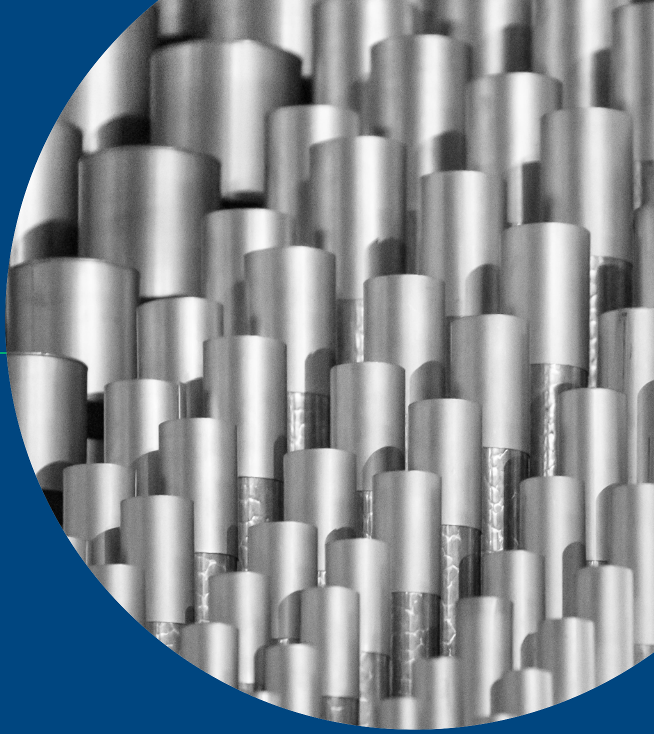
LEADERSHIP GROUP FOR INDUSTRY TRANSITION

From 'hard-to-abate' to net-zero: Policy priorities for decarbonising steel by 2050



Key messages

- Several analyses show that steelmaking can be almost fully decarbonised by 2050 by retrofitting blast furnaces and adding carbon capture and storage (CCS), scaling up hydrogen-based direct reduced iron (DRI), boosting steel recycling, and slowing demand growth through more efficient steel use.
- Major investments in steelmaking capacity are coming. To avoid locking in high levels of emissions, or else creating stranded assets, rapid action is needed to initiate the sector's transition right away and prevent new blast furnaces from being added – and existing ones from being relined – by about 2025.
- Policy-makers have key roles to play in enabling the sector's transition, by ensuring ample supplies of clean electricity as well as green hydrogen; creating lead markets for green steel; supporting research and innovation; and using climate policies, standards and regulation to steer the sector.
- International cooperation is essential to ensure that the sector as a whole moves in the right direction, and laggards do not undercut frontrunners' efforts. It can also help the sector make the most of different countries' strengths, such as abundant renewable energy, to accelerate decarbonisation.

Steel is an essential component of modern economies, used in everything from buildings, to transport infrastructure, heavy equipment, vehicles and consumer goods. It is also used in key green technologies: wind turbines, electric vehicles, public transit, advanced manufacturing.

Yet steel is also a major carbon emitter, producing 7% of global greenhouse gas (GHG) emissions and 10% of global CO_2 emissions in 2018.[1] Primary steel production – made from iron ore, not from recycled scrap – is the main source of those emissions, due to its reliance on metallurgical coal in blast furnaces.[2]

Moreover, global steel demand continues to rise, and global crude steel production capacity has more than doubled in the past two decades.[3] Steel production, already 1,950 Mt today, could increase by a third by 2050. Without a dramatic shift in the industry, steelmaking could emit another 90 Gt of CO_2 by 2050 – almost 20% of the remaining global CO_2 budget for a 50% chance to keep global warming below 1.5°C.

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For decades, policy-makers have treated steel as a "hard-to-abate" sector, citing a lack of viable alternative technologies for primary production and the long lifetimes of steel mills and their equipment.[4] However, technologies have advanced, and multiple analyses now show that with the right policies and investments, the steel sector can be almost completely decarbonised by 2050.[5]

More important, steelmaking has to be decarbonised – quickly – if the world is to avoid catastrophic climate change impacts. The 1.5°C scenario published recently by the International Energy Agency (IEA), for instance, calls for the sector's emissions to drop by 24% by 2030 and almost 91% by 2050.[6]

Net-zero scenarios for steel

Three major new studies explore how the steel sector could achieve net zero by 2050: a bottom-up analysis by the Net Zero Steel project of the Institute for Sustainable Development and International Relations (IDDRI), and top-down analyses by E3G and the Pacific Northwest National Laboratory (PNNL), and by the Mission Possible Partnership (MPP).

