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Forging steel's future

Scrap's leading role in low-carbon steelmaking in the US and Europe

Contents

Executive summary

Trade barriers, technological progress, and decarbonisation are reshaping the steel sector which accounts for over 8% of global emissions. To unlock the full potential of modern steelmaking, we believe industry standards and policy must catalyse, rather than slow the pace of change.

This paper represents the combined output of L&G and Nucor[1], as part of L&G’s ongoing engagements with the sector on decarbonisation. We present insights from Nucor Corporation on recent technological advances in processing steel scrap for high-quality steel applications, alongside Legal & General’s energy transition scenario analysis.

We find that growing scrap availability and technology advances in scrap sorting and refining support much higher market penetration for recycled steel than is possible today. With achievable improvements in the recovery rate of end-of-life (EOL) steel, estimated at ~59% today by USGS, scrap can provide over 80% of ferrous metallics for steelmaking in the US by 2035 and in Europe by 2050, unlocking an emissions benefit of 1.67 tonnes of CO2 per tonne relative to integrated production (Fraunhofer ISNW).

The paper summarises the main industry decarbonisation frameworks and the blind spots around decarbonisation mechanisms created by the “sliding scale” (*see ‘Defining low carbon steel’ section*). In a sector that is increasingly shaped by trade barriers, such as Section 232 tariffs in the US and the carbon border adjustment mechanism (CBAM) in Europe, global investors and steel industry customers need frameworks to compare emissions performance across geographies both at a product level and a company level. **L&G endorses the Global Steel Climate Council (GSCC) as an emissions standard for both product-level accreditation and science-based target setting.**

However, no standard is perfect forever, as an engaged investor in the industry, L&G will continue to work with frameworks such as the GSCC to evolve standards with the latest science, policy and technology and reward ambition on decarbonisation.

The paper provides evidence across three principal areas:

1. **Defining low-carbon steel** – we review markets standards and make the case that many of the leading decarbonisation frameworks are not effectively supporting an orderly transition. We endorse the GSCC for use, particularly in the European and US markets.

2. **Technological progress in Electric Arc Furnace (EAF) steelmaking** – Nucor makes the case that technology advances in scrap sorting and refining, as well as quality improvements for EAF steelmaking; allow EAF to fulfil all major high grade steel applications paving the way towards even higher penetration of EAF based capacity.

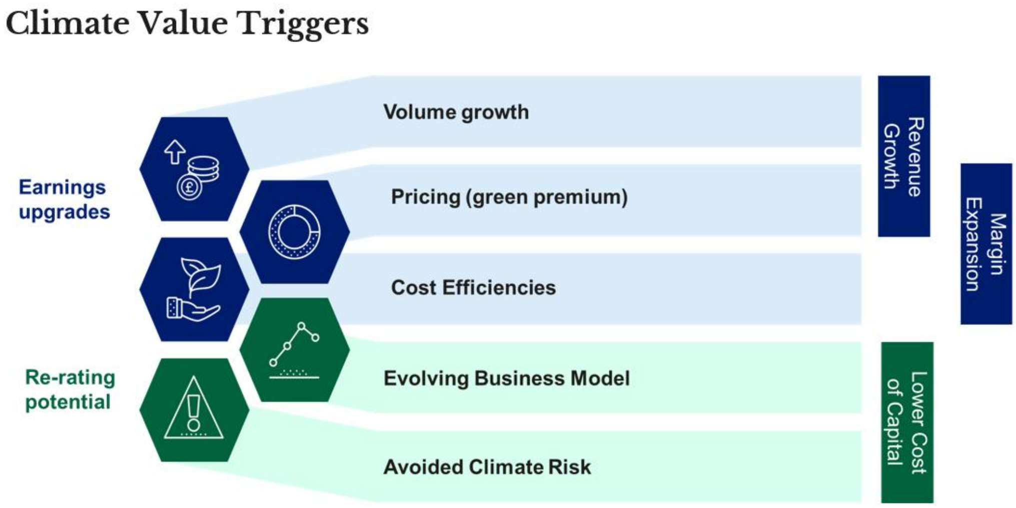
3. **Scrap availability** – L&G find that scrap is globally scarce, but locally abundant. In the US scrap could form 88% and in Europe 82% of the total metallics share by 2050. Above 85% is a level that we estimate can support a full shift to EAF capacity supported by DRI.

[1] **For illustrative purposes only. Reference to a particular security is on a historic basis and does not mean that the security is currently held or will be held within an L&G portfolio. The above information does not constitute a recommendation to buy or sell any security.**

Introduction

Decarbonisation is financially material in steel

For the energy transition to be sustainable over the long-term, it needs to be profitable. L&G use a climate-value-triggers framework to assess where leaning further into the energy transition is valuation positive for companies and aligned with improved financial performance.



Source: L&G, as at September 2025

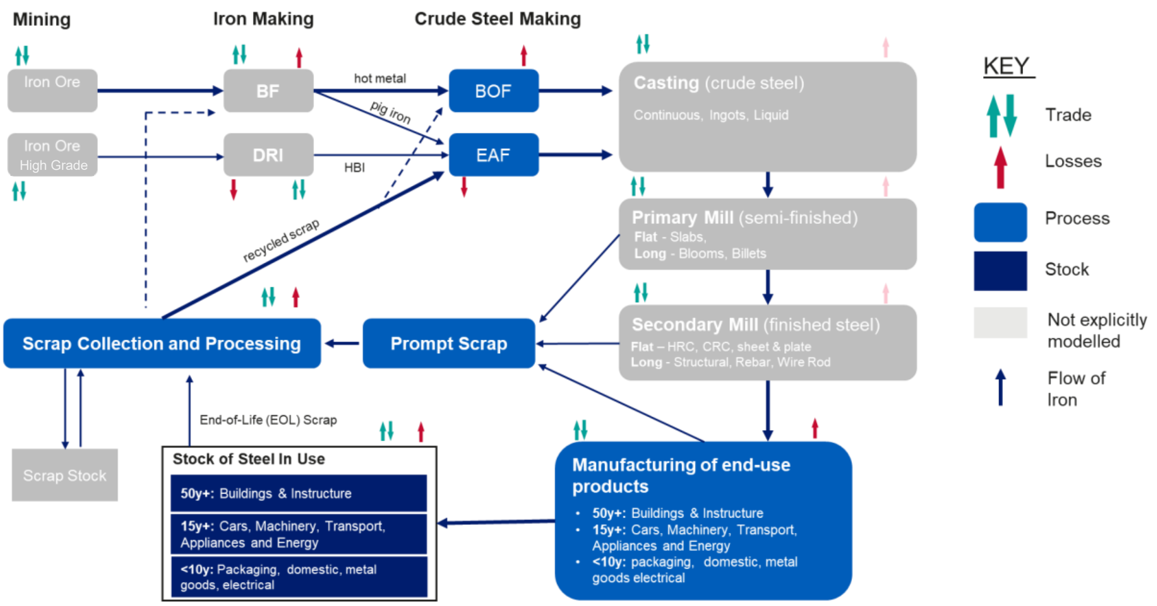
In the steel sector, all of the above triggers are material from an equity perspective. Winning and defending market share increasingly depends on meeting customers' emissions objectives. Parts of the market may soon be accessible only to lower-carbon producers – definitions are critical here. Green steel is already commanding a premium in Europe, with Fastmarkets reporting that steel produced below 800 kg CO_2e per tonne (Scope 1, 2, and 3) earns a price premium of €120–170 per tonne in flat products, and €20–30 per tonne for long products. The buyers that are willing to pay the highest premiums are those in segments such as autos, where steel is a small share of total costs. The willingness to pay is expected to grow as regulatory pressure intensifies and supply remains limited, though such premiums are not yet widely observed in the US. At the same time, carbon regulations like the EU Emissions Trading Scheme (EU ETS) and trade barriers such as Section 232 tariffs and the Carbon Border Adjustment Mechanism (CBAM) are reshaping the cost curve and influencing the competitiveness of different production methods. The fundamental flexibility of EAFs compared to integrated mills enables a more dynamic response to price signals, impacting industry pricing cycles. Ultimately, low-carbon steelmakers are better positioned to avoid climate transition risks and align with evolving regulatory and customer expectations, this has a material effect on what investors should pay for equity in these businesses.

Regulators, management teams and investors, need access to clear transparent data from the industry, on items that are material to the investment case, notably carbon intensity and transition plans. This is why as investors and as steelmakers it is worth engaging with decarbonisation frameworks, since they can impact emissions and financial performance in the sector.

Technology landscape

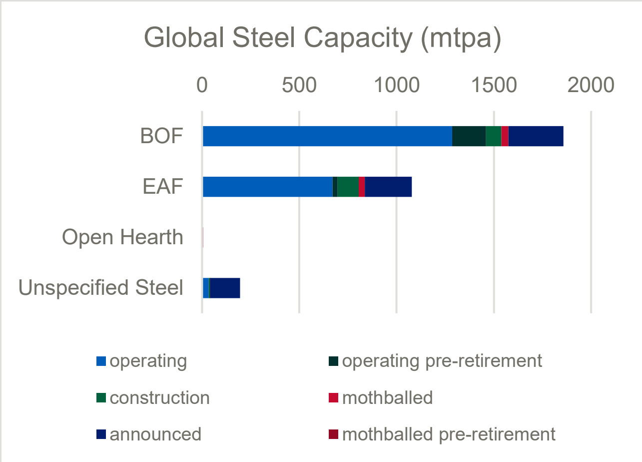
It is essential to understand that there are two primary ways to make steel – blast furnace & basic oxygen furnace (BF-BOF) and electric arc furnace (EAF) – which yield significantly different greenhouse gas (GHG) intensities embodied in the steel they produce.

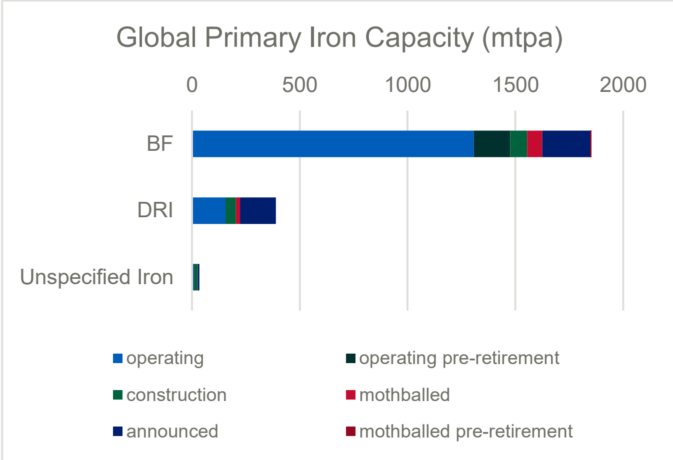
The BF-BOF, or integrated steelmaking, process is the traditional method for producing steel. It starts with mining raw materials out of the ground, including iron ore, limestone and coal. These materials are melted in an energy-intensive blast furnace (BF), which reacts iron oxide and carbon (in the form of coke, a porous coal-based fuel) to form two products: iron (saturated with carbon) and CO2. Liquid iron from the blast furnace is then reacted with oxygen in a second step via a basic oxygen furnace (BOF) to remove excess carbon, producing even more CO2. This reduced form of iron is steel. The EAF process, or circular steelmaking, is a recycling-based steelmaking process that uses electricity to melt scrap and other iron inputs into new, high-quality steel. The circular steelmaking process is significantly less emissions-intensive than the integrated steelmaking process but is limited by availability of scrap.



Source: L&G. *Material flows in the L&G scrap availability model.*

A second-ironmaking method, **Direct Reduced Iron (DRI)** has emerged as an alternative to blast furnaces in regions with access to cheap natural gas or potentially in the future, hydrogen. The DRI process produces iron from iron ore, eliminating the need for metallurgical coal as well as the need to fully melt the iron, cutting energy requirements and emissions as a result. DRI can be feed into an electric arc furnace. Note that DRI in India often uses coal gasification in the DRI process as a way to use cheap thermal coal resources for ironmaking, this process is highly emissions intensive, often more so than blast furnaces. As a result, it is common to differentiate DRI based on the process used (e.g. Natural gas–DRI, Coal-DRI or Hydrogen-DRI).





Source: Global Energy Monitor, Global Iron and Steel Tracker, March 2025 (V1.1) release, L&G

As steel reaches the end of its lifetime it can be collected as scrap and recycled in an electric arc furnace (up to 100% scrap) or blast furnace operations (up to 25%). Scrap that becomes available in the market typically takes two forms.

- **Prompt industrial scrap** (*e.g. Bushelling*) – produced by offcuts and defects during the fabrication of finished steel and end-use products. Prompt scrap has low levels of residuals and tramp elements, making this an attractive feedstock for EAF steelmaking, but one that trades at a premium. Prompt scrap is highly recycled and its availability scales with steel production and manufacturing.
- **End-of-life (EOL) scrap** – recovered from cars, machinery, infrastructure, and equipment at the end of their lifetimes. EOL Scrap is a function of past consumption and recovery rates.

Steel is highly magnetic which helps extract it from other forms of waste, but despite this recycling rates are not at maximal levels, the USGS estimates that only ~59% of steel is recovered at end of life in the US, with one of the more advanced steel recycling infrastructures– **as the value of scrap grows through trade tariffs and carbon pricing mechanisms, recovery rates could materially grow.**

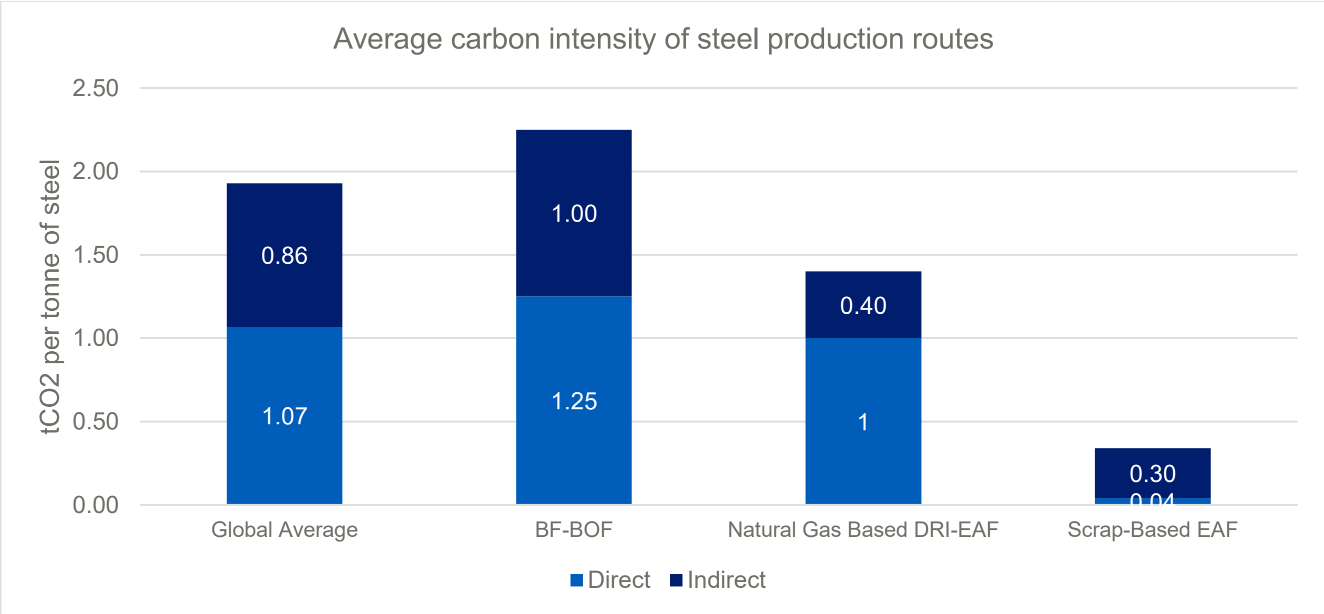
Technological advancements are improving the proportion of recovered scrap that can be recycled into the steelmaking process – due to mechanisms to control for quality. {discussed in Advances in Scrap Recycling Section}

Environmental footprint

There are major energy and emissions savings to be had from maximising the use of scrap in steelmaking and enhancing circularity in the sector – each ton of scrap used in the production of carbon steel saves an average of 1.67 tons of CO_2 compared to production from ore (Fraunhofer ISNW).

