Public policy paper

# Climate change and the production of iron and steel

Whether it is future energy and transport systems, protection from the impacts of natural disasters, climate-resilient infrastructure, construction and housing, low-carbon manufacturing and agriculture, steel is at the heart of delivering solutions.

Increasingly, circular economic approaches are prolonging steel's useful life. The steel industry is an integral part of the circular economy – with our material ideally suited to be remanufactured, reused and ultimately recycled.

## The Paris Agreement

**The Paris Agreement was adopted in 2015. The agreement's central aim is to limit global temperature rise to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. The agreement aims to reach a balance between anthropogenic emissions and removals by sinks in the second half of the century.**

# Transforming steel production

Iron is made by removing oxygen and other impurities from iron ore. When iron is combined with carbon, recycled steel and small amounts of other elements it becomes steel. Once made, it is a permanent resource; it is 100% and infinitely recyclable without any loss of properties.

Steelmaking is a truly global industry, and raw materials (such as iron ore and scrap) and steel products are traded globally to a large extent. Today, over 70% of global steel production takes place in Asia[1].

**The production of steel remains a $CO_2$ and energy-intensive activity. However, the steel industry is committed to continuing to reduce the footprint from its operations and the use of its products.**

**Our industry fully supports the aims of the Paris Agreement.**

**There is no single solution to drastically reducing $CO_2$ emissions from our industry, however, the main elements enabling industrial and societal transformation are:**

## Reducing our own impact

We take responsibility for our impact by reducing our emissions from the production of iron and steel. We strive for efficiency in our processes and maximised use of scrap. We continue our efforts to develop and deploy breakthrough low-carbon steel making technologies.

## Efficiency and the circular economy

We drive more reuse, remanufacturing and recycling, all key elements of the circular economy.

Modern steels are stronger, lighter and more durable than ever before. The steel industry works intensively with its customers, from design to end-of-life, to share our material knowledge to ensure that steel is used as efficiently as possible in any given application. In this way we enable the circular economy and contribute to material efficiency at every stage.

## Developing advanced steel products to enable societal transformations

We are developing and manufacturing the advanced steel products necessary to facilitate the required transformation and adaptation of society to reach carbon neutrality through zero energy buildings, renewable energy infrastructures, electrification and more.

We assist our customers in delivering innovative solutions through the use of our material and the introduction of new advanced steel products.

While each of these will play a strong role, this paper focuses on the first element – mitigating our own emissions from the production of iron and steel.

# Key points from this policy paper

The important elements to enable industrial and societal transformation are: reducing our impact, creating advanced products, and focusing on the circular economy

01 step^up 02 03

There are three components to reducing our impact: step up, maximising scrap use, and developing breakthrough technologies

The steel industry will mitigate its $CO_2$ emissions

The steel industry will create partnerships to enable transformation

The steel industry will be open and transparent

# Being responsible - Reducing our own impact

- In 2020, on average, every tonne of steel produced led to the emission of 1.85[1] tonnes of $CO_2$ into the atmosphere. In 2020, 1,860 million tonnes (Mt) of steel were produced[2], and total direct emissions from our sector were of the order of 2.6 billion tonnes[3], representing between 7% and 9%. of global anthropogenic $CO_2$ emissions.
- In 2020, the International Energy Agency (IEA) released a roadmap[3] that explores potential technologies and strategies necessary for the iron and steel sector to pursue a pathway compatible with the IEA's broader vision of a more sustainable energy sector.

## The IEA Iron and Steel Technology Roadmap

**In October 2020, the International Energy Agency (IEA) released its Iron and Steel Technology Roadmap[3]. This document analyses the impacts and trade-offs of different technology choices and policy targets for the industry to be in line with the goals of the Paris Agreement.**

