NDC ASPECTS

# Policy Brief

## The potential of scrap use for EU steel decarbonization

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## Key messages

- With a strong focus on supporting hydrogen-based primary steel production, scrap-based secondary steelmaking has received little attention as a decarbonization strategy for the EU steel industry.
- Increasing scrap use in steel production reduces fossil fuel use, $CO_2$ emissions, overall energy use and resource extraction.
- Steel scrap is a domestically available resource. Increasing its use reduces import dependencies and takes pressure off the renewable energy production system.
- Increased use of electric arc furnaces allows for a flexible use of green iron and scrap, while new technologies can help improve scrap quality. Together, these developments enable the use of scrap for high-quality steel products.
- An adequate "green steel" definition and Ecodesign rules emphasizing circularity as well as low and stable electricity prices can help incentivize increased scrap use in EU steel production.

# Introduction

Steel is a key material for many aspects of modern life, fulfilling basic needs from housing to mobility to cooking and food storage. It is also crucial for combating the climate crisis, as it is a durable and endlessly recyclable material used in essential green technologies like wind turbines, trains and train tracks and electric cars. Steel production has a long history in Europe, supporting nearly 2.6 million jobs, over 300,000 of which are directly employed in the steel industry. In 2023, it directly created 2.6 billion euros of gross value added (GVA), with another 126 billion euros of indirect or induced GVA (EUROFER, 2024). However, steelmaking is also a highly resource-, energy- and emissions-intensive process responsible for the use of 1.3 EJ coal and 0.3 EJ natural gas in 2023 (Eurostat, n.d.) and 5% of EU $CO_2$ emissions (IEA, 2020). Under the European Climate Law, the EU aims to be carbon-neutral by 2050 (European Commission, n.d.-a). Under the current trajectory of the 2023 reform, allowances under the EU Emissions Trading System (EU ETS) are going to reach near-zero by the end of the next decade (Pahle et al., 2023). The EU steel industry needs to move away from fossil fuels and decarbonize its production in order to survive and thrive in a decarbonized Europe.

55% of steel made in the EU comes from primary production. It is produced in large integrated steel mills using blast furnace (BF) technology for ironmaking, which requires the input of large amounts of iron ore as well as coking coal. The remaining 45% are produced in electric arc furnaces (EAF), where the main inputs are recycled steel scrap and electricity, also referred to as secondary steelmaking (EUROFER, 2024).

Discussions around steel decarbonization have mostly focused on primary production, finding climate-friendly alternatives to the energy- and emissions-intensive BF production route. The technology that has emerged to be most promising in terms of fast and deep emission cuts is hydrogen-based direct reduction ($H_2$-DR) of iron ore. It has been the subject of numerous project announcements, including first investment decisions by major steel companies in Europe. The EU and its member states have begun subsidizing these $H_2$-DR investments (Hill, 2024;

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thyssenkrupp, 2023).

In contrast, secondary steelmaking has received far less attention as a decarbonization strategy for the EU steel industry. However, using scrap as a resource for steelmaking has several environmental and climate benefits, including a reduction in fossil fuel use, $CO_2$ emissions, overall energy use and resource extraction.

Increasing the use of steel scrap in EU steelmaking to its full potential is a no-regret decarbonization strategy that should be pursued as complementary to hydrogen-based primary steelmaking. In efforts to decarbonize the EU steel industry, it should receive more attention from policymakers. In this policy brief, we outline the benefits of scrap use for achieving EU climate goals while contributing to the resilience of the bloc's industrial production and energy system. We also outline the challenges to increased scrap use and the policy priorities for overcoming them.

# Benefits of scrap use

From a climate perspective, the use of steel scrap in EAF-based steelmaking has several key benefits:

- The use of steel scrap eliminates the need for ironmaking, which is the most energy- and emissions-intensive part of the steelmaking process. Secondary steelmaking is associated with 95% lower direct $CO_2$ emissions than in primary steel production.[1]
- Electric arc furnaces already run on electricity, so there is no need to replace them with a new technology.
- Scrap use eliminates the need to mine and transport iron ore and coking coal.

