Circular Cars Initiative

WORLD ECONOMIC FORUM

In collaboration with Systemiq

Closing the Loop on Automotive Steel: A Policy Agenda

BRIEFING PAPER

OCTOBER 2023

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Executive summary

As vehicle tailpipe emissions trend towards net zero with the increasing adoption of battery electric vehicles (BEVs), the focus for decarbonization will increasingly shift to a vehicle's materials and manufacturing.

Representing 16% of BEV material emissions, steel constitutes a critical frontier in achieving deep decarbonization in the automotive sector. Near-zero emissions steel is available through two complementary steelmaking pathways: primary (iron ore-based) and secondary (scrap-based). Although primary steelmaking routes tend to be more suitable for producing the grades required for automotive steel, there are examples of automotive steel being made with 100% scrap.

There are two arguments for using secondary steel over primary steel in the automotive sector:

1. It can be a source of circular economy differentiation for OEMs and help meet emerging regulatory requirements.

2. It can incentivize high-value steel scrap recycling, thereby increasing the long-term availability of high-quality scraps, and thus preventing the accumulation of unusable steel stocks by 2050.

Although there are examples of automotive steel being made with 100% scrap, the quantity and quality of steel scraps need to be improved significantly to enable the widespread use of secondary steel in automotive applications. Key measures include:

- Supply-side measures across the value chain, from vehicle design to recycling, aiming to enhance scrap quantity and quality

- Demand-side measures to establish premium green markets, differentiated by climate or circularity credentials, ensuring supply-side measures' economic viability

- Cross-cutting market enablers that increase data and information availability across the supply chain and thereby overcome barriers related to information asymmetry

Enabling policy frameworks is essential to accelerate the adoption of secondary steel in the automotive sector. As key automotive and steel-producing geographies, the European Union (EU), China and the United States are well-poised to lead the use of secondary steel in the automotive industry. However, a review of the current and planned policies in these areas shows that the use of secondary steel in the automotive industry is not sufficiently enabled.

There are five policy levers that policy-makers in these geographies should prioritize to increase the use of secondary steel in the automotive sector:

1. Introducing material-specific and quality of recovery-related recycling targets

2. Minimizing illegal exports and dismantling of vehicles

3. Ensuring a sufficient supply of high-quality scrap before introducing mandatory recycled content targets

4. Improving transparency around steel scrap quantity, quality and prices

5. Investing in the development of sorting and separation, as well as scrap upgrading and beneficiation technologies

1 Secondary steel is increasingly scrutinized as a pathway for reducing a vehicle's materials emissions

The decarbonization of the automotive sector is progressing rapidly with the increasing penetration of battery electric vehicles. As tailpipe emissions trend towards net zero, the next focus for decarbonization will be on a vehicle's materials.

At an average of 900kg per vehicle and 16% of BEV material emissions, steel constitutes a critical frontier in achieving deep decarbonization in the automotive sector. The majority of steel used in vehicles is advanced high-strength steel to make vehicle body structures lighter, enhance safety and improve fuel efficiency.

Today, most crude steel for automotive applications is produced using an integrated blast furnace (BF)-basic oxygen furnace (BOF) process (primary steelmaking). This enables impurities to be more easily controlled, making it especially suitable for producing higher grades of steel. The BF-BOF process typically yields 1.8-2.3 tCO_2 per tonne of steel (Scope 1 and 2).[1] Efficiency improvements can only marginally improve the carbon emissions from this production process.

Near-zero emissions steel is available from two complementary pathways (see Figure 1):