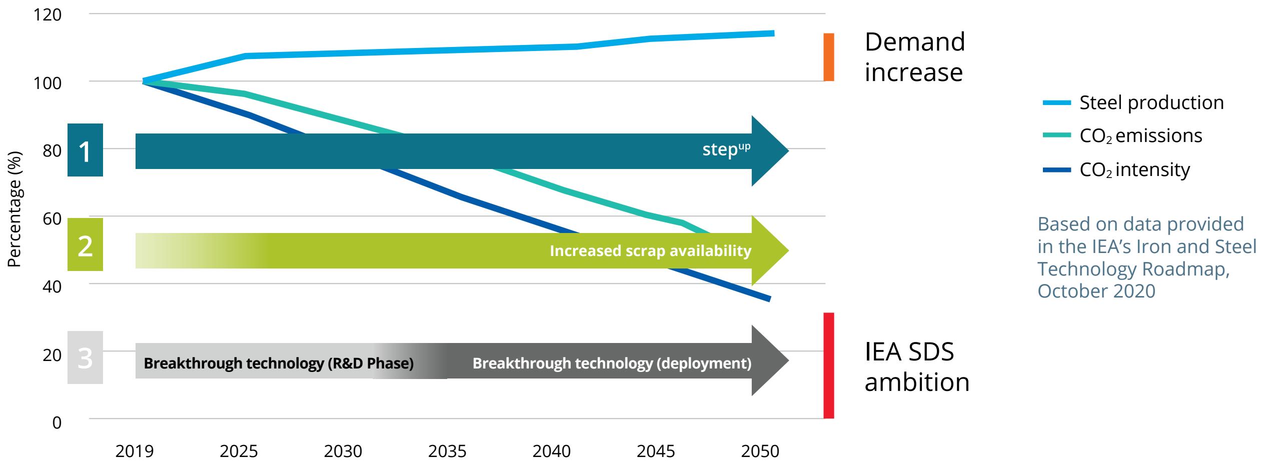
**Under the IEA's Sustainable Development Scenario, total direct emissions from the iron and steel sector fall by more than 50% by 2050 relative to 2019. On the same pathway, the emissions intensity of crude steel production must fall by 58%.**

**The IEA states that steel is vital to modern economies and notes that sustaining the projected demand growth in steel while reducing emissions poses immense challenges. While efficiency improvements will help the industry, there is a need to develop further and deploy a broad portfolio of breakthrough technology options and enabling infrastructure to achieve long term, deep reduction in emissions.**

**Furthermore, the IEA notes the critical role governments must play in ensuring a sustainable transition of the sector, and concludes with a call to action for governments, the steel industry, the research and NGO communities and other stakeholders.**

# Reducing our impact

**Steel production, total $CO_2$ emissions and $CO_2$ intensity, 2019 - 2050 under the International Energy Agency (IEA) Sustainable Development Scenario (SDS)**




Based on data provided in the IEA's Iron and Steel Technology Roadmap, October 2020

## 1. step^up

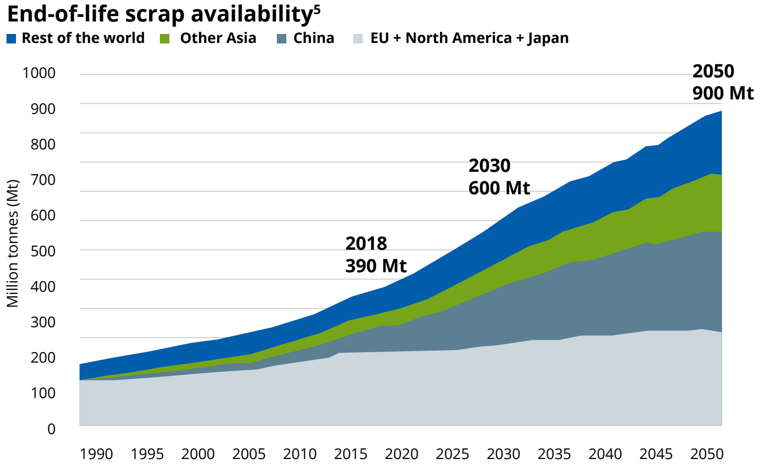
worldsteel's members, who represent around 85% of global steel production, continue to find ways to drive efficiency in energy and raw material use and to invest in energy-saving technologies. On the road to the deployment of breakthrough technology, short and medium-term process efficiency gains will provide important $CO_2$ emissions reductions.

In 2019, the worldsteel Board of Members launched 'step up', a new industry-wide efficiency review process based on leading practices that focus on the key efficiency levers of raw material quality, energy efficiency, process yield and process reliability.

The successful implementation of the step up methodology has the potential of reducing direct and indirect emissions by up to 20% at the average ore-based steelmaking site, and up to 50% at the average scrap-based facility[4]. All of worldsteel's members are encouraged to participate in the step up programme, and broad adoption of the methodology across our industry will elevate the performance of all sites to levels commensurate with the very best performers. As such, it represents a key initiative in the effort to reduce our impact.

## 2. Maximise scrap use

**End-of-life scrap availability[5]**




Every steel plant is also a recycling plant, and all steel production uses scrap, up to 100% in the electric arc furnace (EAF) and up to 30% in the blast furnace (BF) route. All scrap that is collected is recycled, and the overall recycling rate today is estimated to be about 85%. This high level of recycling means that there is limited room for improvement.

Scrap plays a key role in reducing industry emissions and resource consumption. Every tonne of scrap used for steel production avoids the emission of 1.5 tonnes of carbon dioxide, and the consumption of 1.4 tonnes of iron ore, 740 kg of coal and 120 kg of limestone[6].