Furthermore, scrap-based steelmaking has significant benefits for strategic self-sufficiency and reduces pressure on the renewable energy sector. The European Union is vastly dependent on both iron ore and coal imports for primary steelmaking (European Commission, n.d.-b). In addition, the EU plans to be a major importer of green hydrogen (European Commission, 2020), which will be key for carbon-neutral primary steelmaking. For the future of the European steel production system, this implies that steel production would remain dependent on commodity imports and therefore at the mercy of fluctuations in global commodity markets.

In the path to decarbonization of steel production, EU member states have begun to heavily subsidize the development of hydrogen direct reduction technology in order to replace existing coal-fired blast furnaces. While this is key for putting the industry on a path to decarbonizing primary steel production, it also brings many challenges, such as cheap, reliable, green hydrogen supply to the steel industry. The supply of heavy industry with domestically produced green hydrogen to maintain today's primary steel production levels would put significant pressure on the EU's energy system. Alternatively, large quantities of green hydrogen imports would need to be secured. What is more, the steel industry will be competing for hydrogen with other industries on their own path to decarbonization. One way to relieve some pressure on hydrogen supply would be to outsource the ironmaking stage and import green direct-reduced iron (DRI) instead of producing it domestically. However, the industry would be hugely dependent on these imports, again subject to much uncertainty as to the availability and price of this commodity.

[1] Secondary steelmaking currently results mainly in scope 2 emissions, i.e. emissions from electricity production.

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While some mix of domestic hydrogen direct reduction and green DRI imports will be necessary, an improved utilization of available scrap could take pressure off the hydrogen supply and reduce the industry's dependency on commodity imports. This would not only improve the resilience of steel production in the EU but also improves strategic autonomy in global commodity markets.

# The potential for increasing scrap use

## Availability of steel scrap

It is often argued that the share in secondary steelmaking in the EU cannot be increased simply because all the available scrap is already being recycled. With a recycling rate of around 85%, it is true that steel is one of the most recycled materials, although there is still some potential to increase this further (IEA, 2020).

However, not all of the EU's scrap is recycled within its borders. In fact, the trend is going in a different direction: The European Union consumed 88 Mt and exported 10 Mt of scrap in 2018. In the year 2023, scrap consumption decreased to 75 Mt and exports increased to 15 Mt. This implies that the utilization of steel scrap in the European steel production system decreased from 90% to 83%. Furthermore, annual steel scrap exports increased with an annual growth rate of 7.5% in the last 10 years (EUROFER, 2024). From a global climate perspective, it may not make a significant difference *where* the EU's scrap is recycled as long as it is recycled at all. However, this trend of increasing scrap exports indicates that overall scrap availability is currently not the main barrier for increasing steel recycling in the EU.

Existing studies (e.g., Material Economics, 2018), our own modeling and the principles of material flow analysis[2] suggest that domestic scrap availability will increase further in the future, both in absolute terms and as a percentage of EU steel demand.

Overall, current net scrap exports and expected future growth in scrap availability indicate that there is significant potential to increase strap use in the future.

## Applications of scrap-based steel

Another potential barrier to increasing scrap use is limited demand for steel products that can be produced through secondary steelmaking. However, the structure of the future EU steel production system promises to overcome this barrier.

In the current European steel production system, primary and secondary steelmaking are separated from each other not only in terms of production processes but also in terms of final products.

**Primary steel production** – steel production from iron ore – takes place mainly in integrated steel mills, where iron ore is processed into hot liquid pig iron in a coal-fired blast furnace (BF), and then immediately processed into steel

[2] Material Flow Analysis (MFA) is a tool to quantify flows and stocks of materials within a given system, providing information about resource use and waste generation (Laner & Rechberger, 2016). It has been widely applied to the steel system, with different studies outlining the production of steel, the use of steel goods during their useful lifetime, and the recycling flows of steel scrap over the course of many decades. They indicate that, in early industrialized regions such as Europe, there are already large amounts of steel inside the system (in infrastructure, cars etc.), most of which will eventually become available for recycling. In highly economically developed regions, steel scrap thus becomes an increasingly readily available resource. At the same time, the need for adding more steel into the system (to build more bridges, more buildings, more cars) decreases as population growth slows and basic needs (e.g., housing, mobility) are widely met. Secondary steelmaking can thus meet an increasingly larger portion of steel demand, leading to a more circular production system.

