned with keywords "automobile", "vehicle", "building", "construction", "ship_", "renewable" to identify policy status.
Source: Authors' calculations based on Steel Decarbonisation Policy dataset (OECD, 2024).

Circular economy policies are however increasingly focusing on strategic sectors that may have impacts on the steel industry. Many steel-producing countries have put in place a circular economy policy targeting construction and buildings products and, to a lesser extent, integrating the life cycle of steel products as a key input for more circular construction. Automobile is the second most targeted sector with many measures on the scrappage of end-of-life vehicles. However, none of identified policies have considered the entire life cycle of vehicles.

Which policy instruments do steel-producing countries use to promote the circular economy?

Focus countries use a variety of policy instruments to support the transition to a circular economy. In particular, the policy review identified economic instruments, extended producer responsibility (EPR) and green public procurement (GPP) as instruments geared towards circular economy objectives.

All focus countries have put in place economic instruments, ranging from taxes and fees, deposit refund systems to subsidies (Table 3.3). These instruments provide price signals to producers and consumers to incentivise more resource efficient and circular behaviours.

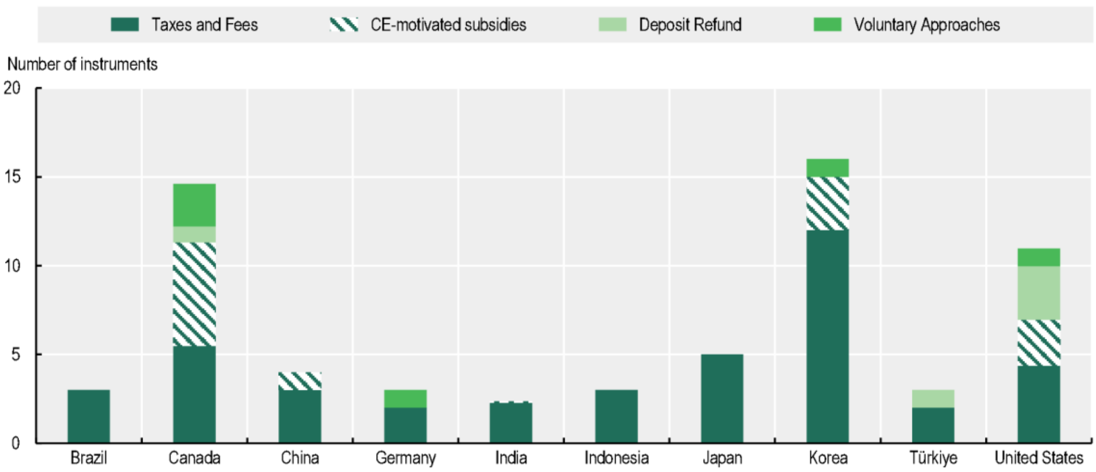
Table 3.3. Economic instruments in place in selected major steel-producing countries

Type of instruments	Objective	Key examples
Taxes	to reduce the consumption of virgin materials or encourage circular economy activities.	VAT policy to incentive the adoption of circular economy business model (China)
Fees	to recover the costs of providing goods or services, meaning that the person paying gets something in return in proportion to the payment, whereas taxes are unrequited payments.	Waste management fees (Canada)
Deposit-refund systems	to place a surcharge on the price of a product likely to pollute the environment to internalise the environmental costs of end-of-life products, such as advanced recycling fees and EPR measures.	Deposit-refund system for glass, metal, laminate, plastic containers (Türkiye)
Subsidies	to support better circularity in industrial activities through waste reduction and investments in improved waste management	Soft loans for fostering recycling industry (Korea)
Voluntary approach	to reduce environmental impacts throughout product or service's life cycle	Green public procurement scheme (United States)

Source: Authors' compilation based on OECD (2022) and examples extracted from the OECD-PINE database.

The ten focus countries have at least one type of circular economy-relevant economic instruments in force. Taxes and fees are the dominant instruments in place to strengthen more resource efficient and circular economies (Figure 3.4). For example, tax reduction on reuse, repair and remanufacture help incentive manufacturers to switch to circular business models. The second most common economic instrument is subsidies which are used in Canada, Korea, and the United States. Meanwhile, both Canada and United States use a mix of the four economic instruments to promote resource efficiency and circular economy objectives.

