The Net-Zero Steel Pathway Methodology Project

Final Report and Recommendations | July 2021

The project would like to thank and acknowledge the contribution provided by the following organisations:

The steering group was composed of the following steel companies, which provided the financial support for the project:

ArcelorMittal is an established metals and mining industry leader, with a unique offering of global scale, product diversity and supply chain integration, backed by continuous innovation and a strong balance sheet. With a commitment to become net zero by 2050, ArcelorMittal is strongly committed to make steel a sustainable product for the future.

BlueScope is a manufacturer of innovative steel materials, products, systems and technologies, and one of the largest global producers of metal coated and painted steel building products. BlueScope is Australia's largest steel manufacturer, and New Zealand's only steel manufacturer. The company's 14,000 employees are spread across 18 countries across Australia, New Zealand, Pacific Islands, Asia and North America.

GFG Alliance create an economically sustainable business model for the industries that are profitable for the long term. Their strategy is driven by four key trends – increasing demand for steel and aluminium, the urgent need to decarbonise these sectors, the decline of traditional manufacturing industries in developed economies, and the need to be competitive in a changing world. Their strategy enables them to identify opportunity and drive positive change in their industries.

Tata Steel is one of the world's most geographically-diversified steel producers, with operations and a commercial presence across the world, supplying high-quality steel products to the most demanding markets. The Tata Steel group is among the top global steel companies with an annual crude steel capacity of 34 million tonnes. In Europe, whilst their operations are amongst the leading and most CO_2 efficient in the world, Tata Steel's ambition is to make its processes more sustainable and to produce steel that is CO_2 neutral by 2050 at the latest.

The World Steel Association (worldsteel) and **ResponsibleSteel** were also members of the steering group. Project management was provided by ResponsibleSteel with the support of an independent consultant appointed by the group to chair meetings.

Technical work on the report's content and recommendations was led by: Javier Bonaplata (Head of Strategic Projects, ArcelorMittal); Ed Heath-Whyte (Head of Environment and Sustainability, Liberty Steel Group); Annie Heaton (Head of Sustainability Dialogue and Disclosure, ArcelorMittal); Pete Hodgson (Manager, Product Sustainability, Tata Steel Europe); and Tim Rodsted (Head of Sustainability, BlueScope Steel).

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The project was supported by a Technical Working Group (TWG), which incorporated contribution from the following steelmakers and organisations.

ArcelorMittal
BlueScope Steel
Celsa Group
GFG Alliance
JSW
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Nippon Steel
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Ternium
voestalpine
Wirtschaftsvereinigung Stahl | German Steel Federation
World Steel Association

The project also established a Stakeholder Reference Group, consisting of civil society and similar organisations with a specialist interest in climate change and the steel sector, to review and provide feedback on the output of the TWG.

The Net Zero Steel Pathway Methodology Project steering group organisations endorse the general thrust of the arguments made in this report but should not be taken as agreeing with every finding or recommendation. Steering group and technical working group organisations have not been asked to formally endorse the report or its recommendations, which are intended to be a contribution to continuing discussion and development with steelmakers, civil society organisations and other stakeholders.

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FOREWORD

The climate crisis and race to zero greenhouse gas emissions is the defining issue of our generation. UN Secretary-General António Guterres described it last year as, "a race we are losing, but it is a race we can win". Indeed, it is a race we must win.

It is an unprecedented challenge, and the steel industry is critical to meeting it. Iron and steel have been central to human development for three thousand years. Steel is in our bridges, cars, buildings, ships, power transmission systems. It is an essential material for wind turbines, hydroelectric dams and electric vehicles – it is fundamental to the transition to a low carbon economy.

But today, according to the International Energy Association (IEA, 2020a), the steel sector is emitting 2.6 gigatonnes of carbon dioxide (Gt CO_2) annually – 7% of the global total from the energy system and more than the emissions from all road freight. If we are to limit global warming to 1.5°C we have just 30 years to reduce steel's greenhouse gas emissions from 2.6 Gt CO_2 to 'net zero'. The challenge is formidable. But with leadership from the steel industry, the effective support of policy makers, and growing demand from customers, it is achievable.

Climate science has defined the global target of 'net zero' emissions. There is a growing understanding in the steel sector of the technologies needed to meet the target. But the industry is missing a comprehensive framework that recognises the characteristics of the sector, and which individual steelmakers can use to develop their own credible, company-specific pathways to net zero.

This is urgently needed, not only by steelmakers, but also by investors and policy makers. The Net Zero Steel Pathway Methodology Project presented in this report marks a significant step towards filling this gap.

The report makes clear recommendations, developed by a broad cross-section of steelmakers from across the world, that provide a basis for defining clear, credible targets to reduce greenhouse gas (GHG) emissions in line with the requirements of climate science.

The report highlights the fact that steelmakers cannot achieve these targets on their own – their success will depend on the policy context in which they operate, which varies across the world. By setting targets, steelmakers will be laying down a challenge to policy makers, but will also be making themselves accountable: put these policies in place, and we are committed to deliver.

This report is a significant step, not a final product. Its recommendations need further development and should be scrutinised by other stakeholders. The project steering group is clear that it welcomes this scrutiny, and that its participants are ready to work with other stakeholders to resolve any outstanding differences.

We need all steelmakers to adopt credible science-based targets, and then to follow through and achieve them. We need them to do this as a matter of urgency.

As Chair of the Energy Transitions Commission, I am pleased to recognise the role that ETC Commissioners from the sector have played in supporting this work. I commend them and all the project's participants for this report and its recommendations, and look forward to seeing the further steps that are needed for it to bear fruit.

Adair Turner
Chair, Energy Transitions Commission

EXECUTIVE SUMMARY

The steel industry faces an unprecedented challenge in contributing to the Paris Agreement objectives of limiting global temperature rise to well below 2.0°C above pre-industrial levels, and to pursue further efforts to limit the temperature increase to 1.5°C. Several organisations and collaborative groups, through their initiatives, have sought to help companies make 2050 'net zero' commitments[1], most notably the Science Based Targets initiative (SBTi). Using the SBTi protocols, some sectors have developed Science Based Target (SBT) guidance specific to their sectoral needs. However, to date, there has been limited specific guidance for the steel sector.

This report is a starting point for developing robust guidance for steelmakers who wish to make a realistic and credible commitment to a net zero or 'SBT'. It is hoped that that this will also open a dialogue with stakeholders on the challenges faced by the steel industry in setting ambitious targets and agreeing on what the right approach for steel is.

The current steel sector decarbonisation approach (SDA) under the SBTi treats the sector as homogenous, assessing a company's carbon intensity target against a single carbon budget for steel, without distinguishing between steel produced from iron ore (primary steel) or steel produced from scrap (secondary steel). Additionally, a company should only include scope 3 emissions if they surpass a 40% threshold, yet within the steel sector there is a high degree of variability in scope 3 emissions reporting between different steel companies. This variability makes it difficult for stakeholders, including financial institutions, to assess the performance and ambition of companies against their peers. The SBTi recognises some of these challenges and is planning to start a collaborative project with the steel sector to develop specific steel sector guidance to help enable more steelmakers to set science based targets.

The Net Zero Steel Pathway Methodology Project report proposes a basis for consistency by articulating a set of key principles to underpin steel sector guidance for net zero targets. These aim to facilitate companies to become consistent in how they measure and set GHG reduction targets, in line with the contribution needed from the sector. Alongside these principles, more work is needed to determine the relevant GHG budgets relevant to both primary and secondary steelmaking, in line with climate science.

Such consistency will enable stakeholders to have more confidence and understanding of what is behind those commitments. With the publication of this report, we are presenting to broader stakeholder initiatives a foundation stone for how the decarbonisation progress of steel companies can be consistently assessed. Where stakeholder initiatives are developing steel sector frameworks, such as the SBTi, Assessing the Low Carbon Transition (ACT), the Energy Transitions Commission (ETC) and the Center for Climate Aligned Finance, we believe this report will provide an invaluable input to their design.

We envisage the content of this report to provide the starting point for the SBTi's development of more detailed technical guidance for the steel sector, and are ready to support both this and other initiatives in their endeavour.

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1 Net zero is taken to mean a balance can be achieved between the greenhouse gases put into the atmosphere when producing steel and emissions taken out of the atmosphere by sinks, or potentially from compensation measures resulting from emissions reductions in other sectors. There is still an evolving conversation around what forms part of a net zero definition.

The following is a summary of the main recommendations that have come out of the Net Zero Steel Pathway Methodology Project:

Recommendation 1: Differentiate between primary and secondary steel

The methodology for emissions target setting needs to differentiate between primary (iron ore) and secondary (scrap) sources of steel production, rather than differentiating by production route. Primary sources of steel production are the main contributor to GHG emissions, whilst secondary-based steel production has low direct emissions, using electricity as the main energy source. Complicating factors to be addressed are that:

- Secondary sources are finite, bound by the amount of end-of-life scrap becoming available in society. Continued growth in steel demand over the coming decades, also as an enabler for decarbonisation, means primary production will remain the main source of steel beyond 2050.
- There are multiple approaches to decarbonise the steel industry and the differences between these approaches need to be fully considered. A methodology to differentiate between primary and secondary steel production needs to be adopted to ensure that trade flows of finite secondary sources do not shift to jurisdictions with strict GHG regulations, without contributing to the overall reduction in global emissions.

It is also noted that global secondary sources of steel production are reliant on steel initially being created from primary steelmaking i.e. global steel production originates from a virgin steel feed source in its first life cycle.

An SBT for a steel company should, therefore, be made up of two targets based on its use of iron ore and scrap metallic inputs:

- **A primary steel SBT** (applicable to steel made from primary iron ore sources)
- **A secondary steel SBT** (applicable to steel made from iron scrap and steel scrap sources)

In order to facilitate this approach, the steel sector carbon budget, against which net zero targets are assessed, should also be made up of an iron ore based (primary) and scrap based (secondary) budget with separate trajectories to 2050. It is noted that within the steel sector total budget, there will be a need to accommodate budgets for specific product families such as for stainless steel, due to a significantly higher contribution of emissions from ferro-alloy additions, which are responsible for up to 70% of stainless steel scope 1, 2 and 3 GHG emissions.

Recommendation 2: Set a consistent scope and system boundary

A consistent system boundary is needed to reduce the variability in reporting and account for the probability that emissions will move further upstream in the future, as the steelmaking process decarbonises. For example, producers can reduce direct scope 1 emissions through the purchase of pre-processed raw materials, such as pellet or direct reduced iron (DRI), where emissions occur upstream of the steel producer. The most significant processes should be included in the system boundary, as well as some mandatory scope 3 emissions, to ensure consistency across target setting boundaries (see Figure 1). This consistent boundary is required to define the core activities that an SBT will be defined for (core SBT). The **core SBT** for steel companies should be made up of two sub-SBTs:

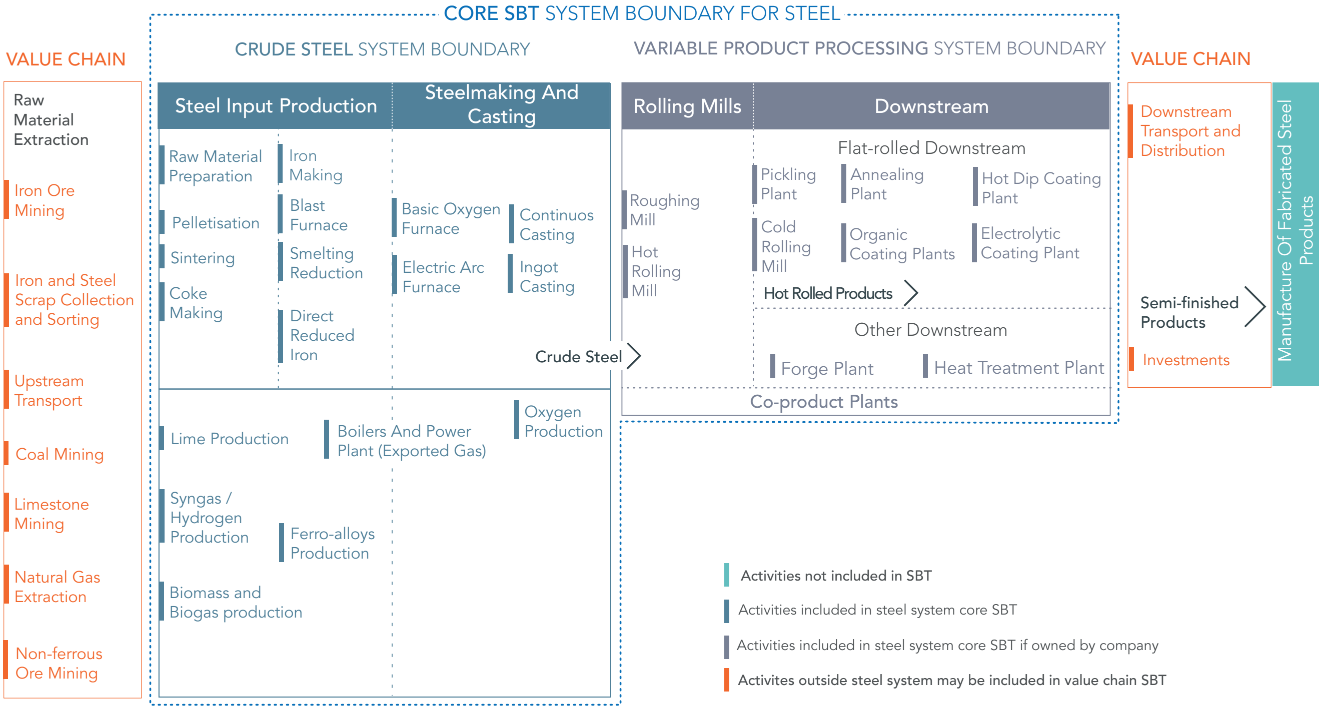
- **Crude steel SBT** (processes within the crude steelmaking system boundary (regardless of whether they are on site or not), split into differentiated subsets of primary and secondary crude steel SBTs)
- **Product processing SBT** (processes within the variable system boundary for downstream processing)

Additionally, a value chain SBT may be added if the company chooses to include additional scope 3 upstream and downstream emissions that are outside of the core steel SBT system boundary.

The process emissions included within the system boundary of the crude steel SBT, as shown in Figure 1, will need to be allocated to either primary or secondary steel SBTs, or shared between the two using an equitable allocation method. Further guidance will need to be developed on this.

Figure 1: Overview of the proposed core system boundary for a steel SBT, made up of crude steelmaking and variable product processing, as well as relevant value chain processes.

Source: Adapted from ACT project draft iron and steel methodology (ACT, 2021). Note: Iron making includes all types of iron production, including pig iron, sponge iron, hot briquetted iron (HBI) etc.



The greenhouse gas emissions targets set within the core SBT should align with the global steel GHG trajectories, relevant to the net zero/Paris aligned pathway for steel, developed in alignment with Recommendation 1. This implies that separate pathways for primary iron sourced steel and scrap sourced steel will be needed, and specific product types, such as stainless steel, where more ferro-alloys are used with higher upstream emissions, will need to be taken into account. Further consideration may be needed on how some of the variable product processes, like rolling mills, will be included in a company SBT. This is because process ownership can differ, yet they can contribute significantly to the emissions profile, and thus, affect the comparability of SBTs.

Recommendation 3:
Establish a consistent steel sector budget and trajectory

It is necessary to develop a global steel sector budget and trajectory consistent with a net zero 2050 target aligned to the Paris Agreement objectives. The total budget should be made up of a primary steel budget and a secondary steel budget, in consistency with the respective targets described above, and a method for calculating this split should be developed, including high alloy and stainless steels. Through collaboration with the International Energy Agency (IEA), the global steel sector budget should also include the power sector emissions associated with combusting iron and steelmaking process gases (coke oven, blast furnace and basic oxygen furnace) to produce electricity, both on and off site.

Recommendation 4:
Acknowledge the GHG reduction from using co-products made by the steel industry

A steel company target should focus primarily on the abatement of core system boundary emissions. Where the targeted abatement doesn't reach the reductions needed, a company can recognise the emissions reduction in other sectors through the use of its co-products. There are various methods that could be used to account for the GHG emissions and benefits associated with making and utilising co-products, including:

- Considering the 'avoided' impacts,
- Redistributing associated sector emissions within a steel sector budget, or
- 'Allocating' a portion of steel sector emissions to downstream sectors.

It is noted that the draft SBTi net zero methodology consulted on in early 2021 included the possibility that avoided emissions, directly resulting from the use of co-products, could be reported under the category of GHG 'compensation'. Alternative approaches include amalgamating a proportion of other sectoral budgets into a steel budget, commensurate with the GHG value of co-products; and building a company's target up of sub-targets based on the sectoral trajectories of each sector they are co-producing for e.g. steel, cement, chemicals. A calculation of the avoided impacts to reflect the actual application of the co-product in the market could be used as a basis to quantify and share the value of co-products in these frameworks.

The application of carbon capture and utilisation (CCU), for example to recover value from process gases, may require different treatment, where captured emissions are, by definition, not released by the steel sector, and so may be partially or wholly deducted from the carbon balance of the site. The way in which captured GHG emissions are attributed to the steel producer or downstream user may depend on how regulations prescribe reporting conventions, as well as how CCU supply contracts are agreed. In addition to emissions not released by the steel sector, there may also be additional avoided emissions in downstream sectors, depending on the application.

Recommendation 5:
Integrate the influence of regulatory policy when setting an SBT

Policy and legislation have an important part to play in helping a steel company to set a meaningful SBT and pathway towards net zero GHG emissions. The level of importance or influence of policy on investment decisions will be affected by several variables:

- The **capital intensity** of the process route (and so reflecting the 'cost to change' the process).
- The **age** of existing installed assets.
- The **carbon intensity** of the existing process route.
- The current **policy landscape** – mature or developing, high support or no support (sticks vs carrots).
- **Stakeholder expectations**, including employees, customers, and financiers.
- **Policy horizon** – anticipated future policies.

A company must consider the policy landscape that its operations are subject to, when making an SBT. Policy is likely to influence the ability to make investments in the short term. For longer term investment plans required to meet specific targets, the company must publicly disclose the policy assumptions it expects to be in place and the uncertainty of those assumptions, as part of the SBT. Progress against these policy assumptions should be included in any subsequent company SBT updates. If communicated this way, SBTs may serve as a message to policymakers of the decarbonisation potential a steelmaker believes they can deliver given certain policies.

Recommendation 6:
Leverage existing standards and methods into a dedicated steel sector decarbonisation approach for more consistent target setting

The GHG Protocol and other existing standards serve to establish a tool that can ensure more consistent and generally acceptable accounting and target setting. In collaboration with SBTi and the wider stakeholder community, further developments and technical guidance are needed to ensure greater consistency in the overall steel accounting method, whilst taking into account the recommendations of this report. This is vital to enable stakeholders and steel companies to prepare, compare and implement the commitments of different steelmakers on a like-for-like basis.

Recommendation 7:
Develop unambiguous guidance for companies making different types of steel products

The methodology for the steel sector SBT needs to be clearly understandable yet able to accommodate the requirements of different product groups that a company may specialise in, including low-alloy carbon steel, high-alloy carbon steel, and stainless steel. In particular, this relates to earlier recommendations:

Recommendation 1:
Differentiate between primary and secondary steel

- Identify how processes are assigned to primary and secondary sources.

