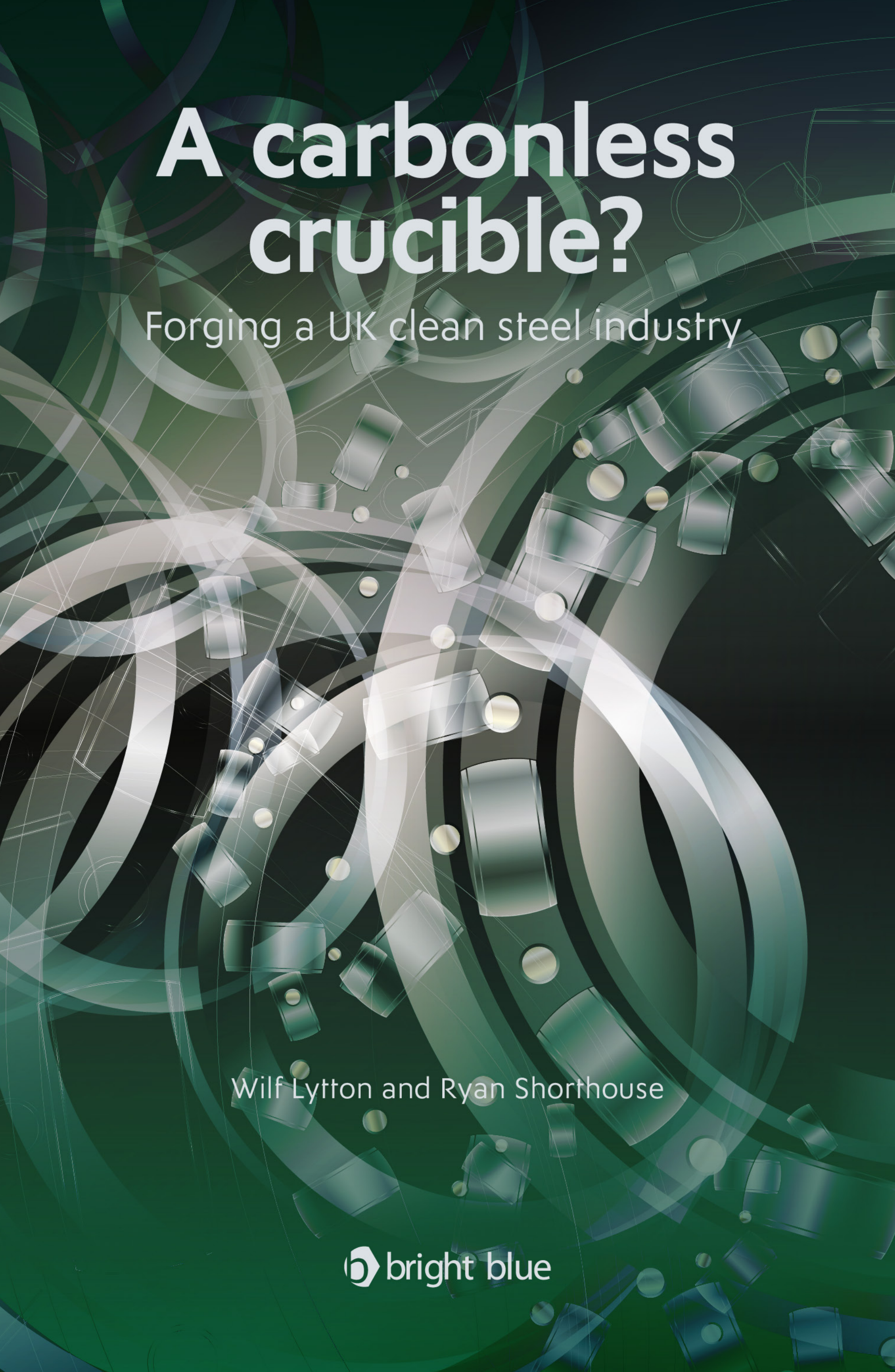
# A carbonless crucible?

## Forging a UK clean steel industry



Wilf Lytton and Ryan Shorthouse

bright blue

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# Executive summary

Steel is a critical part of the UK economy. Despite this, output from UK steelmaking has been in decline for the last 50 years, and this has been accompanied by a loss of jobs in the sector. Today, jobs in the UK steel industry are concentrated in the industrialised regions of South Wales, Yorkshire and Humberside and the North of England.

UK steelmakers have faced significant challenges in recent years, especially higher energy prices and global trade distortions. But with the right policies and investment, the UK can have a competitive, world-leading 'clean steel' industry, which can form the backbone of the UK's net-zero economy, supplying key industries and 'levelling up' communities across Northern England and Wales.

Indeed, this country will need a thriving 'clean steel' industry if the Government is to meet its legal climate targets. The UK Government has a legal target to ensure the country has net zero emissions by 2050. To help achieve this, the Climate Change Committee (CCC) has recommended that emissions from the production of iron and steel in the UK fall to near zero by the mid 2030s. The steel sector accounted for just over one fifth of carbon dioxide (CO2) emissions from all UK industries in 2019. The objective of decarbonising steel is therefore urgent.