Figure 3.4. Number of circular economy policy instruments by type



Note: These counts include national and sub-national instruments in force as of January 1, 2024. The number of sub-national instruments are weighted by the number of large regions (territorial level 2) for every country.
Source: OECD Policy instruments for the Environment (PINE) database January 2024 extraction.

Circular economy policies in a decarbonisation context

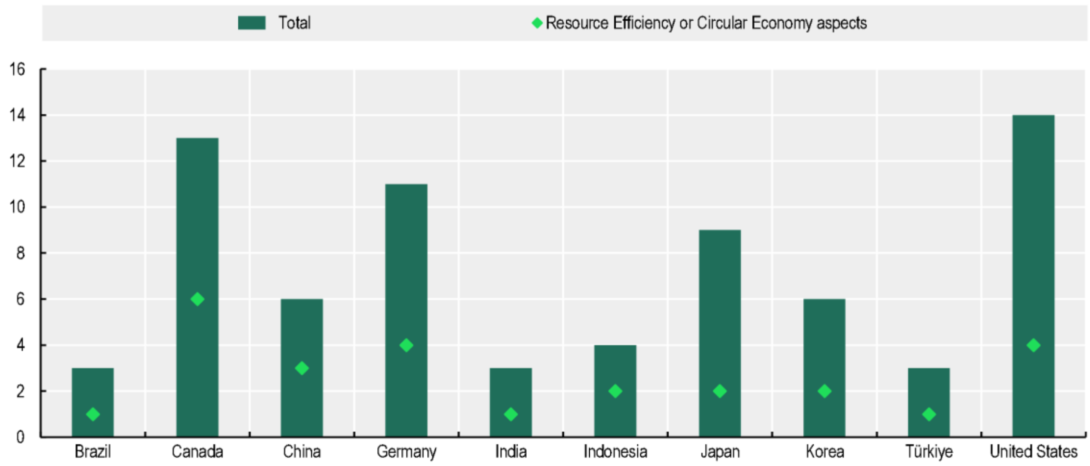
This section explores the complementary role of circular economy policy in achieving the decarbonisation strategies that the ten focus countries have put in place. Some circular economy elements are increasingly being included in decarbonisation policies with a major steel orientation. The applications of many policy instruments to the circular economy have a range of potential beneficial impacts for the environment. However, in many cases, government approaches do not align objectives or/and targets between the circular economy and decarbonisation. Finally, the availability, use and quality of steel scrap are emerging policy areas in some of the main steel producers.

Are circular economy aspects part of steel decarbonisation strategies?

The ten major steel-producing countries have implemented over a hundred of decarbonisation policies. Such policies aim to promote among others green innovation, energy efficiency, better access to strategic raw materials and a larger deployment of low-carbon technologies in hard-to-abate industries.

Circular economy aspects are part of decarbonisation strategies of major steel producing countries. All focus countries reported at least one steel decarbonisation policy introducing some elements of either the circular economy or resource efficiency (Figure 3.5) covering not only the producer side, but also the consumer side. Decarbonisation strategies are in general adopted prior to circular economy strategies. In some countries, decarbonisation policies take inspiration from circular economy ones. Canada, Korea and the United States have recently revised their steel-related decarbonisation strategies to ensure consistency with circular economy objectives.

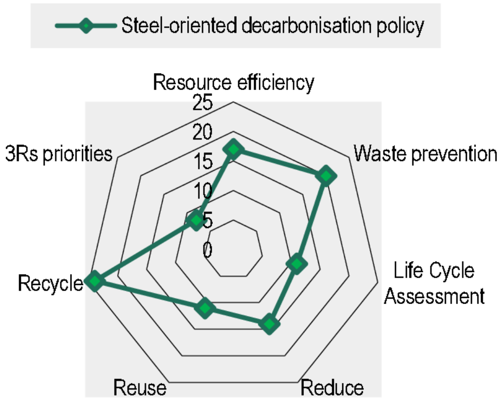
Figure 3.5. Steel-oriented decarbonisation policy considering circularity.