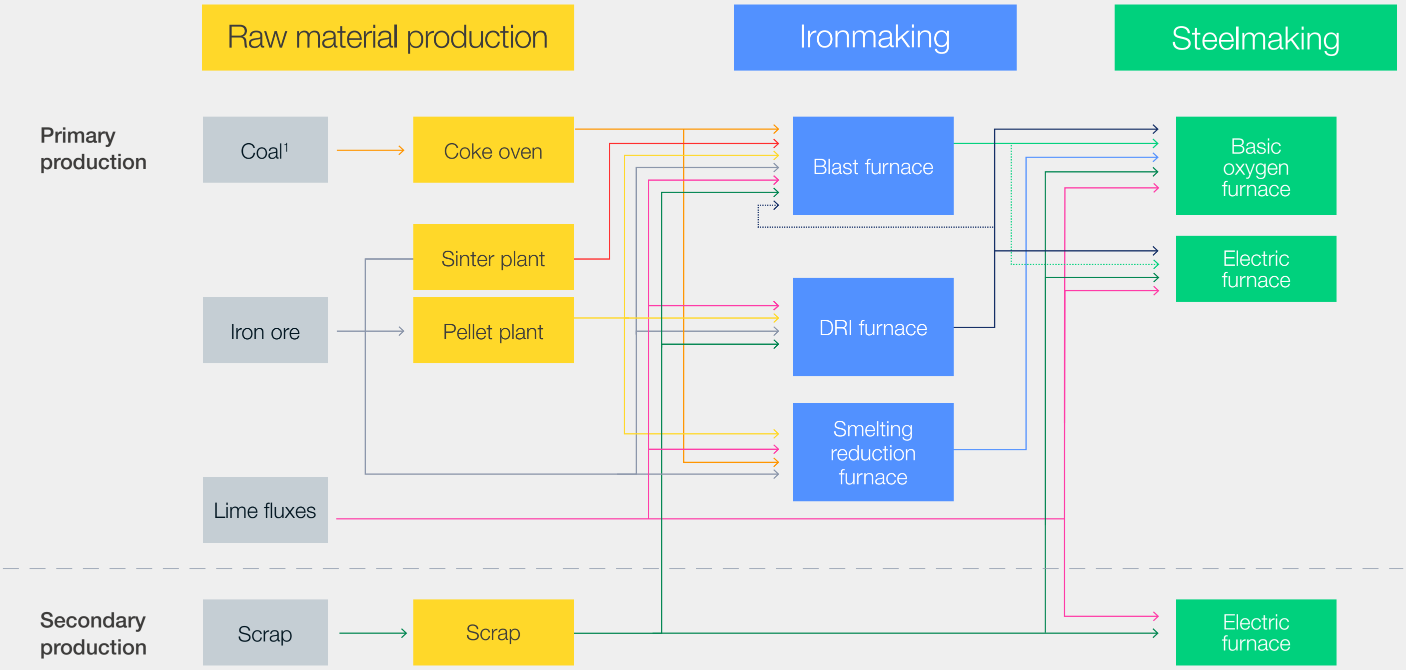
1. **Primary steelmaking (iron ore-based)**: This includes technologies to avoid carbon (e.g. direct reduction of iron ore using green hydrogen coupled with an electric arc furnace (EAF); electrolysis of iron ore). Technologies to capture, utilize and store carbon emissions from fossil production are also potential solutions, but no research facilities or commercial plants exist yet that capture 90% or more of overall emissions.
2. **Secondary steelmaking (scrap steel-based)**: Automotive steel often has a scrap content of about 15-20%, since that is fed into the BF-BOF route as a cooling agent. The EAF route is among the most suitable technologies to increase the scrap content beyond that since it can use scrap steel as its main raw material.

Even though primary steelmaking routes tend to be more suitable to producing automotive-grade steel, there are first examples of automotive steel from 100% scrap. As OEMs and regulators increase their ambitions to transition to a circular economy, secondary steel is increasingly scrutinized as a pathway for automotive steel decarbonization. To enable its widespread adoption in the automotive sector, however, the quantity and quality of steel scraps need to be improved significantly. This insight piece will spotlight the potential of secondary steel and the policy actions required to enable it.

1. Emissions from fossil fuels (Scope 1) and electricity (Scope 2) used in the process are considered. Upstream Scope 3 emissions from coal and iron ore mining, processing at the mine and transportation constitute on average an additional 5-15% of total emissions of crude steel making.