This report examines how the UK's steel industry can be revived through the development of a commercial market for 'clean steel' – which we define as steel produced with no (or virtually no) scope 1, 2 or 3 greenhouse gas (GHG) emissions, as explained in detail in Box 2.1.

## UK steelmaking

As Chapter One explains, there are two principal routes of crude steel production operating in the UK: the blast furnace – basic oxygen furnace (BF-BOF) and electric arc furnace (EAF) routes.

The BF-BOF route is used to process iron ore into crude steel, known as ‘primary steel’, while EAF production is used to recycle scrap metal into crude steel, or ‘secondary steel’. Primary production supplies high quality steel to the market while secondary steelmaking preserves the value of steel already in circulation by recycling steel into new alloys and products while reducing waste and emissions.

Today, crude steel production is focused in six sites across the UK. There are two BF-BOF steelworks located at Port Talbot in South Wales and Scunthorpe in North Lincolnshire, which together account for 80% of the UK’s crude steel production. There are four EAF sites, located across Sheffield, Rotherham and Cardiff, accounting for the remaining 20% of UK crude steel output.

The integrated BF-BOF steelworks at Port Talbot and Scunthorpe are responsible for 95% of the steel sector’s GHG emissions, the majority of which are associated with the use of coal in the steelmaking process. EAF sites have a much lower carbon footprint, with as little as one tenth of the direct emissions per tonne of steel as BF-BOF production. It will be necessary to decarbonise both primary and secondary steelmaking to meet the UK’s climate targets and secure the future of UK steelmaking.

Nearly all UK steelmakers have announced plans to achieve net zero emissions by 2050, with some targeting this level of decarbonisation as early as 2030. Nonetheless, the timing of clean steel investments needed to deliver climate targets is critical.

The steel industry is governed by long investment cycles, reflecting the operational lifetime of production assets. There are very few newly built steel furnaces in the UK and many plants are nearing the end of their investment cycle. The UK’s primary steelmaking capacity in particular is relatively old and plant owners will soon need to decide whether to invest in low-carbon production routes or refurbish their existing capacity. This leaves a brief window of opportunity over the coming years in which to influence steel companies' long-term investment decisions.

To meet the Government's climate targets, the UK's steelmakers will need to make investments worth billions of pounds in clean steel technologies on a relatively short timescale. This is challenging for several reasons.

First, many of the technologies involved are not yet commercially available and developing them carries a significant risk.

Second, steelmakers face a number of current challenges unique to the UK which have raised the cost of doing business and sapped the industry of investment at a time when it is needed for developing clean steel technologies.

Third, existing public policy for decarbonising the steel sector is lagging behind the UK's net zero ambitions, and the resulting lack of clarity surrounding the future direction of policy governing the industry threatens to delay action to reduce emissions.

Solving these challenges is key to the development of clean steel in the UK, and the very survival of UK steelmaking.

## Focus of this report and methodology

In this report, we explore and explain the technologies, policies, challenges and objectives for the development of clean steel in the UK. We conclude by offering original and credible policy recommendations for deepening the decarbonisation of UK steel in the years ahead.

The report seeks to answer the following research questions:

- What are the viable processes and technologies to support the development of 'clean steel'?
- How effective are existing policies at decarbonising the UK steel industry?
- What are the key challenges for building a 'clean steel' market in the UK?
- How can policy enable the transition to 'clean steel' in the UK by the mid-2030s?

In order to answer these research questions, we employed two methods, described in detail in Chapter Two. First, we conducted an extensive literature review of published evidence and analysis pertaining to the steel industry in the UK. Second, we consulted with a number of senior representatives from organisations in the UK steel value chain.

These research methods enabled us to identify: the potential technologies and processes for the decarbonisation of UK steel (Chapter Three); the current policy landscape for UK steelmakers and its influence on the clean steel transition (Chapter Four); the key challenges in developing business models for clean steel production (Chapter Five); and new objectives to guide future policies for accelerating the transition to clean steel (Chapter Six).

## Pathways to clean steel

Efforts to develop clean steel production routes have advanced significantly over the last decade. The most promising processes and technologies include: increasing scrap utilisation; hydrogen substitution; biomass substitution; electrowinning; Carbon Capture and Storage (CCS); and Carbon Capture and Usage (CCU).

A decade ago, the technological solutions proposed for decarbonising steel were based on theoretical knowledge of low-carbon steelmaking processes with little experimental data to draw on. Today, there are dozens of clean steel pilot projects underway or planned in Europe alone and the results gleaned from these trials have vastly improved knowledge of the potential, limitations, and costs of decarbonisation pathways for the steel industry.

Thus, technological limitations of decarbonising steel are no longer as significant a barrier to the development of clean steel as economic considerations. Indeed, evidence from pilot projects demonstrates that the underlying technologies for both hydrogen and CCS-based steelmaking are viable at scale and effective in reducing direct emissions.