Note: Each policy document identified in the policy mapping (see Annex A) were scanned with keywords “resource efficiency”, “recycle”, “reduce”, “reuse”, “life cycle”, “waste” to identify policy status.
Source: Authors’ calculations based on Steel Decarbonisation Policy dataset (OECD, 2024).

Decarbonisation policies differ significantly on how to integrate the key aspects of steel in the circular economy. Recycling, resource efficiency and waste prevention are the main components of steel decarbonisation policies (Figure 3.6). Only one in five (11) policies have some key considerations for integrating the life cycle assessment. Few policies (8) are built on the 3Rs priorities: “Reduce”, “Reuse”, “Recycle” to meet decarbonisation imperatives.

Figure 3.6. Circular economy aspects in steel-oriented decarbonisation policy



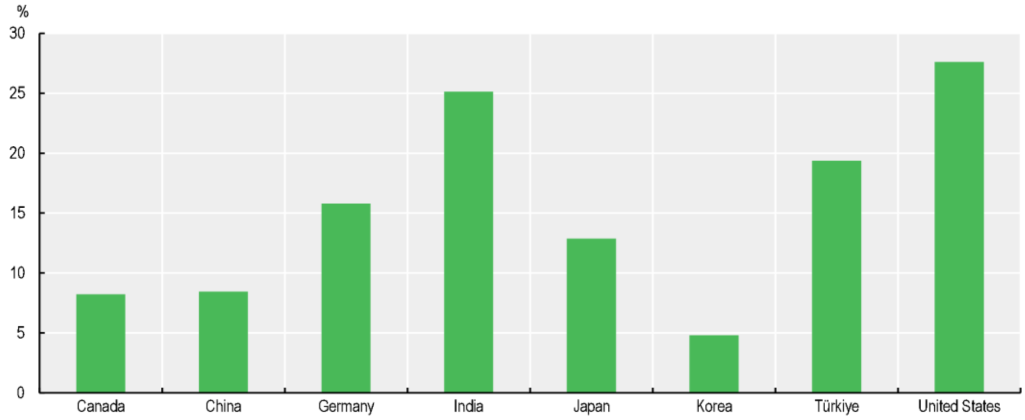
Note: Each policy document identified in the policy mapping (see Annex A) were scanned with keywords “resource efficiency”, “recycle”, “reduce”, “reuse”, “life cycle”, “waste” to identify policy status.
Source: Authors’ calculations based on Steel Decarbonisation Policy dataset (OECD, 2024).

How do circular economy taxation and other instruments contribute to decarbonisation objectives?

The policy review scanned over two hundred active instruments for the circular economy that contribute to address decarbonisation in major steel-producing countries. Circular economy-relevant taxes are the dominant instrument, accounting over half of instruments in place. These include taxes on landfills, solid waste pollution and high-polluting steel-content products to incentivise the prevention of waste, redirect wastes for reuse, recycling and energy recovery.

Circular economy-related taxes are an important instrument for governments to reduce the overconsumption of primary materials and promote the use of secondary materials including steel scrap. In selected steel-producing countries, circular economy-relevant taxes generate in total approximately USD 2.7 million a year. As such, taxes amount to 7.6% of government’s revenues from all environmentally relevant taxes, ranged from 4.8% in Korea to 27.6% in United States (see Figure 3.7). Most of these measures mainly cover end-of-life products from the automobile sector.