While EAF-based steelmaking accounts for approximately 30% of global production, it contributes only 12-15% of industry emissions. Furthermore, while BF-BOF steelmaking processes represent nearly 30% of US production, they account for approximately 80% of US steelmaking emissions. Steel produced via the BF-BOF route is significantly more carbon-intensive than electric arc furnace (EAF) methods using scrap or direct reduced iron (DRI); in addition, BF-BOF steelmaking emits significantly larger amounts of SOx, NOx, and particulate matter due to coke combustion and iron reduction processes.

EAF steelmaking emissions are in the embodied emissions of the steel inputs used and in the carbon intensity of the electricity used in the process. The main determinants of the emissions intensity of an EAF are the ratio of pig iron and direct reduced iron used vs scrap and the carbon intensity of electricity. On average in the US electricity is 350kg/kWh corresponding to 0.2tCO_2/tonne of steel, whereas in Europe it is half of this.



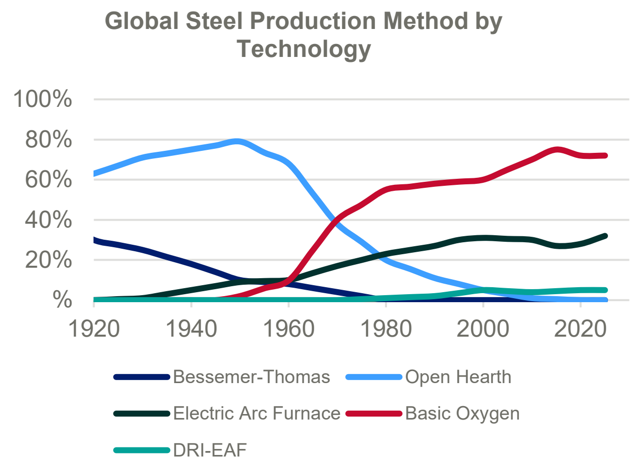
Source: IEA, World Steel, L&G

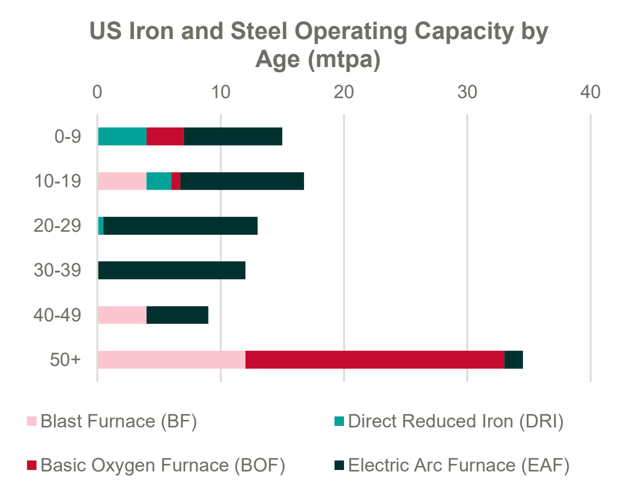
***Note:** Indirect emissions under the IEA definition may include upstream emissions from purchased fuels (mining, processing, transporting coal/coke). For EAF processes the indirect emissions are driven by the carbon intensity of electricity, IEA numbers imply assumptions of 550kwh/tonne steel and 0.55kg tCO_2e/kwh, use of low carbon electricity can significantly lower this number.*

Historical context

Technological progress in this industry is not new; we are continually in a process of creative destruction. For a given product, the cheapest production method makes the best margins and attracts capital, replacing uneconomic and aging capacity within local markets. As carbon emissions increasingly become a part of the economic equation, notably through the EU emissions trading scheme (ETS), lower emissions steelmaking could develop and grow an economic advantage.

In the 1960's the Basic Oxygen Furnace delivered vastly superior energy efficiency and, in a market where demand for steel was rapidly growing, it moved from 10% share to 55% in under 20 years.





Source: JPMAM, Global Energy Monitor, L&G

At the same time, in industrialised economies there was a growing availability of scrap, Electric Arc Furnace steelmakers like Nucor built out capacity to take advantage of this new scrap resource, initially for steel with lower product specifications in long-products for construction. Now EAF has full market share in this segment and higher scrap utilisation in the US must now come by producing higher quality, notably flat products, for end-markets such as autos. This puts the emphasis on "upcycling" lower quality scrap into high quality flat products.

Integrated steelmaking has produced enormous societal and economic value from the 1960's through to the modern day. As technological advancement continues, we believe **frameworks such as the GSCC can be helpful guides for capital allocation in an orderly transition since they reward mix-shift, while also providing customers with a clear unambiguous standard on the carbon intensity of steel products**.

Governments and incumbents have a major part to play in ensuring an orderly transition which involves adequate support for communities affected by technological change. It is important to ensure policy minimises the cliff-edge dynamics and issues caused by sudden bankruptcies as exemplified by British Steel in Scunthorpe, UK.

Defining low-carbon steel

Customers of steelmakers need emissions data to embed carbon intensity into the procurement processes, while investors require enhanced disclosures to assess steelmaker risks and capital allocation in the transition.

Importance of a decarbonisation frameworks

Steel makers compete on multiple dimensions: quality, reliability, cost, customer relationships, and, now as EAFs compete with integrated producers in flat-products, carbon intensity. Multiple definitions for low-carbon steel have emerged to shape this competition, but their varied objectives and assumptions create complexity for customers and regulators – a single framework or agreed on truth with respect to emissions would improve clarity.

We believe that decarbonisation frameworks can help to:

- **Enable comparisons between companies operating in different regions** through consistent accounting and reporting formats

- **Inform capital allocation decisions** by considering profitability and the cost of decarbonisation mechanisms, with periodic updates to reflect the technological readiness level of decarbonisation solutions.

- **Permit decarbonisation by any measurable means** – all proven emissions reduction solutions in the sector should be counted within the decarbonisation framework. Allowing the industry to calibrate to the most economically efficient solutions as technology evolves. This includes expansion of recycling rates.

- **Provide a standardised definition of low-carbon steel** – investment into low-carbon steel often hinges on transparent market pricing signals that identify a premium for low-carbon steel. A green premium to support the business case requires a clear and simple definition and tracking of market pricing across multiple contracts.

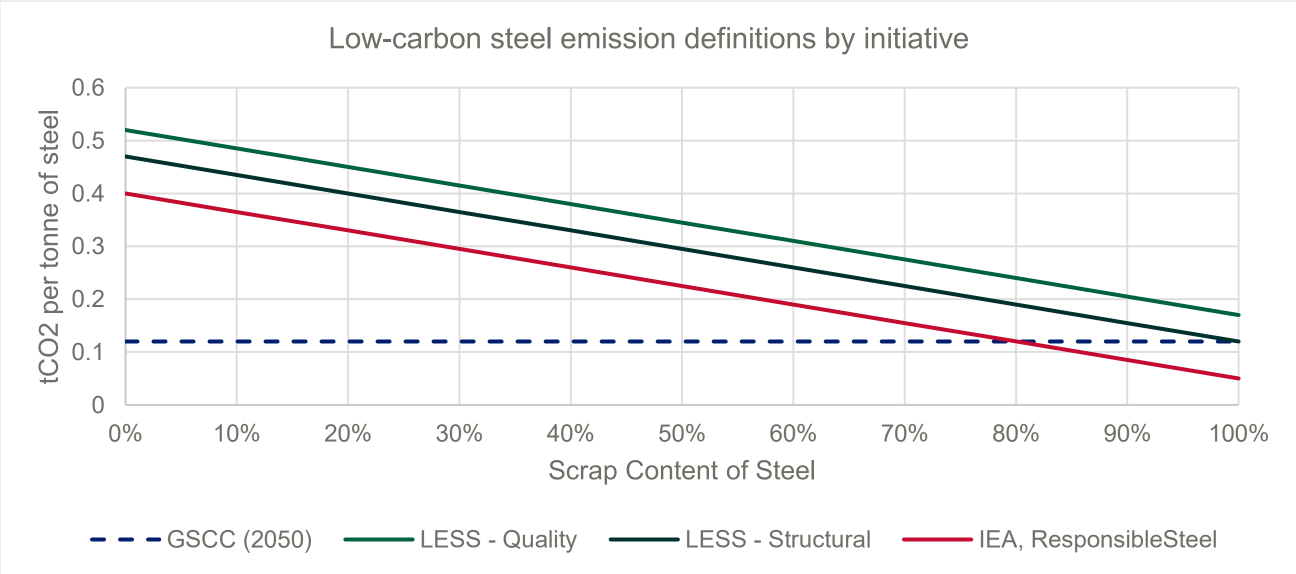
- **Avoid misallocation of capital and emissions lock in** – carbon capture and storage (CCS) for blast furnace steelmaking remains at the pilot and demonstration stage globally, with no commercial-scale deployments to date. While several projects in Europe, North America, and Asia are testing CCS integration with blast furnaces, current capture rates are low, and costs remain high. Technical challenges, such as the dilute and contaminated nature of blast furnace off-gases, further complicate large-scale adoption. As a result, CCS is not yet a proven or scalable solution for decarbonising blast furnace steelmaking, and most industry roadmaps view it as a supplementary rather than primary pathway for emissions reduction. By accrediting integrated steel as "green" today, you risk reinvestments, such as blast furnace relining which have 20-year lifetimes, made in the hope that CCS retrofits are economically viable in future.

However, we note that many of the decarbonisation frameworks in the market today do not achieve these goals and can present blockers on the speed of the energy transition through miscalibration of constraints on the system. In particular, investments to improve scrap recovery and recycling rates.

Comparison of existing frameworks

There are five major initiatives applicable to the US and Europe:
(i) IEA's Near-Zero and Low-Emissions Steel,
(ii) Science-Based Targets Initiative (SBTi)
(iii) ResponsibleSteel,
(iv) The Low Emissions Steel Standard (LESS, Germany),
(v) The Steel Climate Standard (GSCC).

All frameworks use carbon intensity in tonnes of CO_2 equivalent per tonne of steel as the primary metric for assessing the environmental performance of steel. However, **the emissions accounting rules vary greatly between frameworks**, notably in system boundaries, how credits are allocated, and how co-products are treated. These differences lead to inconsistencies in reported emissions and hinder comparability across products, companies and regions.



Source: GSCC, LESS, IEA, ResponsibleSteel, L&G

In defining the emissions performance thresholds there are two main methodological approaches:

1. **Sliding scale** plots the emissions intensity of steel production against the percentage of scrap used in the process. It establishes varying emissions thresholds based on scrap content, allowing higher emissions for steel made with less scrap, and lower thresholds for steel with more scrap. As scrap content increases, the allowable emissions intensity decreases. However, this approach can undermine decarbonization efforts. By adjusting emissions thresholds based on scrap content, it enables steel products made with higher emissions to still qualify as "low carbon" under the scale (IEA, ResponsibleSteel, LESS, SBTi).

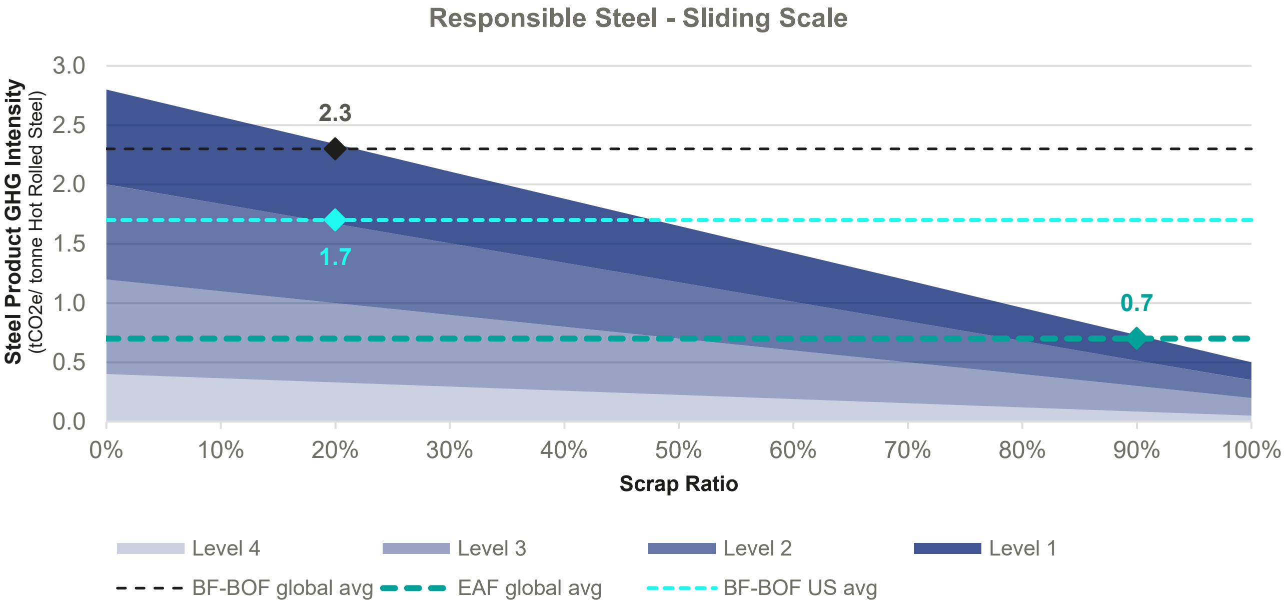
2. **Product-based pathway:** Company-specific decarbonisation trajectories are set for different product types (GSCC), converging on 0.12 tCO2 per tonne of steel in 2050.