The **IDDRI study**, which draws on a global database of steel facilities established by the Global Energy Monitor, finds that the steel sector can decarbonise while continuing to meet demand by using a mix of:

- Recycled electric arc furnace (EAF) steel with renewable electricity;
- Primary steel from hydrogen direct reduced iron (HDRI) followed by an EAF;
- Methane-fed direct reduced iron furnaces with 90% carbon capture and storage (CCS); and
- Blast furnace basic oxygen furnaces (BF-BOF) with CCS capturing 90% of emissions.[7]

Global emissions from the sector would drop even more quickly than the IEA anticipates, by 29–31% by 2030, through reductions in the emissions-intensity of both primary and secondary steel, combined with an increase in steel recycling. (Notably, the IEA 1.5°C scenario envisions more than half the emission reductions by 2030 would come from materials efficiency and recycling.)[8]

The IDDRI scenario models nine scenarios, but all anticipate a sharp increase in HDRI, to 6.0–16.1% of the market by 2030 and 23.1–42.2% by 2050. This and EAF would become the dominant technologies for new steel sector investments. CCS, meanwhile, would be used on 3.7–12.9% of global steel by 2030 and 6.2–21.6% by 2050. The study also suggests potential shifts in the location of production, with iron processing sometimes decoupled from steel production to reduce the overall cost of low-carbon steel. At least 10% of global clean primary iron could be produced in new facilities with ample supplies of renewable energy for hydrogen or geology suitable for CCS, and be traded internationally to supplement recycled steel in EAF production.

Hydrogen-based technologies play a key role in all net-zero scenarios

The **E3G/PNLL study**, based on the Global Change Analysis Model (GCAM),[9] highlights the need for a rapid and large-scale shift towards breakthrough near-zero-GHG steelmaking technologies, including HDRI (projected to start in the mid-2020s and rise to 19% of global production by 2050) and EAFs.[10] CCS is needed as soon as 2025 to retrofit existing or equip new blast furnaces, but over time, the share of blast furnaces declines as other low-carbon technologies become more cost-competitive.

The **MPP study** suggests that 40–55% of primary steel production in 2050 could use hydrogen-based technologies, requiring 35–55 Mt per year of green hydrogen.[11] Hydrogen steelmaking could become competitive with CCS technologies when zero-carbon hydrogen prices hit $2.20–2.90/kg later in the 2020s. Growth in the supply of steel scrap, meanwhile, particularly in China, is expected to enable its share of total steel charge composition to grow from 30% today to over 40% by 2050, replacing iron ore.

Another key take-away from the MPP study is that different technologies will be cost-competitive in different locations. While most primary steelmaking today is in places with access to coal mines, iron ore deposits, and transport infrastructure, in the future, locations may be chosen for their access to low-cost clean electricity, CCS, low-cost natural gas, and proximity to industrial clusters, or other factors.

Time is of the essence

Like the IEA 1.5°C scenario, all three of these studies stress the importance of moving quickly to stop building conventional blast furnaces – as soon as 2025. With average lifetimes of 20–25 years, the E3G/PNLL study notes, any furnaces without CCS that come online in 2025 or later risk becoming stranded assets.[12] The same is true for existing furnaces that are relined but not retrofitted with CCS.

No new blast furnaces without CCS after 2025

Letting these blast furnaces continue to operate, on the other hand, would have serious implications for the climate. One study found that if every furnace that needs to be replaced or relined were to be retrofitted or retired starting in 2022, existing plants would still emit 21 Gt CO_2.[13] A five-year delay would bring cumulative emissions to 40 Gt CO_2e, and a 10-year delay, to 53 Gt CO_2e.[14]

Conversely, the studies stress the need to bring both HDRI plants and blast furnaces with CCS online as soon as possible. Europe appears to be on track to meet its goal to have several HDRI plants operating by 2028, but progress on CCS-equipped plants may be too slow to meet a 2030 goal.[15] MPP's net-zero scenario requires about 280 Mt of green primary steel production by 2030, about 70 plants' worth.[16] To achieve this, R&D and commercialisation efforts will need to accelerate significantly around the world.