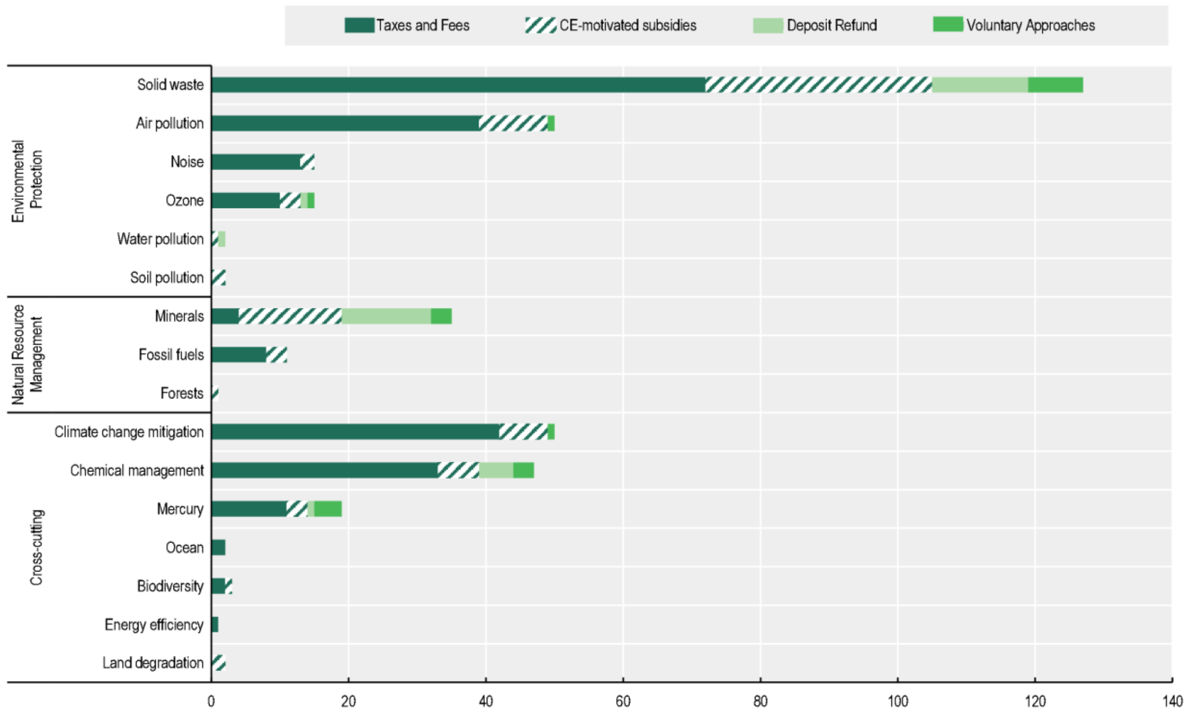
Figure 3.7. The share of revenue generated from circular economy-relevant taxes as a percentage of environmentally relevant taxes, in selected countries, average 2017-19



Note: The calculation included national and sub-national instruments in force as of January 1, 2024.
Source: OECD Policy instruments for the Environment (PINE) database January 2024 extraction.

Overall, governments are increasingly using a variety of market-based instruments to address several aspects of national decarbonisation objectives. Major steel-producing countries use circular economy-relevant instruments dedicated to support environmental protection and natural resource management (see Figure 3.8). A policy mix composed mainly of taxes and subsidies help countries in not only preventing and reducing solid waste, but also reducing and limiting highly polluting activities. The use of subsidies and deposit refunds participate to enhance the management of mineral extraction, by reducing the amounts of “lost” scraps and recovering end-of-life materials and products.

Figure 3.8. Number of circular economy policy instruments by environmental domains and type



Note: The policy count includes national and sub-national instruments in force as of January 1, 2024.
Source: OECD Policy instruments for the Environment (PINE) database January 2024 extraction.

Circular economy-relevant instruments have direct effects on extending the lifetime of products and materials in key sectors like construction, transport, and heavy industries, which at the same time, help limiting greenhouse gas emission from the adverse consumption of newly primary materials.

What targets have steel-producing countries put in place for the circular economy transition?

Major steel-producing countries are increasingly using a range of specific targets for the circular economy. Recent policy developments of the focus countries target four key aspects of the circular economy: recycling, recovery, resource efficiency and waste reduction (see Table 3.4). All countries have one or several targets dedicated to the circular economy, that could support the implementation of their decarbonisation strategies. When it comes to steel specific targets, only India and China have set recycling and recovery targets for steel scrap.

In practice, the use of circular economy targets differs widely across major steel-producing countries. Key differences include the sector coverage, date targets, quantitative thresholds as well as circular priorities. Germany, Türkiye, and the United States, for example, reported cross-sectoral targets in achieving circular economy objectives. Others have opted for a sectoral approach targeting more circular steel, plastics, and end-of-life vehicles, in India, Japan and Canada respectively. A sectoral approach provides opportunities for governments to prioritise circular potential for certain inputs, where resource-specific challenges cannot be addressed in siloes.