The choice of methodology taken in the construction of these metrics makes the difference on whether higher emissions *integrated steel can achieve a green label today.*

Carbon intensity calibration by framework

ResponsibleSteel

ResponsibleSteel calibrates its lowest accreditation level, based on the World Steel stated global averages of integrated producers which use ~20% scrap and produce ~2.3 tCO2/tonne steel and the EAF producers which use ~90% scrap and produce ~0.7 tCO2/tonne steel.



Source: ResponsibleSteel, World Steel, L&G

The second accreditation level is calibrated to correspond with integrated and EAF capacity in developed markets. Notably 1.7 tCO2/tonne of steel in the US using 20% scrap and ~0.5 tCO2/tonne of steel for EAF in developed markets using 90% scrap.

The result is that the average US integrated facility today can achieve Level 2 on the ResponsibleSteel framework whereas the average EAF facility in the US remains at Level 1 – although will likely improve as the US grid decarbonises over time. As a result, in the procurement process, **customers that demand the best climate performance band, may end up buying the highest carbon products.**

This affects the ability of new EAF capacity to be placed into the market slowing the transition and demand pull for Direct Reduced Iron (DRI) from EAFs in the US market. The scrap-DRI-EAF system is much more likely to be deliver deep and affordable decarbonisation in the long term.

ResponsibleSteel allows offsets and does not set specific interim milestones, only four levels of decarbonisation accreditation. This risks plateauing decarbonisation where companies, dip inside a level and stop decarbonisation spending, if the next level is out of reach.

The problem with the calibration is that EAF producers in regions without the very lowest power grid emissions struggle to make Level 2 thresholds, while integrated producers that have low emissions relative to global averages are easily inside. This sends the wrong signal to the market.

Science-Based Targets Initiative (SBTI)

The SBTi, uses a Sectoral Decarbonisation Approach (SDA) which provides differentiated pathways for primary (ore-based) and secondary (scrap-based) steelmaking routes. The percentage reduction in emissions intensity that must be achieved (*illustration below*) is related to the proportion of scrap used in the base year relative to the target year. The impact is that any mix-shift toward scrap-oriented steelmaking, vastly increases the decarbonisation rate that must be achieved under the protocol.

Illustration of the carbon intensity reduction (%) per tonne of steel in 2030 versus a 2019 base year under SBTi

		Base year scrap proportion (%)		
		0%	**50%**	**100%**
2030 scrap proportion (%)	**0%**	29%	0%	0%
	50%	57%	30%	0%
	100%	85%	77%	32%

Source: SBTI, L&G

While this calibration does use high ambition levels on decarbonisation there are some fundamental challenges with the methodology.

- *Exclusion of mining emissions from the Iron and Steel Sectoral Decarbonisation Approach (SDA)* – mining of coal is a highly emissions intensive activity and has high risk of fugitive methane emissions. Excluding this part of the supply chain does not create a fair comparison between integrated and EAF producers.

- *Absolute emissions limit* – the limit on not expanding absolute emissions disincentivises EAF producers from expanding to DRI, since they are not afforded additional headroom in emissions to move upstream to primary production under SBTi, so cannot do so without missing their targets.

- *Forecasting a production growth rate* – the methodology requires forecasting of absolute production levels, which constitutes long-term capex guidance, over time this may conflict with business cycles and force companies to retract or miss targets. Company capex guidance may need change in response to business cycles and balance sheet strength. The need to forecast growth rate in the SBTi calibration makes it very likely that companies will be forced to deviate from their committed pathways.

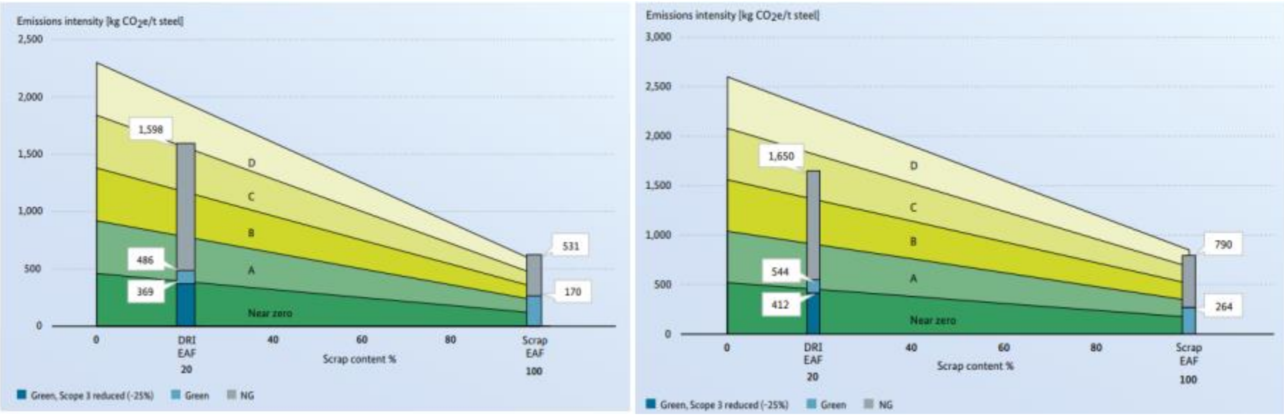
- *Forecasting a scrap ratio* – in practice the scrap ratio is flexible for EAFs and determined by the cheapest source of ferrous iron net of prevailing carbon pricing/ tariffs. This is very hard to forecast, given geopolitical sensitivity and China's dominance in steel and pig iron. SBTI decarbonisation targets are very levered to future and current scrap ratios which are volatile.

- *Baseline effect* – decarbonisation leaders which have done significant amounts of decarbonisation prior to accreditation are penalised with a lower baseline making incremental improvements harder.

Low Emissions Steel Standard (LESS)

Uses a sliding scale approach but with additional product level granularity and regional calibration for the European market. This makes it a more helpful framework in the European market where alignment to LESS is more likely to also align to regulatory requirements and the Carbon Border Adjustment Mechanism (CBAM).

We do believe that regionally calibrated frameworks that align to policy can be helpful for steel companies as operating and capital allocation tools, particularly in a more regionalised steel market driven by tariff barriers. However, sliding scale calibrations, shown below plot scrap content vs emissions intensity and categorise steel in bands within this plot. If the gradient relative to scrap is too high, the framework, masks increase in scrap use as a viable decarbonisation mechanism, the lower the gradient the more credit scrap is given. LESS has a lower gradient than ResponsibleSteel, which improves the calibration.



Source: LESS *(structural left, quality steel right)*

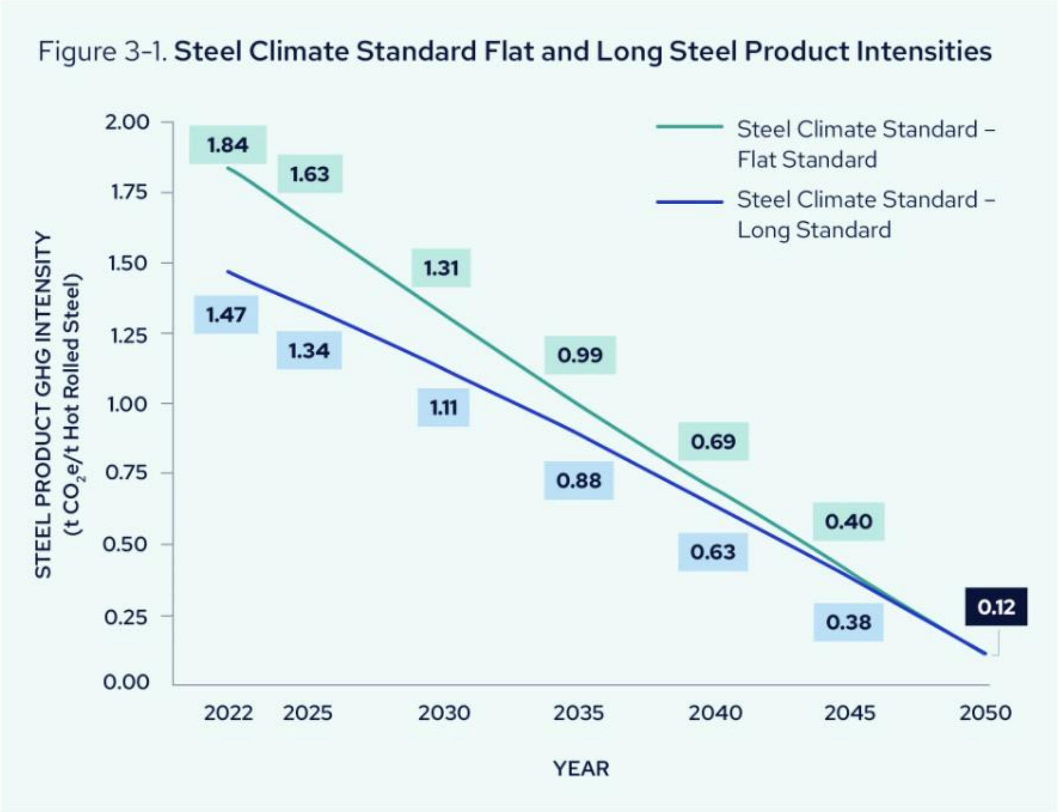
However, as investors comparing companies between geographies, differences in accounting methodologies between regional frameworks can make comparisons challenging. We are supportive of European companies utilising LESS in capital allocation frameworks, given regulatory alignment, but comparability between geographies and overall simplicity leads us to favour GSCC.

Global Steel Climate Council (GSCC) – Steel Climate Standard

The Steel Climate Standard, developed by the GSCC, offers a transparent, science-based, and technology-neutral framework for decarbonising the steel industry. It provides a clear and consistent pathway to achieving net-zero emissions by 2050, applicable to all steel producers regardless of the production methods they use. Central to the framework is a comprehensive system boundary that includes all relevant Scope 1, 2, and 3 emissions from mining and resource extraction through to the hot rolling process. This boundary ensures alignment with a science-based decarbonisation glidepath that supports global climate goals.

The Steel Climate Standard is built around three core objectives. First, it aims to establish a unified, technology-neutral framework for both steel product certification and corporate-wide science-based emissions target-setting. This framework is designed to apply equally to all steel producers globally and incorporates a timebound scale. Second, it seeks to empower steel customers by providing transparency into the carbon emissions associated with the steel products they purchase. Third, it serves as an industry-wide standard for achieving the emissions reduction targets outlined in the Paris Climate Agreement by 2050.

The Steel Climate Standard consists of two primary components. The first involves science-based emissions target setting for participating steel companies. These companies are required to establish emissions reduction targets at the corporate level that align with the limiting of global warming to 1.5°C by 2050. This includes setting both interim targets and a long-term goal. All targets must meet or fall below the emissions levels outlined in the Steel Climate Standard's decarbonization glidepath, ensuring consistency with the framework's guiding principles and the prevailing climate science.



Source: GSCC, 2025**. Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

The second component is a set of product certification criteria that define carbon intensity benchmarks for steel products at the facility level. These benchmarks differentiate between flat and long products, acknowledging that their distinct chemical compositions make it technically infeasible to achieve equivalent carbon intensities for both. This differentiation ensures that the certification process remains both rigorous and realistic.

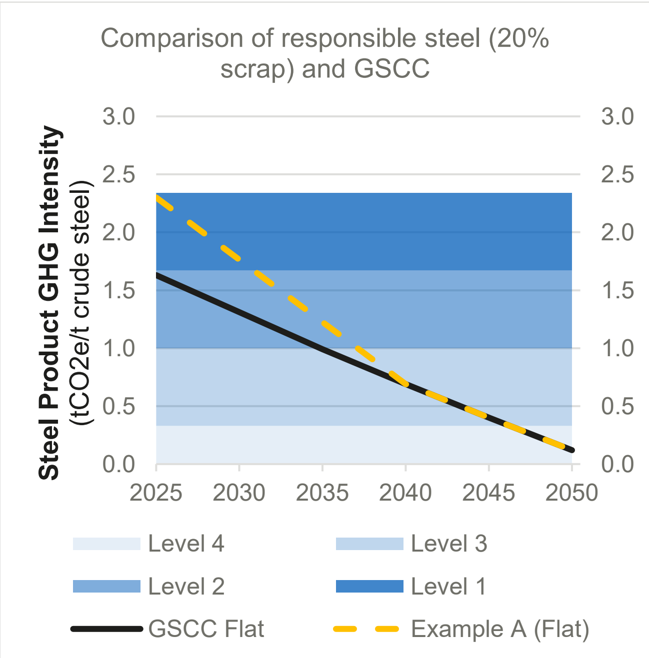
By adopting the GSCC Steel Climate Standard, steel producers and consumers worldwide gain access to a single, consistent benchmark for evaluating emissions performance. The Standard enhances transparency in procurement decisions, enabling customers to make informed choices about lower-carbon steel products. Additionally, it provides a replicable and credible method for tracking, planning, and implementing emissions reduction strategies across the steel industry, supporting a global transition toward a more sustainable future.

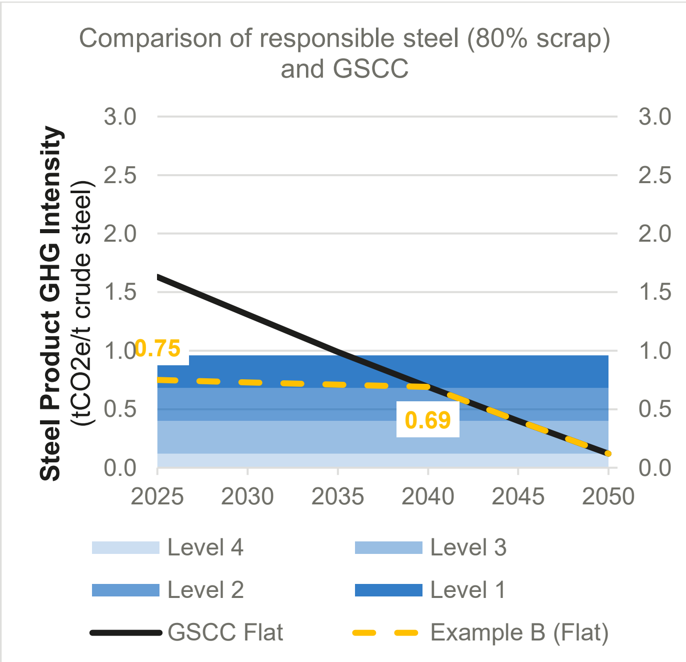
Examples:

The GSCC uses a convergence methodology to set the glide path, this ensures that companies have an imperative to continue to decarbonise.