Recommendation 2:
Set a consistent scope and system boundary

- Which processes should be reported by all companies making an SBT and which should be variable e.g. depending on ownership or control.

Recommendation 3:
Establish a consistent steel sector budget and trajectory

- How each product group fits into the budget and trajectory and how they might differ between product groups.

1. INTRODUCTION

The steel industry faces an unprecedented challenge in contributing to the Paris Agreement objectives of limiting global warming temperature rise to well below 2.0°C above pre-industrial levels and to pursue efforts to further limit the temperature increase to 1.5°C.

According to the International Energy Agency (IEA), the volume of steel production has more than doubled in the past two decades, leading to an overall doubling of direct GHG emissions (IEA, 2020a). In the next three decades to 2050, end use demand for steel could continue to increase by a further 40%[2], whilst at the same time having to reduce emissions by up to 95%. In response, many steel companies are making commitments to meet net zero greenhouse gas emissions by 2050, however there is no common understanding of what that means in practice.

Several organisations and collaborative groups have established initiatives to consider or frame how companies can make Paris-aligned commitments, including the SBTi and the Transition Pathway Initiative (TPI). Some sectors have developed SBT guidance specific to their sectoral needs, however, there has been limited specific guidance for the steel sector to date. More comprehensive guidance would be needed to address the complexities of measuring emissions associated with the different configurations of steelmaking technologies. In particular, guidance is needed on setting meaningful targets to deliver both GHG reduction and the mix of primary and secondary steel production needed to meet overall demand.

IEA and SBTi have so far considered sectoral trajectories for steel towards 2050 from a 'sectoral average' perspective for carbon steel production. Indeed, SBTi recommends that 'homogenous sectors' should follow an SDA based on the IEA trajectories of GHG emissions reduction needed per sector. However, individual steel company decarbonisation pathways are very much influenced by their configuration, both with respect to primary and secondary production, and their level of vertical integration.

This mismatch between individual company starting situations, relative to the average sectoral decarbonisation pathway, has made it difficult for some companies to set SBTi targets that are compatible with the sector trajectory. This has resulted in the use of SBTs in the steel sector being extremely limited, particularly among primary producers. Added to the complication is the variable interaction of the steel sector with other sectors through the use of steel industry co-products other than steel, including process gases, electricity, chemicals and slags. This means that the activities of the steel industry have a direct bearing on the GHG emissions of other sectors, and so the knock-on impacts and contribution to global GHG emissions must be carefully considered in order to avoid a 'silo-based' analysis. The SBTi recognises some of these challenges and is planning to start a collaborative project with the steel sector to develop specific steel sector guidance.

The objective of this report is, therefore, to provide further guidance for steelmakers that wish to make a realistic and credible commitment to a net zero or 'science based target (SBT)'. This should allow more companies to set meaningful and credible SBTs in the future. The guidance will address the specific complexities within the steel sector mentioned above, namely:

- How to account for the decarbonisation of primary and secondary sources of iron and steel.
- Defining the scope of what emissions should be included in the target, relevant to the steel sector.
- How to account for the contribution of co-products produced within the boundary of the steel sector that are utilised outside the steel sector.
- Defining a pragmatic accounting mechanism for consistent implementation of the proposed methodological approaches.

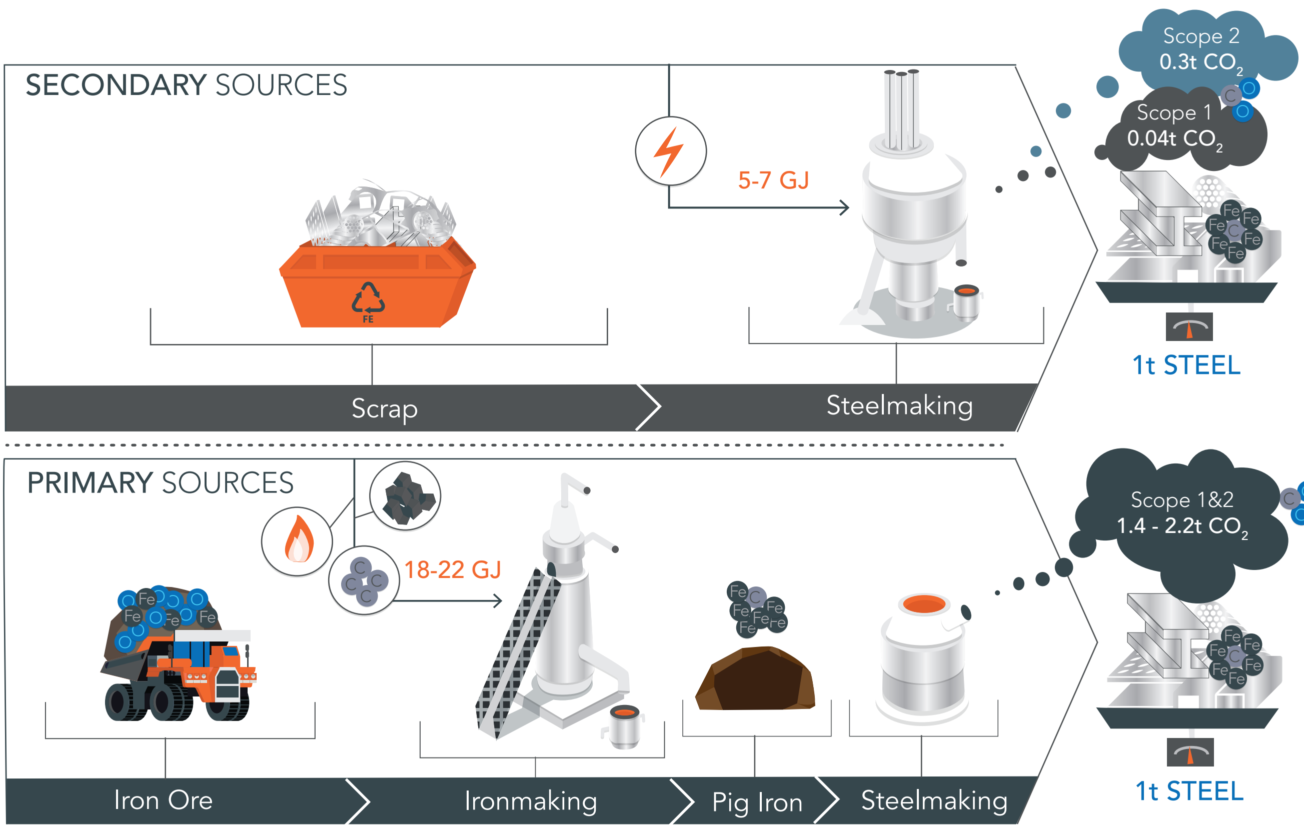
[2] IEA models a 40% increase in steel end user demand from 2019 to 2050 under the Stated Policies Scenario. Under the more ambitious Sustainable Development Scenario, material efficiency improvements play a significant role in limiting demand growth to 10% by 2050 from 2019 levels (IEA, 2020a).

2. STEEL INDUSTRY GHG EMISSIONS: CALCULATING BUDGETS FOR PRIMARY AND SECONDARY STEEL PRODUCTION

There are two main sources of steel used today: primary sources of steel involves separating iron from its natural iron oxide state (iron ore), whilst the secondary sources of steel come from collecting pre-consumer and post-consumer iron and steel scrap which are then re-melted and recycled into new steel.

The energy needed, and resulting GHG emissions[3], to re-melt carbon steel from scrap is about ¼ of that needed to make steel from iron ore, as illustrated in Figure 2. This is due to the significant amount of energy needed to separate iron atoms from oxygen atoms in the iron ore, through a reduction chemical reaction, whereas scrap is already in the metal state. Included under primary sources is DRI which can have lower CO_2 emissions of 1.4 t CO_2 /t (for natural gas based DRI-EAF), compared to 2.2 CO_2 /t via BF/BOF.

Figure 2: Illustration of the primary and secondary sources of steel, and associated CO_2 emissions per tonne of crude steel produced. (Indicative numbers for illustration purposes only and representative of carbon steel generally; CO_2 figures from IEA (IEA, 2020a) may not completely separate out primary and secondary emissions. Energy figures are adapted from IEA to account for primary energy use, as used by worldsteel, since IEA report final energy use).



3 Throughout this report references are usually made to steel industry GHG emissions. Over 90% of GHG emissions from the steel sector (including upstream mining emissions) are in the form of CO_2.

Stainless steel is mainly produced by secondary raw material scrap and primary produced ferro-alloys. An estimated primary route would result in an emissions factor of at least 4.2 tonnes CO_2 per tonne stainless steel. An estimate using data collected by the International Stainless Steel Forum (ISSF), based on mainly EAF production, and using on average 53% stainless scrap, shows emissions are 2.9 tonnes CO_2 per tonne stainless steel[4].

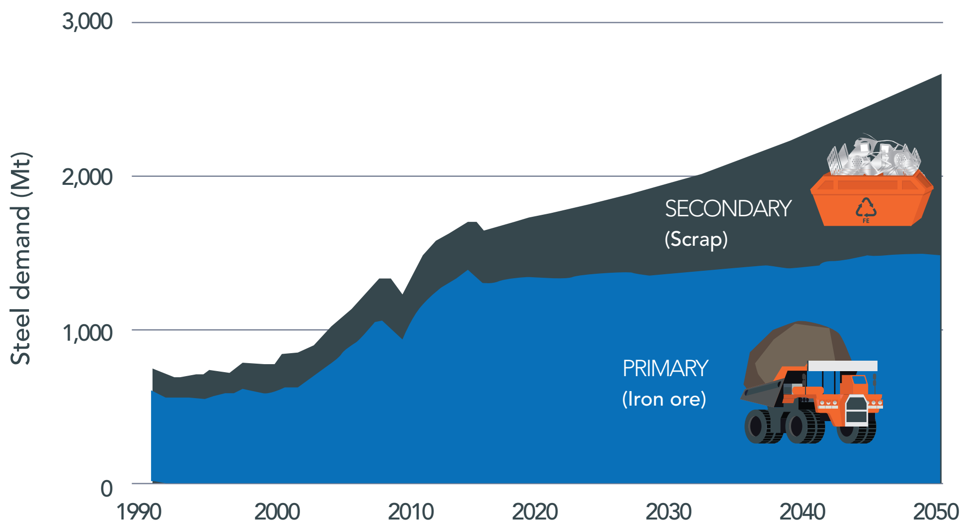
Secondary sources of steel

Secondary sources (iron inputs from scrap) are mainly used through electric arc furnaces (EAFs), and as complementary metallic sources in integrated primary source-based steel production. The ability to produce steel from secondary sources is limited by the finite availability of scrap, as it is bound by the amount arising from end-of-life buildings, infrastructure, vehicles, equipment, and products becoming available, which is a function of historical activity and product lifetime:

- The collection rates for end-of-life scrap are already high, thanks to steel's unique magnetic properties and high economic value. This means that typically, over 85% is recycled, and some reused, in the high-volume end-use sectors like construction, automotive and machinery.
- The high-volume applications like construction and machinery tend to also have long average lifetimes due to their high durability and corrosion resistance, ranging from 15 years to over 60 years. In a growing market, the volume of scrap becoming available from historical levels can never meet total current demand.

Today, approximately 30% of the global demand for steel can be satisfied by secondary sources, which is used in both EAF and basic oxygen furnace (BOF) steelmaking processes. Scrap input to the EAF can range from 0% to 100%, whereas scrap fed to a BOF is technically limited to about 30% in mixing with the hot-metal, pig-iron or DRI formed from iron ore from the preceding process step. By 2050, IEA modelling shows that under the Stated Policies Scenario (as well as the Sustainable Development Scenario), the share of secondary steel could rise to 45%, whilst overall steel demand increases 40% to 2,535 Mt (IEA, 2020a). This is illustrated in Figure 3.

Figure 3: Projection of global steel demand to 2050 with split of primary and secondary production (source: ArcelorMittal).



Steel production from scrap releases much less GHG compared to primary steel from iron ore, but it will only satisfy about 45% of future demand due to limited scrap availability. A focus on reducing the primary steel emissions intensity is, therefore, essential to have a chance of reaching net zero targets.

This illustrates that secondary sources alone cannot deliver a decarbonised steel sector, without a significant contribution coming from reductions in primary source emissions. Individual companies may be tempted, and indeed encouraged, to switch to producing more of their steel from secondary sources, however this raises the following issues:

- Scrap is a globally traded commodity with limited ability to increase supply due to finite availability, even where collection rates of what becomes available are high. Therefore, scrap will flow to regions of highest demand.

[4] Stainless Steel and CO_2: Facts and Scientific Observations (worldstainless.org).

- Increasing the secondary to primary steel ratio cannot be applied universally at the scale needed to decarbonise the whole sector, due to the limited availability of scrap.
- Adopting a higher secondary steel strategy would result in scrap moving to places of highest demand and leaving others to use more primary steel sources, without reducing global emissions overall.
- Availability is exacerbated by regional differences in climate ambition and climate regulation.

Primary sources of iron/steel

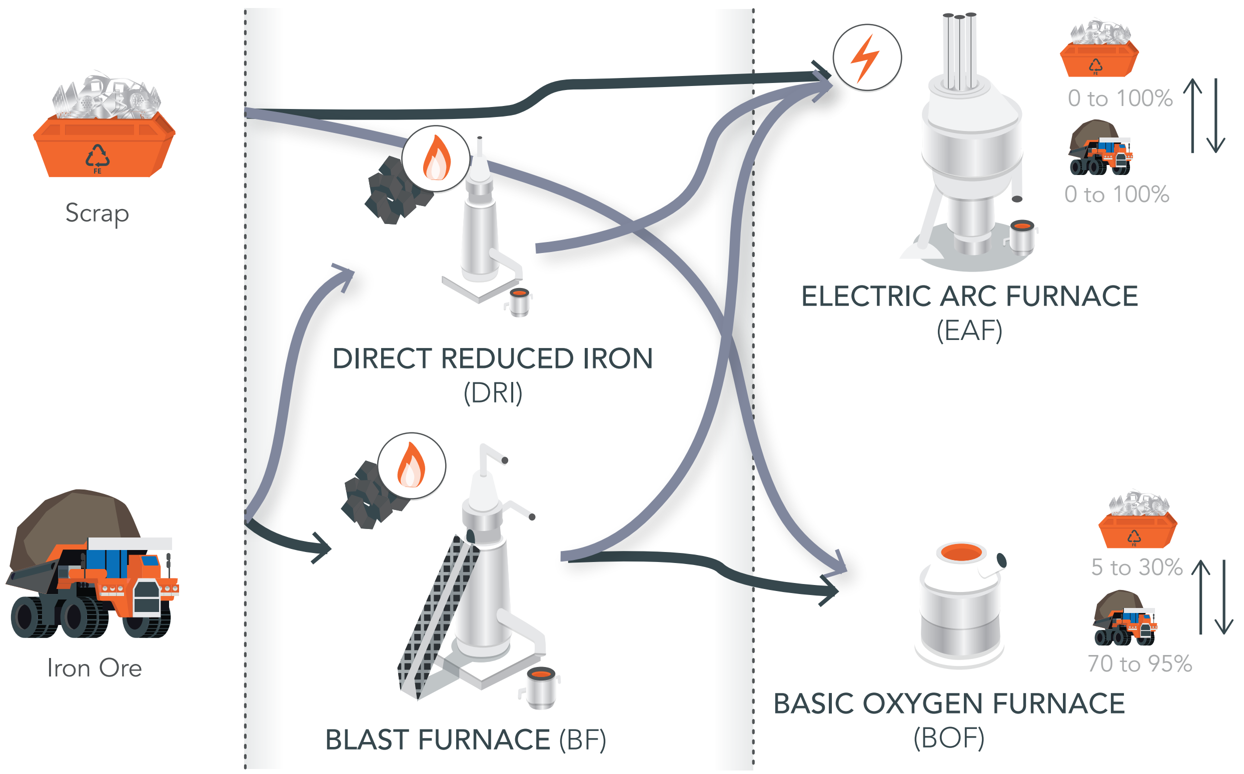
In contrast to secondary sources, primary sources of iron are expandable to meet demand as there are plentiful sources of iron ore, with iron being one of the most abundant elements in the earth's crust. The challenge is to be able to meet the demand for steel whilst dramatically reducing the GHG emissions, since primary steel is responsible for the majority of the sector's emissions.

Primary sources of steel, originating from iron ore, are made via different intermediate iron products, including pig iron, DRI and hot briquetted iron (HBI). 90% of iron is made via the blast furnace (BF) (IEA, 2020a), whilst other sources of primary iron, such as DRI and HBI, are also used in the EAF. There are ongoing technology developments to transform both the BF-BOF route and DRI route into carbon neutral routes. These technological developments leverage clean energy sources such as electricity (including via hydrogen), bioenergy, and carbon capture and storage. Additionally, alternative technology routes are being researched, such as direct iron electrolysis.

Why technology routes are not a good proxy for primary and secondary sources

The EAF is capable of using 100% secondary (scrap) or 100% primary iron sources, whilst the BOF can take up to about 30% secondary, as shown in Figure 4. Given that both EAF and BF/BOF production routes use varying ratios of primary and secondary iron sources, the production route alone is not a good proxy for defining GHG emissions or for target setting.

Figure 4: Why a steelmaking route is not a good proxy for GHG emissions differentiation. Note: ferro-alloy additions will also be primary and secondary sources of metallic input, but this is not shown in the figure for simplicity.



> *Given that both EAF and BF/BOF production routes use varying ratios of primary and secondary iron sources, the production route alone is not a good proxy for defining GHG emissions or for target setting.*

A more reliable method of net zero target setting for individual companies, therefore, needs to be able to separate out the primary and secondary sources of steel in order to define each individual company starting and end point.

To address the intertwined complexities of steel production routes and incentivise effective decarbonisation of the steel industry, the methodology for emissions target setting needs to differentiate between primary and secondary sources of steel production, rather than looking at production routes separately.

Differentiating between primary[5] and secondary[6] sources of steel

Due to the different challenges primary and secondary sources face to decarbonise, and the regional nature of GHG decarbonisation regimes, it becomes critical to have separate emissions targets on primary and secondary sources of steel production. This will make sure the industry has the right incentives to decarbonise primary steel, as the main contributor to GHG emissions, whilst also ensuring that the decarbonisation of secondary steel production is encouraged. This will also ensure technology neutrality for existing technologies as well as being compatible with the transition to new developments that are being scaled up.