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in a basic oxygen furnace (BOF). Only small amounts of steel scrap can be added to this process. The resulting virgin steel is usually used to produce high-quality steel goods that are mainly demanded by automotive or industrial equipment industries.

In **secondary steel production**, steel scrap is processed into liquid steel in an electric arc furnace (EAF) using electricity. Due to impurities in the scrap, the resulting recycled steel is usually used to produce lower-quality steel goods that are mainly demanded by the construction industry as well as certain high-alloy steels such as stainless steel (IEA, 2020).

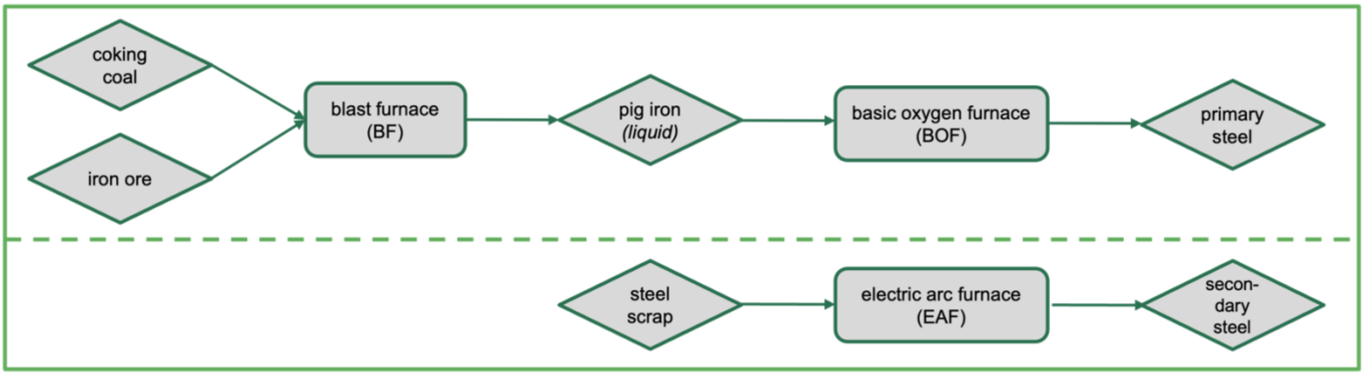


**Figure A: Simplified diagram of primary and secondary steel production (Source: own graphic)**

This clear separation, with primary and secondary steel production supplying almost entirely separate markets, largely limits scrap use to those applications served by the secondary steelmaking sector. This creates a ceiling for scrap use regardless of its availability.

With the deployment of $H_2$-DR technology, this sharp line of division between primary and secondary steelmaking will likely look a lot blurrier in the future, enabling greater scrap use. In contrast to liquid hot metal from the blast furnace, direct-reduced iron (DRI) produced in a shaft furnace exists in a *solid state***.** This has two main advantages for flexibilization:

- Unlike liquid hot metal, there is no need to immediately process DRI. It can be stored and transported. This means that primary steelmaking no longer needs to be temporally or spatially integrated. DRI could be produced where iron ore and green hydrogen are readily available, then shipped to steelmaking sites around the world.
- Just like scrap, DRI can be processed in EAFs. While in current primary steel production, scrap input is technologically limited, the switch to $H_2$-DR allows for flexible use of DRI and scrap in EAFs to achieve the desired quality standards for a given product.