Company A starts with a carbon intensity of 2.3tCO2 per tonne of steel, well above the sectoral average glide path. Under the GSCC rules the companies required glide path is drawn from where the company starts to a convergence point with the sectoral average in 2040. This implies if the company uses 20% scrap, a progression through ResponsibleSteel Level 1 in 2025, L2 in 2032 and L3 in 2038 for an integrated producer.

Company B starts with a carbon intensity of 0.75 tCO2 per tonne of steel, well below the glide path. It is expected to converge to the sectoral average at a point 2 years beyond the horizontal intersect, requiring it to reach 0.69 tCO2 per tonne of steel by 2040. In ResponsibleSteel terms, at 80% scrap ratio this is Level 1 until 2040, so while being lower emissions is sold as having a worse environmental footprint under ResponsibleSteel.





Source: ResponsibleSteel, GSCC, L&G. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

Conclusion

The Steel Climate Standard, developed by the GSCC, is preferred because it offers investors a single accounting framework with which to compare steelmakers between geographies while also crediting steelmakers for advances in the use of scrap as an emissions reduction tool. In particular, it rewards what we call 'mix-shift' which is the conversion of integrated capacity to EAF.

Mix-shift allows the industry to utilise higher scrap availability through the decade, increases demand pull for DRI, improves energy efficiency and introduces more flexibility into capacity factors allowing the industry to respond more effectively to demand. L&G see all of these as climate value triggers – factors than can improve financial performance while delivering lower emissions.

In the remainder of the paper, we explore the potential to increase in "*recovery rates*" of steel at end-of-life and "*recycling rates*" of recovered steel. On both counts we find an expanding role for scrap in the US and the European markets. "T*echnological improvements"* in the electric-arc furnace (EAF) process now mean that EAF steel can meet the quality requirements in the flat products market, which is currently dominated by integrated producers and take market share there to expand the overall market share of EAF facilities.

Emerging markets

Due to the transparency and consistency provided by the GSCC emissions accounting and reporting, we would encourage emerging markets companies to consider reporting under the GSCC – however we also note that many considerations involving industrialisation, just transition and Nationally Determined Contributions (NDC's) timelines ,may impact the rate at which emerging markets can decarbonise and this may not fully align with the calibrations of the GSCC. We encourage EM companies to identify the limits of decarbonisation and identify if the GSCC calibration is viable to balance climate objectives, policy environment and financial performance as well as just transition considerations.

We consider the framework as valuable where EM steel companies that have a significant portion of their products export to DM. Current GSCC members already include steel companies from Mexico, Brazil, Turkey, we believe that as buyers globally look to procure low-carbon steel there are advantages for companies that are early adaptors to GSCC in EM. Companies could consider adopting standards that are beyond their compliance requirements in response to market demand.

In the developed Asian market economies, there is a clear indication of demand from automakers for green steel, this creates regional demand pull for low-carbon steel, which could spill into developing markets in the region.

Ongoing engagement and evolution

No framework will be perfect forever. As an engaged investor in the sector, L&G and as a steelmaker Nucor will continue to work with frameworks such as the GSCC to evolve standards with the latest science, policy and technology and reward ambition on decarbonisation. It is important that decarbonisation frameworks reward mix-shift to lower carbon processes, but it is also important that this does not create a ceiling effects or lower ambitions among EAF steelmakers. We are careful to emphasise the role for low carbon DRI-based production that will be a key feature of a modernised steel industry in the US and Europe.

Advances in scrap recycling

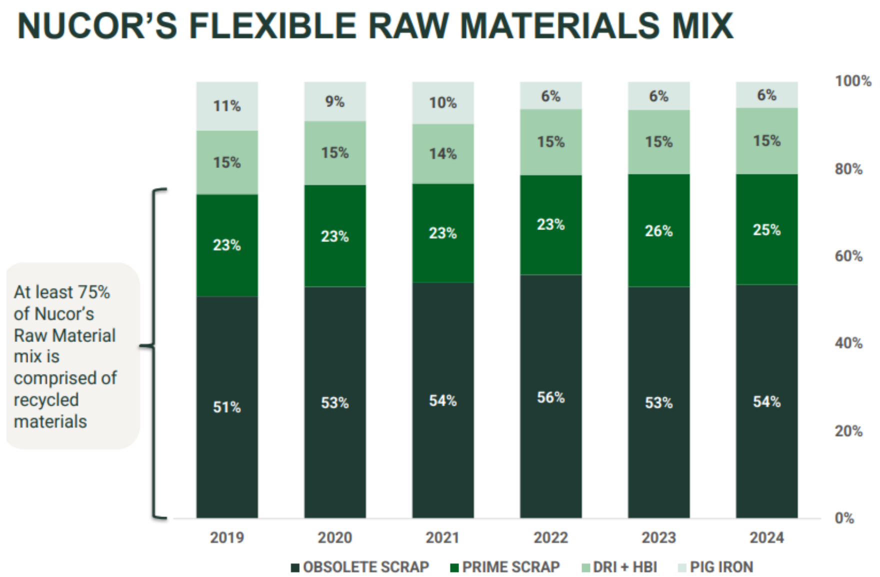
Advances in scrap sorting, refining, and EAF steelmaking are enabling electric arc furnaces to compete in higher-value product markets, paving the way to higher EAF shares in regions with abundant scrap supply.

Unlocking new markets with advances in scrap-EAF processes (Nucor)

Neither technology nor quality are limiting factors on transition to higher EAF capacity. Technology advances made by modern electric-arc furnace steelmakers such as Nucor, allow them to manufacture nearly all grades of steel using EAF processes. The few grades that are not produced are primarily low volume grades where the market size does not justify production.

Electric Arc Furnace (EAF) steelmaking process utilises scrap steel resources, this offers flexibility in capacity factors and lower like-for-like emissions than integrated process. However, managing residual elements in scrap remains a key technical challenge. Unlike Blast Furnace–Basic Oxygen Furnace (BF-BOF) steel, EAF steel often contains higher levels of residuals and nitrogen due to its reliance on recycled scrap. While most elements can be oxidized and removed during processing, tramp elements like copper, tin, nickel, molybdenum, and chromium are more persistent, especially copper, which is closely monitored.

To mitigate residuals, EAF mills blend scrap with virgin iron units such as Direct Reduced Iron (DRI), Hot Briquetted Iron (HBI), and pig iron, which contain no tramp elements. Prompt industrial scrap, like busheling, also offers low residual content. Mills further control chemistry by segregating scrap types and charging furnaces with precise blends to meet grade-specific requirements. High-copper scrap, such as shredded auto scrap, can be treated using ballistic separators, robotic pickers, or manual removal of copper-rich components. This upcycling has a material improvement in the grades of steel that this scrap can support. Several companies have begun to integrate AI into the scrap sorting and refining process to optimise scrap-use in specific steelmaking operations, wider adoption has the potential to drive more value out of recovered scrap and improve recycling rates.



Source: Nucor

The US is in a strong position for scrap availability, it consumes far more steel than it has historically produced, leading to a high stock of steel relative to production capacity. The US can support a material increase in EAF capacity through higher recovery rates of obsolete (EOL) scrap, lower exports of scrap and increased DRI capacity that is coming online in the market.

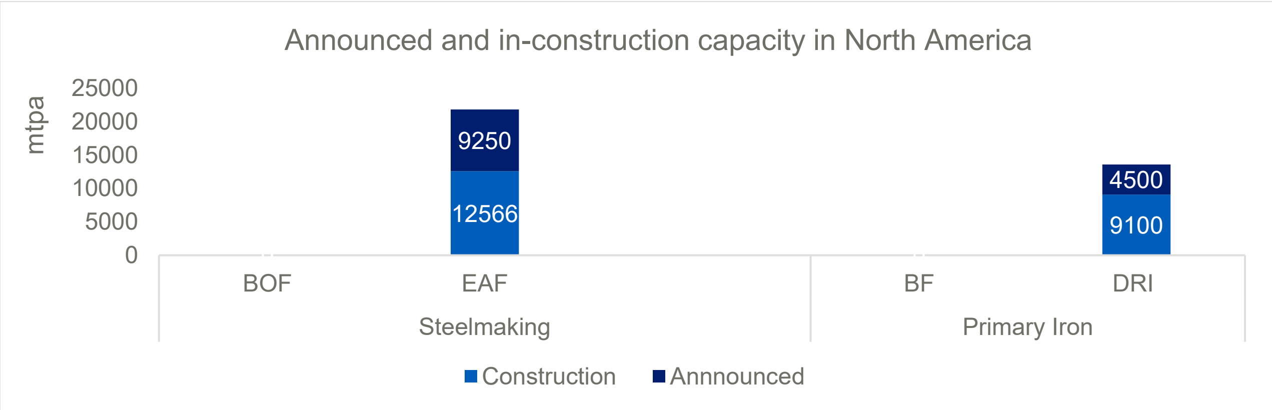
Scrap pricing continues to influence supply dynamics; higher prices lead to greater supply both from increased collection efficiency but also an incentive to retire end-of-life equipment rather than run it for longer. These forces can help improve the energy efficiency of the economy over time. But care must be taken to manage the early scrapping of steel which in some cases can be a net negative outcome if steel is scrapped during its useful life.

North American producers like Nucor have been able to manufacture even sensitive grades of steel like Extra Deep Drawing Steel (EDDS), by reducing nitrogen levels in tank degassers, enabling EAF mills to produce interstitial-free steels comparable to BOF outputs.

Advanced casting strategies also support quality. Nucor's West Virginia mill, for example, uses thicker slabs for better surface quality and alloy flexibility. Its Compact Strip Production (CSP) process enhances energy efficiency, though thinner slabs limit some chemistry options. Nucor's strategic choices – not technical limitations – explain its current exclusion of martensitic and aluminium-silicon press 'hardenable' steels, with trials underway for 3rd Generation Advanced High-Strength Steel (AHSS).

Capital is betting on EAF steelmaking

Trade barriers create space for new capacity to come to market by displacing imports, which are much less competitive post-tariffs. This has unlocked a wave of investment into domestic EAF production in the US, shown through the capacity that is in construction or announced. The US is a strong net exporter of scrap (17MT). As EAF capacity is added to the market in the US it is likely that scrap is used more domestically to facilitate the addition of this capacity to the market. DRI is being added to displace tariffed imports of pig iron to provide purer iron for addition to production mixes.

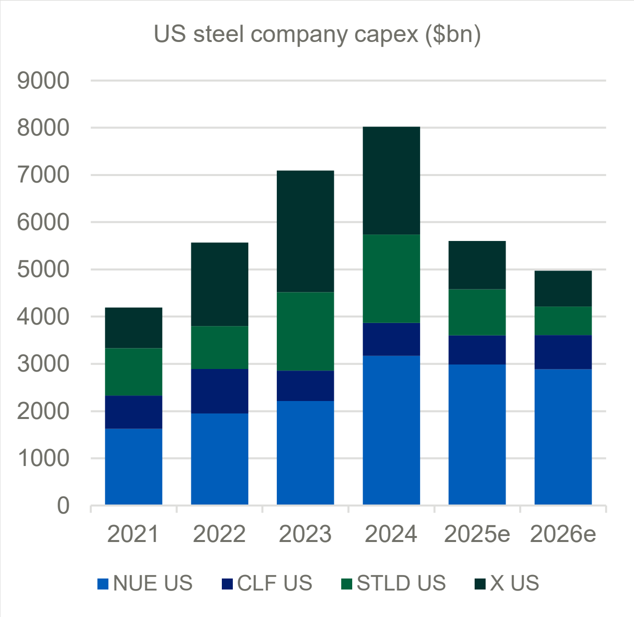


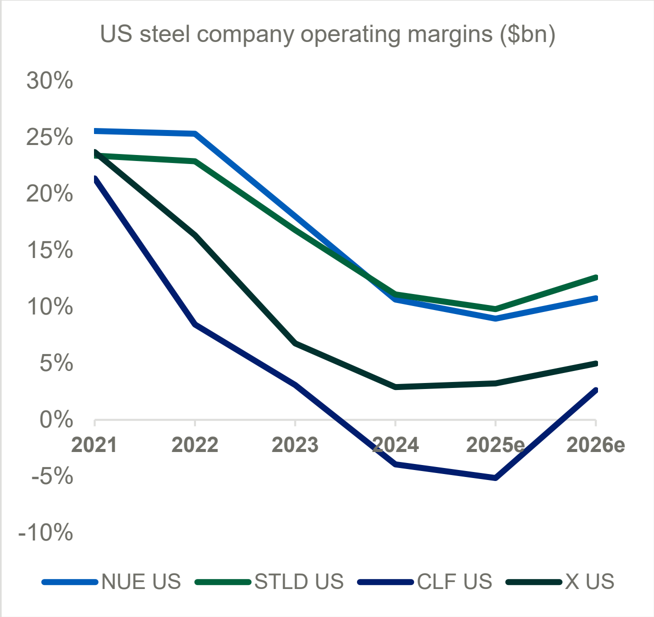
Source: Global Energy Monitor, Global Iron and Steel Tracker, March 2025 (V1.1) release, L&G

In recent years EAF producers have produced superior financial performance, notably 5-10% higher operating margins than blast furnace peers in both pricing upcycles and downcycles in the US market over the last five years.

Greater flexibility in utilisation rate and lower fixed costs gives an EAF system the ability to respond much more rapidly to demand swings and mitigate the worst pricing outcomes in downcycles, while in undersupplied markets it often has some slack capacity in the system that can come online rapidly to limit price spikes, benefitting end-use customers.

The improved financial performance has given EAF steelmakers the balance sheets to invest in modernised capacity, with the bulk of Capex in the last five years reflecting the ramp up of the 3MT facilities at Sinton, Big River 2 and Nucor West Virgina – all of which are EAFs serving largely the automotive steel market.





Source: Bloomberg, L&G, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

Blast furnaces (BFs) and electric arc furnaces (EAFs) differ significantly in their operational lifecycles, maintenance strategies, and capital intensity. A typical blast furnace operates continuously for 15 to 20 years per campaign, with most furnaces supporting two to three campaigns over a total lifespan of 40 to 60 years. Each campaign generally involves a full refractory relining, which is a costly and complex process. In contrast, EAFs are designed for flexibility, with frequent refractory maintenance—often every few months—due to intense thermal cycling and slag wear. While the EAF shell can last for decades, its linings are treated as consumables. EAFs can be started and stopped with ease, making them ideal for variable production schedules and scrap-based steelmaking.