The basic principle of the methodology is that a steelmaker first needs to account for the composition of the steel it produces, in terms of what percentage came from primary (iron) sources and what percentage from secondary (scrap) sources, whether in the BOF or EAF. The steelmaker should then apply an SBT for the part of the steel produced from primary and another for the part produced from secondary sources. This requires developing two SBTs:

- **Primary steel SBT** (applicable to steel made from iron ore sources)
- **Secondary steel SBT** (applicable to steel made from iron scrap and steel scrap sources)

The formula for calculating each SBT will depend on the global production split between primary and secondary steel, and the global GHG budget for steelmaking at a specific point in time, that is commensurate with reaching net zero emissions in 2050:

$$SBT_{primary} = \frac{\text{Global primary steel GHG budget}}{\text{Global primary steel GHG production}}$$

$$SBT_{secondary} = \frac{\text{Global secondary steel GHG budget}}{\text{Global secondary steel GHG production}}$$

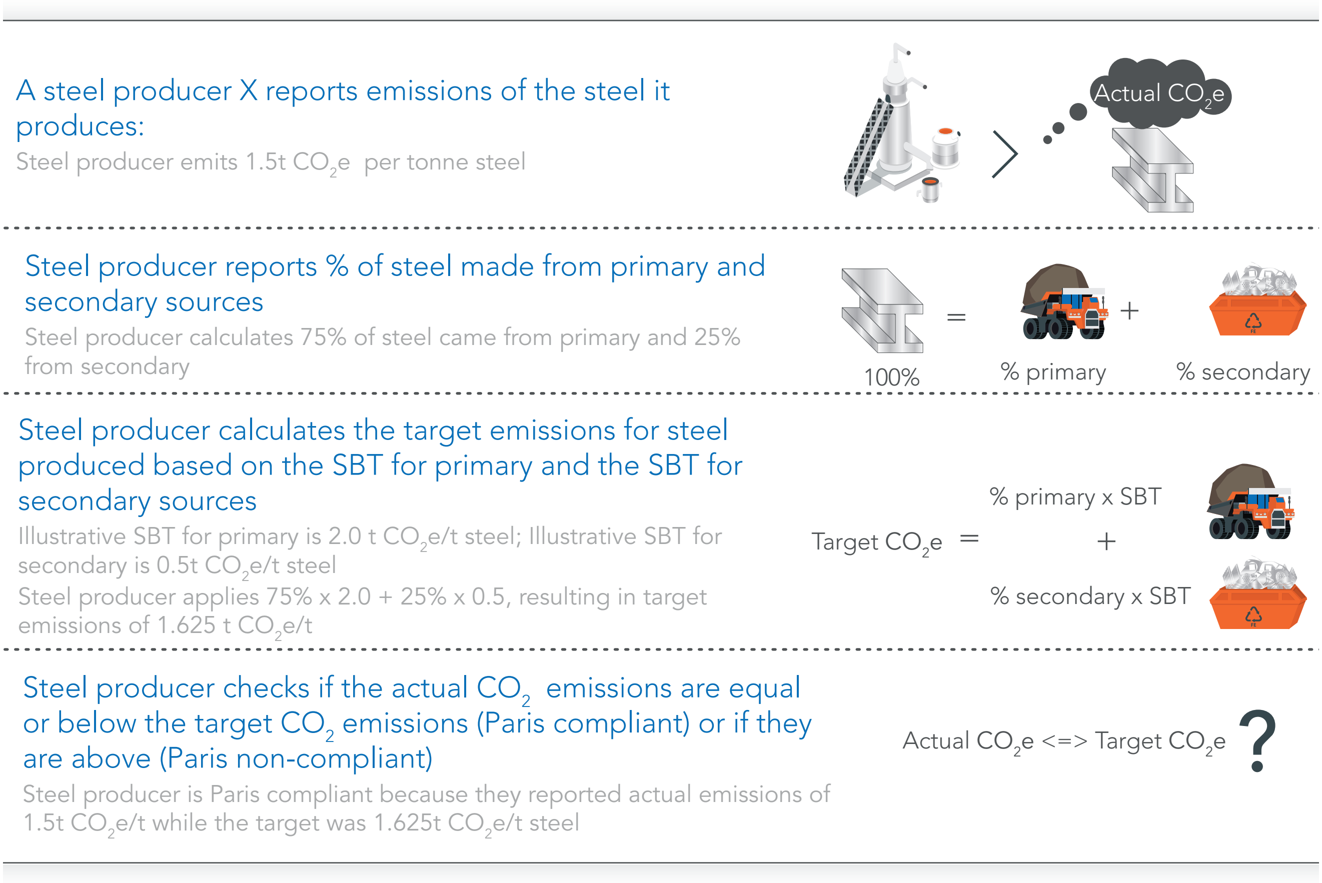
$$\text{Company SBT} = (\%\text{ primary steel x } SBT_{primary}) + (\%\text{ secondary steel x } SBT_{secondary})$$

5 The part of steel made solely from iron sources that originate from iron ore.

6 The part of steel made solely from pre-consumer and post-consumer iron scrap and steel scrap.

Figure 5 shows an illustrative example of how a company would go about setting an SBT by applying the above approach.

Figure 5: Illustrative example of calculating an SBT for a company's GHG emissions based on the mix of primary and secondary steel produced. Numbers are purely fictitious and are not specific to a defined system boundary.



The trajectory for each budget in the above formulae should follow a net zero pathway. IEA has, so far, published a budget trajectory for the steel sector based on a 'Sustainable Development Scenario' (IEA, 2020a) where absolute emissions from the iron and steel industry are reduced by 54% between 2019 and 2050 (see Figure 6) and 90% by 2070. Emissions intensity (per tonne of crude steel) falls by 66% in 2050, but is balanced somewhat by increased demand i.e. 54% in absolute emissions overall.

This 'Sustainable Development Scenario' represents a much more ambitious end point compared to the IEA's business as usual scenario, by assuming:

- an early peak in emissions,
- less growth in demand helped by greater material efficiency,
- widespread deployment of new steelmaking technologies, including hydrogen and CCUS, and
- a decarbonised electricity grid by 2050.

IEA believes that this steel sector target is compatible with overall energy systems meeting the Paris Agreement temperature targets and reaching global net zero GHG emissions by 2070, based on each sector's ability and readiness to de-carbonise (i.e. some sectors can go faster than others). An even more ambitious scenario has been developed in a separate report on clean energy innovation (IEA, 2020b), which explores the implications of bringing forward the date at which net zero emissions are reached, i.e. to 2050, through a 'Faster Innovation Case'.

More recently, the IEA has published "Net Zero by 2050: A Roadmap for the Global Energy Sector" (IEA, 2021), where industrial emissions, including steel sector direct emissions, are modelled in a net zero scenario (see Figure 7).

Figure 6: IEA direct and indirect emissions and intensities of crude steel production over time, using different modelling scenarios (overall budget shown without splitting into primary and secondary steel sources) (IEA, 2020a).

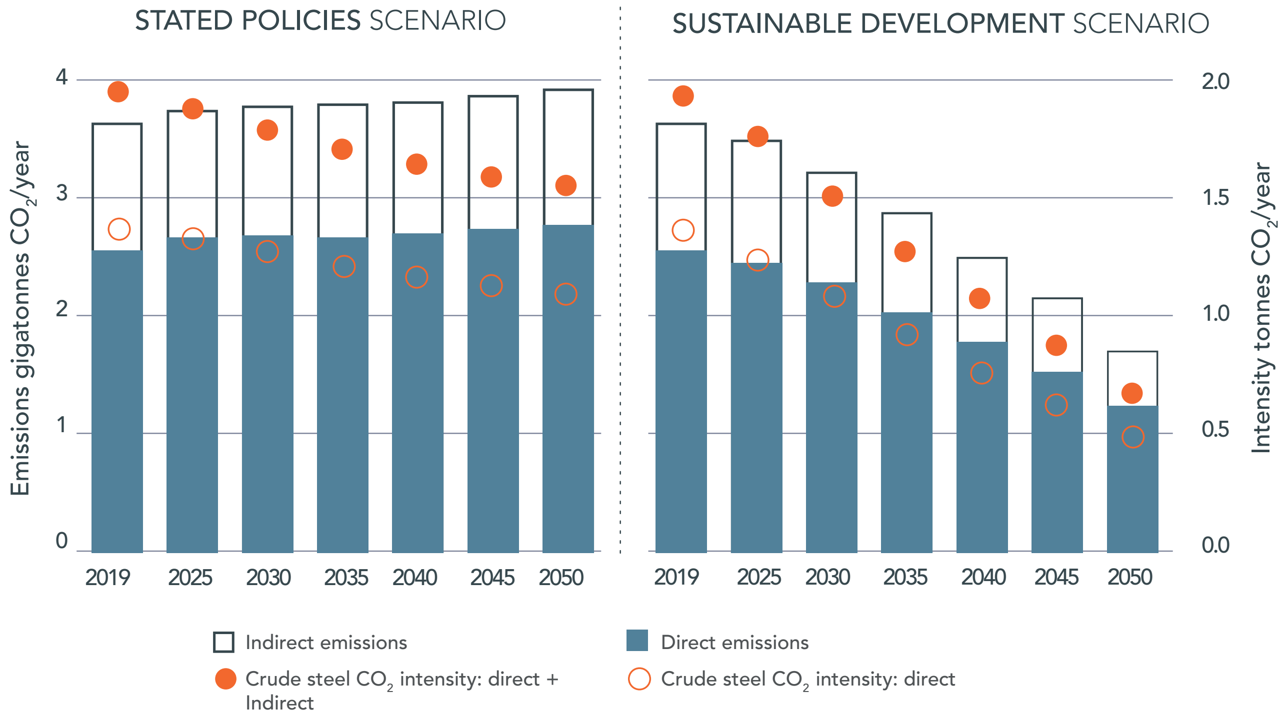
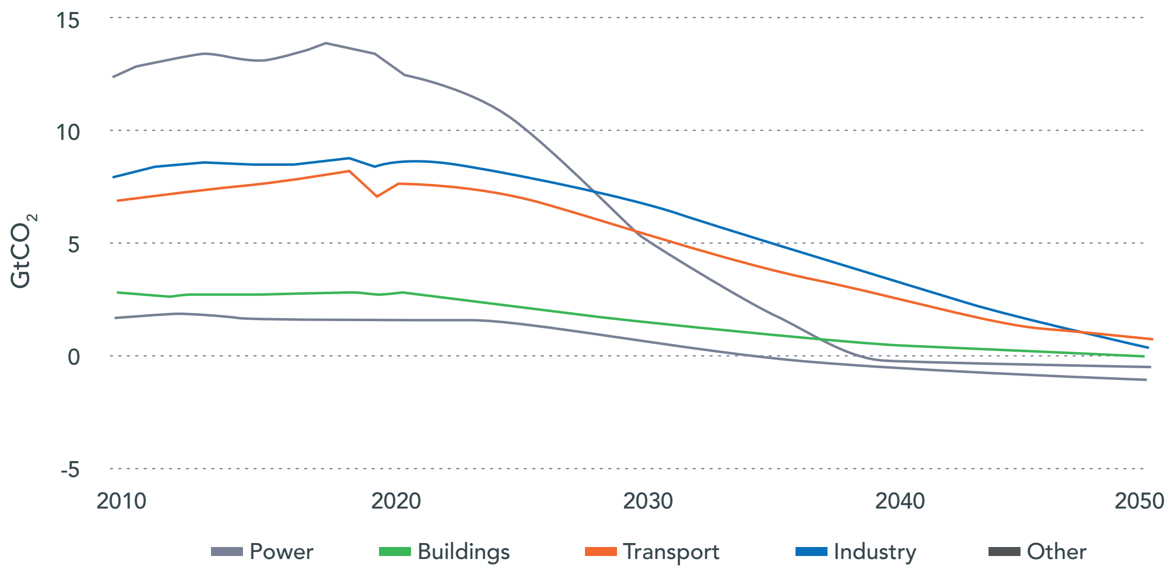


Figure 7: IEA net zero by 2050 scenario for global CO_2 emissions, by sector (IEA, 2021).



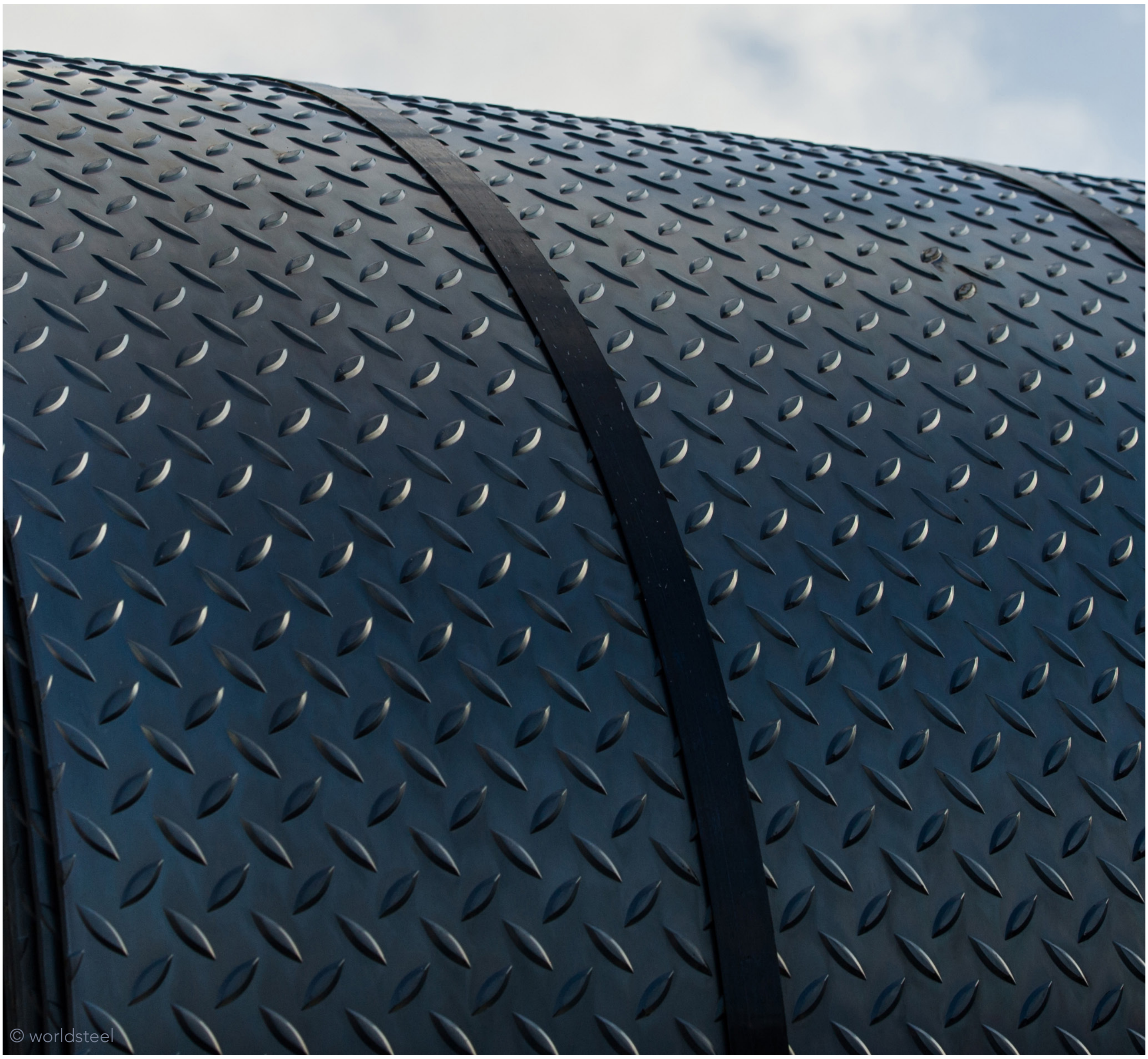
Emissions fall fastest in the power sector, with transport, buildings and industry seeing steady declines to 2050. Reductions are aided by the increased availability of low-emissions fuels.

Note: Other = agriculture, fuel production, transformation and related process emissions, and direct air capture.

The proposed approach of splitting the overall steel sector GHG budget between ore-based and scrap-based steel production would require the following to be implemented:

- Companies calculate the ratio of their primary and secondary steel using a prescribed standard on determining the secondary content of crude steel produced, such as ISO 14021.
- To investigate how IEA or worldsteel can provide provide regularly updated GHG emissions for primary crude steel production and secondary crude steel production separately, including separation of carbon steel low alloy, high alloy and stainless steel contributions.
- A 2050 decarbonisation trajectory, agreed with the SBTi community, should be applied to current emissions to model the necessary future 'budgets'[7] for primary and secondary emissions.
- Adjustment of the steel budgets to encompass a more relevant scope of steel sector emissions with respect to decarbonisation strategies.

It is noted that the IEA emission calculations are based on the IEA scope and system boundaries for emissions accounting which include scope 1 and 2 emissions but not all relevant scope 3 emissions, or emissions from process gases used in power generation. Chapters 3 and 4 of this report explore some of the important upstream steel industry emissions, as well as the significant inter-connections with other industrial sectors, and why some adjustment of the IEA GHG budget scope may be needed.



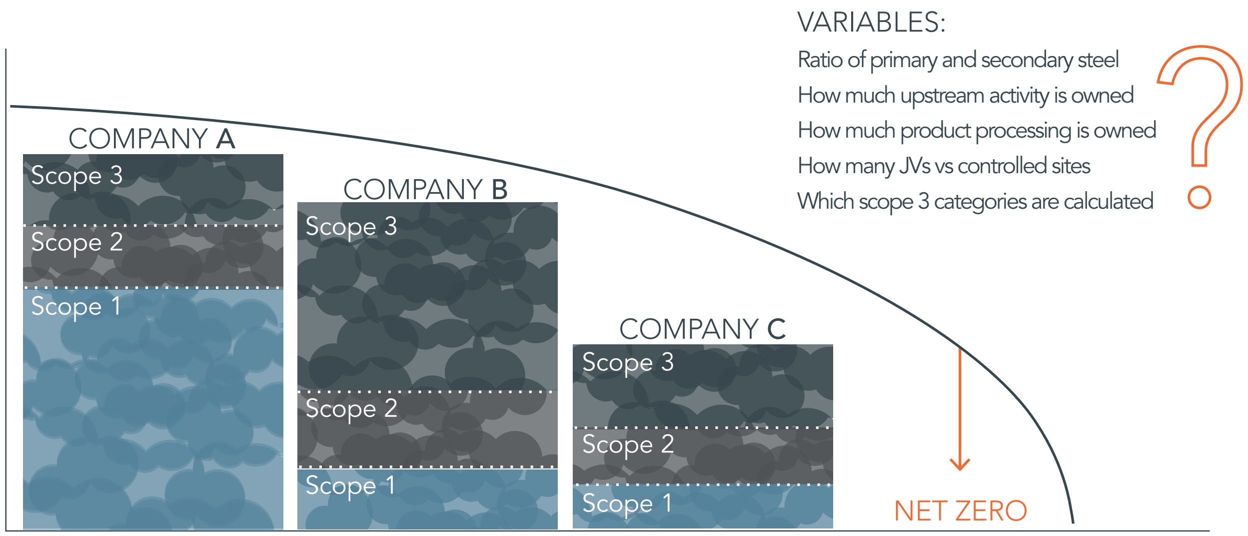
[7] Whether or not there should be regional variations in the scenario has to be clarified.

3. SETTING A **CONSISTENT SCOPE AND SYSTEM BOUNDARY**

The SBTi has published several guidance documents, including a manual (SBTi, 2020a) as well as criteria and recommendations (SBTi, 2020b) to help guide company target setting. The guidance uses existing terminology to categorise different emissions sources into scope 1 (direct), scope 2 (indirect - purchased electricity) and scope 3 emissions (other indirect) in accordance with the GHG protocol (WRI/WBCSD, 2004).