The future expansion of scrap-based steel production will depend on the availability of high-grade scrap. While iron ore supply can flex with demand, global scrap availability is a function of steel demand and the arising of scrap when steel-containing products reach the end of their life. Global steelmaking capacity experienced a phase of explosive growth from the early 2000s largely fuelled by investment in new capacity in China. With steel products having an average lifespan of 40 years[7], this steel will begin to enter the scrap market in the next decade, enabling a significant reduction of steel industry emissions.

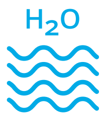
# 3. Breakthrough technology

Currently, the only technically and commercially feasible way to produce steel from iron ore[8] is through the use of fossil fuels as reducing agents.

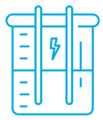
The blast furnace is the dominant technology used to reduce iron ore today. The modern blast furnace is continually being developed and refined and currently operates close to the efficiency limit of the reduction process.

Therefore, to achieve the drastic reductions needed, an entirely new, transformative approach to ironmaking is required and there are several promising initiatives under development. These fall into three broad categories:


1. Using carbon as a reductant while preventing the emission of fossil $CO_2$, for example using carbon capture, utilisation and storage (**CCUS**) and/or sustainable **biomass**.




2. Substituting **hydrogen**[9] for carbon as a reductant, generating $H_2O$ (water) rather than $CO_2$.



3. Using electrical energy through an **electrolysis**-based process.

This reliance on fossil fuels defines the steel industry's past as a major emitter of greenhouse gases, but we are committed to a low-carbon future.

## A portfolio of technology options

**There is no single solution to low-carbon steelmaking, and a broad portfolio of technological options will be required to be deployed alone or in combination as local circumstances permit. Our industry is leading many research, development and deployment (RD&D) efforts globally to develop each of these options.**

**In any given location, the choice of which breakthrough solution to deploy will be determined by the availability of resources and local policy support.**

**For example:**

- In areas rich in low-carbon energy, one might expect to see the deployment of water electrolysis and hydrogen reduction.
- In areas with access to $CO_2$ storage, for example the UAE, the USA or the Netherlands, CCS or blue hydrogen[9] reduction may emerge as the most appropriate choice.
- In areas offering potential access to biomass resources, such as Australia or Brazil, sustainable biomass and biochar may be used to substitute coal in existing steelmaking processes.
- Carbon capture and utilisation (CCU) can combine carbon-rich waste gases with renewable energy to create synthetic fuels and chemicals such as acetone and isopropanol that can be used as feedstock by the chemicals sector.

**What is low-carbon steel?**

worldsteel defines low-carbon steel as steel that is manufactured using technologies and practices that result in the emission of significantly lower $CO_2$ emissions than conventional production.[10]

# Climate Action

## Carbon capture and storage (CCS)

At Emirates Steel in the UAE up to 800 kt of $CO_2$ per year is captured from the $CO_2$ rich gas stream from the ironmaking plant. The gas is compressed, dehydrated and pumped through 50 km of pipeline before being injected into a mature oil field for permanent storage.

## Hydrogen

HBIS is building a 1.2 Mt capacity hydrogen metallurgy DRI demonstration project. The project in China will use green and blue hydrogen technologies to explore a path to zero $CO_2$ emissions from the iron and steelmaking processes. The plant is scheduled to begin production by the end of 2021.

## Carbon capture, use and storage (CCUS)

ArcelorMittal is constructing a large-scale facility in Ghent, Belgium to convert process gases to ethanol, which can be used in a wide range of applications, including the production of synthetic fuels. The plant will have a capacity of 80 million litres of ethanol per year. A similar commercial facility began operation in 2018 at Shougang Group in China, producing 30 million litres of ethanol for sale in the first year of operation.

## Renewable energy

Evraz's Rocky Mountain Steel in Colorado, USA, is transitioning from coal to solar power. The Evraz plant will be the largest on-site solar plant in the country dedicated to a single customer when it comes online in 2021.

**The IEA roadmap projects that the broad deployment of breakthrough technology will accelerate between 2030 and 2050. However, we can expect to see first movers trial and implement first of a kind plants providing increased quantities of low-carbon steel to the market from the mid-2020s. Learnings from these innovations will support broader deployment across the wider industry by mid-century.**

## Cost implications

Each company's choice of which breakthrough technology to invest in will to a large degree depend on the resources available and the policies in place. However, even if the conditions are good, it is clear that the production of low-carbon steel is going to be more expensive than steel production today.

The higher production cost will result from a combination of the following:

- increased operational expenses, due to, for example: use of more expensive low carbon resources such as green hydrogen or low-carbon electricity; CCS equipment requiring additional energy to operate and for $CO_2$ storage
- increased capital expenses due to, for example: replacement of coal-based blast furnace units with hydrogen-based DRI units and basic oxygen furnaces with electric arc furnace units; the conversion of existing equipment to use hydrogen or other fuels; the retrofitting of CCS or CCUS infrastructure
- capital losses due to, for example: the potential early retirement or write-off of long-lived steelmaking assets

The IEA estimates the additional production cost to be between 10% and 50%[11] compared to today, a cost increase significantly exceeding production margins. However, the steel industry will continue to reduce costs by improving its operational efficiency and deploying intelligent manufacturing technologies, partly offsetting the additional cost.