We are in a cycle of adding significant capacity to the US market, to displace traditional imported supply. As this capacity comes to market it is essential that procurement functions in the automotive sector – a key target segment for the new capacity – has accurate information on the climate performance of steel that they are buying through the GSCC or similar framework.

As new EAF capacity is added in autos, this creates direct economic competition between the remaining integrated steelmakers in North America and the EAFs that are making flat products.

L&G

Scrap availability

Scrap is locally abundant but globally scarce – trade barriers are reinforcing regional differences – this makes it more important than ever for investors and customers to have a globally transparent framework to capture climate performance across geographies.

Scrap availability and decarbonisation frameworks

L&G's scrap availability model implies that with achievable improvements in the recovery rate of end-of-life (EOL) steel – estimated at ~59% today by USGS – scrap can provide over 80% of ferrous metallics for steelmaking in the US by 2035 and in Europe by 2050. Our scenarios show that between 2025 and 2050 use of recycled steel for steelmaking in the US and Europe could result in 8 billion fewer tonnes of CO2 than would have been produced through integrated production. These findings corroborate scenarios depicted in JRC previous briefings, by 2050, EU scrap-based steelmaking routes are expected to increase significantly from +30% to +78%.

Decarbonisation frameworks which use a sliding scale, implicitly mask the emissions reductions achieved by expanding the role of scrap. This could result in the industry reporting strong 'climate alignment' at below par recycling levels which disincentives companies to maximise circularity in the industry. In this section we discuss the potential for and implications of:

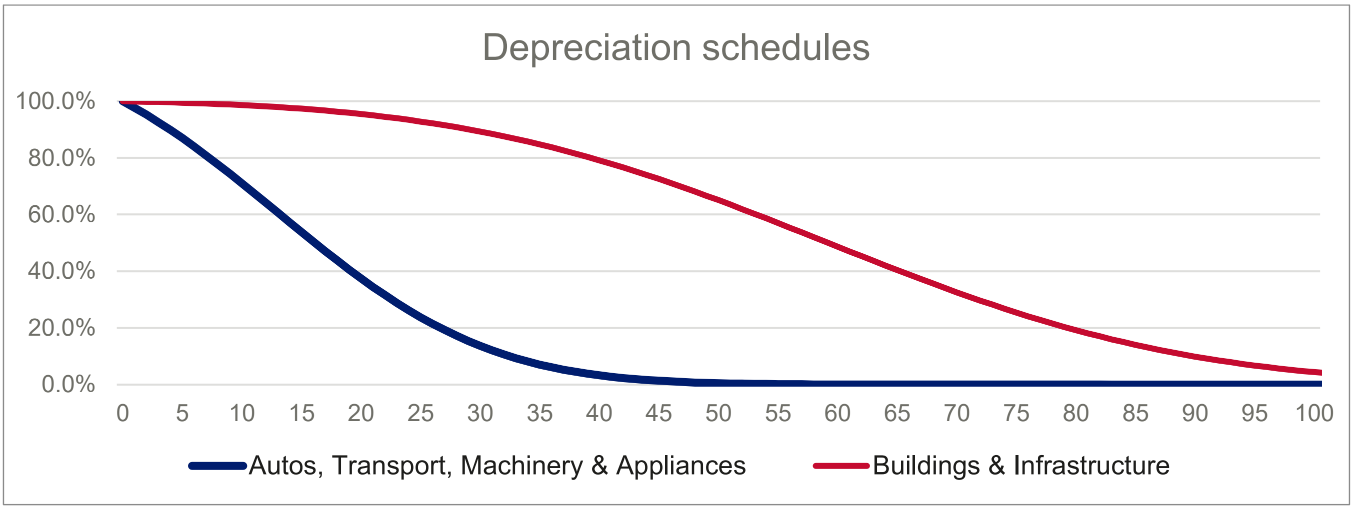
(i) **Improving availability** of end-of-life (EOL) scrap due to past consumption
(ii) **Higher recovery rates** of EOL scrap
(iii) **Higher recycling rates** of the recovered EOL scrap.

We test the sensitivity of these factors to the overall maximal level of EAFs that can be supported by the market.

Main drivers of scrap

Scrap generation in steelmaking comes from two sources: **prompt scrap**, which is produced during current manufacturing, and **obsolete (end-of-life) scrap**, which is released as products reach the end of their useful life. The amount of scrap available depends on accumulated past steel consumption (the steel stock), current production and prompt scrap rates, product lifetimes, the end-of-life recovery rate (about 59% according to USGS), and the recycling rate of recovered steel. These factors together determine how much steel can be reclaimed and recycled in an economy.

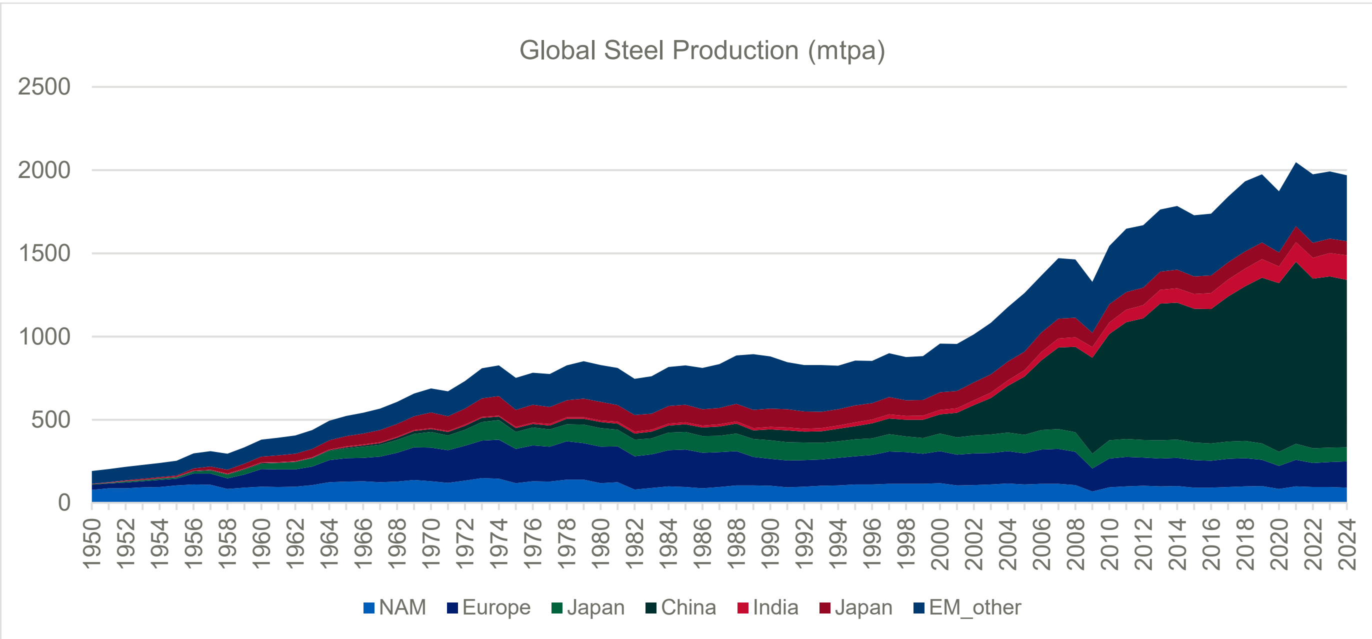
We can segment the products as manufactured goods and longer-cycle construction steel, each with different, lifecycles, recovery rates and prompt scrap rates.



Source: L&G

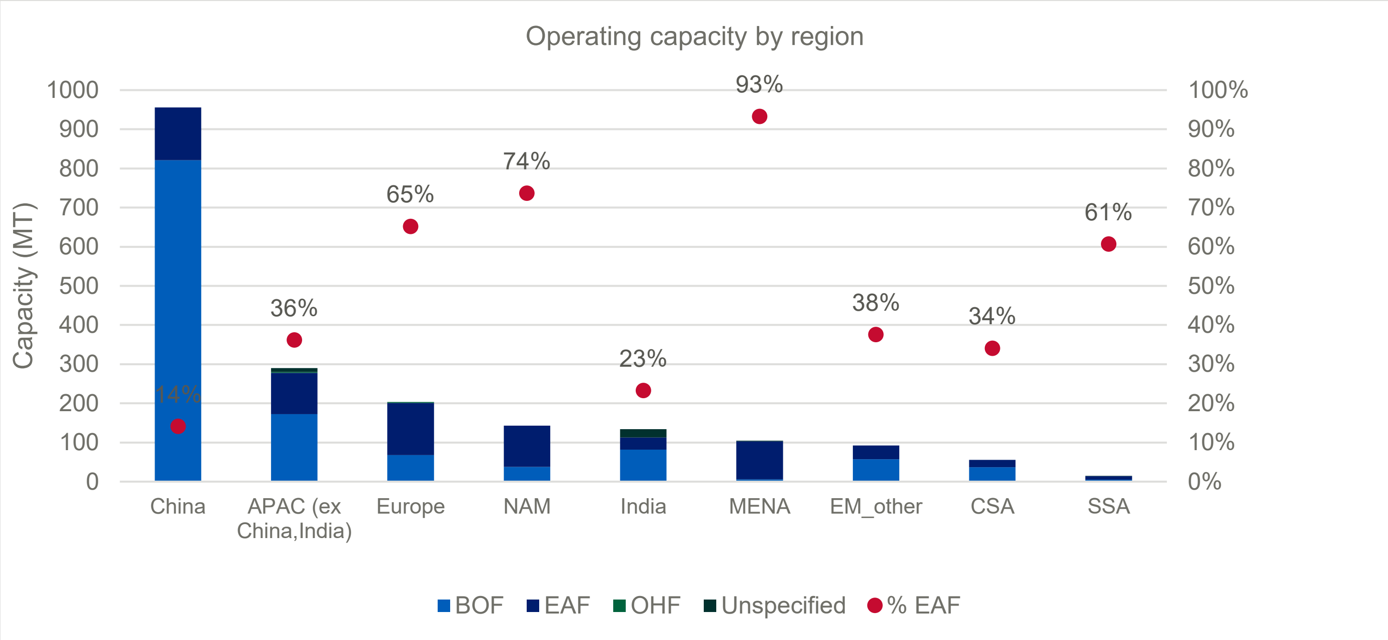
Global picture

China dominates global production and capacity, with a high proportion of blast furnace steelmaking accumulated from its rapid growth in the 2000's.



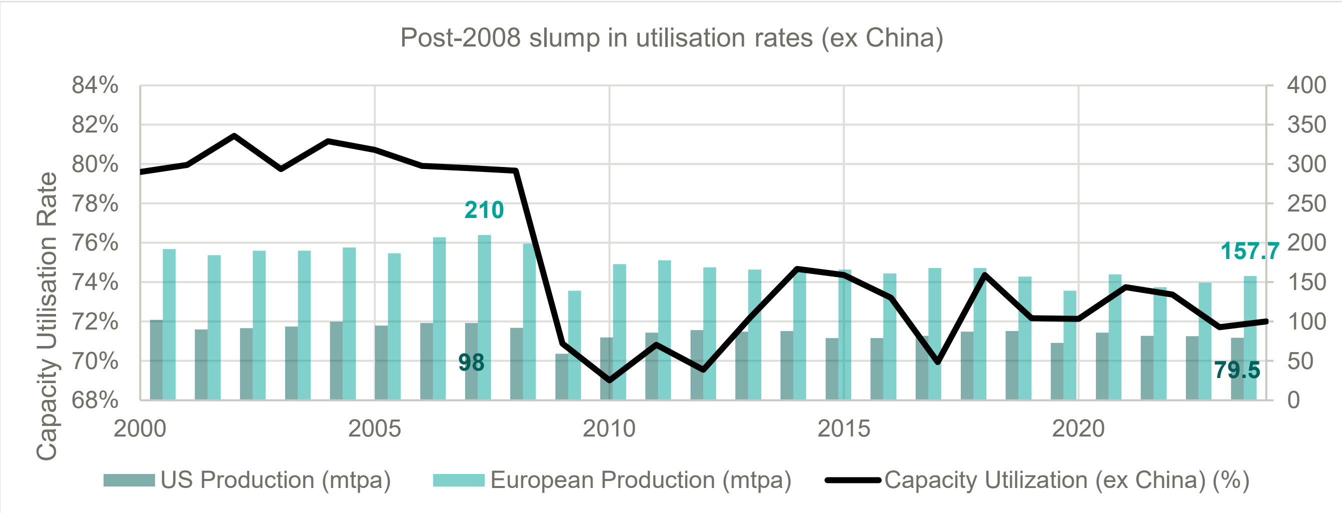
Source: World Steel Association, L&G, 2024.

Other regions such as the North America and Middle East are far more reliant on EAFs which benefit from cheap gas resources in DRI ironmaking and electricity for EAF facilities, as well as abundant scrap resources in the case of the North America.



Source: Global Energy Monitor, Global Iron and Steel Tracker, March 2025 (V1.1) release, L&G

The expanding overcapacity in the Chinese market as growth slows, estimated by the OECD at 600MT, has depressed utilisation rates by 9% since the Global Financial Crisis (GFC) in the rest of the world and challenged pricing. The reaction to this has been trade barriers in the US and Europe notably, Section 232 tariffs, the Carbon Border Adjustment Mechanism (CBAM), anti-dumping duties (AD) and countervailing duties (CVD).