The steel industry is characterised as being highly fragmented with varying levels of vertical integration, and so defining what should be in and out of scope for a company SBT is a challenge, especially if it is to encourage sector-wide emissions reduction or be used for benchmarking between steel companies.

Figure 8: Company emissions reporting relative to a net zero pathway can be influenced by a number of variables.



A reliance on considering a company's GHG emissions in terms of scopes 1, 2 and 3 may not be helpful or sufficient for setting steel SBTs, since each company's core emissions may be spread differently across all scopes, depending on a number of variables. These variables include the company's structure and, therefore, the amount of upstream and downstream processing that is owned or controlled, as well as the type of steels produced (e.g. high alloy or low alloy).

A system boundary approach would be more effective.

The SBTi has published sector specific guidance called an SDA, which focuses on scopes 1 and 2 but allows for the provision of specific guidance on scope 3 emissions where relevant. There is currently no published guidance on how to consistently assess scope 3 emissions for the steel sector. Under the current SBTi methodology, a company must simply set a scope 3 SBT if its scope 3 emissions exceed 40% of their total emissions.

The current level of corporate scope 3 reporting within the steel sector is highly variable, as illustrated in Figure 9. This may be the result of a number of factors. If the company already owns upstream processes, such as coke making, sintering or ferro-alloy production, then emissions from these are automatically included in its scope 1 emissions. In contrast, if upstream process emissions are not owned by the company, yet resulting from core steelmaking processes, and account for less than 40% of total emissions, then some considerable scope 3 emissions from processes essential to steelmaking may be excluded from the target. In addition, without sector guidance, company assessments of the relevance of certain aspects of scope 3 emissions may be unreliable. In the worst-case scenario, a strict focus on scopes 1 and 2, with no guidance on scope 3, could even drive carbon leakage from a company's SBT as companies shift their asset base away from the most emissions-intensive activities. All these factors make it difficult to assess whether steel companies' SBTs are really driving appropriate progress on the pathway to net zero emissions.

Since the application of corporate GHG accounting currently tends to encourage a focus on those key emissions resulting from a company's activities that it is responsible for (scope 1 and 2), the entire value chain tends to be split up into reports focused on emissions from different sectoral activities, such as mining, shipping, product manufacturing, product use and end of life. This is the approach encouraged by the current SBTi model. In contrast to corporate GHG reporting, product GHG reporting uses a life cycle approach to account for the entire value chain emissions, which can vary by the product produced and the end application. Both approaches can lead to complexities and overlaps, or omissions, in reported emissions with other sectors, and so neither may be entirely fit for purpose i.e. for setting sector baselines and targets in a consistent way.

A further consideration is important in the context of decarbonisation: as technology routes to steelmaking evolve in the coming years and decades, emissions may move 'up the value chain'. For example, whereas the production of coke and sinter often takes place at an integrated steelworks, in future the production of hydrogen and iron ore pellets may take place elsewhere under the control of another company. Unless a consistent system boundary is identified, the GHG emissions intensity of different tonnes of steel could be calculated using very different sets of emissions sources.

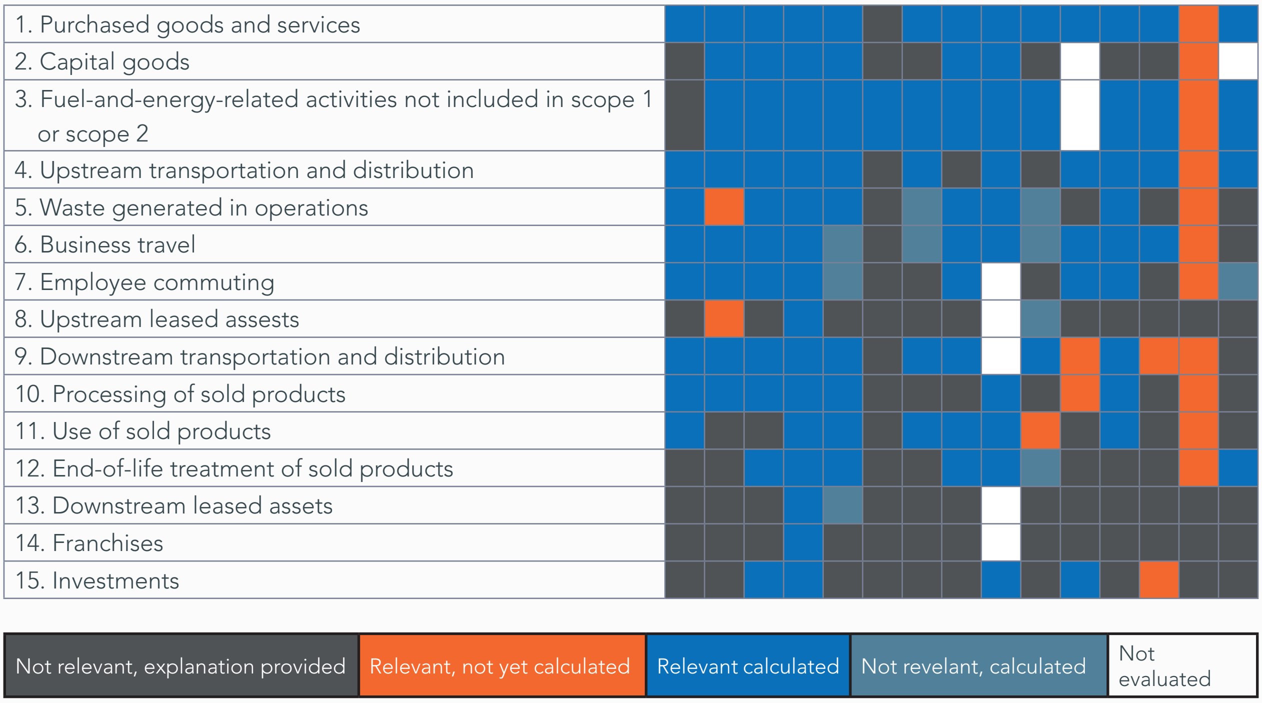
To ensure that a steel company target tackles the real footprint of steelmaking, and to enable targets to be understood consistently, a common system boundary is needed to define the sources of GHG emissions that should be included.

An analysis of steel company CDP (formerly Carbon Disclosure Project) responses in 2020, shows the current level of variation of what steel companies consider as significant emissions (see Figure 9); however, it also shows the categories of emissions that are most frequently considered relevant. These include[8]:

- Purchased goods and services
- Fuel-and energy-related activities not included in scope 1 or 2
- Upstream transportation
- Downstream transportation

This provides a basis for identifying which areas are in need of further guidance to achieve greater consistency in reporting and target setting.

Figure 9: Variation in steel company reporting (columns) on scope 3 emissions (CDP responses, 2020).



[8] The other most common category was category 6: Business travel, which is disregarded here as not being a material source of emissions for a steel company in terms of relative quantity.

The IEA recently published a roadmap towards more sustainable steelmaking (IEA, 2020a). In assessing, the GHG emissions of the steel industry in different scenarios, it uses a model that includes all the significant upstream emissions from inputs that are considered key to the steel industry. Between steel companies, these may be considered a company's scope 1 or scope 3 emissions, depending on its level of vertical integration. This includes the production emissions of reductants, like coke and hydrogen, as well as the production of pre-processed sources of iron ore (sinter or pellets). The IEA GHG budget for the steel sector and their downward projection to 2050 could therefore be used as a basis for an SBTi steel sector approach.

It is noted that there are some complications within the IEA model in accounting for overlaps of emissions with other sectors. For instance, although the emissions associated with the use of steelmaking process gases (coke oven gas, BF gas and BOF gas) to generate electricity are controlled by the steel company, they are included in the power sector GHG budget and roadmap trajectory, rather than that for steel (IEA, 2020a). These overlaps, caused by the steel industry making useful co-products, will be discussed in more detail in chapter 4, and solutions for taking them into account will be proposed.

Which emissions should be included in the **core steel SBT**?

There are several other initiatives outside of SBTi and IEA that standardise the measurement of steel company emissions. worldsteel uses a standardised CO_2 data collection tool, in keeping with the ISO 14404 series of standards, in order to allow companies to benchmark their own steel emission intensities across their own sites (worldsteel, 2021). The Assessing Low Carbon Transition (ACT) initiative also proposes to use a similar approach as currently used by worldsteel, whilst future-proofing the system boundary to accommodate new low carbon steelmaking technologies (ACT, 2021).

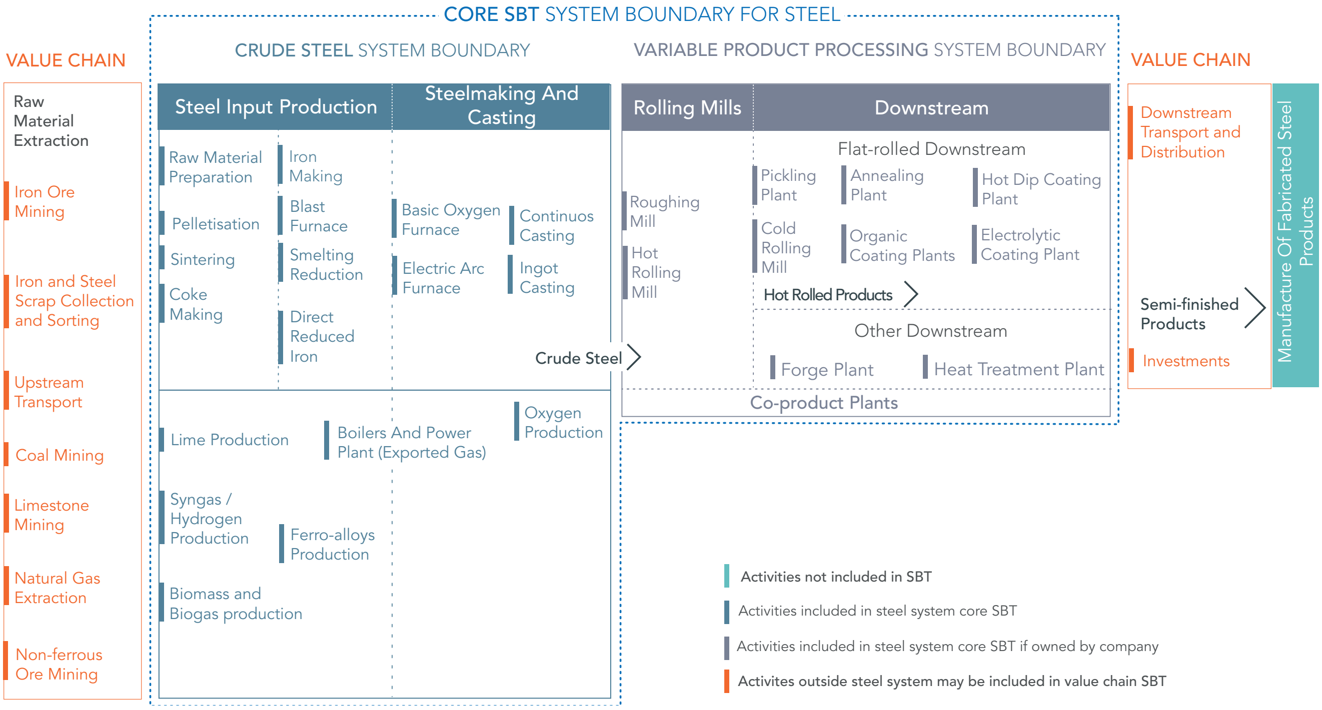
Both approaches include offsite pre-processing emissions from input materials and reductants within a more 'inclusive scope 1 and 2' steel system boundary. This is critical because GHG emissions relating to processes that are integral to iron and steelmaking are likely to shift upstream in the future[9]. Figure 10 provides an overview of the system boundaries proposed for the core SBT for steel, which are further described in the sections below.

The **core SBT** for steel companies is made up of two sub SBTs:

- **Crude steel SBT** (processes within the crude steelmaking system boundary, split into primary and secondary sources of crude steel production based on the ratio of metallic inputs).
- **Product processing SBT** (processes within the variable system boundary for downstream processing).

[9] Low emissions options for upstream raw materials processing might increasingly occur outside of the steel company boundary (e.g. use of pellets, pig iron, sponge iron).

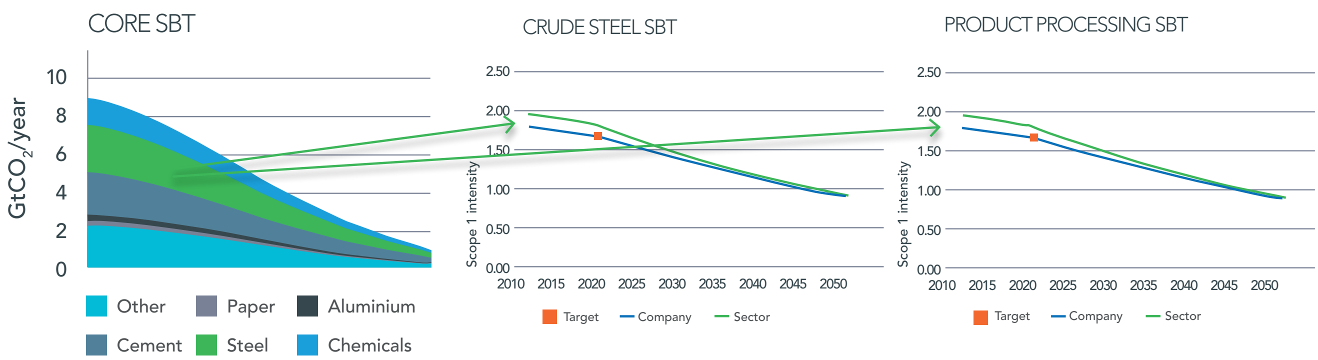
Figure 10: Overview of the proposed core system boundary for a steel SBT, made up of crude steelmaking and variable product processing emissions, which may be a steel company's scope 1, 2 or 3. Their other indirect emissions may be adopted within a 'value chain' target.



Source: adapted from ACT project draft iron and steel methodology (ACT, 2021).

This approach also translates into trajectories based on those two system boundaries, so essentially the steel sector budget is made up of two trajectories as illustrated in Figure 11.

Figure 11: Translating the core SBT into separate decarbonisation budgets (adapted from IEA 'Sustainable Development Scenario' for illustration purposes)



Crude steel target (system boundary for crude steelmaking)

The crude steel system boundary corresponds to all the processes necessary for crude steel production (to a cast product like slab, bloom, billet or ingot). This includes scope 1 and 2 emissions and specified scope 3 emissions, regardless of ownership or control. Purchased goods and services, and fuel/energy related activities not included in scope 1 and 2, should be included within a core SBT in as far as they fall within the crude steel system boundary. Excluded scope 3 emissions are raw material extraction processes, like mining of raw materials, and transport of mined materials (see value chain target). A company should have a **crude steel SBT** based on at least 95% of the GHG emissions for making crude steel within the system boundary. The SBT should be aligned to the relevant trajectory by 2050 using a GHG budget that follows the same scope of emissions[10].

10 A 1.5°C pathway scenario for steel is being made available as the result of the work of the IEA Global Net-zero 2050 Roadmap (IEA, 2021) and the Energy Transition Commission 1.5C steel pathway due in 2021.

The processes shown within the crude steel SBT (see Figure 10) will need to be allocated to either primary or secondary steel SBTs, or shared between the two using an equitable allocation method. Further guidance will need to be developed on this; for example, the BF process emissions should be counted towards the primary steel SBT, whereas the BOF emissions should be split between primary and secondary steel i.e. based on the ratio of metallic inputs from pig iron and scrap, and taking into account the pure metal content of each.

PREPARATION OF RAW MATERIALS AND REDUCTANTS

Emissions from making pellets or sinter from iron ore are included in the core system boundary to account for any shift upstream, for example, by changing from on-site sintering of iron ore, to importing pellets or even DRI made off site. This would, in effect, cause carbon leakage from a steelmaker's direct emissions up the value chain, and so it is necessary to set a consistent and inclusive system boundary that can accommodate this change. Further guidance will need to be developed on the question of whether to include the transport emissions for those pre-processed materials produced off site, as well as for other significant iron bearing materials, since 'upstream transport' currently sits within the value chain SBT boundary.

Similarly, for reductants, decarbonisation pathways are likely to prompt switching in the future from coal and coke to biomass and hydrogen. For consistency, all reductants and their associated production emissions should be included within the system boundary.

FERRO-ALLOYS

Ferro-alloys are also sources of iron, as well as other metal inputs such as chromium, nickel and manganese. It is important to note that there is considerable variation in the contribution of upstream ferro-alloy emissions to total steel production emissions, depending on the type of products made by a particular company. For instance, stainless steel upstream emissions from ferro-alloys contribute up to 70% of the total GHG emissions, whilst for carbon steels (low alloy) the contribution is typically 5% or less. Care is needed when comparing company emissions, as it can be influenced by the mix of products being produced (high or low alloy).

Emissions from the production of ferro-alloys are included in the IEA steel roadmap, although they are so far not included in the draft ACT methodology. This project has noted that there could be significant variations in SBTs between companies owning ferro-alloy production vs. those buying in ferro-alloys from third party suppliers. This is particularly relevant for stainless steel producers, but also applies to any producers of alloyed steel products – for the automotive industry, for example. Whereas stainless steel producers would probably be already required to include supply chain ferro-alloy emissions within their scope 3 SBT (since they would exceed the 40% threshold), this project concludes that ferro-alloys should always be included for consistency.

PROCESS GASES USED FOR MAKING POWER AND STEAM

Integrated steel plants usually capture process gases and use these to create additional value, for example, by generating electricity in a power plant. The power plant may be owned by the same company that owns the steel plant, or by a third party. Emissions from the combustion of process gas are significant (accounting for 10-40% of total emissions), and so their inclusion avoids discrepancies due to complexities in financial ownership structures for power plants and exported process gases.

Emissions from the export of process gases that are subsequently combusted, therefore, shall be included in the core system boundary, regardless of whether or not the power plant is owned by the company. This is consistent with the GHG methodology developed by worldsteel to manage this issue.

The steel SBT GHG budget, therefore, needs to include the steel industry power-related emissions included in the IEA power sector budget, as explained in chapter 4.

OTHER CO-PRODUCTS

The GHG emissions associated with the production processes that generate both steel and co-products simultaneously, are currently included within a steel company's direct emissions according to the GHG Protocol. Chapter 4 outlines different approaches that could be used for attributing emissions to co-products. The emissions from further processing of co-products however, e.g. grinding of granulated BF slag and CCU refining, should be excluded from the core steel SBT. In the case of CCU products, since the carbon captured in the product is not released within the steel system boundary, these should not be considered as direct emissions but accounted for within the value chain.

These complexities for accounting for co-products are explored further in chapter 4.

Product processing target (variable product processing system boundary)

The **product processing SBT** is made up of the additional downstream processes, after crude steel production, that are owned or controlled by the company (see also chapter 6). At least 95% of the emissions from the processes within the product processing system boundary should be accounted for. Where product processing emissions make up over 5% of a steel company's total GHG emissions, the company should include these emissions in a **product processing SBT.** The SBT should be consistent with a Paris-aligned GHG trajectory, using a GHG budget which incorporates the same scope of emissions.