Table 3.4. Examples of circular economy targets in selected countries and sectors

Country	Sectors	Recycling target	Recovery target	Resource efficiency target	Waste reduction target
Canada	Plastics	≥ 55% of plastic packaging by 2030	=100% of all plastics recovered by 2040.	No target	= 30% of wastes reduced by 2030 = 50% of wastes reduced by 2040 (vs. 2014 baseline)
China	Steel, Non-ferrous metals, Construction	=20 million tons of recycled non-ferrous metals by 2025	=320 million tons of steel scrap by 2025 = 60% of re-used construction waste by 2025	=20% of more resource productivity by 2025 (vs. 2020 baseline)	No target
Germany	Cross-sectoral	>65 % of municipal wastes recycled from 2020 onwards	=70 % of reusable beverage containers	No target	Reduction of municipal solid waste intensity (vs 2004-18 baseline)
India	Steel, Plastics	=90% of steel recycled in 2030	= 85% of slag re-used by 2030 =100% of plastics recovered	No target	No target
Indonesia	Plastics, Waste Management	=50% of recycled content in all materials	=100% of recyclable materials	No target	30% of waste reduction by 2030
Japan	End-of-life vehicles (ELV), Plastics	=95% of ELV recycled by 2015	=100% effective utilization of all used plastics by 2035	=490,000 yen/ton of resource productivity in 2025	Cumulative 25% reduction in one-way plastic emissions by 2030
Korea	End-of-life vehicles	=85% of ELVs recycled	=87% of all waste recovered	<3% of waste treatment	No target
Türkiye	Cross-sectoral	=35% of recycled materials in 2023	=65% of waste disposed in 2023	No target	No target
United States	Cross-sectoral	=50% of recycled materials by 2030	No target	No target	No target

Note: The table is not extensive and does not cover every circular economy targets.
Source: Authors' compilation based on various sources: (European Commission, 2023) (China Briefing , 2021) (Government of India , 2019) (HM Government, 2018) (New Zealand Government, 2022) (Japan Ministry of Economy, Trade and Industry, 2020) (EPA, 2021) (Ministry of the Environment Government of Japan, 2024).

The major steel producing countries have different circular ambitions along national recycling and recovery targets. Each country has at least a quantitative target dedicated to recycling. National ambitions range from 50% (Türkiye) to 95% (China) and differ across focus sectors. While many recycling targets are in place, there are no specific targets on collecting, sorting, and processing waste materials.

Material recovery is a common high priority in steel-producing countries, to transform wastes to valuable resources, by recycling, reusing, or repurposing. Only China and India have established quantitative targets to recover steel scraps, while Indonesia, Korea and Türkiye have generic targets on waste materials. Both resource efficiency and waste reduction targets are relatively less used by major steel-producing countries. However, recycling targets may contribute to national targets on waste reduction, by reducing the potential use of primary materials.

The compliance with targets is a critical factor for circular progresses in focus countries. Existing targets in major steel-producing countries are set up for strategic purposes, reflecting their ambition for the transition to the circular economy. Korea has established mandatory targets in the implementation of Green Public Procurement (GPP) policy, targeting at least 60% of the public sector including circular economy aspects (UNEP, 2019). There is still important variation in the scope of ambition and implementation of circular economy strategies across target sectors. This in turn reinforces the challenge of the lack of policy guidance with a clear sectoral orientation.

How is steel scrap related to circular economy policy priorities?

Scrap is a vital raw material for the decarbonisation strategies of major steel-producing countries. It aligns perfectly with circular economy principles, enabling continuous reuse and reducing waste while minimizing environmental impact. At the same time, circular economy policies are mainly intended to support core objectives of resource efficiency, decarbonisation, and energy efficiency. But equally, circular economy policies contribute to achieving broader goals of market competitiveness, life cycle integration, innovation, and supply chain security. Scrap considerations play an important part along these different objectives.