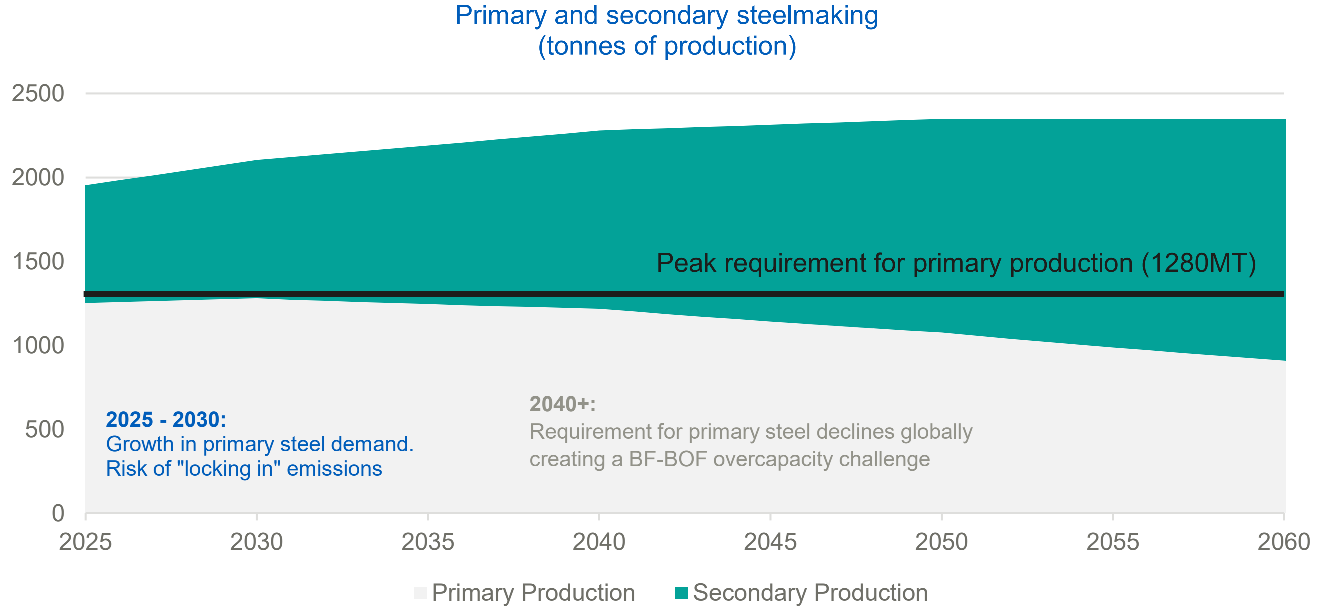
Source: World Steel, Global Energy Monitor, Global Iron and Steel Tracker, March 2025 (V1.1) release, L&G

Trade barriers make it likely that we have a more regionally supplied steel market going forward – with Chinese supply side reforms. **We expect end-of-life scrap availability to double from 650 MT in 2024 to 1270 MT or to 54% of metallics inputs by 2050**, much of this in China – this translates to ~68% EAF market penetration globally. This occurs with a maximal total steel demand of 2350MT in 2050, but a primary steel demand peaking much earlier at 1280MT in 2030. This compares to total blast furnace capacity today of around 1530MT – indicating there is ample primary iron supply in the market.

World Steel Dynamics estimates that EAF production share in OECD countries could rise from 50% to 81% by 2050, while China's share may grow from 10% to over 50%, as this dynamic evolves.

Today's existing blast furnace capacity can fill a peak primary steel requirement (1280MT) – but geopolitical factors prevent China's capacity finding markets. We anticipate much of this will be retired early and replaced by capacity additions in other markets such as India. Our long-term scenarios illustrate that overcapacity in primary production is likely to persist as a consequence of the ongoing build out of capacity in the 2020s and 2030s and a subsequent easing of primary demand as scrap catches up, leading to longer-term BF-BOF overcapacity, which we see as supportive of trade barriers long-term and a more regionalised industry.

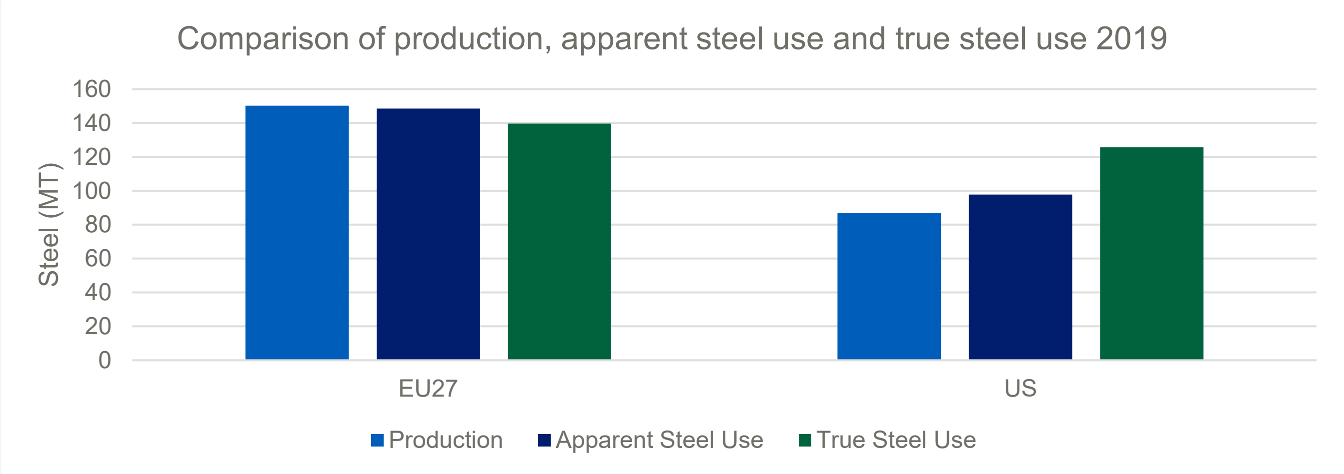
As regional policies and technology pathways diverge, it is increasingly important for investors to have a single simple and comparable standard on which to compare companies such as the GSCC.



Source: World Steel, L&G analysis. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

Trade

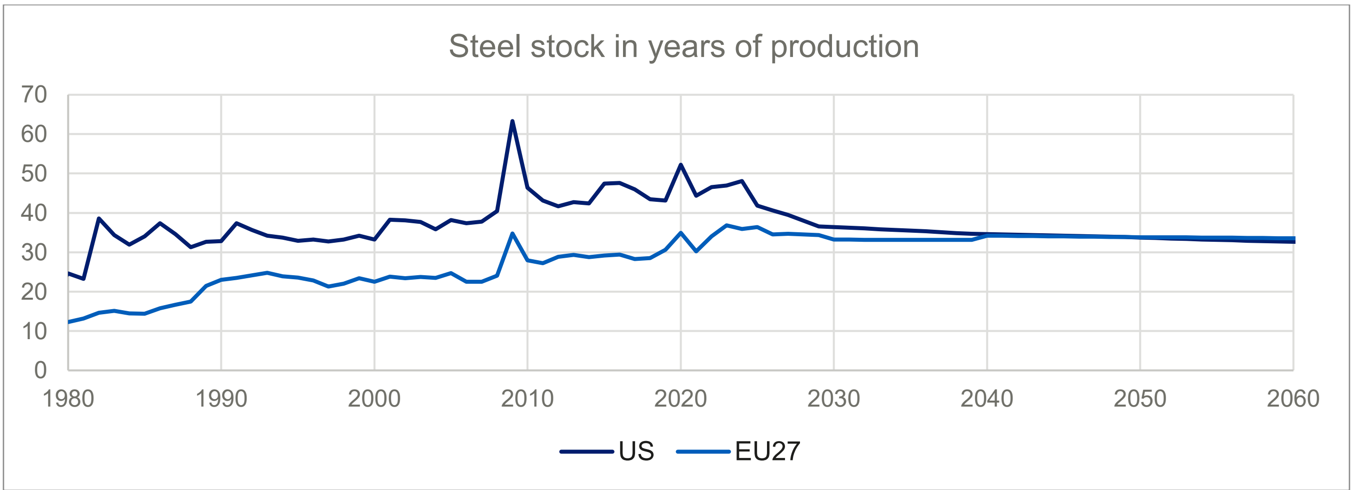
If true steel use (TSU) is higher than apparent steel use (ASU), then the economy is a net importer of steel in the form of manufactured goods. Similarly, if apparent steel use (ASU) is higher than production, then the country is a net importer of crude steel, semi-finished and finished steel products.



Source: World Steel, L&G analysis, as at September 2025.

The US has for an extended period been a net importer of steel both directly and in manufactured finished products. In 2019, US production of steel was less than 70% the true steel use. Over time this has led to an accumulation of 42 years of production in steel stocks in 2025 and hence high scrap availability. We model this normalising to 35x in 2040 as Section 232 tariffs reduce imports, resulting in higher domestic production and increased utilisation factors.

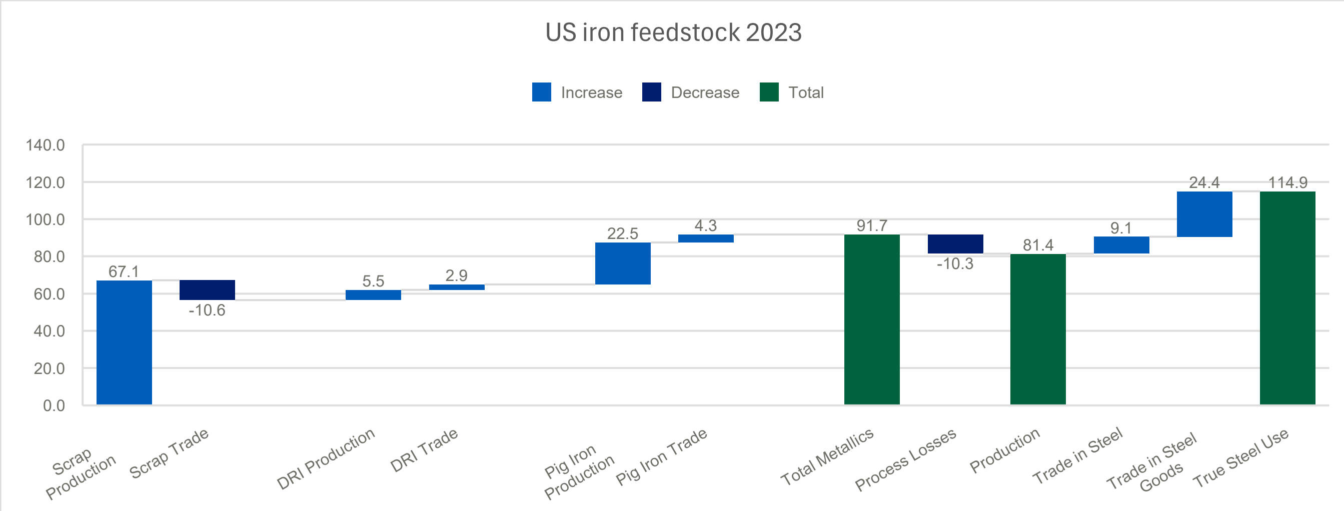
The EU is more export-oriented, with a manufacturing base that exports ~17MT steel in the form of manufactured goods, including 4-5MT in cars. With this much steel leaving the trading block in the form of exports, the stock of steel runs at a much lower ratio to production than in the US market, this permits a lower EAF penetration and a higher role of primary production in this market. The stock of steel normalises at around 35x production.



Source: USGS, World Steel, L&G, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

United States

The US is a major exporter of scrap (15-17mtpa) and a major importer of steel products (26-27mtpa). Much of this is with USMCA trade partners, but with notable contributions from South America and Asia. The US is also a major net importer of steel in manufactured products (~20-25mtpa).

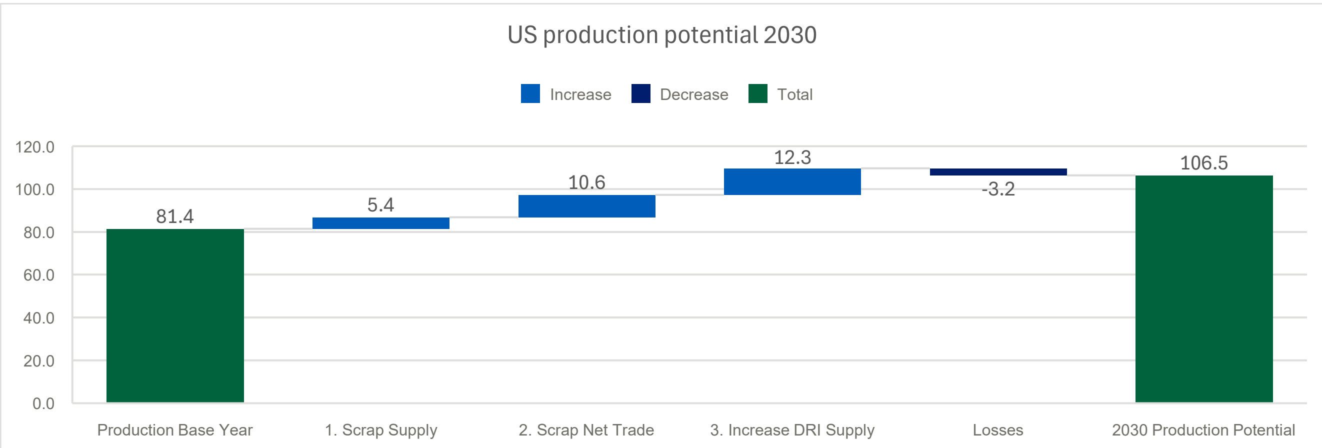


Source: USGS, World Steel, L&G

As a result of tariffs we expect domestic steel production to improve its position on the cost curve and take share from imports through to 2030. This will improve capacity factors in the US market. New EAF capacity that is planned and in construcution adds ~20MT capacity (Global Energy Monitor), and will need a source of feedstock to run on.

Three factors that are likely to result from the trade barriers that can raise the domestic metallics feedstock for this new EAF capacity. (i) increasing price catalyses higher scrap supply (ii) net exports of scrap drop as domestic producers can afford to outbid foreign buyers due to higher steel pricing (iii) DRI supply increases due to planned capacity, as a result of supply pull from anticipated demand from new EAF capacity.

On a forward looking basis, we model resilient trade barriers for the industry and a rapid growth in domestic production as it takes 18MT share from non-USMCA imports which face a 50% tarrif – coupled with demand growth driven by reshoring.

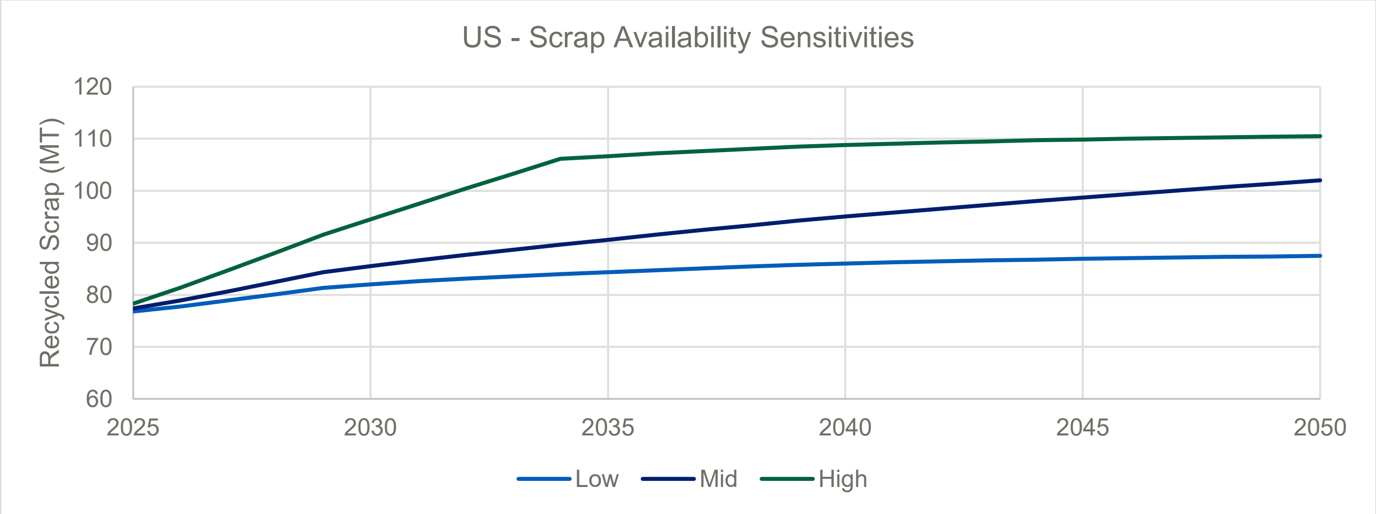


Source: L&G, USGS, WorldSteel, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

Scrap availability sensitivities in the US

Scrap supply responds to pricing in the US market. In a scenario in which prices rise, it is possible that recycled scrap could rise materially, potentially reaching as high as 100MT before 2035 in a stretch scenario driven by significant improvements in recovery rates. Advanced scrap sorting and refining enables a higher recycling rate of recovered scrap over time, due to upcycling.