A consensus view is emerging around which technological approaches will be necessary for decarbonising the UK steel industry:

- **Increased scrap utilisation and EAFs.** This approach uses the well-established EAF production route to recycle scrap steel back into crude steel. Every tonne of scrap steel ('scrap') recycled in an EAF reduces emissions by up to 90% compared to conventional blast furnace steelmaking from iron ore.
- **Hydrogen based steelmaking.** Hydrogen can be used to displace coal, both as an energy source and as a reducing agent. Hydrogen direct reduced iron (DRI) steelmaking offers a carbon neutral alternative to processing iron ore in a conventional blast furnace. Hydrogen can also be used to displace fossil fuel inputs in secondary steelmaking.
- **Conventional (primary) steelmaking with carbon capture and storage (CCS).** CCS is a process that involves retrofitting existing steel plants with equipment to capture CO2 emissions from exhaust gases which are then transported away from the site to be permanently sequestered in geological storage reservoirs. Due to economies of scale, CCS is better suited to large integrated BF-BOF steelworks than EAF sites which produce much lower volumes of direct emissions.

Improvements in energy and material efficiency will also result in further reductions in energy use and emissions from steelmaking, particularly as older furnaces and processing equipment are replaced or augmented with more efficient technologies that can operate more flexibly.

For the UK's two integrated steelmaking sites to continue producing primary steel, the transition to clean steel will involve a diversification away from BF-BOF steelmaking, to hydrogen direct reduced iron (DRI) and EAF-based processes, with possible additional CCS steelmaking capacity.

Decarbonising EAF sites will primarily involve switching to 100% renewable electricity and replacing coal and natural gas inputs with hydrogen and/or biomass.

## Policies for clean steel

The current UK Government has three main types of policies for decarbonising steel: carbon pricing; industrial policy; and public funding.

It is clear current public policy regarding the steel industry has developed significantly in recent years but is still insufficient to support the necessary transition to clean steel.

## Carbon pricing

UK steelmakers are regulated by the UK's new Emissions Trading System (ETS), a cap and trade carbon market which creates a financial incentive to reduce emissions. However, high levels of free allocation have diluted the incentive, and carbon pricing has had very little impact on emissions from steelmaking and investment in decarbonising since the inception of the ETS as a result.

## Industrial policy

The current Government has produced a series of strategies for industry – including the *Plan for Growth, Industrial Decarbonisation Strategy, UK Hydrogen Strategy,* and *Net Zero Strategy* – outlining policy and regulatory changes designed to support the decarbonisation of UK industries.

While implementation of a number of initiatives set out in these strategies is now underway, many of the plans announced lack detail on the timing or scope of government action to decarbonise the steel industry. Moreover, none of the proposed changes address the higher operating costs of producing clean steel which represent a fundamental barrier to investment in commercial scale projects.

## Public funding

The Government plans to provide £2 billion in total public funding between 2020 and 2028 to support decarbonisation across all industries. This will be distributed under the Industrial Energy Transformation Fund (IETF) (£315 million), the Clean Steel Fund (£240 million) and the Net Zero Hydrogen Fund (£240 million), among other sources.

Concerns have been raised that this level of funding is not sufficient to attract the investment needed to transform the industry, particularly as UK steelmakers are in competition for investment internationally.

## Challenges for clean steel

The UK steel industry has already faced a series of challenges in recent years, including chronic global overcapacity in the sector, which has depressed steel prices, and the impact of the COVID-19 pandemic, which resulted in a dramatic reduction in steel orders in 2020.

In addition to these economic disruptions, UK steelmakers face a series of ongoing and well-documented challenges that limit their ability to raise the capital needed to transition to commercial clean steel production. These include high energy prices, lack of visibility around opportunities to bid for public contracts, global trade pressures, and – as explained in detail in Chapter Four – inadequate public policy.

### High energy prices

UK steelmakers have faced persistently higher electricity prices than their counterparts in Europe and elsewhere. Analysis by Ofgem shows that electricity prices paid by the UK's energy intensive industries (EIIs), including steel, are consistently above the EU average and the highest overall, even when excluding environmental levies. This situation has been made worse by the ongoing energy crisis.

The discrepancy between UK electricity prices and those elsewhere in Europe is due to a combination of factors which, according to Ofgem, include:

- An electricity generation mix that relies on natural gas
- The additional cost of the Carbon Price Support (CPS), a levy on fossil fuels used in power generation that is additional to the carbon price
- Comparatively low levels of interconnection

### Lack of visibility around opportunities to bid for public contracts

Steelmakers have reported a lack of visibility of opportunities for supplying into taxpayer-funded projects and the Steel Procurement Taskforce, in their recent report, urged the Government to adopt new public procurement practices that increase engagement with industry.

A recent publication from the Department for Business, Energy and Industrial Strategy (BEIS), *Steel procurement pipeline*, showed that public authorities will require an estimated 7.6Mt of steel over the next decade – equivalent to 10% of current UK steel output over the same period. This spending power could be harnessed to create markets for clean steel.