Hot rolling is usually the first process after the crude steel production of slab, bloom, billet or ingot casting. In some cases, hot rolling can follow on straight from casting, although it is more usual to have to re-heat the steel before hot rolling. The reheating process uses significant amounts of energy and is considered part of the core system boundary if the process is owned or controlled by the company. The fuels used can be natural gas, propane or other process gases, and this can be on-site or off-site of the crude steel production. Often reheating is fuelled using energy contained in waste gas from other processes within the crude steel system boundary, and so it should be noted that the associated CO_2 emissions are already accounted for. A fair allocation of GHG emissions between the two systems would be needed.

Hot rolled products are often further processed in a sequence of process steps, which become highly varied depending on the end application. These processes include pickling, cold rolling, annealing, tempering, hot dip galvanising, electroplating, organic coating, forging, heat treating, hot forming and cold forming. Collectively they can contribute 5-8% of total emissions with the example of a hot dip galvanised product and a higher proportion for products made via the EAF.

Given the nature of integrated steelworks, technical guidance will be required to assist organisations in applying appropriate procedures to account for emissions that stem from energy flows across the crude steel and product processing boundaries and which may not be internally metered on a consistent basis.

Value chain target (additional upstream and downstream scope 3 emissions)

Companies may adopt an additional **value chain SBT** including significant further scope 3 emissions upstream and downstream of steelmaking and product processing. Increasingly, value chain targets are regarded as key to achieving global net-zero goals, and whilst these are currently applicable where relevant, we recognise guidance may evolve in the future. These processes will include the scope 1 and 2 emissions of companies within other sectors, such as mining (or indeed within the steel company itself), and can help identify further opportunities for GHG reduction.

RAW MATERIAL EXTRACTION AND TRANSPORT

GHG emissions from mining or raw material extraction may not be insignificant as a proportion of total steel value chain GHG emissions (cradle-to-gate[11]). Studies indicate this may be in the range of 12-20% (various studies including from worldsteel LCI data). However, since these are generally controlled outside of the steel industry's processes, they are not included in the **core steel SBT system boundary.**

Nonetheless, partnerships between steel companies and mining companies may help both sectors in their decarbonisation goals: steel companies may want to consider high quality sources of iron ore and low emissions sources of pellets, and mining companies may be interested in reducing their downstream emissions. Value chain SBTs including mineral extraction emissions are, therefore, to be encouraged.

For clarification, some metallic inputs such as ferro-alloy production are already included in the core steel SBT and may already include some mining emissions. The underlying SBT for these raw materials should be in line with SBTs for the steel sector.

11 Total scope 1, 2 and 3 emissions from natural resource extraction through to steel product leaving the steel production facility.

Upstream emissions from the transport of input materials may contribute between 1% and 5% of total steel value chain GHG emissions, however they are highly dependent on the geographical location of the steelmaking facility to the source of input materials and availability of transport mode infrastructure, such as shipping, rail or road.

Downstream transport and distribution of steel products to customers can contribute 2-10% of total steel value chain GHG emissions, and again, their scale depend on the geographical location of its customer base. Companies may have some more influence on road transport with respect to the mode of transport, efficiency or transport distance, load capacity utilisation and minimising empty returns.

Put together, emissions from raw materials extraction and transport appear on average to represent between 14% and 30% of the value chain emissions of steel. Whilst this does not surpass the 40% threshold in current SBTi guidance, where these are significant, steel companies may nonetheless want to include transport emissions in an additional voluntary **value chain SBT**, especially where there is opportunity to influence their source and scale.

PRODUCT USE PHASE AND END-OF-LIFE

Steel products may contribute to scope 3 product use phase emissions, but it is not usually straight forward to directly attribute these to steel, and so steel companies are advised not to include this category in their estimation of scope 3 emissions or **value chain target**.

Methodologies for calculating GHG emissions avoided by steel products (i.e. through stronger, lighter steels in cars) have been the subject of some analysis, and is something that a range of stakeholders have expressed interest in investigating further. However, to date there has been no consistent set of methodologies for incorporating 'use phase' emissions or avoided emissions into companies' corporate GHG accounting or their targets. Where companies include them (see Figure 9), this can lead to significant distortions in company value chain emissions. In the recent SBTi consultation paper (SBTi, 2020c), it was suggested, rather, that avoided emissions from products might be included by in a 'compensation' target alongside an abatement target. However, until credible and consistent methodologies are established, it is recommended that emissions from steel product use phase (GHG Protocol scope 3 category 11) are not included within steel companies' corporate GHG accounting or net zero targets. This should not prejudice the accounting of direct use phase emissions which can be clearly accounted, such as the combustion of a co-product.

Regarding steel recycling at end of life, whilst the methodology is established for accounting for the GHG benefits of recycling steel, it is more suited to product life cycle assessment (LCA) or footprinting rather than corporate GHG emissions accounting of production activities and target setting for companies. End-of-life processes, including recycling of steel products (GHG Protocol scope 3 category 12), should, therefore, be excluded from a steel **value chain SBT.**

METAL RECOVERY FROM RESIDUES

Dust, scales or sludges, such as from stainless steel production, contain metals with high economic value such as nickel. These residues are treated to extract the valuable metals, which are then recycled in the melting process. The residues are collected, transported to and resent from a processor or processed on-site and reduced to metals. Metal residues that are recovered within the system boundary are internally recycled, so the GHG benefit from avoided primary metals production is already included in the emissions inventory. For materials that leave the system boundary and are not returned, then the material can be considered as a co-product (see chapter 4 for more information).

4. ACCOUNTING FOR THE ADDITIONAL FUNCTIONALITY OF **STEEL INDUSTRY CO-PRODUCTS**

Resource efficiency is a key mechanism by which industry can decarbonise, especially through collaboration among different sectors, through industrial symbiosis. Therefore, it is essential that different sectors are able to work together for mutual benefit to help decarbonise industrial emissions as a whole. An important attribute of the steel industry is that it is not only a producer of steel, but also an important producer of other co-products that are used by a variety of sectors, as well as by the steel sector itself. Figure 12 provides an overview of the variety of co-products and their application in different sectors.

The importance of these co-products, from a GHG reporting and target setting perspective, is that they can exhibit similar functionality to products developed in other sectors via primary production, and can help reduce those emissions by product substitution. The steel sector should, therefore, account for its emissions in a way that considers the multifunctionality of the processes that produce co-products. Since co-product allocation is an issue that has to be addressed by many sectors, the most critical aspect is to apply a consistent approach between producers and users of co-products, to avoid double accounting, or a fraction of emissions not being reported. The majority of the emissions are rightly associated with producing the main steel product, whilst some are associated with producing co-products.

Whilst trying to account for this multifunctionality, it is important to bear in mind that the benefits, in terms of emission reductions, are often accounted for outside of the steel sector. This could lead to double accounting benefits or under accounting, if production emissions are not accounted for in the steel sector. The IEA sectoral emissions accounting approach for the steel, cement and power sectors illustrate this point. From an IEA perspective, the emissions from combusting BF gas to generate electricity are allocated and reported within the power sector, whereas the emissions for making BF slag for use in cement are kept in the steel sector, whilst the emissions avoided through reduced cement clinker production are within the cement sector. These examples illustrate how co-products can affect the setting of sectoral decarbonisation budgets, because they relate to emissions that are affected by company decisions but could have consequences elsewhere.

From a sectoral decarbonisation target setting perspective, the approach for dealing with co-products should have the following features:

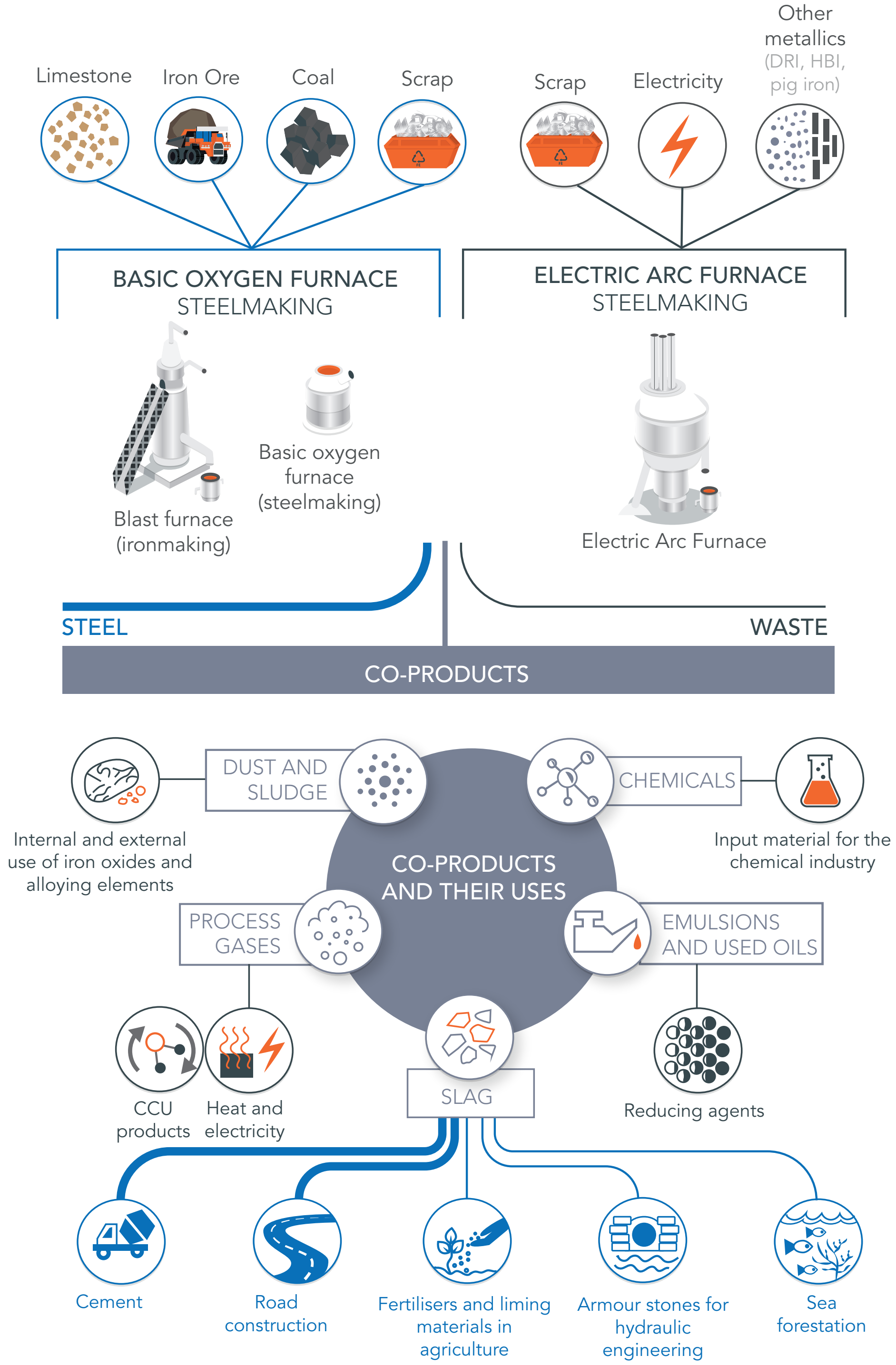
i. Work cohesively with all other aspects of the target setting approach.

ii. Be applicable across a range of steel industry co-products.

iii. Be acceptable to a range of stakeholders and pragmatic in recognising the benefit of co-products to the manufacturer of the co-product, the user and the wider industrial/societal system.

iv. Recognise/incentivise the potential of innovation and/or new co-products e.g. CCU.

Figure 12: Overview of the many steel industry co-products that help reduce GHG emissions of other sectors through substitution of primary production (source: worldsteel).



Allocation approaches

Co-products can be accounted for differently in company GHG reporting or product LCA approaches. Company accounting tends to keep all emissions associated with steel production and its co-products in the same basket, although there has been the possibility to separate out some of those emissions, for example in the worldsteel CO_2 data collection and reporting methodology (worldsteel, 2021). The LCA approach for providing steel product inventory data seeks to separate out the emissions so that only emissions associated with the steel product remain. The preferred system expansion approach, also known as substitution or avoided impacts, considers the real-life emissions avoided as a result of the co-product being used in place of something else. Essentially this 'credits' the system for the additional functionality provided to other sectors in terms of avoided emissions.

Table 1 provides a list of the co-products accounted for through system expansion when calculating steel product life cycle inventory data according to worldsteel (World Steel Association (worldsteel), 2019) and in ISO 20915: 2018 (Life cycle inventory calculation methodology for steel products).

Other approaches have also been explored, particularly for slag co-products that look at 'allocating' a proportion of emissions to the co-product, which should then be carried forward as an 'environmental rucksack' to the sector that uses the co-product and reported as their scope 3 emissions. This often results in using physical or economic relationships to estimate the proportion of GHG emissions that is reasonable to share between the producer and consumer of the co-products. These allocation methods can be complex to implement and can be difficult to apply across the full range of different co-products, especially if data is lacking. Each approach for dealing with multifunctionality has its strengths and weaknesses, which are further compared in Annex A.

Table 1: List of co-products leaving the steel system boundary and the emissions avoided when modelling product LCIs (source: worldsteel). Additional co-products from stainless steel include EAF dust and scales containing valuable nickel, chromium and iron.

STEEL CO-PRODUCT	CO-PRODUCT FUNCTION	AVOIDED PRODUCTION
Blast furnace slag, basic oxygen furnace slag, electric arc furnace slag	Cement or clinker production	1 tonne per tonne cement. Portland cement (CEM 1)
	Aggregate or roadstone	Gravel production
	Fertiliser	1 tonne slag replaces 0.5 tonnes lime
Process gases (coke oven, blast furnace, basic oxygen furnace, off gas)	Heat production for internal or external use	Coal, heavy fuel oil, light fuel oil or natural gas
	Electricity production	1MJ gas = 0.347 MJ electricity + burden of 0.275 kg CO_2/MJ BF Gas, 0.03667 kg CO_2/MJ COG, 0.1796 kg CO_2/MJ BOF Gas
Electric arc furnace dust	Zinc production	1 kg dust = 0.5 kg zinc
Electricity from energy recovery	Electricity production	Electricity production
Steam from energy recovery	Heat generation	Steam production from natural gas 85% efficiency
Hot water from energy recovery	Heat generation	Steam production from natural gas 85% efficiency
Ammonia	Any ammonia application	Ammonia production
Ammonium sulphate	Any ammonium sulphate application	Ammonium sulphate production
Benzene	Any benzene application	Benzene production based on different technologies
BTX (benzene, toluene, xylene)	Any BTX applications	Benzene production based on different technologies
Scales	Metallurgical input to steelmaking	Iron ore extraction
Sulphuric acid	Any sulphuric acid applications	Sulphuric acid production
Tar	Any tar application	Bitumen production
Used oil	Heat generation	Coal, heavy fuel oil, light fuel oil or natural gas: + burden of 3.2 kg CO_2/kg
Zinc	Any zinc application	Zinc production
Zinc dust	Any zinc application	Zinc production
Electrode	Electrode making	Electrode mix

Exploring framework options

This project has explored three framework options for dealing with co-products in the context of an SDA:

OPTION 1
A redistribution of sectoral budgets e.g. a proportion of other sectoral budgets are 'amalgamated' into a steel budget, commensurate with the GHG value of co-products.

OPTION 2
A steel company's direct emissions are assigned to products and co-products according to their GHG value. When setting a company target, the overall target is built up of sub-targets based on relevant sectoral trajectories e.g. for steel, cement, chemicals etc.

OPTION 3
The emissions avoided in other sectors by using steel company co-products are acknowledged as a valuable means of GHG reduction, or compensation. In this approach the steel sector still reports any scope 1, 2 and 3 co-production emissions from processes occurring within the core steel system boundary.

Each option has its merits, for example option 1 has the advantage that it would account for all of the interactions of steel industry co-products within the steel GHG budget and trajectory. In reality, this would be a complex exercise, not least because it would need other sectors to leave out any co-product benefits in terms of emissions reduction and may disincentivise the use of the co-products and the real emissions abatement/displacement benefit they provide.

Option 2 is similar to option 1 in that it integrates the decarbonisation trajectories of other sectors within a steel trajectory. One of the difficulties would be in deciding on how to weight the contribution of, for example, the cement sector trajectory in the steel trajectory.

Using BF slag as an example, one could weight the contribution according to the mass of the BF slag used, the energy content or other factor such as GHG emissions or economic value. As an illustration using mass weighting: if the steel sector GHG emissions reduction rate was, for a given period, linear at 1.4% per year and the cement sector trajectory was 1%, and 20% by mass of a steel company's total production was BF slag, then the weighted trajectory for the steel company would be (1.4 x 0.8) + (1.0 x 0.2) = 1.32% per year.

Recently the concept of compensation mechanisms (Option 3) has been introduced (e.g. SBTi, 2020c) as a means to recognise the benefits of company actions that mitigate GHG emissions beyond their value chain. In this approach, the direct GHG emissions that can be attributed to co-products remain within the steel sector basket and SBT, but the GHG mitigation resulting from the use of those co-products in other sectors is acknowledged in a transparent way.

One reason for the introduction of the compensation mechanisms concept was specifically for 'hard to abate' sectors: "Avoided emissions, the purchase of carbon credits, and other interventions enable companies to contribute positively to climate action beyond their value chains and can actively contribute to other goals of the Paris Agreement - namely climate adaptation, climate finance, and the sustainable development agenda. These activities may be highly impactful, despite the fact that they may not counterbalance a company's unmitigated emissions and should be considered as options that enable companies to contribute to society reaching net zero. That is a valuable goal in itself and helping others to reduce emissions and adapt to climate change, will also help make it possible for all companies to reach net zero more efficiently" (SBTi, 2020c)[12].