Some existing circular economy policies have direct linkages to scrap availability, usage, or quality requirements. At least six policies are intended to address the specificities of scrap availability. Twelve policies emphasise the importance of scrap usage and only five calls for considering the quality issue of scrap. A policy focus on scrap usage may be driven by the higher number of circular economy policies for downstream sectors (construction, automobile, renewable energy).

Scrap-driven policies are taking different directions between major steel-producing countries. Recent developments in scrap-based policies are the following:

- **China**: In China, scrap is increasingly used as a strategic policy area to better align industrial growth and environmental imperatives. The latest roadmap “Circular Economy Promotion Law” included 11 circular economy projects.
- **Germany**: Germany’s approach is dedicated to a wider scope of waste, making a legal definition of waste in the Germany Circular Economy Act (2021). Recent policy developments emphasise the critical importance of digitalisation and a better integration into the product life cycle based on the life cycle assessment.
- **India**: India has implemented a steel scrap-specific policy to create a comprehensive scrap management system, provide guidelines for the regulation of scrap dismantling and processing facilities, and outline compliance responsibilities for each stakeholder including the informal sector (Box 3.1). Downstream policies on ship recycling and vehicle scrappage are also complementary in presence of several challenges including limited domestic availability and high reliance on imports.
- **Japan**: Japan is recognized as an early adopter of the circular economy, promoting technological advancements to overcome some scrap-related challenges. The five-year Sound Material-Cycle Society plan is an example that promote circular economy innovation.
- **Korea**: Korea has recently adopted the circular economy (CE) 9 policy including two steel-specific projects. The use of Artificial Intelligence could contribute both to improve the scrap selection stage for EAF steelmaking and prevent leakage of domestic scrap. The Framework Act on Resource Circulation (FARC) law promoted a resource circulating society and established rules to enhance waste quality.

Policy insights on cross-cutting issues

This section highlights three main cross-cutting issues along circular economy policies and scrap-based policies of relevance to policy makers.

How could digitalisation support the implementation of circular economy policy?

Some steel-producing countries are using digitalisation to advance their transition to a circular economy. Technological advancements can help address important technical challenges the steel industry will face on the quantity and quality issues of scrap. These technologies can be a game changer to expand the deployment of secondary steel production.

Blockchain technologies are gaining policy attention to better track, monitor and regulate the flows of products and raw materials including steel products and scrap. The Digital Product Passport is one of the key regulatory tools in European Union (WBCSD, 2023) to enhance the transparency and traceability of products and their components (including the steel industry).

The use of Artificial Intelligence (AI) can also be mobilized to improve the quality of steel products. A common issue with the use of EAF production is lower-quality steel products (Yao, Zhu, Zhang, Chang, & Wang, 2024). Some Asian countries – China, Japan, South Korea – have invested in the use of AI to overcome scrap-specific challenges. Despite a surplus of scrap, Japan targets the production of high-quality steel products based on EAF production. (Transition Asia, 2023).

The private sector is also increasingly investing in the development of intelligent scrap rating systems (Xu, et al., 2023). For example, a Finnish company uses AI to better control scrap processing and ensure the quality of steel products; a German company also provides monitoring tools to improve the traceability of end-of-life product supply chain including ferrous metals; an American start-up promotes the use of AI technology to improve efficiencies in steel recycling.

Strengthening synergies between steel decarbonisation policies and circular economy policies

Evaluating and improving the alignment between circular economy and decarbonisation objectives can help increase policy benefits. The policy mapping found that steel decarbonisation policies in major steel-producing countries are considering some key aspects of the circular economy like resource efficiency, recycling, waste prevention.

Measurable targets at the country level are important milestones to align strategic considerations of scrap with decarbonisation objectives. However, there are few specific targets dedicated to steel circularity and decarbonisation. Few countries like United States have explicitly mentioned the strategic importance of circular economy innovation to achieve net-zero emissions by 2050 (Ellen MacArthur Foundation, 2023).

Policy instruments for steel circularity are underutilized across major steel-producing countries. While steel-producing countries are extensively using a mix of policy instruments for the circular economy, few, or no policy instruments are specifically dedicated to steel circularity. Nonetheless, it would be a critical step to incentive steel circularity and discourage high-polluting primary steel production.