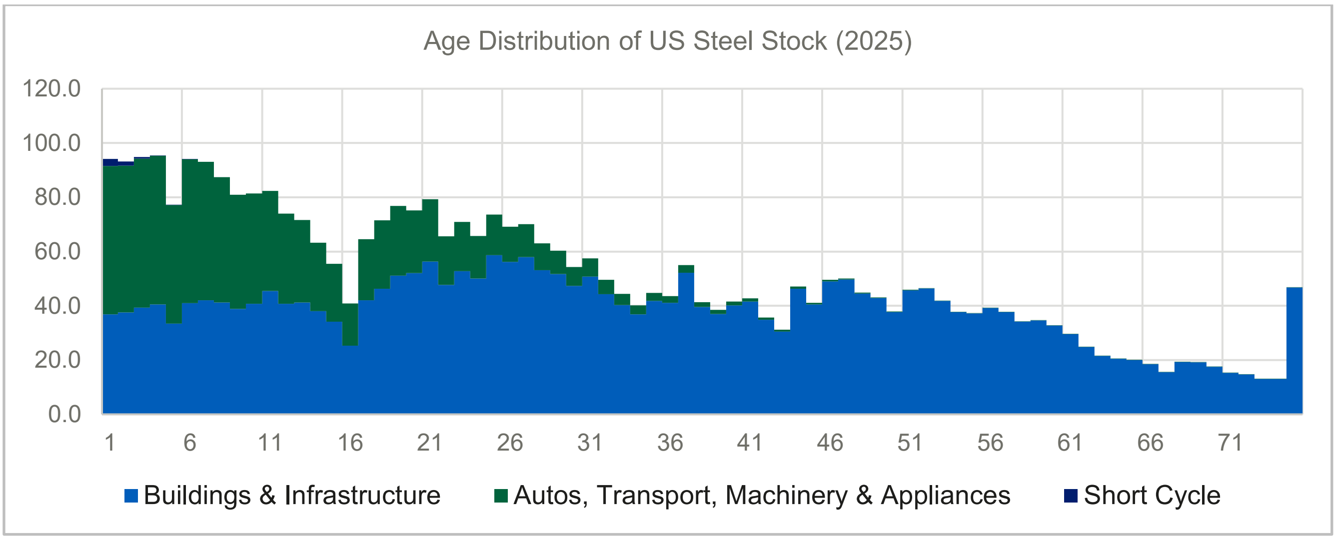
Parameter→	Combined recycling rate - Construction	Combined recycling rate - Machinery	Prompt scrap production rate - Machinery
By Year →	2035	2035	2035
Low	50%	70%	25%
Mid	55%	75%	30%
High	70%	90%	35%



Source: L&G, USGS, WorldSteel, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

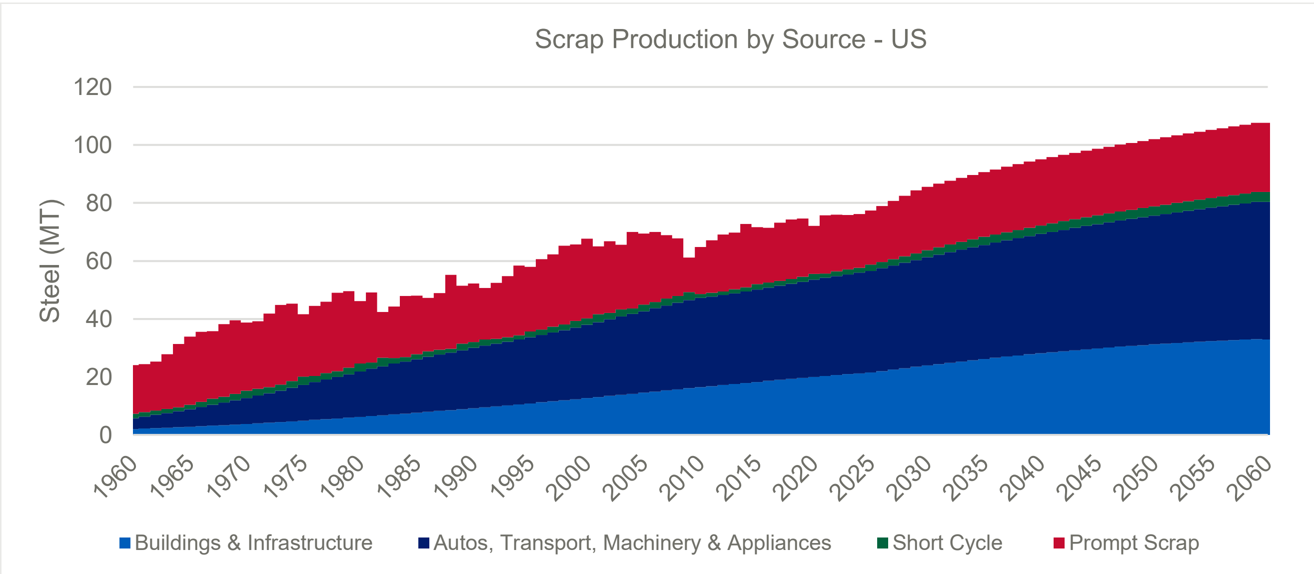
Long-term

Long-term our model predicts a long-term increase in the scrap generated by the US economy driven by the existing and aging stock of buildings, infrastructure, cars, machinery, transport, appliances, and other steel stocks, which are a feature of past consumption. This stands to generate a significant growth in the availability of relatively low-quality obsolete scrap to the market. Nucor and other steelmakers investments into advanced sorting and refining will be required to ensure maximal recycling rates are achieved for this material.



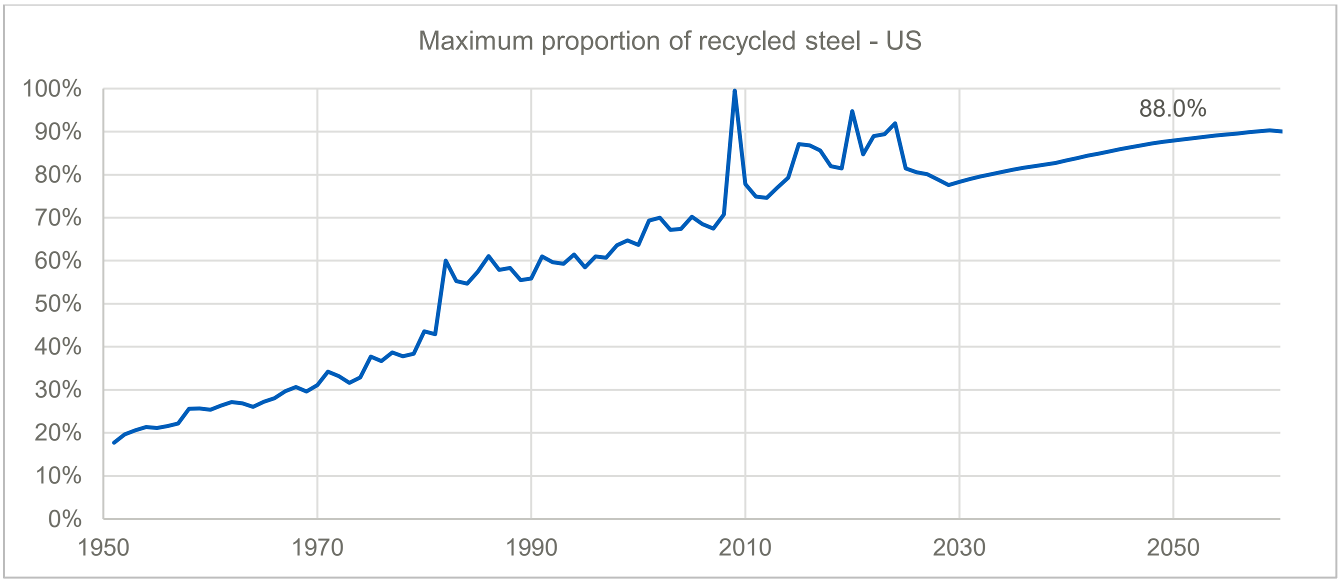
Source: L&G, USGS, WorldSteel as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

As this material reaches the end of its life, we expect that the US economy will generate 100MT of scrap by 2050, enough to support a fully decarbonised DRI-scrap-EAF system, aligned at the system level in line with the calibrations of the GSCC (0.12 tCO_2 per tonne of steel).



Source: L&G, USGS, WorldSteel as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

The low rate of demand growth in steel over the last half century coupled with high consumption has given the US a **scrap resource that is able to cover up to 80-88% of the metallics share on a forward looking basis through to 2050.**



Source: L&G, USGS, WorldSteel, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

Scrap will dominate the metallics share in the US market in the future, supported by expansion of DRI and a general localisation of the supply chains. As such we find that scrap availability is compatible with the GSCC decarbonisation pathways and endorse this framework for the US market.

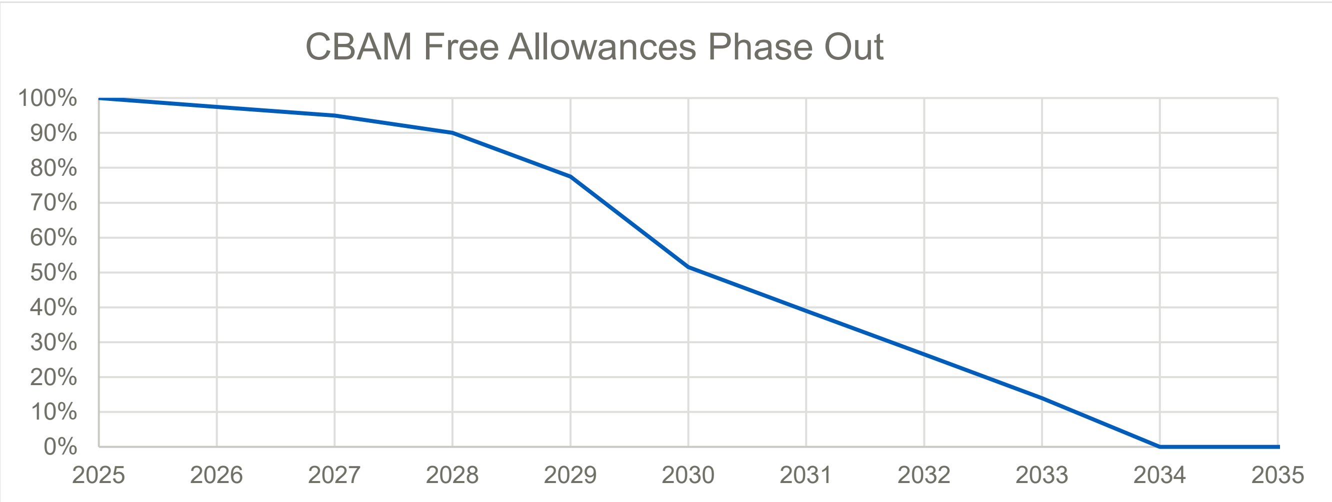
Europe

Having lost more than a third of production since its peak, the European steel industry has suffered from lower utilisation rates and with the exception of strong pricing during Covid, a falling return on capital employed.

In response, Europe has deployed a series of policy tools to address structural challenges in the sector. Central to its trade strategy are **safeguard** and **anti-dumping** measures designed to protect domestic producers from import surges and unfair pricing.

Since 2018, a quota-based safeguard system in response to US 2018 Sec. 232 tariffs has imposed a 25% duty on excess imports. Recent (2025) revisions have tightened quotas and reduced liberalisation rates. These measures remain in place until mid-2026, after which the EU plans to introduce long-term protections, including a '**melted and poured**' clause to curb circumvention. Complementing safeguards, anti-dumping (AD) duties often exceeding 20% target specific countries, with new tariffs recently applied to hot-rolled coil (HRC) from Egypt, Japan, and Vietnam.

In parallel, the EU is implementing the **Carbon Border Adjustment Mechanism (CBAM)** to prevent carbon leakage and ensure fair competition. CBAM will gradually replace free carbon allowances by 2034, with full enforcement beginning in 2026. However, concerns remain over its scope, particularly the exclusion of downstream products and Scope 2 and 3 emissions, which may be addressed in a legislative review in Q4 2025. The review will also explore export carbon leakage and anti-circumvention measures.