Since the transformation of the industry will be gradual, with some companies/countries/regions moving faster than others, steel produced using low-carbon technologies will be competing with conventionally produced steel (and other conventionally produced materials) in the same market for some time. This will create a first mover disadvantage and policy support will therefore be needed.

# Partnerships between governments and the steel industry are fundamental to a sustainable future

**The tools available to governments, the steel industry profile, and anticipated access to affordable and low-carbon technologies differ by region and by country. As with the Paris Agreement, we believe that individual countries are best placed to assess and implement policy and technical strategies to suit their particular circumstances.**

**Nevertheless, it is absolutely clear that governments, the steel industry and other stakeholders will all need to collaborate closely to overcome the technological and economic challenges and create the market conditions necessary for the steel industry to transition to low-carbon steelmaking effectively.**

**In practice this means that:**

## The steel industry will:

### Mitigate our own emissions

- Accelerate efforts to improve energy and $CO_2$ efficiency across the global industry and work with partners and neighbours to create synergies
- Develop a portfolio of breakthrough technologies through increased research and development
- Ensure that all scrap that is collected is recycled into new steel products by developing technologies that maximise the value of all collected scrap

### Create partnerships to enable transformation

- Engage with governments to make clear what will be needed in terms of low-carbon resources and finance to deploy these breakthrough technologies at scale

### Be transparent

- Continue to measure and report on our $CO_2$ emissions

## Governments need to put a supportive and enabling framework in place that:

- Does not pick winners and losers among possible technologies but recognises that a number of different technologies will be used
- Reduces the first mover disadvantage by increasing the demand for low-carbon materials and creating a market for low-carbon steel, keeping in mind that producing low-carbon steel will be up to 50% more costly than conventionally produced steel today.[12] At the same time, ensuring that policies reward proactive efforts and do not create an economic disadvantage for companies who have already invested in efficient steelmaking
- Enables access to finance for the transition, through, for example, frameworks for sustainable finance.
- Ensures availability and affordability of low-carbon resources, including CCS infrastructure and hydrogen, in quantities necessary
- Takes a life cycle approach and supports the circular economy, including the collection and sorting of end-of-life scrap
- Takes an innovative approach to the regulation of low-carbon processes and products, such as the products from CCU processes

## Stakeholders and users of steel also have a role to play and should:

- Demand low-carbon steel and understand that this will come at an additional cost
- Consider the entire life cycle and design steel containing products suitable for remanufacturing, reuse and recycling

## Notes and references:


1. worldsteel data; includes scope 1, scope 2 and process critical scope 3 emissions, weighted average including both ore and scrap based steel production. Calculated using a methodology consistent with the ISO 14404 series.
2. worldsteel, press release, https://www.worldsteel.org/media-centre/press-releases/2021/Global-crude-steel-output-decreases-by-0.9--in-2020.html
3. IEA, Iron and Steel Technology Roadmap, October 2020 (https://www.iea.org/reports/iron-and-steel-technology-roadmap)
4. The emission reduction potential relates to Scope 1, 2 and 3 emissions associated with key steelmaking operations even if these are outsourced. Source: $CO_2$ Data summary report 2020, worldsteel
5. worldsteel, scrap availability model, September 2019 estimate
6. worldsteel, Life Cycle Inventory (LCI) data
7. worldsteel calculation, https://www.worldsteel.org/about-steel/steel-facts.html
8. Iron ores are materials rich in iron oxides. Significant amounts of energy are required to reduce, or break, the strong bonds between iron and oxygen atoms to produce metallic iron, which is the first step in making virgin steel.
9. Carbon free hydrogen can be classified as 'green' (produced by electrolysis of water using carbon-free electricity) or 'blue' (derived from natural gas in plants equipped with CCS)
10. worldsteel, blog: What do we mean by low-carbon steel, https://www.worldsteel.org/media-centre/blog/2021/blog-low-carbon-steel-meaning.html
11. IEA, Iron and Steel Technology Roadmap, October 2020, https://www.iea.org/reports/iron-and-steel-technology-roadmap
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World Steel Association

Avenue de Tervueren 270
1150 Brussels
Belgium

T: +32 (0) 2 702 89 00
F: +32 (0) 2 702 88 99
E: steel@worldsteel.org

C413 Office Building
Beijing Lufthansa Center
50 Liangmaqiao Road
Chaoyang District
Beijing 100125
China

T : +86 10 6464 6733
F : +86 10 6468 0728
E : china@worldsteel.org

worldsteel.org

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