### Global trade pressures

The ability of steelmakers in many parts of the world to sell their products overseas has exposed UK steelmakers to competition from non-UK producers that are heavily subsidised, or that operate in regions where steel can be produced more cheaply, often with more damaging consequences for the environment. Trade tariffs put in place by the US and EU since 2016 have further eroded the competitiveness of UK steel in those markets.

These key challenges have contributed to a business environment that is unfavourable to the development of clean steel in the UK. To overcome them and enable UK steelmakers to invest, a new set of objectives and policies is needed.

## Objectives for clean steel

Technological readiness is no longer a significant barrier to deep decarbonisation. Instead, steelmakers need the support and confidence to invest in new technological approaches and develop clean steel business models.

We have identified five overarching objectives to support commercial-scale clean steel production in the UK.

1. **Ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity.** Competitively priced

electricity incentivises lower-emissions steelmaking in EAFs and can support longer-term investments in clean steel technologies that utilise electricity and green hydrogen. For steelmakers, demand response, energy efficiency and price hedging will continue to be important strategies for minimising their electricity costs, but are not a substitute for adequate policy protections.

2. **Making hydrogen available and affordable to steelmakers in sufficient quantities to enable clean steel production in the 2030s.** Hydrogen will be essential to the long-term decarbonisation of most UK steelmaking sites, which are not well suited for the development of CCS. The first hydrogen network projects – HyNet and East Coast Hydrogen – are beginning to take shape and the Government has recently pledged to double planned hydrogen production capacity to 10 GW by 2030. However, there remain uncertainties over the future availability and price of hydrogen for steelmakers who are likely to face competition from other sectors that also need hydrogen to decarbonise.
3. **Establishing a policy framework to overcome investment barriers to producing clean steel.** Clean steel technologies, particularly those used to convert iron ore, are capital intensive to develop and have higher operating costs compared to conventional steelmaking routes. In order for steelmakers to commit to such investments, solutions will need to be found for electricity pricing, connecting steelmaking sites with low-carbon infrastructure, and developing markets for clean steel. Our international competitors have dedicated significantly larger public funding commitments to delivering net zero steel than the UK.
4. **Enabling access to suitable raw materials, particularly scrap steel.** Increasing scrap utilisation in the UK helps retain steel in the UK economy and will improve material circularity leading to a significant and rapid reduction in emissions from domestic steelmaking. However, a balance does need to be struck between reducing exports of scrap that might otherwise be

recycled in the UK and maintaining the basic value of scrap so as not to jeopardise investment in scrap collection and processing infrastructure.

5. **Developing a market for clean steel products, backed by appropriate regulations.** For clean steel to capture market share, one or both of the following must occur: clean steel becomes less expensive to produce and source than steel with a high carbon footprint; or users of steel are compelled to specify and purchase clean steel, even while cheaper, more polluting alternatives are available. On the first, carbon pricing could play a crucial role in tipping the balance of costs in favour of clean steel. To limit the risk of carbon leakage when fully exposing domestic steelmakers to the UK carbon price, an equivalent levy would need to be applied to carbon emissions from imported steel. On the second, there is an opportunity for the government to leverage both public and private sector spending to bring forward demand for clean steel through the introduction of specific requirements for the carbon content of steel used in UK projects.

## New policies

In Chapter Seven, we make seven policy recommendations that further the overarching objectives introduced in Chapter Five to support the development of a clean steel market in the UK.

The policies we proposed are underpinned by five key principles. First, that they enable deeper decarbonisation, by promoting public and private sector behaviour that is consistent with the government's net zero target. Second, that they ensure fair treatment across economic sectors, avoiding undue advantage or burden for any particular industry. Third, that they are technologically neutral, driving markets for low-carbon materials while preserving flexibility in how the companies choose to do that in terms of the technologies they invest in and deploy. Fourth, that they are politically implementable, aligning with the UK's current policy approach and which can, to a large extent, be implementable without the need for new primary legislation. Fifth, they are fiscally responsible, creating value for the taxpayer both directly or indirectly and not shifting the burden of decarbonising steelmaking onto the taxpayer.

## Ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity

**Recommendation one: Extend the EII Compensation Scheme until 2030, with the level of compensation reviewed annually**

The UK Government recently renewed the EII Compensation scheme which provides relief to steelmakers from indirect carbon costs in the electricity they use which are set to last until 2025. However, it is likely that the scheme will be required on a longer-term basis, not least because French and German steelmakers are expected to benefit from equivalent exemptions indefinitely.

We propose the Government extend the scheme until at least 2030 to provide a longer-term signal to steelmakers that reduces uncertainty around the level of compensation available after 2025. The change is expected to be revenue-neutral for government since the current scheme would likely be extended anyway.

The level of compensation provided by the scheme should, however, be reviewed annually by government in line with the latest available evidence. Recommendations to the Secretary of State at the Department of Business, Energy and Industrial Strategy on whether to retain or adjust the level of compensation should also be made public.