With the possibility of flexible charge of DRI and scrap, EAFs will be able to produce not only low-quality steel goods (currently seen as “secondary steel”), but also high-quality steel goods (currently seen as “primary steel”). The flexible operation of EAFs could thus change the current categorization of primary and secondary steel and result in a product-specific steel production system, which optimizes scrap use.

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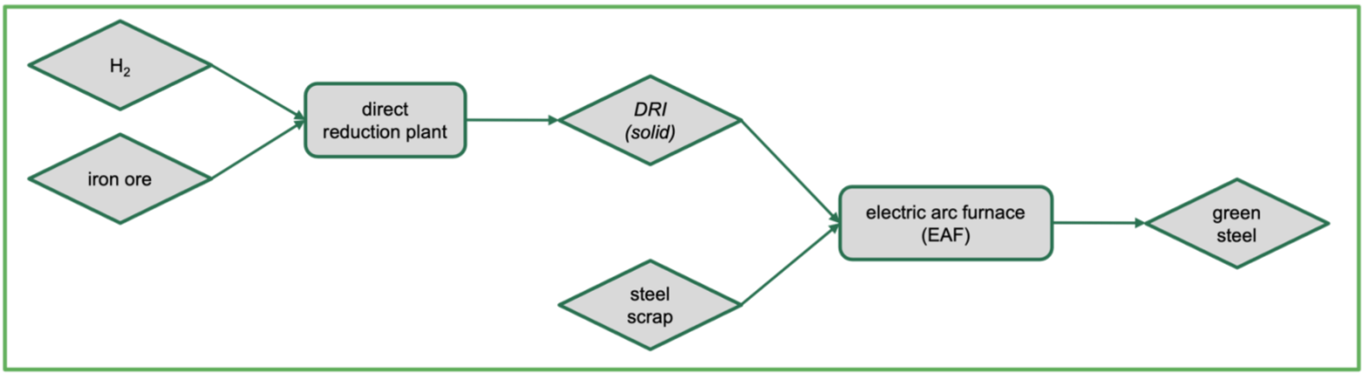


**Figure B: Simplified diagram of EAF-based green steel production (Source: own graphic)**

Our modeling results show that with the deployment of DRI-EAF technology and optimal use of scrap in the European steel production system, scrap use can increase to 130 Mt/a by 2050, accounting for more than 40% increase in scrap use as compared to 2018. The share of scrap as metallic input increases from 43% in 2018 to 52% in 2050, under identical quality standards in steel goods.

The best example for this phenomenon is the US steel production system. In 2019, the US produced 87.7 Mt/a of crude steel, with primary production via blast furnace and basic oxygen furnace accounting for only 35% of the production, resulting in 65% steel production in electric arc furnaces. With scrap and direct reduced iron used as flexible input in electric arc furnaces, the US steel production system achieves a scrap share as metallic input of over 70% (IEA, 2020). The example of the US production system shows that the flexible use of scrap and DRI, improved scrap sorting and product design enable further scrap use in the steel production system, way above the 52% indicated by our modeling results.

# Challenges to increased scrap use

The main challenge to exploiting the steel scrap potential to its fullest lies in the quality of the scrap. Many scraps are contaminated with unwanted tramp elements such as copper or tin. This makes them unsuitable for demanding applications with high purity requirements. Recycled steel made from this lower-quality scrap is thus used for less demanding applications, mainly in the construction industry. However, this is not a feasible long-term solution, as the impurities will build up with each round of recycling, effectively leading to downcycling. Even in a decarbonized steel production system where quality concerns can be addressed more flexibly by using DRI in addition to scrap, this approach would eventually reach its limits.

Unlike with certain plastics, downcycling of steel is preventable if impurities are avoided or removed, making recycled steel just as viable for demanding applications as primary steel. Impurities can be avoided if scrap quality is prioritized throughout the steel’s lifecycle:

- In the product design stage, taking the recyclability of the type of steel used and the ease of disassembly at the product’s end of life into consideration can contribute to preventing downcycling.
- At the end of the product’s useful lifetime, proper disassembly and sorting can reduce impurities in the steel melt, while also ensuring that precious alloying elements are reused. Investing in the development of new technologies such as AI-aided sorting technology can further improve results.