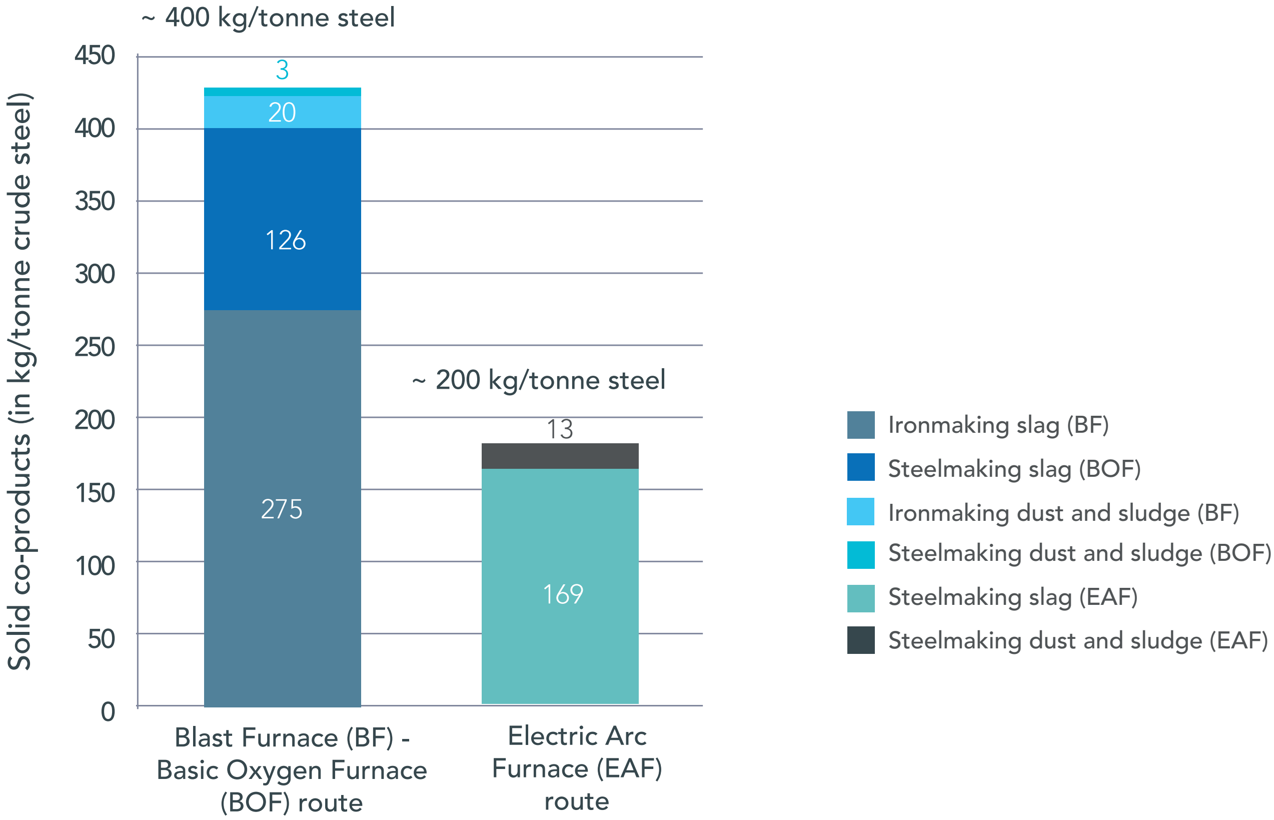
Whilst the concept of avoided emissions 'compensation' can be used to recognise emissions savings beyond the value chain of the co-product producer, it is not suggesting the producing sector claims all the savings. However, it is important to measure their effect throughout the low carbon transition, otherwise any changes to the quantity and quality of co-products, and consequential impacts on external GHG emissions, won't necessarily be visible. Where there are agreements made between sectors on a sharing of co-product emissions or their avoided emissions, then this should also be considered in future guidance so as to ensure methods are applied consistently across all sectors.

12 SBTi report: Foundations for Science-based Net-zero Target Setting in the Corporate Sector, Page 33. (SBTi, 2020c).

Example of blast furnace slag used to **replace Portland cement**

BF slag forms a significant part of the solid co-products produced in an integrated BF and BOF facility, as illustrated in Figure 13.

Figure 13: Quantities of solid co-products produced by the two main steel production routes (source: worldsteel).



According to worldsteel, typical uses for BF slag include cement replacement (78%), roadstone aggregate replacement (21%), and fertilizer (<1%) (World Steel Association (worldsteel), 2019). The average avoided emissions from this mix of end applications were calculated to be 0.62 tonnes GHG emissions per tonne BF slag.

One positive action a steel company could take would be to direct its co-products towards higher quality, and consequently higher GHG saving applications. This may require improvements in slag-making processes and quality aspects to allow more of the BF slag to be used in cement applications instead of roadstone applications, where the GHG savings of replacing natural aggregate are much lower.

For instance, if 100% of the BF slag was used as a cement replacement, the GHG avoided emissions would be 0.82 tonnes GHG per tonne BF slag, which represents 1.15 million tonnes of GHG emissions avoided for a 5 million tonnes of steel per annum integrated steel plant, or approximately 10% of its emissions. The additional GHG emissions required to further process BF slag to the equivalent point of substitution as cement, i.e. granulation of BF slag to make ground and granulated blast furnace slag, should be taken into account in any mechanism to quantify the value of its production and use.

A compensation mechanism could also recognise a 'sharing' of the benefits of GHG emissions avoided, however this would need agreement between sectors to ensure consistent reporting i.e. to agree what emissions could be deducted from a steel sector budget, rather than being reported solely under compensation. The above approach could equally apply to other co-products listed in Table 1, where emissions are released within the core steel system boundary.

Proposal for **carbon capture** and utilisation of process gas

One of the promising carbon reduction pathways for the steel industry is through the use of CCU technologies, that capture the carbon and hydrogen from process gases, to make chemicals that can be used in a variety of applications for making plastics or low carbon fuel. CCU can also be combined with carbon capture and storage either for the remaining carbon in the process gas that is not used, or in the subsequent use of the CCU product. Due to the high volumes and capacity required to store the gas for long periods, the conventional use of process gas is to make electricity and steam in a power plant. The GHG emissions of this process are high compared to alternative means of making electricity and steam through natural gas or renewable power sources. Therefore, there is significant GHG reduction potential if the process gas could be put to better use through CCU. The contribution of process gas to current emissions of different steel production sites can vary from 10% to 40%, depending on the raw materials used and plant configuration.

One of the reasons why emissions from combusting process gas should remain within the system boundary of the core steel SBT, regardless of the ownership structure for power plants, is because of their significant emissions. If they were not automatically included, a company could significantly reduce its emissions simply by exporting the process gas to a separate power company. As a result of the aforementioned issue, it is necessary for some of the power sector emissions, reported by IEA, to be part of the core steel SBT and SDA, since the IEA report states that emissions from combusting process gases are included within the power sector budget. Any excess electricity, and consumed heat produced beyond the core steel system boundary needs (regardless of where the power station is located or where its outputs are consumed) can be reported under the compensation mechanism described in the previous section.

An important distinction compared to other co-products is that CCU products physically contain carbon that is exported that would otherwise be released as direct scope 1 emissions if they were used on site. Other co-products, like slag, do not physically contain the GHG emissions associated with their production, and the GHG emissions are released from processes within the system boundary. Using process gases to make CCU products is also distinct from the use of process gases for combustion in a power station for several reasons:

i. Process gases combusted in a power station are immediate, inevitable, and released within the prescribed system boundaries for the steel core SBT. Whereas a CCU product has an element of storage and choice involved e.g. made into a plastic product or a fuel that is later used elsewhere, meaning that GHGs are not released within the steel core SBT.

ii. CCU products require several additional process steps after the capture process of the gas. These process steps may or may not be owned or controlled by the steel company, complicating their inclusion in a steel SBT.

iii. The final end use of the CCU product may not be known by the steel company due to the multiple uses possible for the captured carbon.

For these reasons, the captured carbon may be partly or wholly deducted from the carbon balance of the site. This should recognise the effort a company makes to put process gases to better use, rather than immediately combusting them in a power station. Any processing emissions for the CCU product become the responsibility of the downstream sector. The way in which captured GHG emissions are attributed to the steel producer or downstream user may depend on how regulations prescribe reporting conventions, as well as how CCU supply contracts are agreed. In addition to emissions not released by the steel sector, there may also be additional avoided emissions in downstream sectors, depending on the application.

Further clarification is also needed for specific sources of carbon, since the captured feedstock can originate from renewable biogenic sources or from waste, as well as from fossil sources. This proposal is subject to a developing regulatory environment for calculating and reporting CCU product emissions, which could have an influence on SBT reporting. It should be noted, however, that different methods and system boundaries for accounting for CCU products may be legitimate, where there is a different goal and scope defined. For instance, calculating the life cycle emissions of a CCU product for the purposes of a policy on fuels requires a different goal, scope and system boundary to that needed for calculating a steel company's decarbonisation target. An important consideration will be to avoid double accounting of the captured carbon GHG benefits among the different sectors.

5. POLICY CONTEXT AND PRE-REQUISITES FOR **SETTING A COMPANY 2050 TARGET**

The steel sector is seen to be 'hard to abate' for several reasons:

- Coal and fossil fuels are intrinsic to the primary production process.
- The sector has numerous capital intensive assets.
- The sector has a long investment cycle from approximately 25 years (interim investments) to 40 years.
- The lock-in effect, due to rapid growth in production capacity in China since 2000 (now 50% of global capacity), means that there is a low average asset age of approximately 13 years (IEA, 2020a).
- Steel is a globally-traded commodity, competition is high, selling price for commodity steels is low, and this leads to low profitability which, in turn, reduces the ability to invest.

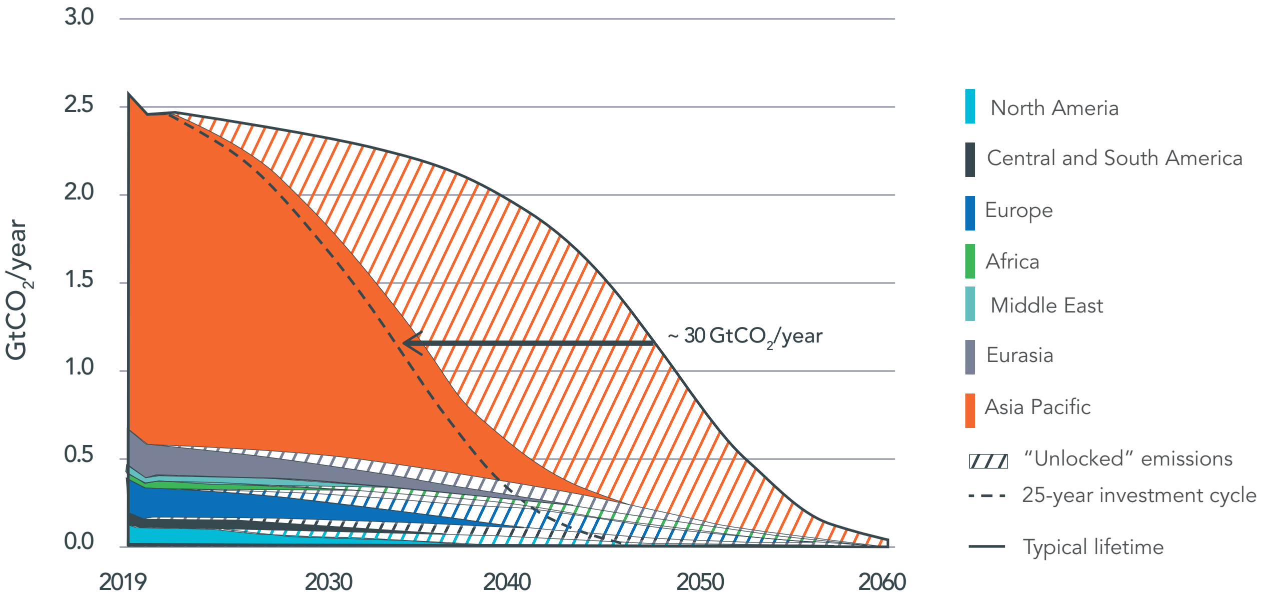
This means that policy interventions are needed to incentivise and unlock rapid decarbonisation of the steel sector to meet net zero targets. Policy and legislation are generally driven at a state or regional level, which leads to regional disparity in how policy affects the decarbonisation trajectory of the steel sector. In certain markets, steel is also subject to 'carbon leakage' as a result of the disparity of carbon policy compared to other trading blocks. It is also a market where tariffs can be applied, leading to trade distortion.

The IEA has listed several strategies that can be deployed to prevent the 'locked-in' emissions from occurring decades into the future before the next investment cycle. These include:

- Early retirement or interim underutilisation of assets.
- Refurbishment and retrofitting, such as enhanced process integration to boost energy efficiency, or the application of emission-reduction technologies such as replacing natural gas by hydrogen or applying carbon capture, use and storage (CCUS).
- A change in material inputs, for example a higher share of scrap use in various process units.
- Fuel switching and incremental blending, sometimes combined with some degree of retrofit.

Analysis of these interventions by the IEA has suggested that there is potential to unlock 30 Gt of CO_2 emissions reduction from the steel sector. That is 30 Gt of CO_2 emissions that would otherwise occur without policy intervention, as shown in Figure 14.

Figure 14: IEA analysis shows that intervening at the end of the next 25-year investment cycle could unlock roughly 30 Gt CO_2, or around 50% of projected emissions from existing equipment in the steel industry (IEA, 2020a).



Sources: Estimates informed by Steel Insitute (2018), Steel Insitute VDEh PLANTFACTS database, and OECD Steel Committee (2019a)), Latest Developments in Steelmaking Capacity.

Considerations in **setting a company SBT**

The potential trajectory for the sector as a whole, as well as at a regional or national level, is dependent on a number of factors. In Figure 15, the IEA illustrates the stakeholder framework that is needed to accelerate the steel sector's transition to net zero. This framework should be assessed in the context of the geographic region for which the SBT is being set. Absence of any of the policy and other stakeholder pre-requisites, could influence the company's ability to set a realistic trajectory in line with the Paris Agreement objectives. Financial institutions are one such stakeholder that can play an important role, where there is a pressing need for more disclosure to reduce climate risk for the financial sector. Sustainable finance is also a policy initiative that will help accelerate investment in more sustainable industries and projects, whilst making the financing of unsustainable projects, like coal fired power stations, more difficult.

Figure 15: IEA framework for accelerating the iron and steel sector's clean energy transitions (IEA 2020a).

DRIVING FORCE: STAKEHOLDER COLLABORATION

- **Leading role:** governments, steel producers and associations
- **Supporting role:** intermediate and final steel users, financial institutions and investors, other industries, technology suppliers, trade unions, researchers, non-governmental organisations

FRAMEWORK **FUNDAMENTALS**

Planning and policy for long-term CO_2 emission reductions

- **Roadmaps and plans addressing multiple levels:** climate change, industry, steel sector, companies, just transition
- **Legislated policy:** emissions trading systems, carbon taxes, tradeable emissions standards

TARGETED ACTIONS FOR SPECIFIC TECHNOLOGIES AND STRATEGIES

Steelmaking technologies

Managing existing assets and near-term investment

- Retrofits and retrofit-ready builds
- Tradeable energy efficiency schemes
- Differentiated policy for existing plants
- Sunset clauses

Creating a market for near-zero emissions steel

- Carbon contracts for difference, public and private procurement, minimum content regulations
- Low interest and concessional loans, blended finance

Developing earlier-stage technologies

- RD&D funding, public-private partnerships
- Knowledge sharing, innovation co-ordination

Scrap use and steel demand

Accelerating material efficiency

- Improved networks for scrap collection and better sorting
- Modified design and regulations to optimise life-cycle emissions
- Extended end-use lifetimes

NECESSARY **ENABLING CONDITIONS**

International co-operation and a level playing field

- Intermediate carbon markets, sectoral agreements, carbon border adjustments, climate clubs, consumption-based emissions policy
- Technology transfer, best practise sharing, international finance

Infrastructure planning and development

- Co-ordinated planning and financing for CO_2 transport and storage and for reliable, decarbonised electricity and hydrogen production and distribution

Tracking progress and improved data

- Increased data collection and reporting
- Low-emissions steel labelling and standards
- Sustainable investment schemes and taxonomies

Capital intensity and carbon intensity **cost to change**

Depending on the specific situation within this framework, there could be different speeds at which companies can decarbonise. In particular, this is related to the different financial investments needed in relation to technology deployment:

i. The cost of CAPEX is vastly different for an EAF producer compared to an integrated BF/BOF producer.

ii. Policy-related investments relate to compliance investments. For example, European producers need to meet the latest Industrial Emissions Directive (IED) emission limit values. These can also vary significantly depending on if you are an EAF or integrated BF/BOF producer.

iii. Normal CAPEX expenditure, for example, on energy efficiency improvements.

iv. Normal OPEX expenditure, for example, making a power purchase agreement to source renewable electricity.

2030 PATHWAY

Some steelmaking companies or sites may have the potential to reach net zero emissions by 2030, where the combination of policy instruments and available clean energy make it viable. This could apply to an EAF-based site, or an integrated BF/BOF site that has assets at the end of their useful life, operating in a jurisdiction where policy makes low-emissions steelmaking at least as competitive as existing steelmaking technologies. They are likely to be located in a region with a mature GHG policy landscape, such as the existence of a carbon tax with a carbon border adjustment mechanism in place. They are also likely to have access to governmental financial support.

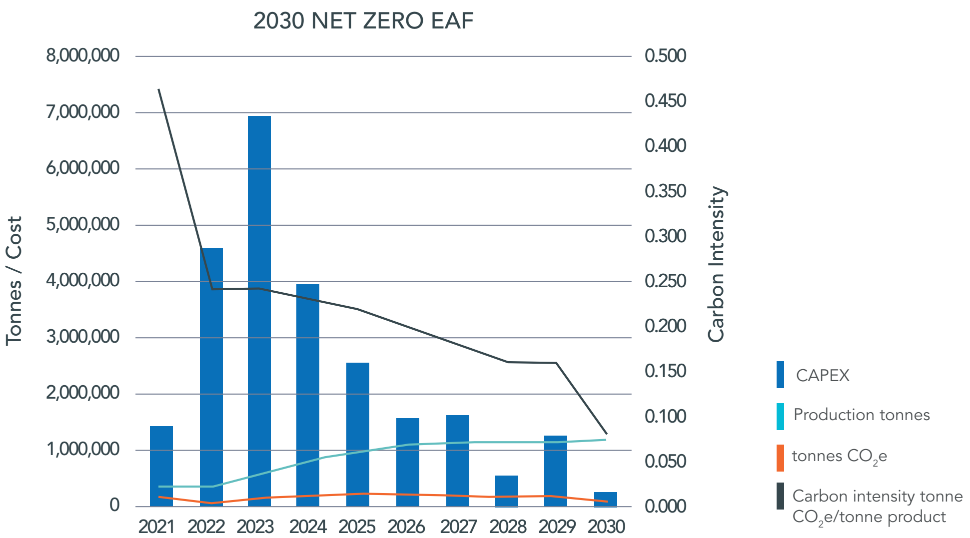
Figure 16: Illustration of a 2030 pathway for a carbon steel EAF steel producer operating in a mature policy environment with technology deployment and CAPEX requirements.

ILLUSTRATION

- Region with mature policy
- EAF Based Steelmaking & Hot Rolling And Processing
- Investment but no technology change
- Market Growth and Increase in Production

Baseline 2021

Renewable PPA Electricity 2022	OPEX
Fuel Switch + Process Elimination 2023	CAPEX
Efficiency 5% + Process Elimination 2024	CAPEX
Efficiency 5% 2025	CAPEX
Fuel Efficiency (BAT) NG 2026	Policy - IED
Fuel Switch 20% NG Grid Renewable 2027	Policy - Energy
Electric and Hydrogen Transport 2028	Policy - Transport
Electricity GRID Zero 2029	Policy - Energy
Fuel Switch 100% Renewable 2030	Policy - Energy



2050 PATHWAY

In this pathway, companies or sites will reach net zero by 2050. Large integrated producers are more likely to make their big investments from 2030 onwards, by deploying emerging hydrogen ironmaking or CCUS technology at increasing scale, for example. For this to happen, the right policies should be in place by 2025 to give confidence in making very large CAPEX investment decisions e.g. that there will be enough decarbonised hydrogen and suitable input material at an affordable price.

Figure 17: Illustration of a 2050 pathway for an integrated BF/BOF steel producer with technology deployment and CAPEX requirements

2070 PATHWAY

Late adopters will make incremental improvements and then deploy hydrogen-based or CCUS technology from 2040 onwards, at the end of their assets' life. Policy or governmental support may not be effective, resulting in reaching net zero emissions by around 2070.