## Making hydrogen available and affordable to steelmakers in sufficient quantities to enable clean steel production in the 2030s

**Recommendation two: Publish a list of priority users for low-carbon hydrogen supplied through the UK's planned hydrogen**

**networks and ringfence a proportion of low-carbon hydrogen purchase contracts for those sectors**

The Government has committed to developing 10GW of low-carbon hydrogen production capacity by 2030. We consider that a competitive market for hydrogen could effectively be established by offering two-way CfDs that allow hydrogen producers and purchasers to competitively bid for long-term government contracts to supply and purchase low-carbon hydrogen, with contracts awarded through a competitive bidding process.

Access to low-carbon hydrogen purchase contracts should be prioritised for certain sectors, taking account for:

- How effectively the sector's use of hydrogen contributes to meeting the Government's net zero target, measured in terms of emissions savings generated
- The ambition of sectoral emissions targets set by government
- The availability and cost of alternatives to hydrogen for decarbonising the sector

We urge the government to publish a list of sectors that are eligible for priority access to low-carbon hydrogen and to ring fence a proportion of low-carbon hydrogen purchase contracts for those sectors, commensurate with their needs.

## Establishing a policy framework to overcome investment barriers to producing clean steel

**Recommendation three: Introduce a carbon border adjustment mechanism (CBAM) by or before 2026 whilst phasing out free allocation from the UK Emission Trading Scheme (ETS) for sectors covered by the CBAM**

The UK ETS could play an important role in supporting commercial clean steel production, but existing provisions for free allocation undermine the carbon price signal for Energy Intensive Industries (EIIs).

We therefore urge the current Government to establish a UK Carbon Border Adjustment Mechanism (CBAM) linked to the UK ETS. To reduce trade barriers, the UK CBAM should broadly align with similar schemes being considered by its trading partners.

The CBAM should initially cover products regulated by the UK ETS that are at risk of carbon leakage and take effect by or before 2026, when the EU plans to introduce its own CBAM.

To maintain compliance with World Trade Organisation rules, the UK CBAM should form an extension of the UK ETS, with importers required to adopt the same compliance standards as UK manufacturers, and to pay a levy on embodied carbon in their products at a rate pegged to the UK carbon price.

The introduction of a CBAM should be followed by the rapid phase-out of free allocation in the UK ETS for industries covered by the scheme. As part of ongoing reform of the UK ETS, the Government should, as a minimum, introduce a mechanism through which free allocation can be reduced more rapidly for products covered by a CBAM. This will enable government to generate additional revenues from carbon pricing which can be used to fund policy interventions that support the net zero transition for EIIs.

## Enabling access to suitable raw materials, such as scrap steel

**Recommendation four: Introduce a cap – reducing over time – on the total weight of scrap metal exports, with the intention of at least halving scrap exports by 2030**

High levels of scrap exports are unsustainable in the context of decarbonising the UK's steel industry.

A cap on total UK scrap exports by weight should be introduced, rather than an export ban – as some have proposed – which might lead to unintended consequences such as scrap metal losing its value.

The cap should be set at historic average levels initially and reduce over time with the intention of at least halving scrap exports by 2030.

**Recommendation five: Provide total VAT relief on the purchase of low-residual scrap to offset the increased costs of scrap processing**

Large quantities of poor condition scrap are produced in the UK in excess of what UK steelmakers require for their own production. Scrap that is in poor condition can, however, be upgraded to low-residual scrap, which has greater value to UK steelmakers, if processed to remove contaminants.

To offset some of the higher costs associated with processing and upgrading scrap metal in the UK, the Government should zero rate VAT on zero rate VAT on low-residual scrap sold in the UK.

## Developing a market for clean steel products, backed by appropriate regulations

**Recommendation six: Introduce new mandatory carbon footprint standards for large construction projects from 2026 that require a certain proportion of construction materials used to be low-carbon, and expand both the scope products covered by the standard and the required proportion of low-carbon materials over time**

The construction sector is the largest consumer of steel products in the UK. Publicly funded construction projects account for a significant portion of this demand.

The UK Government has established guidance on public procurement for construction projects via the Procurement Policy Notice and the Treasury's Green Book. However, both are advisory and require extensive training and resourcing at central and local government levels to be applied effectively owing to their complexity.

Government should introduce a requirement for large construction projects to incorporate a minimum percentage of certifiable low- and zero-carbon materials. The requirement should apply to the use of specific products in constructions, rather than to the project as a whole.

The requirement should come into effect from 2026 to allow time for the development of product carbon footprint labelling standards.

The requirement could initially be applied to a selection of widely used and standardised construction products which, for steel, might include reinforcement bar, beams, columns, heavy sections, flat sections, angled sections, and hollow sections. The scope of materials covered by the requirement should be expanded over time to include steel products used outside the construction sector.

The required percentage of low- and zero carbon products used in projects should also be increased over time in line with the UK Government's 2050 net zero target.