The crucial role of policy-makers

Unlocking investment in these first-of-a-kind plants will require policy and value-chain collaboration to make them competitive, as their operating costs could be up to 55% higher in the 2020s than conventional steelmaking.[17] Policy can promote an early switch to low-GHG technologies, through standards and regulations, economic incentives, and carbon pricing. The MPP report estimates that up to 1.3 Gt CO_2 of steel emissions could be avoided in 2030 with a carbon price around US$70, and the acceleration of the sector's transition would avoid an additional 14 Gt CO_2 by 2050.

The E3G/PNLL study stresses the importance of scaling up steel recycling and adopting several material efficiency measures, which together would achieve 50% of the mitigation needed by 2050 for a 1.5°C trajectory.[18] These solutions can be deployed right away and can start to reduce GHG emissions while breakthrough technologies for primary steel production are commercialised.

Another key task for policy-makers is to provide the clean energy supply needed to support green steel. In the E3G/PNLL 1.5°C scenario, electricity and hydrogen account for 65% of global fuel consumption in the iron and steel sector by 2050. The industry's electricity use would rise from 1,300 TWh in 2019 to 1,900 TWh in 2050, while hydrogen use would reach 4.5 EJ in 2050. For meeting this demand abundant clean electricity and green hydrogen are essential.

Global collaboration is key

Steel is a global commodity, and it is developing and emerging economies, mainly in Asia – not Europe or North America – that are driving demand growth. This means decarbonising the sector is not a task for a few leaders; individual countries or regions cannot succeed alone, especially given the higher cost of green steel. The E3G/PNLL study stresses that while each of the major steel producers may follow different technological pathways, all need to step up their efforts right away.

This is the motivation behind the Glasgow Breakthrough on Steel, announced at the World Leaders Summit at COP26.[19] Countries representing 32% of global steel production agreed to collaborate on steel innovation, procurement, industry standards and finance to ensure that green steel is the preferred choice by 2030. Participants include all the top producers except China: the EU, the US, Japan, Korea and India.

Several additional events at COP26, hosted by LeadIT and other key actors, are bringing together public officials, corporate leaders, industry associations and civil society groups to discuss ways to accelerate the steel sector's decarbonisation – including a high-level event on how to achieve a "just transformation".[20]

Countries also need to explicitly incorporate steel decarbonisation in their climate strategies. A LeadIT analysis of the latest round of nationally determined contributions (NDCs)[21] found 36% mentioned specific industries such as steel or aluminium – up from 25% in the first round, but still far too few. Two positive examples include the Republic of Korea's focus on hydrogen reduction in steelmaking, and the UK's plan to invest £12 billion in a green industrial revolution, aiming to create 250,000 high-skill jobs.

In 2022, the LeadIT Secretariat will support members to develop or update national decarbonisation roadmaps, with a focus on the industrial transition. LeadIT will also continue to encourage its members (countries and companies) to showcase new industry transition policies, partnerships, and value chain collaborations between developing and developed countries at Stockholm+50 in 2022 and at the Global Stocktake in 2023.

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[8] IEA (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. International Energy Agency, Paris. https://www.iea.org/reports/net-zero-by-2050.

[9] GCAM is an open-source, global integrated assessment model. The source code and assumptions are available at https://github.com/JGCRI/gcam-core.

[10] Yu et al. (2021). 1.5C Steel.

[11] MPP (2021). Net-Zero Steel Sector Transition Strategy.

[12] Yu et al. (2021). 1.5C Steel.

[13] Vogl et al. (2021). Phasing out the blast furnace to meet global climate targets.

[14] Similarly, the E3G/PNLL study estimates that a 10-year delay in action would result in the steel industry emitting an additional 20 Gt CO2 between 2020 and 2050. See Yu et al. (2021), 1.5C Steel.

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