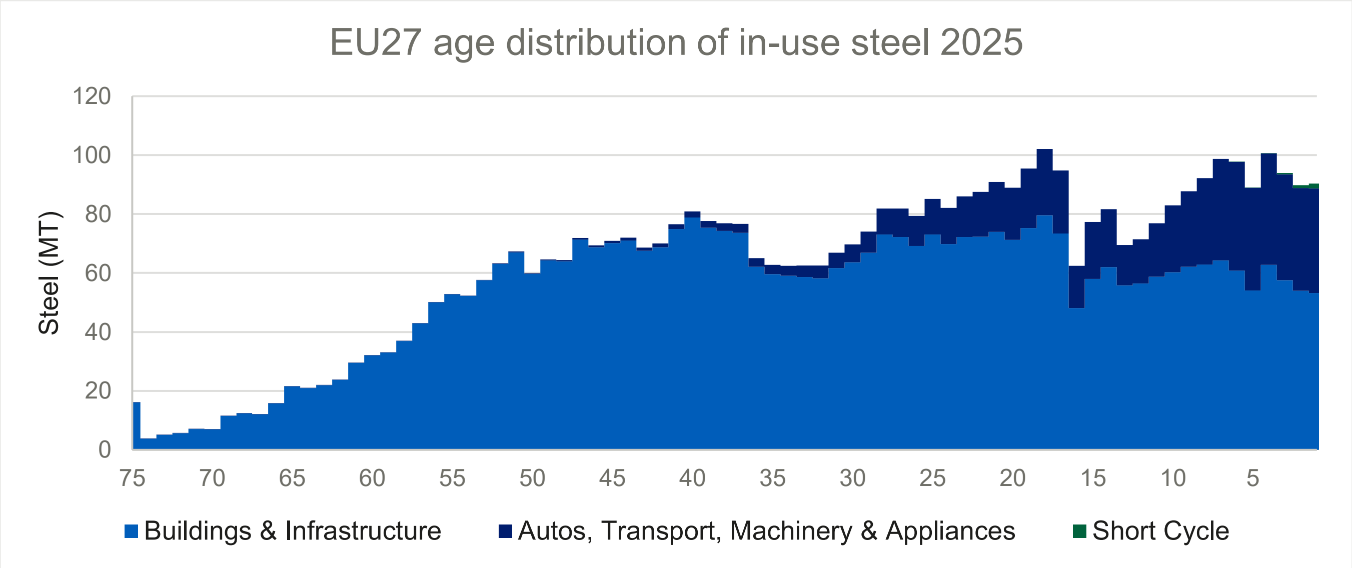


Source: European Commission, L&G, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

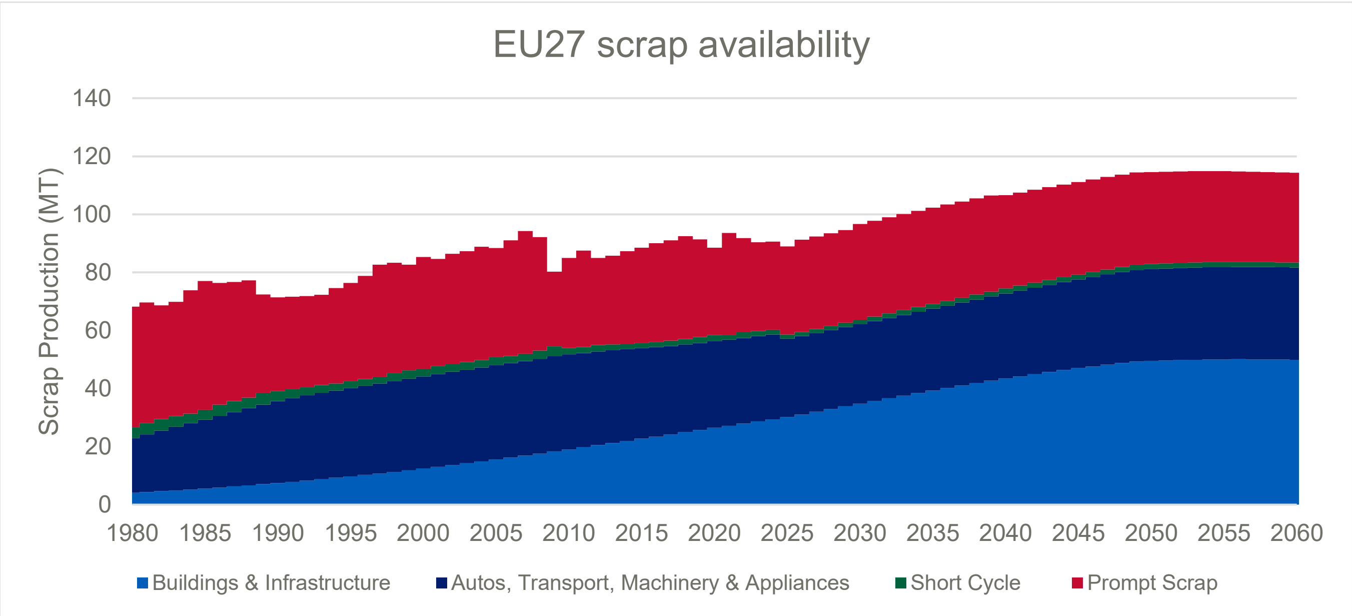
Beyond trade, the EU's Clean Industrial Deal and **Steel and Metals Action Plan (SMAP)** aim to enhance energy affordability, infrastructure, and raw material security. With electricity costs significantly higher than in the US, the EU is pursuing reforms to reduce energy charges, expand grid capacity, and accelerate hydrogen infrastructure. Circularity is also a priority, with initiatives to boost scrap use and potentially restrict scrap exports. To support decarbonisation, the EU is increasing public funding and embedding sustainability criteria in procurement to stimulate demand for green steel. Together, these measures reflect a strategic shift toward a more regional, resilient, and low-carbon steel industry.

We estimate that the EU has a steel stock of 4500MT relative to a production, with an average age between 25-30years, around 35x the levels of production. The result is a longer-term need for primary production in region.

Primary production through the DRI route in Europe is significantly less economic than blast furnace steel due to high gas and electricity prices compounded with a lack of locally sourced high grade iron ore. This creates an imperative for blast furnaces to run for longer in the trading block to support the export oriented automotive industry.



Source: L&G, World Steel, Eurofer, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**



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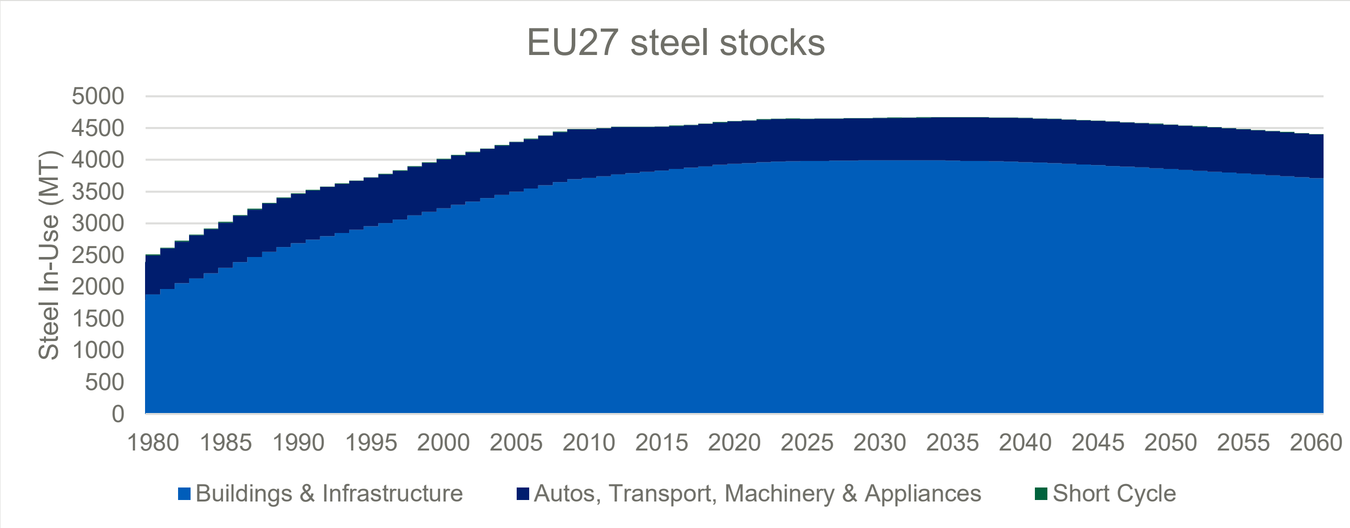


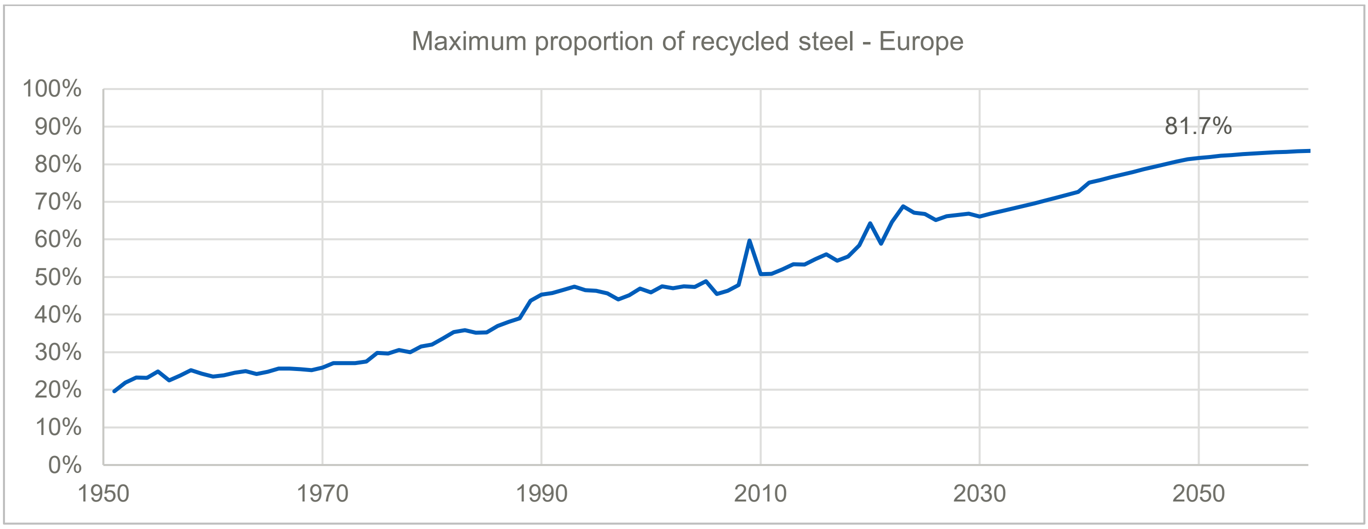
Source: L&G, World Steel, Eurofer, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

While the steel generated by the economy grows over time reaching a ratio of recycled steel to total production of 81.7% net of losses in 2050. The high gas and electricity prices make the transition to a fully DRI-scrap-EAF system much more challenging in Europe than they are in the US.

The application of the CBAM to European assets will force a series of capital allocation decisions to either decarbonise existing capacity, fund new greenfield DRI capacity or convert primary production to secondary production – driven by the economics of avoiding a carbon price. A complex interplay between the EU carbon price, gas pricing, scrap and electricity pricing will determine the cost curve on a forward-looking basis. With carbon pricing in the 100-120EUR per tonne range would likely to drive integrated capacity out of the market in the long term, if not shielded by subsidies or government policy.

If integrated producers plus the carbon price set the marginal tonne in Europe, the investment characteristics of EAF and DRI capacity is likely to improve, as carbon allowances run off. Here producers should plan capital allocation decisions based on the economics embedding a carbon price – this is the approach taken by the Low Emissions Steel Standard – which is the leading framework in Europe and influencing policy and regulations in the region.

The greater ongoing need for primary production in Europe, combined with high gas prices that limit DRI indicate a wider role for LESS as a decarbonisation framework in Europe, as integrated producers continue to produce. Incremental improvements in carbon performance of capacity from integrated producers which align with CBAM and policy frameworks are important for regional planning and capital allocation, however as investors, we would still like to see parallel GSCC reporting and transition plans by European steel producers for comparability across markets. The GSCC framework is well aligned with the policy objectives of the block and significantly simpler and easier to interpret than the more detailed technical analysis of the LESS.



Source: L&G, World Steel, Eurofer, as at September 2025. **Assumptions, opinions, and estimates are provided for illustrative purposes only. There is no guarantee that any forecasts made will come to pass.**

Challenges and opportunities for expanding EAF steelmaking

Electricity price and access

EAF steelmaking requires about 350–500 kWh of electricity per tonne of steel produced. With data centres and AI driving electricity demand, global power consumption is expected to rise by over 15% in the next five years. In some regions, wholesale electricity prices have doubled since 2021, reaching €100–150/MWh in parts of Europe. This competition for grid capacity and rising costs could erode the economic advantage of EAFs, especially where renewables are limited or grid congestion is severe.

Getting access to clean dispatchable power is a critical challenge that companies need to solve in order to continue to add EAF capacity to the grid.

Nucor is securing cheap and clean power for its EAFs through a mix of large-scale renewable PPAs, investments in advanced nuclear and fusion, demand aggregation partnerships, and flexible grid strategies. These efforts position Nucor as a global leader in low-carbon steel production and energy innovation. Around 40% of its power comes from clean or renewable sources.

Additional DRI capacity

EAFs need high-purity iron units, typically supplied by direct reduced iron (DRI). In the US, natural gas prices have averaged $2–3/MMBtu, supporting competitive DRI production at costs around $250–350/tonne. In Europe, natural gas prices have spiked above $10/MMBtu since 2022, making gas-based DRI much less viable. Carbon pricing of 100-150EUR in Europe may be sufficient to make DRI cost competitive with integrated facilities in the block. However, the real unlock would be cheap hydrogen.

Hydrogen-based DRI requires hydrogen at less than $2/kg to be competitive, but current green hydrogen prices are typically $4–6/kg or higher. As a result, blast furnaces which can produce steel at carbon intensities of 1.7–2.2 tCO_2/tonne may remain in operation longer, especially if policy or subsidies continue to support integrated steelmakers.

Conclusion

Expanding availability of scrap, improvements in technology and regionalisation of steel markets, resulting from trade barriers, make the shift to a high >80% penetration of EAFs increasingly viable in the US and Europe. While near term there is a continued need for BF-BOF steel production from integrated steelmakers in developed markets, the trajectory implied by the GSCC is a reasonable trajectory to target for traditional integrated players looking to align with the energy transition.

We believe existing calibrations of the sliding scale in ResponsibleSteel, and other similar frameworks, can confuse investors and customers by labelling existing integrated capacity as green or net-zero aligned in developed markets– while under-rewarding the emissions savings that can be generated through increasing the efficiency of scrap recovery and EAF steelmaking in developed markets. L&G continue to engage with decarbonisation frameworks across the sector, to evolve thinking as the transition progresses.

We support steelmakers in using the Global Steel Climate Council (GSCC) standard for setting science-based targets as well as **customers and governments in using the GSSC for product specifications during procurement** in the European and US markets. Since we believe this is likely to result in regionally effective capital allocation for an orderly transition in the coming decades.

L&G look forward to continuing to engage with the GSCC and with Nucor, to ensure the Steel Climate Standard continues to evolve with technology progress, climate science and policy priorities in the regions it is adopted – and continues to be calibrated in a way that rewards ambition on decarbonisation.

All views expressed by L&G as at September 2025.

L&G Global

Unless otherwise stated, references herein to "L&G", "we" and "us" are meant to capture the global conglomerate that includes:

- **European Economic Area:** LGIM Managers (Europe) Limited, authorised and regulated by the Central Bank of Ireland as a UCITS management company (pursuant to European Communities (Undertakings for Collective Investment in Transferable Securities) Regulations, 2011 (as amended) and as an alternative investment fund manager (pursuant to the European Union (Alternative Investment Fund Managers) Regulations 2013 (as amended).

The L&G Stewardship team acts on behalf of all such locally authorised entities.

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