Infrastructure needs in partner economies

Infrastructures play a pivotal role for collecting, sorting, and processing scrap. Lack of recycling and transportation infrastructures can be an important obstacle for the decarbonisation of developing steel-producing countries. Infrastructure quality for scrap is key to support circular economy adoption and decarbonisation efforts across these regions. Certain developing and emerging countries like African countries and India will need to increase their scrap flows to meet their scrap use. However, many developing countries lack adequate recycling infrastructures, which constraints the potential for expanding their secondary steel market.

Another related challenge is to ensure adequate transportation infrastructure. India, for example, tackle this issue by implementing a logistical framework that prevent pilferage and facilitate containerized transport in an environment friendly manner (Government of India - Ministry of Steel, 2019).

Box 3.1. India’s Steel Scrap Recycling Policy

India's steel sector has undergone a transformation over the last three decades, evolving from a production capacity of 17 million metric tons (mmt) in 1991 to 138.2 mmt in 2023 ((PwC, 2019), (World Steel Dynamics, 2024)). The National Steel Policy (NSP) 2017 by India aims for a 300 million tonnes per annum steel production capacity by 2030 (Government of India - Ministry of Steel , 2017).

Considering the climate impact of this capacity increase, the Government of India implemented the Steel Scrap Recycling Policy (SSRP) (Government of India - Ministry of Steel, 2019). The SSRP sets ambitious targets to sustainably increase production capacity by promoting environmentally sustainable practices. The focus is on efficient resource use and recycling by shifting from traditional production methods to more sustainable ones like Electric Arc Furnaces (EAF) and Induction Furnaces (IF) which will contribute to 35-40% of the production. The SSRP aims to boost domestic scrap supply, minimize dependence on imports and reduce transportation-related emissions.

The informal sector in India is known to collect and recycle about 95% of the total generated e-waste. The SSRP proposes a systematic integration of this informal sector to boost scrap availability from current levels of 25 MT (domestic) and 7 MT (imports) to self-sufficiency by 2030. The policy outlines the establishment of organized scrapping centres across the country. These centres will adhere to stringent environmental norms, ensuring safe and efficient scrap processing. The hub-and-spoke model, central to this system, connects small scrap aggregators and dealers to larger processing centres, streamlining scrap supply chains.

Source: Authors’ compilation.

4 Conclusions

Scrap and the circular economy are two key building blocks for steel decarbonisation. To comply with Paris Agreement objectives, direct emissions of global steel production should decrease by 90% by 2050. Despite regional heterogeneities in decarbonisation pathways, net-zero scenarios suggest that circular economy practices and ferrous scrap will play a key role in reaching near-zero emissions for the global steel industry.

The potential for emission reduction can be harnessed by material efficiency strategies, at every stage of steel products' lifecycle. The concept of material efficiency refers to delivering goods and services using less material. Such strategies can be applied at various stages in the life cycle, including in the design, manufacturing, use and end-of-life phases. Material efficiency strategies could significantly contribute to reducing global emissions from the steel sector. Net-zero scenarios highlight that such measures could lower steel demand by at least 20% in 2050, compared to a business-as-usual approach.

Despite on-going efforts in the steel industry, the circular economy faces multiple barriers. Steel producers are taking up circular economy practices, but challenges remain for a wider implementation. Economic barriers - whether related to secondary metals market, government support or non-priced environmental externalities as well as the lack of policy incentives and governance structure - may hamper the uptake of circular models. Enabling market forces to drive price signals should also receive greater attention. Another challenge relates to the need to adopt a product's life cycle, and the involvement of all the stakeholders along the value chain. Finally, other challenges related to scrap include the downgrading of recycled steel, the required infrastructure for sorting and collecting, and insufficient data and tracing of scrap composition.

Accelerating circular transformations is a policy priority for major steel-producing countries. Recycling is a top priority among circular economy policies. Few, if any, include the full set of 4Rs towards the steel sector. The current policy orientation is continuing to drive higher demand for more circular and sustainable steel products. Major steel-producing countries are adopting a mix of horizontal, sectoral, and product-level policies tailored to strategic downstream sectors, which are also of critical importance for the steel industry.