The policy landscape: different types of policy support available

Policy and legislation can be used in different ways through incentives (the 'carrot' approach) or through some sort of penalty (the 'stick' approach), and often in combination. When setting an SBT, the company should assess the policy landscape and horizon, which means considering what is happening now and what is likely to happen in the medium to longer term. Regions that have a more mature policy landscape, will have a wide range of policies in place to encourage and push towards more decarbonisation, such as:

- An emissions trading scheme with an established market for CO_2/GHG emissions reduction, with a declining cap on total emissions and an ambition to increasing the price for CO_2/GHG allowances.

- National GHG budgets and roadmaps.
- Strict industrial emissions regulations – placing limits on industrial emissions and increasing efficiency.
- Policies to drive the clean energy systems, including renewable electricity, green hydrogen and bioenergy.
- Circular economy – policies to increase resource efficiency, including recycling.
- Access to research and development funding and scale up funding for pilot plants.

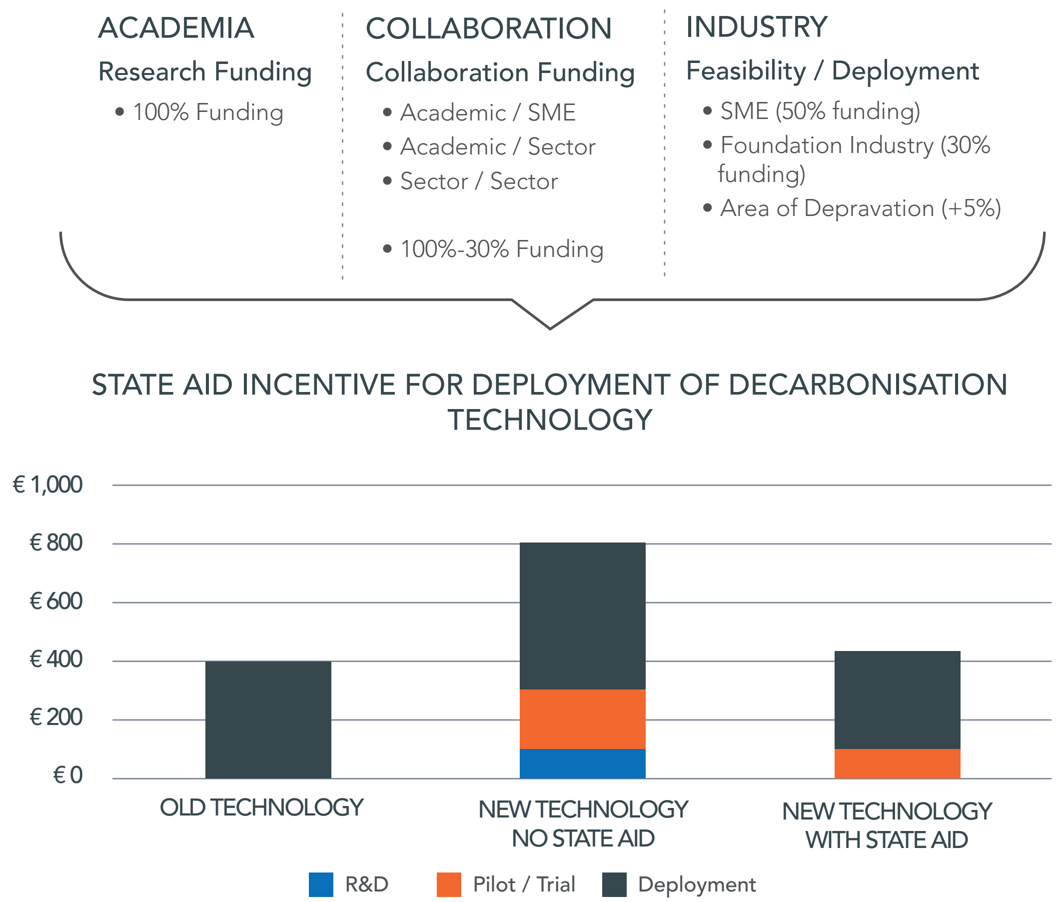
Some jurisdictions will be less developed or less stringent in terms of the policies in place, and this can have a bearing on the company's confidence or ability to invest in new technology. The IEA has looked into the differences in policies between regions in more detail (IEA, 2020a), and also updates a policy database for each country.

Jurisdictions with more mature policies in place will also have a longer-term perspective and try to address barriers to technology implementation, or risks, with policies to overcome those risks. This will give businesses more confidence in being able to make investment decisions and set the level of ambition accordingly. In less developed governance systems, the policy horizon may be more short term, which will be reflected in businesses being more reactive and unable to plan for future risk mitigation.

STATE AID

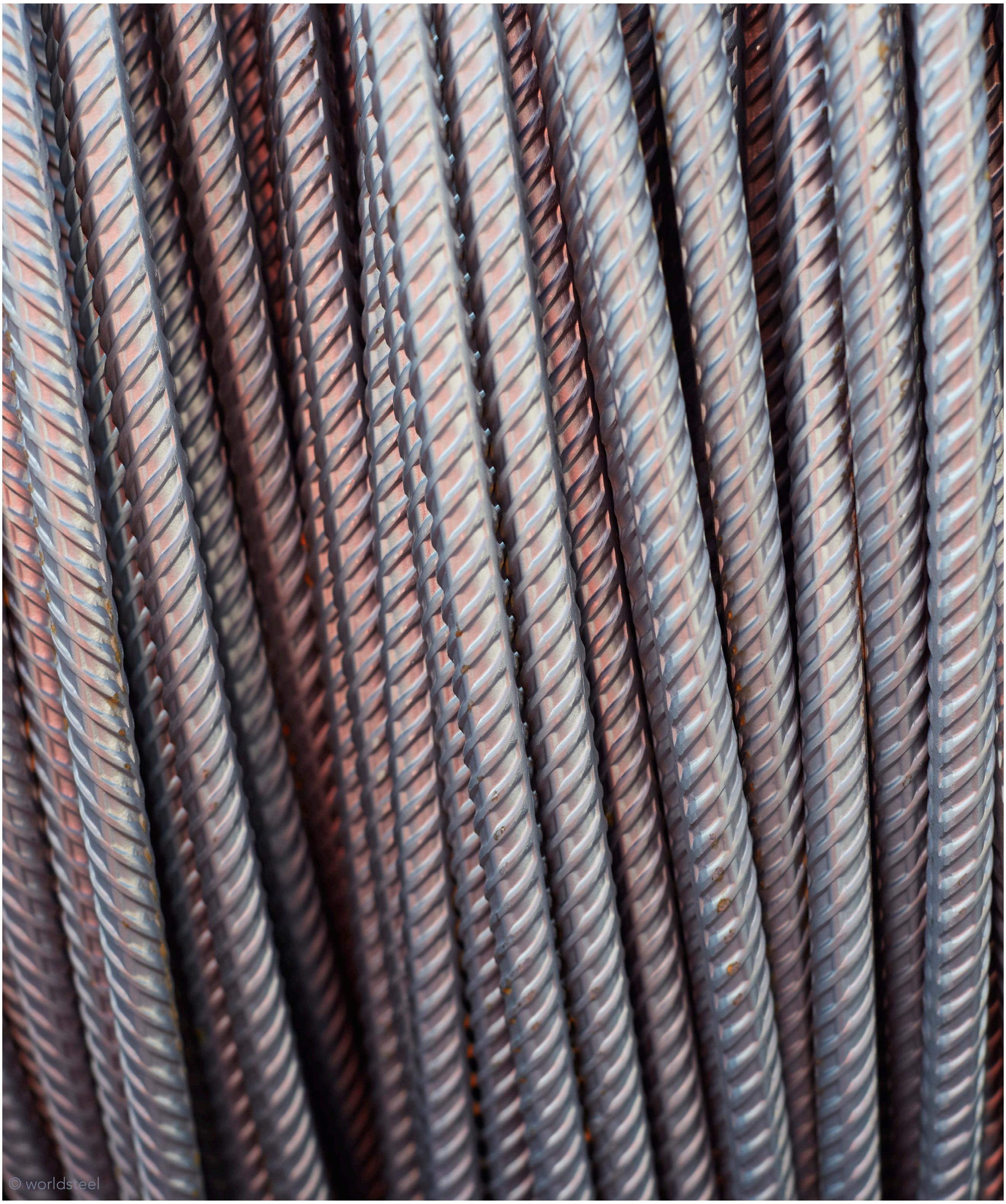
State aid for an industrial sector can vary from country to country, depending on national priorities. There are rules in place (World Trade Organization and national/regional) to determine what is an acceptable level of support that can be provided by the state. In the context of enabling decarbonisation, state aid can be used to support the developmental process from the academic research stage to the industrial deployment stage. Funding from the state decreases throughout the process but is designed to be at a level so that the risk, or cost disadvantage, of deployment is removed (as seen in Figure 18).

Figure 18: Illustration of state aid funding levels for different stages of technology development and potential effect on decarbonisation costs.



CARBON BORDER ADJUSTMENTS (CBA)

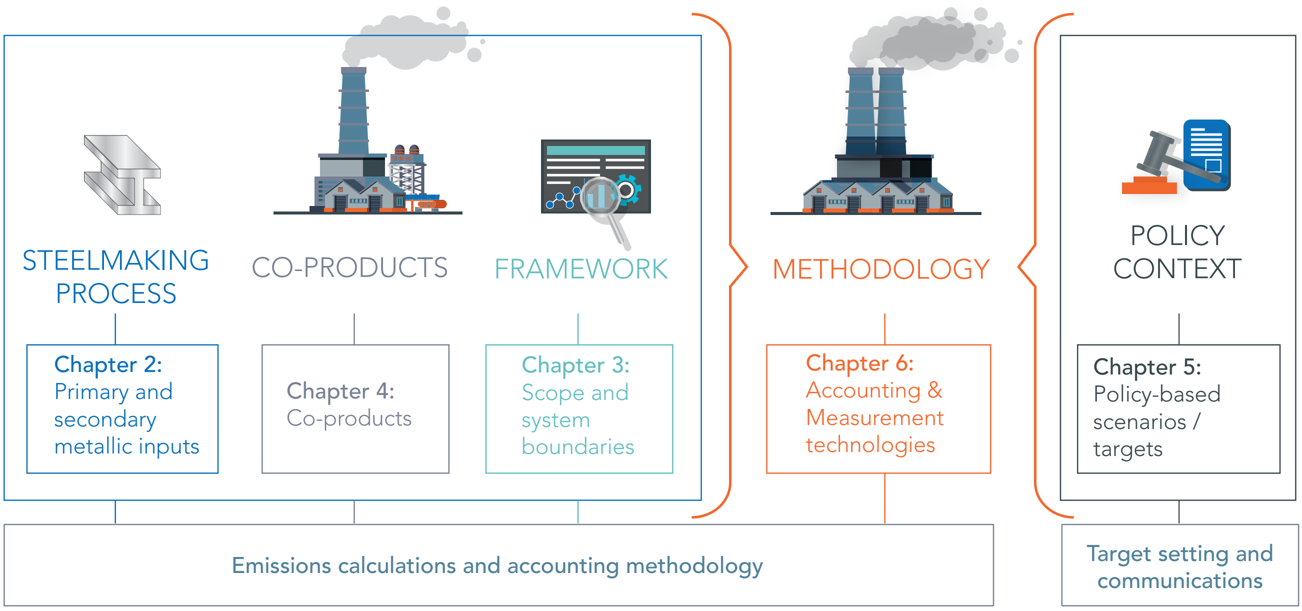
Some trading blocks, or individual countries, may introduce a mechanism to support domestic industry and protect decarbonisation policies from being undermined by imported products that have a higher carbon / GHG footprint. Importers from regions that do not have a mature carbon tax system have the potential to be more competitive on prices compared to domestic producers. This is because they do not face the same regulatory cost to reduce GHG emissions. This differential could become starker once low GHG technologies are scaled up with their associated higher capital cost and also higher operating costs. A CBA can be designed to help re-balance the costs associated with the non-level playing field on carbon costs, and give confidence to domestic producers that investments can be made without endangering their market share.



6. COMPATIBILITY WITH EXISTING STANDARDS AND ACCOUNTING METHODS

The Net Zero Steel Pathway Methodology Project has sought to follow existing guidance wherever possible, whilst highlighting areas where further clarity is needed that are specific to the steel sector. Figure 19 gives a summary of the areas that the project focused its attention on, and how it fits together, in order to achieve greater consistency and confidence for companies to make meaningful SBTs.

Figure 19: Summary of areas of methodology that were considered during the Net Zero Steel Pathway Methodology Project.



This chapter assesses how existing guidance and standards can be used in conjunction with the complementary specific guidance and recommendations identified within this report.

GHG protocol

The project has sought to follow the principles set out in the GHG protocol (WRI/WBCSD, 2004) covering: relevance, completeness, consistency, transparency and accuracy. The protocol also provides appropriate guidance for defining and reporting against organisational boundaries.

ORGANISATIONAL BOUNDARIES

This report has largely focussed on the approach, scope and boundaries for GHG emissions accounting and target setting associated with the production of steel from individual steel sites and their corresponding value chains. However, there is a need for guidance to assist steel companies apply this methodology across their corporate footprints.

In order to demonstrate company level targets are consistent with the Paris Agreement objectives, companies must utilise a recognised approach to defining and reporting against organisational boundaries. Companies should apply the same organisational boundaries to its SBT as its GHG inventory (e.g. equity share approach, or control approach (financial or operational)).

i. **Equity share approach:** Organisation accounts for GHG emissions from sites according to its share of equity in the operation.

ii. **Control approach:** Organisation accounts for 100% of the GHG emissions from sites over which it has control. It does not account for GHG emissions from operations in which it owns an interest but has no control. Control can be defined in either operational or financial terms.

- **Operational control:** A company has operational control if the former or one of its subsidiaries has the full authority to introduce and implement its operating policies at the operation. This criterion is consistent with the current accounting and reporting practice of many companies that report on emissions from facilities, which they operate (i.e. for which they hold the operating license).

- **Financial control:** The company has financial control if the former has the ability to direct the financial and operating policies of the latter with a view to gaining economic benefits from its activities.

In each of the organisational boundary approaches above, the company must apply the core steel boundary (and where appropriate the value chain boundary) to each facility and then overlay its organisational boundaries approach.

SCOPE 2 EMISSIONS

The direct procurement of low emission electricity is an important driver to accelerate the decarbonisation of the electricity sector. The existing SBTi SDA for steel, requires companies to use a single, specified scope 2 accounting approach using a 'location-based' or 'market-based' approach (WRI/WBCSD, February 2020 (updated)) for **setting and tracking progress** towards an SBT. Organisations should apply the same scope 2 accounting approach to its SBT as its GHG inventory.

1. **A location-based method** reflects the average emissions intensity of grids on which energy consumption occurs (using mostly grid-average emission factor data).
2. **A market-based method** reflects emissions from electricity that companies have purposefully chosen. It derives emission factors from contractual instruments, which include any type of contract between two parties for the sale and purchase of energy bundled with attributes about the energy generation, or for unbundled attribute claims.

It is recommended, in principle, that the net zero steel pathway methodology recognises the contribution of incentivising steel companies to procure low emission electricity supply through the market-based method, however further work is required to validate how to integrate this approach as part of the sector budget accounting approach.

Steel industry **GHG accounting** standards

The standards ISO 14404 (*calculation method of carbon dioxide emission intensity from iron and steel production – parts 1 to 4) and EN 19694-2:2016 (stationary source emissions - GHG* emissions in energy-intensive industries - Part 2: Iron and steel industry) are a starting point for the calculation of GHG emissions using prescribed emission factors for key inputs unless more specific values are available. Whilst the system boundaries for those standards generally align with those proposed by this project, there will be some adjustments needed to ensure the processes included match those in the proposed core steel system boundary. The separation of primary and secondary steel emission calculations for carbon and stainless steel would also be needed.

Whilst the European standard EN 19694-2 should, in theory, provide a similar result as ISO 14404, there are some differences worth further investigation. In particular, the emission factors and alignment of scope 1, 2 and 3 emissions would need to be ensured. EN 19694-2 also gives the possibility for companies to benchmark performance of individual processes, and different configurations, as opposed to just the production facility. This approach probably goes beyond the needs of calculating and setting emissions targets at a company level.

Due to the need to regularly update emission factors, it is suggested that the worldsteel CO_2 reporting tool (worldsteel, 2021), which formed the basis of ISO 14404 and is therefore very similar, is used as a practical way to ensure a consistent calculation method. This tool has a high take-up in the industry, and is regularly updated and managed by worldsteel. The above-mentioned adjustments would need to be implemented, as well as capturing GHG emissions and not just

CO_2. This would imply a review of the emission factors used in the CO_2 reporting method is needed, to ensure any materials with a low CO_2 but high GWP emissions are not missed.

Steel industry **life cycle inventory** standards

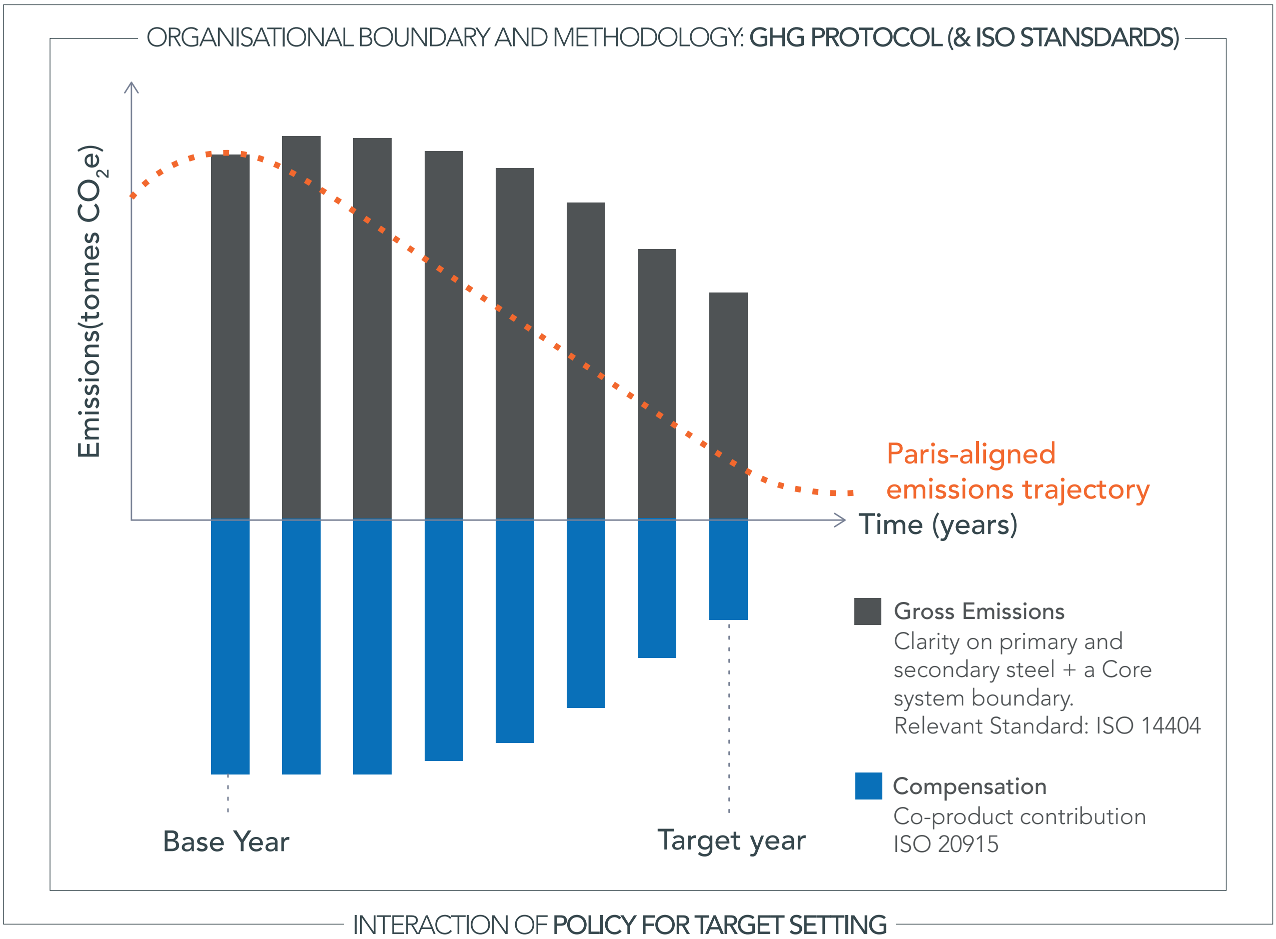
ISO 20915 (2018) (***Life cycle inventory calculation methodology for steel products***) sets out the method for calculating the avoided impact of steel industry co-products, which follows a similar approach as used by worldsteel for LCI data collection and reporting (World Steel Association (worldsteel), 2019). This approach can be used as the basis for calculating 'compensation' emissions for co-products. The standard does not provide for any distribution of emissions and associated benefits between co-product producer and user, however this requires further consideration. It should also be noted that ISO 20915 does not account for the burden of combusting the excess process gases (on site or exported) and only applies a credit for the displaced energy. The worldsteel LCI methodology included the burden at the point of substitution, where there is equivalence between the process gas and the fuel being substituted, which was the point of combustion.