To promote compliance, a requirement to submit a sustainable procurement plan should be introduced in planning and tender processes for large projects. As part of these procurement plans, project developers would be obliged to demonstrate compliance with the requirement to source a certain percentage of low- or zero-carbon materials.

**Recommendation seven: Introduce mandatory carbon footprint requirements for Contracts for Difference (CfD) from 2024 and Capacity Market (CM) contracts from 2025, raised in each round until 2035 when embedded carbon content should be net zero**

In the power sector, the UK's Contracts for Difference (CfD) and Capacity Market (CM) mechanisms represent a major source of government-administered funding to support investments in low-carbon power generation and marginal capacity, respectively.

Government is responsible for setting the rules that participants bidding for both CfD and CM contracts must adhere to, which already includes emissions performance standards for fossil power generation. A similar approach should be taken to setting standards for the embodied carbon of generation assets contracted through these schemes.

We propose minimum requirements for the carbon content of materials used in contracted projects or by setting upper limits for embodied carbon emissions on a per kWh contracted basis. These requirements could be used for materials in the construction of electricity generation assets (including renewables, nuclear, dispatchable power, storage and flexibility), starting with the 2025 T-4 auction for CM applications, and with the sixth allocation round (AR6) for CfDs in March 2024. These new requirements should be set in line with the Government's net zero target for the power sector, and raised at each round such that newly contracted capacity is required to achieve net-zero embodied carbon emissions from 2035 onwards.

## Conclusion

Steelmakers, and the industries that rely on them, have rarely been more critical to securing the UK's place in the world than is the case today.

With ongoing global trade tensions, supply disruptions related to the war in Ukraine, and the need to cut greenhouse gas emissions, both the government and the steel industry now face many common challenges ahead, from national security to net zero.

Recent efforts to safeguard the UK's steel industry from high energy costs and trade pressures have shown a willingness on the part of the UK Government to address the immediate issues facing the steel sector.

However, existing policies intended to support the decarbonisation of the steel industry will not deliver clean steel on a timescale consistent with the Government's emissions reduction targets. New and ambitious policies are needed.

By acting on the policy recommendations put forward in this report, the Government can enable the UK's clean steel transition to take place in a timely and cost-effective manner, and in doing so will create a policy model that can be applied to decarbonising other energy intensive industries.

# Chapter One: **Introduction**

Steel is an indispensable building block of the UK economy. But existing steel production technologies require large amounts of energy and are carbon-intensive: in 2019, the steel sector accounted for just over one fifth of carbon dioxide (CO2) emissions from all UK industries.[1]

The UK Government has a legal target to ensure the country has net zero emissions by 2050.[2] More immediately, through the Sixth Carbon Budget, the UK has a demanding target of achieving a 78% reduction in emissions by 2035 relative to 1990 levels.[3] This country will therefore need a thriving 'clean steel' industry if the Government is to meet its climate targets.

The challenge of decarbonising steel is particularly urgent: the Climate Change Committee (CCC) has recommended emissions from the production of iron and steel in the UK fall to near zero by the mid 2030s, although this is not at present an official government target.[4]

1. Business, Energy, and Industrial Strategy. (2022). Final UK greenhouse gas emissions national statistics 1990-2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1051407/2020-final-emissions-statistics-one-page-summary.pdf
2. "2050 Target Amendment, Order 2019", *The Climate Change Act 2008*, No. 1056 Article 2.
3. GOV.UK, "UK enshrines new target in law to slash emissions by 78% by 2035", https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035, (2021).
4. Climate Change Committee, "Sixth Carbon Budget", https://www.theccc.org.uk/publication/sixth-carbon-budget/, (2020).

## Steelmaking in the UK

Steel is an alloy of iron, carbon and other elements that can be forged and machined into many different forms. It is both durable and highly versatile, making it suitable for use in large-scale infrastructure projects as well as for precision components in electrical and engineering technologies.

There are two principal routes of crude steel production – that is, the initial solid product formed once liquid steel has cooled – operating in the UK: the blast furnace – basic oxygen furnace (BF-BOF) and electric arc furnace (EAF) routes. The BF-BOF route is used to process iron ore into crude steel, known as 'primary steel', while EAF production is used to recycle scrap metal into crude steel, or 'secondary steel.'[5] Many, though not all, steel products produced via the BF-BOF route can also be produced via the EAF route with no appreciable difference in the quality or performance of the steel.

Both primary and secondary steelmaking are important to the sustainability of the UK steel industry. Primary production supplies high quality steel to the market while secondary steelmaking preserves the value of steel already in circulation by recycling steel into new alloys and products while reducing waste and emissions.

These two principal steelmaking routes are described in further detail in Box 1.1 below.

5. Differences in the grade of steel produced via primary and secondary steelmaking sites depend on the type of feedstocks used. Primary steel typically contains few residual elements whereas secondary steel can be produced to a range of specifications which are determined by the condition of the scrap metal used.