Circular economy aspects need to be a key part of steel decarbonisation policies. Recycling, resource efficiency and waste prevention are the most common components of steel decarbonisation policies. Taxes are one of the main instruments used by the major steel-producing countries to address both circular economy changes and climate change mitigation. Few existing instruments are still dedicated to focus on the high potential of circular steel.

Circular economy strategies of major steel-producing countries target four key aspects including recycling, recovery, resource efficiency and waste prevention. In most cases, these policies lack measurable targets and implementation metrics to address scrap-specific challenges (excepting in China and India). Some new circular economy policies are increasingly reflecting the importance of scrap availability, usage in downstream sectors and quality requirements.

Annex A. List of circular economy policies by country and type of sources

Policy name	Government website	Country-specific report	Media articles	Dataset research
Circular Economy Action Plan (Canada)	CE summit (link)			
Greening Government Strategy (Canada)		Summary strategy (link)		
National Guidelines for Whole-Building Life Cycle Assessment (Canada)	Guideline report (link)			
National Vehicle Scrappage Programme (Canada)				Climate policy database (link)
14th Five-Year Circular economy development plan (China)				Circular Innovation Lab (link)
Roadmap for high-quality development (China)	Official news (link)		People's daily (link)	
Scrapped purchase tax on new-energy vehicles (China)			China briefing (link)	
Swap the Old for Remanufacturing (China)	Notice (link)	Ellen MacArthur foundation (link)		
Circular Economy Act (Germany)				Umwelt Bundesamt (link)
National recovery plan (Germany)	Federal Minister of Finance (link)			

Steel Scrap Recycling Policy (India)	Official document (link)		Blog (link)	National Law School of India University (link)
Policy name	**Government website**	**Country-specific report**	**Media articles**	**Dataset research**
National Resource Efficiency Policy (India)	Draft (link)		Drishti (link)	Empower IAS's blog (link)
Vehicle Scrappage Policy (India)		Policy brief (link)	Article (link);	IBEF blog (link)
Recycling of Ships Act (India)			Article (link)	Legislative note (link)
Circular Economy Vision 2020 (Japan)	METI official document (link); Event material (link)	EU-Japan report (link)		
Construction Recycling Act (Japan)				Research article (link); Paper (link)
Automobile Recycling Act (Japan)	METI act (link)	Policy brief (link)		Conference paper (link)
Act on Promotion of Purchase of Green Products (Korea)		UNEP report (link); Policy brief (link)		
Green Steel Committee (Korea)		Global Efficiency Intelligence report (link)		Climate Policy Database (link)
Framework Act on Resource Circulation (Korea)	Act (link)	OECD report (link)		Research article (link)
Low carbon steel production strategy (Korea)		Trends brief (link)	News article (link)	
Circular Economy 9 Projects (Korea)			News article (link)	
Scrapping Scheme Programme for Old Vehicles (Türkiye)		White paper (link)		Climate Policy Database (link)

Control of End-of-Life Vehicles Regulation (Türkiye)		SKD Türkiye Research report (link)		
Policy name	**Government website**	**Country-specific report**	**Media articles**	**Dataset research**
Mediterranean Sustainable Consumption and Production Regional Action Plan (Türkiye)		UNEP report (link); Final Draft Report (link)		
National Recycling Strategy (United States)	Draft (link); Strategy (link)			
National Science Foundation's Convergence Accelerator's investment in the circular economy (United States)			NSF news (link)	
"Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability" Executive Order (United States)	Presidential document (link)			
Buy Clean Standards: purchase of low-emissions steel (United States)	Buy clean news (link)			
Buy Clean California Act (United States)		Global Efficiency Intelligence report (link)		
Clean Shipping Act (United States)			News (link)	Insights (link)

Source: Authors' compilation based on various sources.

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Endnotes

[1] Circular economy approaches may vary across industries. This report focuses specifically on circularity in the steel sector.

[2] Focus countries for the policy mapping are the major steel-producing countries and scrap-producing economies. These include Brazil, Canada, China, Germany, India, Indonesia, Japan, Korea, Türkiye and the United States. The selection of these countries is based on the top-10 steel-producing countries and scrap-dependant countries in 2022.