SBTi guidance and target setting

The Net Zero Steel Pathway Methodology Project seeks to align with the existing SBTi guidance for target setting, whilst proposing more detailed elements within that framework. Figure 20 illustrates how the project considerations might complement SBTi and other approaches. A comparison of main SBTi requirements with the proposals in this report is provided in Annex B.

Figure 20: Illustration of an approach for emissions target setting, overlaid with Net Zero Steel Pathway Methodology Project proposed guidance.

TIME HORIZON



The SBTi guidance enables organisations to set medium term science-based emissions abatement targets aligned with longer term net zero targets.

- **Medium term:** Cover a 5 (minimum) to 15 (maximum) year period from the date the target is publicly announced.
- **Longer term:** Up to 2050.

INTENSITY TARGETS

The setting of an intensity target is proposed, utilising the different allocations for primary ore and scrap pathways. Consistent with the current SBTi approach, intensity targets **must lead to absolute emissions reductions** in line with the modelled sector-specific decarbonisation pathway or aligned to climate science.

THE ROLE OF CARBON OFFSETS

Carbon offsets are likely to play a role in the achievement of net zero goals within the steel industry in order to abate residual emissions that new technologies cannot achieve in time. In addition, as the evidence of the need to accelerate decarbonisation advances, the measures needed become more innovative. The wider issue of offsets, including use of the voluntary offset market, is beyond the scope of this project. However, important issues are raised by the potential for voluntary carbon offsets/credits in relation to industrial decarbonisation that are worthy of a mention.

As the demand for carbon offsets grows, so too does the market for voluntary carbon credits. The market offers nature-based credits or other types of credits based on carbon reductions and removal. However, the quality of these credits and their role in net zero targets becomes increasingly difficult to govern. Both the Task force on Voluntary Carbon Markets and the SBTi have this year held consultations to consider how to ensure quality and an effective role for offsets in global GHG reductions. The drive to encourage high quality carbon credits is accelerating, ensuring that theses enable GHG emissions reductions and removals that are both additional and permanent.

It is often assumed that the steel industry will be a buyer of carbon credits to offset its residual emissions. However, it is also foreseeable that the industry could be a supplier of credits. The combined use of Bio Energy and Carbon Capture and Storage (BECCS) for example, could generate net carbon positive outcomes. Where principles such as additionality and permanence can be established, such credits could provide a source of investment finance for decarbonisation. Investments in the steel sector's decarbonisation could well be seen as a reliable way to permanently reduce, and in some cases remove, emissions.

7. **SUMMARY** RECOMMENDATIONS

This report seeks to open a dialogue with stakeholders on the challenges faced by the steel industry in setting meaningful, yet ambitious, SBTs that follow a net zero GHG emissions pathway to 2050. It is hoped that the SBTi will collaborate in developing dedicated sectoral guidance for a steel SDA, and help bring together insights from emerging initiatives such as ACT.

This report goes some way towards establishing the necessary guidance, so that companies become more consistent in how they measure and set GHG reduction targets, and that stakeholders have more confidence and understanding of what is behind those commitments. Where stakeholder initiatives are developing steel sector frameworks, such as the Science Based Target initiative (SBTi), Assessing the Low Carbon Transition (ACT), the Energy Transitions Commission (ETC) and the Center for Climate Aligned Finance, we believe this report will provide an invaluable input to their design.

The following is a summary of the main recommendations that have come out of the Net Zero Steel Pathway Methodology Project:

Recommendation 1:
Differentiate between primary and secondary steel

The methodology for emissions target setting needs to differentiate between primary (iron ore) and secondary (scrap) sources of steel production, rather than differentiating by production route. Primary sources of steel production are the main contributor to GHG emissions, whilst secondary based steel production has low direct emissions, using electricity as the main energy source.

Complicating factors to be addressed are that:

- Secondary sources are finite and bound by the amount of end-of-life scrap becoming available in society. Continued growth in steel demand over the coming decades, also as an enabler for decarbonisation, means primary production will remain the main source of steel beyond 2050.
- There are multiple approaches to decarbonise the steel industry and the differences between these approaches need to be fully considered. A methodology to differentiate between primary and secondary steel production needs to be adopted to ensure that trade flows of finite secondary sources (scrap) do not shift to jurisdictions with strict GHG regulations, without contributing to the overall reduction in global emissions.

It is also noted that world secondary sources of steel production are reliant on initial steel being created from primary steelmaking i.e. global steel production originates from virgin steel feed source in its first lifecycle.

An SBT for a steel company should, therefore, be made up of two targets, based on its use of iron ore and scrap metallic inputs:

- **A primary steel SBT** (applicable to steel made from primary iron ore sources)
- **A secondary steel SBT** (applicable to steel made from iron scrap and steel scrap sources)

In order to facilitate this approach, the steel sector carbon budget, against which net zero targets are assessed, should also be made up of an iron ore based (primary) and scrap based (secondary) budget with separate trajectories to 2050. It is noted that within the steel sector total budget, there will be a need to accommodate budgets for specific product families such as for stainless steel, due to a significantly higher contribution of emissions from ferro-alloy additions, which are responsible for up to 70% of stainless steel scope1,2 and 3 GHG emissions.

Recommendation 2:
Set a consistent scope and system boundary

A consistent system boundary is needed to reduce the variability in reporting and account for the probability that emissions will move further upstream in the future, as the steelmaking process decarbonises. For example, producers can reduce direct scope 1 emissions through the purchase of pre-processed raw materials, such as pellet or DRI, where emissions occur upstream of the steel producer. The most significant processes should be included, as well as some mandatory scope 3 emissions, to ensure consistency across target setting boundaries (see Figure 1). This consistent boundary is required to define the core activities that an SBT will be defined for (core SBT).

The **core SBT** for steel companies should be made up of two sub-SBTs:

- **Crude steel SBT** (processes within the crude steelmaking system boundary (regardless of whether they are on or off site), split into differentiated subsets of primary and secondary crude steel SBTs)
- **Product processing SBT** (processes within the variable system boundary for downstream processing)

Additionally, **a value chain SBT** may be added if the company chooses to include additional scope 3 upstream and downstream emissions that are outside of the core steel SBT system boundary.

The process emissions included within the system boundary of the crude steel SBT, as shown in Figure 1, will need to be allocated to either primary or secondary steel SBTs or shared between the two using an equitable allocation method. Further guidance will need to be developed on this.

The greenhouse gas emissions targets set within the core SBT should align with the global steel GHG trajectories relevant to the net zero/Paris aligned pathway for steel, developed in alignment with Recommendation 1. This implies that separate pathways for primary iron sourced steel and scrap sourced steel will be needed, and specific product types such as stainless steel, where more ferro-alloys are used with higher upstream emissions, will need to be taken into account. Further consideration may be needed on how some of the variable product processes, like rolling mills, will be included in a company SBT. This is because process ownership can differ, yet they can contribute significantly to the emissions profile, and thus, affect the comparability of SBTs.

Recommendation 3:
Establish a consistent steel sector budget and trajectory

It is necessary to develop a global steel sector budget and trajectory consistent with a net zero 2050 target aligned to Paris Agreement objectives. The total budget should be made up of a primary steel budget and a secondary steel budget, in consistency with the respective targets described above, and a method for calculating this split should be developed, including high alloy and stainless steels.

Through collaboration with the IEA, the global steel sector budget should also include the power sector emissions associated with combusting iron and steelmaking process gases (coke oven, blast furnace and basic oxygen furnace) to produce electricity, both on and off site.

Recommendation 4:
Acknowledge the GHG reduction from using co-products made by the steel industry

A steel company target should focus primarily on the abatement of core system boundary emissions. Where the targeted abatement doesn't reach the reductions needed, a company can recognise the emissions reduction in other sectors through the use of its co-products.

There are various methods that could be used to account for the GHG emissions and benefits associated with making and utilising co-products, including considering the 'avoided' impacts, redistributing associated sector emissions within a steel sector budget, or 'allocating' a portion of steel sector emissions to downstream sectors. It is noted that the draft SBTi net zero methodology consulted on in early 2021 included the possibility that avoided emissions, directly resulting from the use of co-products, could be reported under the category of GHG 'compensation'. Alternative approaches include amalgamating a proportion of other sectoral budgets into a steel budget, commensurate with the GHG value of co-products; and building a company's target up of sub-targets based on the sectoral trajectories of each sector they are co-producing for e.g. steel, cement, chemicals. A calculation of the avoided impacts to reflect the actual application of the co-product in the market could be used as a basis to quantify and share the value of co-products in these frameworks.

The application of CCU, for example to recover value from process gases, may require different treatment, where captured emissions are, by definition, not released by the steel sector, and so may be partially or wholly deducted from the carbon balance of the site. The way in which captured GHG emissions are attributed to the steel producer or downstream user may depend on how regulations prescribe reporting conventions, as well as how CCU supply contracts are agreed. In addition to emissions not released by the steel sector, there may also be additional avoided emissions in downstream sectors, depending on the application.

Recommendation 5:
Integrate the influence of regulatory policy when setting an SBT

Policy and legislation have an important part to play in helping a steel company to set a meaningful SBT and pathway towards net zero GHG emissions. The level of importance or influence of policy on investment decisions will be affected by several variables:

- The **capital intensity** of the process route (and so reflecting the 'cost to change' the process).
- The age of existing installed assets.
- The **carbon intensity** of the existing process route.
- The current **policy landscape** – mature or developing, high support or no support (sticks vs carrots).
- **Stakeholder expectations**, including employees, customers, and financiers.
- **Policy horizon** – anticipated future policies.

A company must consider the policy landscape that its operations are subject to, when making an SBT. Policy is likely to influence the ability to make investment in the short term. For longer term investment plans required to meet specific targets, the company must publicly disclose the policy assumptions it expects to be in place and the uncertainty of those assumptions, as part of the SBT. Progress against these policy assumptions should be included in any subsequent company SBT updates. If communicated this way, SBTs may serve as a message to policymakers of the decarbonisation potential a steelmaker believes they can deliver given certain policies.

Recommendation 6:
Leverage existing standards and methods into a dedicated steel sector decarbonisation approach for more consistent target setting

The GHG Protocol and other existing standards serve to establish a tool that can ensure more consistent and generally acceptable accounting and target setting. In collaboration with SBTi and the wider stakeholder community, further developments and technical guidance are needed to ensure greater consistency in the overall steel accounting method, whilst taking into account the recommendations of this report. This is vital to enable stakeholders and steel companies to prepare, compare and implement the commitments of different steelmakers on a like-for-like basis.

Recommendation 7:
Develop unambiguous guidance for companies making different types of steel products

The methodology for the steel sector SBT needs to be clearly understandable yet able to accommodate the requirements of different product groups that a company may specialise in, including low alloy carbon steel, high alloy carbon steel, and stainless steel.

In particular this relates to earlier recommendations:

Recommendation 1:
Differentiate between primary and secondary steel

- Identify how processes are assigned to primary and secondary sources.

Recommendation 2:
Set a consistent scope and system boundary

- Which processes should be reported by all companies making an SBT and which should be variable e.g. depending on ownership or control.

Recommendation 3:
Establish a consistent steel sector budget and trajectory

- How each product group fits into the budget and trajectory and how they might differ between product groups.

8. ANNEXES

Annex A:
Comparison of methodologies for dealing with process multifunctionality

PHYSICAL PARTITIONING	
Co-product emissions calculated according to scientific / thermodynamic principles	
Advantages	**Challenges / considerations**
Attempts to allocate emissions accurately to co-product, taking into account actual process parameters	Can be a complex method
Approach is allowed in standards e.g. those covering Environmental Product Declarations (EPDs)	Different calculations needed for each co-product (only developed for BF slag to date)
Methods and calculations for using BF slag has been developed by steel industry experts and is being used by several steel companies	Not easy to standardise across a range of co-products
ECONOMIC ALLOCATION	
Emissions assigned to co-product according to commercial value	
Advantages	**Challenges / considerations**
Economic data is available for most, if not all, co-products	Emissions assigned to co-product varies as its commercial value changes, and can vary geographically
Approach is allowed in standards, albeit generally less preferred than other methods	A co-product with low (or high) economic value becomes counter-intuitively synonymous with it having low (or high) GHG embodied emissions
	Is subject to being able to collect sensitive data
SYSTEM EXPANSION	
WHAT EMISSIONS ARE AVOIDED BY USING THE CO-PRODUCT?	
Quantify the processes / products avoided (and their carbon intensity) by the use of a co-product	
Advantages	**Challenges / considerations**
System expansion is a reasonable basis for recognising the benefit or impact of the use of co-products	No advantage to the user of the co-product if the GHG value is defined as being the same as the avoided product / process
A preferred method in international LCA standards	A risk of emissions not being accounted for at all
Usually relatively straightforward to define what process / product is avoided	Can introduce complexity if a 'footprint' approach is being adopted
Could form the core of a 'hybrid' approach, where the benefit of an avoided impact is shared between co-product user and producer	Some standards don't accept avoided impact / system expansion (e.g. EPD standards)
Similar sharing principles are being developed e.g. in EU's Product Environmental Footprinting (PEF)	
Examples of 50:50 approaches being applied in regional mechanisms for reducing energy demand (e.g. sharing the benefit of lightweight products between steel producers and car manufacturers)	

Annex B:
Comparison of key SBTi requirements with the recommended approach in this report

COMPONENT	SCIENCE BASED TARGETS – DRIVING AMBITIOUS CORPORATE CLIMATE ACTION – KEY REQUIREMENTS OF EXISTING SBTi	APPLY TO NZSPMP?	DETAILS ON HOW REQUIREMENT IS CONSIDERED IN PROPOSED NZSPMP RECOMMENDATIONS
GENERAL	A SBT should lead to emission reductions from scope 1 and 2 sources and should be aligned with well below 2 ˚C or 1.5 ˚C decarbonisation pathways	✓	NZSPMP is seeking alignment to a recognised, credible 1.5 ˚C climate scenario, including appropriate iron and steel sector emission budgets
	SBTs should be periodically updated to reflect significant changes that would otherwise compromise their relevance and consistency	✓	Changes related to business structure / operations (e.g. acquisitions, product mix) would require an update to the SBT
TIME HORIZON	Medium term: Cover a 5 (minimum) to 15 (maximum) year period from the date the target is publicly announced	✓	Recommendation: The NZSPMP seeks to enable organisations to set medium term science-based emission abatement targets aligned with longer term net zero targets • **Medium term:** Cover a 5 (minimum) to 15 (maximum) year period from the date the target is publicly announced • **Longer term:** Up to 2050
	Longer term: Companies are also encouraged to develop longer term tagets (e.g. up to 2050	✓	
INTENSITY TARGETS	Intensity targets may be set for scope 1 and 2 sources, however should only be done if it leads to absolute emission reductions in line with the modelled sector-specific decarbonisation pathway or aligned to climate science	✓	Recommendation: Intensity target proposed utilising the different allocations for scrap and primary ore pathways Consistent with current SBTi approach, intensity targets must lead to absolute emission reductions in line with the modelled sector-specific decarbonisation pathway or aligned to climate science
REPORTING BOUNDARY	The boundaries of a company's SBT should align with those of its GHG inventory	✓	Recommendation: Organisations should apply the same organisational boundaries to its SBT as to its GHG inventory (e.g. Equity share approach, or control approach (financial or operational))

COMPONENT	SCIENCE BASED TARGETS — DRIVING AMBITIOUS CORPORATE CLIMATE ACTION — KEY REQUIREMENTS OF EXISTING SBTi	APPLY TO NZSPMP?	DETAILS ON HOW REQUIREMENT IS CONSIDERED IN PROPOSED NZSPMP RECOMMENDATIONS
SCOPE AND COVERAGE	Companies should use a single, specific scope 2 accounting approach ("location-based" or "market-based" for setting and tracking progress towards an SBT	✓	Recommendation: As per SBTi both scope 2 accounting approaches should be made available for external grid purchased electricity, however a single, specified approach must be applied
	SBTs should cover at least 95% of company-wide scope 1 and 2 emissions If a company has significant scope 3 emissions (over 40% of total scope 1, 2 and 3 emissions), it should set a scope 3 target Scope 3 targets should be ambitious, measurable and clearly demonstrate how a company is addressing the main sources of value chain GHG emissions in line with current best practice The scope 3 target boundary should include the majority of value chain emissions (i.e. two-thirds of total scope 3 emissions)	Mostly aligned but methodology differs in application	The recommendations from Topic: Scope and boundaries adopts a more whole of value chain perspective, with the intent of consistent application of emissions sources (regardless of plant configuration and ownership) and a focus on material emission sources. The recommended methodology includes S1, S2 and S3 emissions on an activity basis and its relationship to the production of iron and steel. The methodology proposes a Core Steel SBT: Crude Iron and steel SBT + Steel finishing SBT, and a voluntary Scope 3 SBT with clear guidance on what should be included
OFFSETS	Offsets and avoided emissions should not count towards SBTs.	Not consistent with existing SBTi approach, however elements consistent with options proposed in SBTi's net zero consultation	Co-product approach consistent with options discussed e.g. in SBTi's net zero definition consultation e.g. Compensation emissions Additional work to be undertaken in relation to proposals to utilise traditional (but high-quality offsets) in the achievement of targets

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