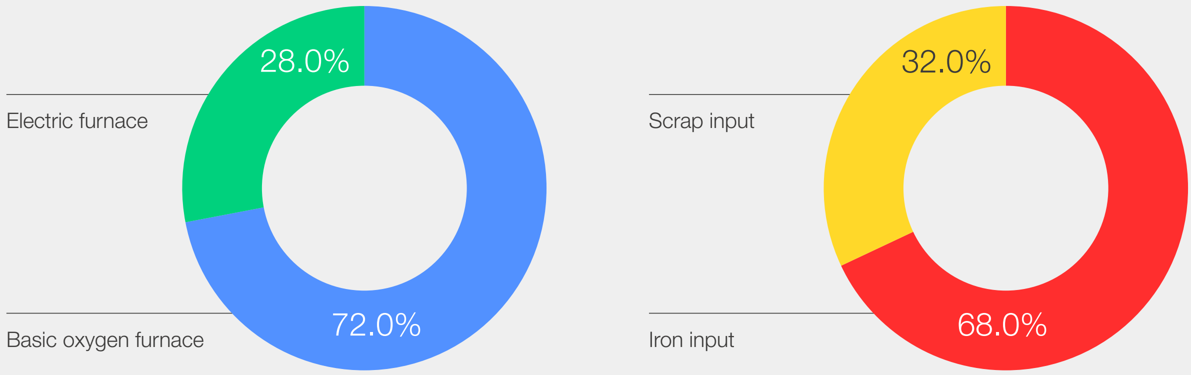
FIGURE 1 | **Overview and share of different steelmaking routes**

Main steel production pathways and material flows in 2019



Global crude steel production 2019

1,869 Mt



Source: IEA, 2020

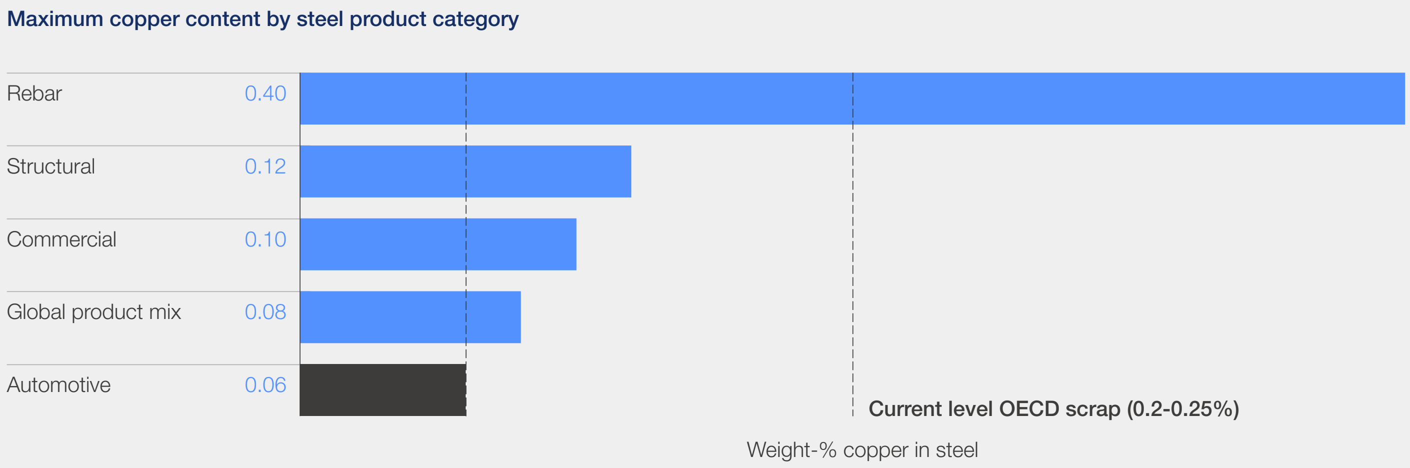
2 Two arguments support increasing the use of secondary steel in vehicles

Both for OEMs/consumers and at systems level, there are two main arguments for using secondary over primary steel to produce near-zero emissions automotive grade steel:

1. **It can be a source of circular economy differentiation for OEMs and help meet emerging regulatory requirements:** Many OEMs are increasingly eyeing voluntary recycled content targets as a differentiation opportunity. For example, Volvo committed to use 25% recycled steel by 2025 and to offer circular products by 2040. BMW plans to use 50% scrap steel by 2030. And Mercedes-Benz aims to increase the share of secondary materials by an average of 40% by 2030. In addition, there are also emerging regulatory requirements. As part of the circular vehicles regulation, the EU is investigating the introduction of a recycled steel content target.