### Box 1.1. Existing steelmaking technologies

**BF-BOF steelmaking**

The BF-BOF route is a two-stage process. First iron is extracted from its ore at temperatures of up to 1,200°C using coke, a carbon-rich product made from coal. This process produces CO2 as a byproduct and is responsible for the vast majority of steelmaking emissions. The iron is then remelted in a basic oxygen furnace with carbon and other additives to produce steel. On average, for every tonne of crude steel produced via the BF-BOF route, 1,370 kg of iron ore, 780 kg of metallurgical coal, 270 kg of limestone, and 125 kg of recycled steel are used in the process.[6]

**EAF steelmaking**

EAF steelmaking is used to convert a charge of iron or scrap into crude steel. The charge is melted by passing an electric current through it while additives such as limestone and coal are used to aid the process. Inputs to EAF steelmaking vary considerably depending on the availability of feedstocks and the desired grade of steel. Typically, to produce one tonne of crude steel in an EAF, 710 kg of recycled steel, 586 kg of iron ore, 150 kg of coal, 88 kg of limestone and 2.3 GJ of electricity are required.[7]

Crude steel production is focused in six sites across the UK, which manufactured 7 megatonnes (Mt) of steel in 2021.[8]

The UK's two BF-BOF integrated steelworks, and their owners, are:

- Port Talbot (Tata)
- Scunthorpe (British Steel / Jingye).

6. Worldsteel, "Steel and raw materials", https://worldsteel.org/wp-content/uploads/Fact-sheet-steel-and-raw-materials.pdf, (2021), 1.
7. Ibid.
8. UK Steel, "Key Statistics Guide April 2021", https://www.makeuk.org/-/media/uk-steel-key-stats-guide-2021.pdf, (2021).

These two sites accounted for 80% of the UK crude steel production (5.7Mt) in 2020[9] and close to one fifth of the steel industry's workforce.[10,11]

The remaining 20% share of crude steel (1.3Mt in 2020) was produced at four EAF sites:[12]

- Liberty Specialty Steels, Rotherham (Liberty Steel / GFG)
- Celsa Steel, Cardiff (CELSA Group)
- Outokumpu, Sheffield (Outokumpu Oyj)
- Sheffield Forgemasters (UK Ministry of Defence).

The UK's two BF-BOF integrated steelmaking sites are currently operated by companies that form part of large international conglomerates headquartered outside the UK. Similarly, three of the UK's four EAF steelmaking sites are under ownership of multinational organisations. The UK's Ministry of Defence recently took ownership of Forgemasters.

The UK steel industry is fundamental in supporting the wider economy, supplying products that are vital for the energy, transport, infrastructure, aerospace and defence sectors, among others. Indeed, the Government has recognised steelmaking as a "national strategic asset" that will "play a critical role in providing the materials necessary to drive the UK's green industrial revolution",[13] a view shared across the political divide.[14] The recent purchase of UK steelmaker, Sheffield Forgemasters, by the Ministry of Defence[15] underscores the importance of steelmaking to national security and points to broader concerns surrounding the UK's ability to ensure the supply of critical raw materials.

9. Ibid., 4.
10. BBC News, "Port Talbot steelworks: 'Resist speculation' over future", *BBC News*, 14 November 2020.
11. Jasper Jolly, "British Steel lost £140m in 2020 under new Chinese ownership", *The Guardian*, 30 December 2021.
12. UK Steel, "Key Statistics Guide April 2021", https://www.makeuk.org/-/media/uk-steel-key-stats-guide-2021.pdf, (2021), 4.
13. GOV.UK, "Business Secretary co-chairs third UK Steel Council meeting of 2021: 21 July", https://www.gov.uk/government/news/business-secretary-co-chairs-third-uk-steel-council-meeting-of-2021-21-july, (2021).
14. Lucy Powell, "Labour calls for stronger buy british steel guarantees as failure to back steel industry exposed" https://labour.org.uk/press/labour-calls-for-stronger-buy-british-steel-guarantees-as-failure-to-back-steel-industry-exposed/, *Labour*, 2021.
15. GOV.UK, "UK Government to acquire Sheffield Forgemasters International Limited" https://www.gov.uk/government/news/uk-government-to-acquire-sheffield-forgemasters-international-limited (2021).

Despite its important role in the economy, output from UK steelmaking has been in decline for the last 50 years, and this has been accompanied by a loss of jobs in the sector.[16] At its peak in the early 1970s, the UK steel industry directly employed 320,000 workers yet, by 1991, this figure had fallen to just 44,000 with many plants closed as a result. According to the Stockholm Environment Institute, the decline of the UK steel industry over this period was "partly due to the effect of frequent labour disputes on production, and partly due to external factors including the financial crisis brought on by the 1975-76 oil-price recession and the public spending cuts demanded by the International Monetary Fund in exchange for a large support package it provided to the British government."[17]

As of 2019, there were 1,100 businesses in the UK steel industry providing direct employment to 33,400 workers, and contributing £2 billion to the UK economy in terms of gross value added.[18] Jobs in the UK steel industry are concentrated in industrialised regions of South Wales, Yorkshire and Humberside and the North of England,[19] and contribute significantly to local economies where opportunities for skilled employment are otherwise limited. Steel workers are also relatively well-paid, with average salaries 33% higher than the national average salary.[20]

## Emissions of UK steelmaking

It will be necessary to decarbonise both primary and secondary steelmaking to meet the UK's climate targets and secure the future of UK steelmaking.