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- Ensuring proper transfer of information from producer to recycler on the properties of the materials used can help with adequate recycling.
- Investment in research and development of new technologies enabling the removal of impurities from the steel melt can be a way to address any impurities that cannot be avoided by improved design, disassembly and sorting (Daehn et al., 2019; Raatz et al., 2022).

However, all of these strategies require considerable investments. Under current market conditions, investing in improving scrap quality does not appear to be economically viable. Instead of addressing quality issues to maximize scrap use within the EU, excess scrap is increasingly exported.

The projected increase in scrap availability and ongoing increase in scrap exports indicate that scrap exports are likely to increase further without adequate policies to incentivize investment in scrap quality and scrap use in EU steel production.

# Policy recommendations

## The "green steel" definition should favor circularity

In the last years, many standards for green/low emission steel have been published. Notably, the International Energy Agency (IEA) published its report "Achieving Net Zero Heavy Industry Sectors in G7 Members" in 2022 and suggested a sliding scale that depends on steel scrap use to promote low carbon steel production (IEA, 2022). The German Steel Association published its concept paper for low emission steel standards (LESS) in 2024 with a similar concept as the IEA (Wirtschaftsvereinigung Stahl, 2024). The main difference of the low emission standards of the German Steel Association is the different classification of steel products from A to E, with A corresponding to the lowest carbon emissions in steel production, after the category Near-Zero.

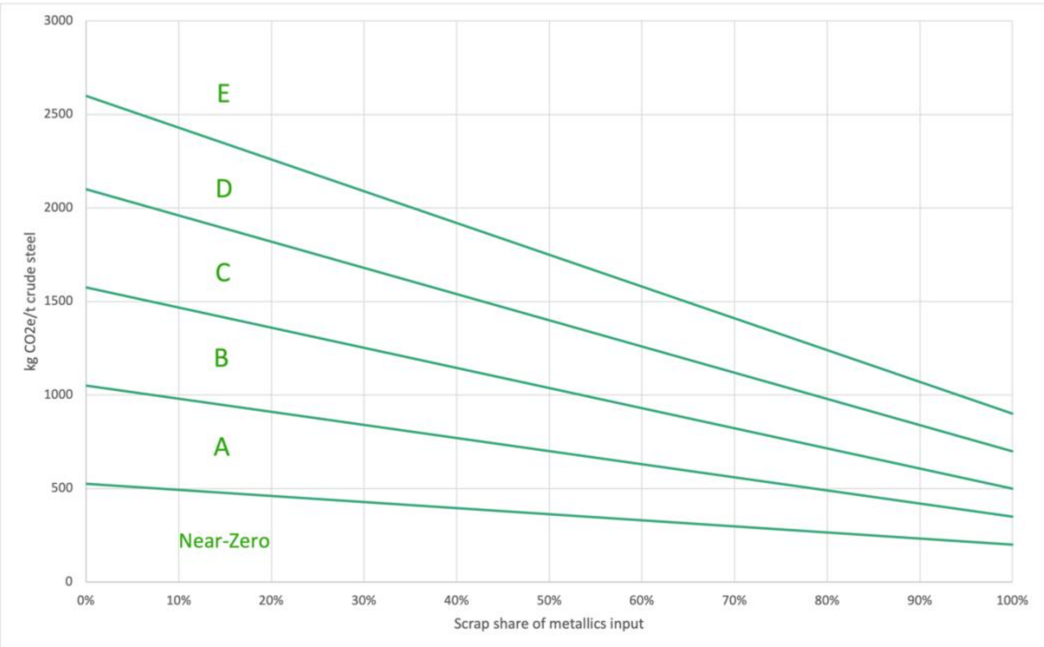


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**Figure C: Sliding scale green steel definition (Source: own graphic based on Wirtschaftsvereinigung Stahl (2024))**