2. **It can incentivize high-value steel scrap recycling, thereby increasing the long-term availability of high-quality scraps and thus preventing the accumulation of unusable steel stocks by 2050:** While 80-90% of steel is recycled today, it is typically downcycled. As depicted in Figure 2, the potential usage applications for scrap steel are typically limited to rebar. Increasing the use of secondary steel in the automotive sector could incentivize high-value steel scrap recycling, thereby increasing the long-term availability of high-quality steel scraps. This in turn could increase the number of products in which secondary steel can be used, thereby preventing the accumulation of stocks by 2050 and ensuring the future circularity of the steel sector. Compared to other industries, such as construction or renewables, the automotive industry is well-positioned for closed-loop steel recycling, due to the comparatively quick stock turnover rates.

FIGURE 2 **Copper tolerances of different steel products**



Source: Adapted from Agora Energiewende, 2022; Material Economics, 2018; and Daehn et al., 2017.

3 Several levers need to be activated to increase the use of secondary steel in the automotive industry

Increasing the use of secondary steel in vehicles requires a range of supply- and demand-side measures as well as cross-cutting market enablers (see Table 1).

TABLE 1 **Overview of the necessary levers to scale scrap use in vehicles**

Supply-side levers	Demand-side levers	Cross-cutting market enablers
– Improving design for recycling – Improving scrap collection – Improving separation of scraps – Improving the sorting of scrap grades – Improving scrap upgrading	– OEMs committing to voluntary recycled content targets – Setting mandatory recycled content targets for products – Providing tax breaks or subsidies to manufacturers who use recycled steel in their products	– Improve supply chain transparency through digital product passports

Supply-side levers

On the supply side, it is necessary to increase the supply of high-quality scraps. This is a critical condition to enable a higher use of secondary steel in vehicles. This requires a range of interventions across the automotive value chain, which include:

- **Improving design for recycling:** Managing copper contamination starts at the vehicle design stage. However, reducing it may affect price or performance outcomes and will therefore have to be driven by legislation, consumer interests, or an OEM's own efforts to close material loops. Potential design measures can include:

  - Avoiding the use of problematic materials in vehicles (e.g. reducing the number of electronic features or by replacing copper wirings with aluminium or optic fibre alternatives).

  - Designing vehicles for disassembly (e.g. detachable wire harnesses).

  - Minimizing complex material compositions (e.g. alloys).

- **Improving scrap collection:** One barrier to the available quantity of steel scraps is scrap collection. In the EU, for example, about a third of all end-of-life vehicles – between 3 to 4.5 million vehicles – are lost to illegal dismantling or exports annually. These losses need to be minimized to increase total scrap availability for high-quality processing.

- **Improving separation of scrap:** This involves separation of materials at a higher granularity than today to physically remove contaminants in the following steps. This could involve either a manual disassembly and/or the use of a range of advanced sensor-based technologies.

- **Improving the sorting of scrap grades:** This involves automated sorting technologies that facilitate efficient analysis of scrap composition and impurities. In this step, it is about making sure to sort them better into different scrap grades.

- **Facilitating scrap upgrading:** At this stage, the focus is on metallurgical processes to manage contamination, such as extraction. These are, however, often very expensive and still need to be further developed and scaled to bring down the costs of copper management post-mixing.

Demand-side levers

Advances in the circular economy to improve the quantity and quality of steel scrap will increase costs due to the additional processing and separation. For these business models to function, premium green markets need to be established that are differentiated by climate or circularity credentials. There are three levers through which this can be achieved:

- **OEMs committing to purchasing secondary steel:** As buyers of steel, OEMs can send demand signals for high-quality automotive-grade secondary steel. For example, they can set voluntary recycled content targets, like BMW or Volvo, or they can commit to purchasing specific quantities of secondary steel, ideally at a premium. By sending clear demand signals, OEMs can help establish premium markets for automotive-grade secondary steel.

- **Setting mandatory recycled content targets for products:** Regulations can mandate a minimum percentage of recycled content in steel products. However, any target setting needs to account for the availability of high-quality scraps. Without sufficient supply, the following issues may arise:

  - **Recycled content targets may not decrease greenhouse gas (GHG) emissions globally**, due to an inefficient deployment of scraps at systems level. For example, using scraps to reduce emissions in geographies with efficient production capabilities, such as Europe, would reduce their availability in geographies with higher production footprints.

  - **Recycled content targets may reduce the overall quality of steel products**, due to insufficient supply of high-quality scraps. This could potentially compromise the safety or fuel efficiency of vehicles.

- **Providing tax breaks or subsidies to manufacturers who use recycled steel in vehicles:** These incentives can offset the higher production or procurement costs associated with increasing scrap content and make it more attractive for OEMs to increase the recycled content of vehicles.

Cross-cutting market enablers

There is also a range of cross-cutting market enablers that can increase data and information availability across the supply chain and thereby overcome barriers related to information asymmetry. For example, introducing digital product passports or data spaces can increase transparency regarding the copper content of scrap or the recycled content of vehicles and thereby facilitate the implementation of the appropriate supply- and demand-levers across the value chain.

4 Current and planned policy frameworks do not sufficiently incentivize high value recycling

To accelerate the use of secondary steel in the automotive sector, enabling policy frameworks are needed. This section will review ongoing policy efforts by key global vehicle and steel producers EU, China and the United States to increase steel circularity in the automotive value chain. These policy frameworks are presented in more detail in Table 2.

TABLE 2 **Synthesis of current used vehicle policies**

	EU (based on circular vehicles regulation draft)	China	US
Supply-side levers	– Ensuring design for recyclability and for disassembly – Increasing the collection and treatment of ELVs – Facilitating the dismantling of vehicles	– Requiring the recycling of ELVs – Incentivizing ELV returns to authorized treatment facilities – Increasing the recyclability of vehicles	No policy framework present on automotive steel recycling.
Demand-side levers	– Introducing a feasibility study on recycled steel content targets – Providing potential to introduce recycled content in green public procurement criteria	N/A	– The Resource Conservation and Recovery Act, encourages the public procurement of vehicles with remanufactured parts; however, it does not encourage the use of recycled steel.
Cross-cutting market enablers	– Introducing a digital circularity vehicle passport – Reporting on recycled content targets – Requiring manufacturers to implement a circularity strategy	N/A	N/A

4.1 Europe

In the EU, the relevant regulations to the high-value recycling of automotive steel are the new circular vehicles regulation draft and the eco-design for sustainable products regulation (ESPR).

Supply-side levers

- **Ensuring design for recyclability and for disassembly:** Regarding recyclability, the circular vehicles regulation draft suggests the same requirement of 85% recyclability (by mass) as the previous Directive on End-of-Life Vehicles (ELV) (Article 4). In regard to disassembly, the draft adds that vehicles shall be designed such that certain components, which often add to steel contamination, such as electronic and electrical equipment or wire harnesses, can be easily disassembled (Article 7, Annex VII part C).

- **Increasing the collection and treatment of ELVs by authorized treatment facilities:** First, the circular vehicles regulation extends the requirements to include vehicles, trucks, buses and trailers (Article 1). Second, it obligates owners to deliver vehicles to authorized treatment facilities and to present the certificate of destruction for vehicle de-registration (Articles 24 & 26). While these measures address important gaps, they do not financially incentivize delivery to authorized treatment facilities.

- **Facilitating the dismantling of vehicles:** The circular vehicles regulation draft helps reduce scrap contamination by mandating the removal of certain components in the disassembly process, such as wire harnesses (see Article 30, Annex VII part C).

Demand-side levers

- **Introducing a feasibility study on recycled steel content targets:** While a recycled content target for plastics is introduced, the circular vehicles regulation does not introduce one for steel. Instead, it proposes that a feasibility study on the introduction of a recycled content target for steel be conducted and finalized within two years after the introduction of the regulation (Article 6).

- **Providing potential to introduce recycled content in green public procurement criteria:** The ESPR regulation introduces the possibility of introducing additional award criteria in public procurement based on eco-design requirements (e.g. recycled content) (Article 58).

Cross-cutting market enablers

The regulation draft suggests a few cross-cutting measures that can help overcome barriers related to information asymmetry, which include:

- **Introducing a digital circularity vehicle passport: Following the introduction of a** digital battery passport, the EU Commission proposes a digital vehicle passport. This tool would provide data on the safe removal and replacement of vehicle parts and components and could thereby enable informed decision-making for the optimal vehicle processing at end-of-life (Articles 11 and 13; Annex V).