What both standards have in common is the sliding scale for scrap use as a share of total metallic input, which means that the steel production using more scrap for the same product must result in lower $CO_2$ emissions in order to be classified in the same category as primary production. While no doubt helpful for primary steelmakers during their transition phase, this classification system would arguably discourage the use of scrap in steel production while achieving identical quality standards and harm the innovation needed to produce high quality steel from scrap. Steel companies addressing the decarbonization challenge by innovating in secondary production and achieving identical qualities with flexible use of DRI and scrap would be disadvantaged in this classification system and would have little incentive to innovate in this field. The market value of scrap would be kept artificially low, discouraging investments in better disassembly and sorting and reinforcing scrap exports. Instead, a green steel definition underlying any EU steel decarbonization policies should encourage circularity.

## Improving the business case for scrap use

Direct reduction plants to replace existing blast furnace capacity have been the focus of recent investment subsidies. The supply of green hydrogen to run the new plants has been at the forefront of steel decarbonization debates. In contrast, electric arc furnace capacity – both existing and new – has received rather little attention. In fact, capacity utilization rates of existing EAFs in the EU have been suboptimal, suffering from global overcapacity, low steel prices and high electricity prices. EAFs will be key on the way to a decarbonized steel system, both for the switch to DRI and for increased scrap use. In addition, the possibility of importing green DRI will create an important new use case for stand-alone EAFs.

The capacity utilization rate of electric arc furnaces can be increased by securing low and stable electricity prices for steelmakers and ensuring a level playing field with basic oxygen furnaces. Focusing on low and stable electricity prices would not only increase the capacity utilization rate of electric arc furnaces but also motivate steelmakers to produce high quality steel using electric arc furnaces with the use of DRI and scrap.

Our modeling results suggest that the EU would need to increase its EAF capacity by 50% until 2050 in the case of optimal scrap use and moderately increasing steel demand. Hence, a reasonable business case is needed for EAF steelmakers not only to increase their production but also create incentive to invest in the technology to utilize increasing scrap availability in the future. Since electricity is the major cost factor in electric arc furnaces, securing low and stable electricity prices to ensure a reasonable business case should be a policy priority.

The development of the steel industry in Türkiye over the last few decades serves as an interesting case study in creating a business case for secondary steelmaking. Energy-intensive industries in Türkiye have had access to one of the lowest electricity prices in European countries through ongoing state subsidies. The industrial policy of Türkiye for low-cost electricity created a reliable business case für Turkish steelmakers to invest in EAF, which resulted in a massive increase in crude steel production, from 14 Mt/a in 2000 to more than 40 Mt/a in 2021. Electric arc furnaces do not only account for 72% of Turkish crude steel production, but also 43% of the flat steel production using only scrap (Istanbul Policy Center, 2023). In contrast, in the EU, virtually all flat steel products are produced through the primary steelmaking route. Currently, Türkiye is the leading scrap importer in the world, with its imports mostly from the EU.

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## Ecodesign rules for steel as a tool to boost scrap-based steelmaking

The EU's new Ecodesign for Sustainable Products Regulation (ESPR) provides a solid framework for more recycling-forward policies for steel and other materials and products (European Commission, 2024). Steel is one of the first product-specific measures being developed under the ESPR. This is a chance to promote the use of secondary steel, resource efficiency, recyclability and material recovery in the design phase, increasing ease of recycling and improving the market value of steel scrap. This in turn will encourage investment in better disassembly and sorting technologies and incentivizing domestic use of steel scrap without having to actively curtail scrap trade. Digital product passports (DPP), as outlined in the ESPR, should enable recyclers to efficiently sort end-of-life steel goods by their composition, contributing to the prevention of downcycling.

Any product-specific measures pertaining to steel under the ESPR should be carefully designed to specifically encourage the use of available steel scrap and promote advancements in secondary steelmaking for high-quality steel products. The long-term goal should be to increase the recycling share in EU steelmaking to its full potential, and the Ecodesign rules for steel provide an opportunity to set the course for this now.

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**POLICY BRIEF**

# The role of scrap for EU steel decarbonization


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