- **Reporting on recycled content targets:** According to the circular vehicles regulation, manufacturers must declare the recycled content of steel for vehicles (see Article 10).

- **Requiring manufacturers to implement a circularity strategy:** These strategies can help improve data availability and information on the sector's circularity transition. Among others, manufacturers need to report on their efforts to collect supply chain information, improve vehicle circularity and invest in end-of-life treatment (see Article 9, Annex IV).

4.2 China

Since the late 2000s, China has adopted the circular economy as a national priority.

Supply-side levers

- **Requiring the recycling of ELVs:** Originally passed in 2001, the Measures for the Administration of the Recycling of End-of-Life Motor Vehicles (2019) established an ELV collection system to prevent accidents caused by old vehicles. The law also established basic requirements for the establishment of dismantling and recycling facilities.
- **Incentivizing ELV returns to authorized treatment facilities:** Since the 2019 update of the Measures for the Administration of the Recycling of End-of-Life Motor Vehicles, ELVs do not have to be picked up anymore by authorized dealers at the price of scrap metals. Before this adjustment, the price of ELVs was capped, which reduced owners' incentives to deliver ELVs to authorized facilities and instead resulted in outflows to illegal markets.
- **Increasing the recyclability of vehicles:** With the 2015 policy on Requirements for the Management of Hazardous Substances and Recyclable Utilization Rate of Automobiles, China introduced comprehensive eco-design requirements for vehicles (e.g. use of non-toxic materials and recyclability), requirements for vehicle recycling at end-of-life, and increased transparency over materials used in vehicle components.

4.3 United States

The United States is one of the largest producers of secondary steel, with 70% of all steel being produced through the EAF route. However, contrary to the EU and China, the US does not have a national policy framework. Instead, it employs a market mechanism to govern the management of ELVs. On the demand side, there are also no policies that encourage the use of recycled steel in vehicles. The Resource Conservation and Recovery Act, encourages the public procurement of vehicles with remanufactured parts. However, it does not yet encourage the use of recycled steel.

5 Recommendations

The policy recommendations relate particularly to the EU and China, which already have a developed policy framework on ELV and steel recycling. Nevertheless, the US can also further bolster its market-based approach, by increasing the transparency around automotive steel recycling and investing into technology development. The recommendations include:

– **Introducing material-specific and quality of recovery related recycling targets**: Countries could introduce steel-specific recycling as well as quality of recovery-related targets for ELV steel recycling. For example, copper content limits could be introduced to ensure the quality of scrap steel from ELVs.

– **Minimizing illegal exports and dismantling of vehicles**: On the quantity side, more efforts need to be undertaken to minimize illegal exports and dismantling of vehicles. For example, there could be increasing incentives to return vehicles to authorized treatment facilities.

– **Ensuring sufficient supply of high-quality scraps before introducing mandatory recycled content targets**: Recycled content targets can support the development of premium markets for high-quality secondary steel. Nevertheless, it is important to ensure high-quality scrap availability before introducing these. One solution could be to announce a target so long in advance to allow for supply to develop or to carefully ratchet the target up over time.

– **Improving transparency around steel scrap quantity, quality, and prices**: More efforts are needed to minimize information asymmetries related to steel scraps. The EU, China and the US could support the development of harmonized definitions, for example, of collection and recycling rates, as well as the development of global standards and initiatives to track and trace steel scraps and their quality throughout the global economy. In addition, more transparency around scrap prices is needed to formalize global steel markets.

– **Investing in the development of sorting, separation, as well as scrap upgrading and beneficiation technologies**: Policy-makers in the EU, China and the US could support the development of technologies to enable the sorting, separating and treatment of steel scraps. This can include advanced sorting technologies, purification technologies to remove impurities, or process control technologies to optimise recycling processes.

Acknowledgments

This briefing paper was developed as an output of the World Economic Forum Circular Cars Initiative's policy workstream in collaboration with Systemiq. It was funded and supported by the ClimateWorks Foundation, with inputs from the China Automotive Technology and Research Center (CATARC). This deep dive insight piece relied on material and insights previously developed by the Mission Possible Partnership's Net-Zero Steel Initiative.

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