Efficiency improvements have enabled both BF-BOF and EAF

16. Aaron Atteridge and Claudia Strombo, "Decline of the United Kingdom's steel industry", *Stockholm Environment Institute*, https://cdn.sei.org/wp-content/uploads/2021/07/decline-of-the-steel-industry-in-the-uk.pdf, (2021), 2.
17. Ibid.
18. Georgiana Hutton, "UK Steel Industry: Statistics and policy", https://researchbriefings.files.parliament.uk/documents/CBP-7317/CBP-7317.pdf, (2021) 4.
19. Ibid., 8.
20. UK Steel, "Key Statistics Guide April 2021", https://www.makeuk.org/-/media/uk-steel-key-stats-guide-2021.pdf, (2021), 3.

operators to reduce the energy intensity of their operations over time.[21] However, steelmaking remains a highly energy- and carbon-intensive process. In 2019, greenhouse gas (GHG) emissions from the iron and steel sector accounted for 21% of total UK industrial emissions,[22] making it the largest industrial emitter. Since existing methods of steelmaking all involve burning fossil fuels, efficiency improvements alone will not be sufficient to put the sector on a path to net zero.

The Sixth Carbon Budget envisages emissions from the iron and steel sector falling far more rapidly than most other sectors of the economy, reaching close to zero emissions by the mid 2030s. This is not an arbitrary target: the CCC's proposed trajectories are based on capabilities for emissions reductions within each sector and, as the CCC's authors clarified in their subsequent progress report, "it is difficult to compensate for lower ambition in one area with greater ambition elsewhere".[23]

The integrated BF-BOF steelworks at Port Talbot and Scunthorpe are responsible for 95% of the steel sector's GHG emissions,[24] with an average carbon-intensity of 1.92tCO2 per tonne of crude steel in 2018.[25] The majority of these emissions are associated with the use of coke (coal) as a fuel source and reducing agent. Coal accounts for approximately 89% of the energy inputs in BF-BOF steelmaking while electricity (7%), natural gas (3%) and other sources (1%) account for the remainder.[26]

By contrast, a highly efficient EAF can produce steel with a carbon

21. The energy efficiency of steel plants is not only governed by technologies used but is also linked to plant utilisation rate, raw material inputs and plant configuration. Efficiency increases at higher production levels due to reduced specific energy consumption per tonne of steel. Publicly available statements reveal that output has been significantly below capacity for a number of years at several UK steelworks, possibly reflecting changes in demand in the markets they serve.
22. GOV.UK, "Final UK greenhouse gas emissions national statistics: 1990 to 2020", https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2020, (2022), Table 1.2. Quoted figure includes emission from *Sinter production and Iron and steel production*.
23. Climate Change Commission, "Progress in reducing emissions", https://www.theccc.org.uk/wp-content/uploads/2021/06/Progress-in-reducing-emissions-2021-Report-to-Parliament.pdf, (2021), 22.
24.BEIS, "Industrial Decarbonisation Strategy", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970229/Industrial_Decarbonisation_Strategy_March_2021.pdf, (2021), 50.
25. Ember "Decarbonising UK Steel", https://docs.google.com/presentation/d/1EWIJK6lgsD-IjOL3B34Cl-IT-ycxfDKaCTKPXhE2USE/edit#slide=id.p, (2021).
26. BEIS Committee, "Liberty Steel", 30.

footprint as low as 0.215tCO2/tonne,[27] close to one tenth of the emissions from BF-BOF production, although this figure excludes indirect emissions from electricity use. EAFs consume on average 400 kWh per tonne of crude steel produced[28] which accounts for 50% of the energy used in EAF steelmaking. The remaining energy input comes from natural gas (38%), coal (11%), and 1% from other sources.[29]

Admittedly, three UK steelmakers, including the owners of the two integrated BF-BOF steelmaking sites, have independently set targets to reach net zero emissions by 2050[30] while Liberty Steel and Celsa – both of which operate EAFs – plan to achieve carbon neutral production by 2030.[31]

Nonetheless, the timing of clean steel investments needed to deliver climate targets is critical. The steel industry is governed by long investment cycles, typically between 20 and 50 years, reflecting the operational lifetime of production assets.[32] There are very few newly built steel furnaces in the UK and many plants are nearing the end of their investment cycle.[33] The UK's primary steelmaking capacity in particular is relatively old[34] and plant owners will soon need to decide whether to invest in low-carbon production routes or refurbish

27. European Commission, "COMMISSION IMPLEMENTING REGULATION (EU) 2021/447" https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0447&qid=1615797821614, (2021).
28. Yonmo Sung et al., "Improvement of energy efficiency and productivity in an electric arc furnace through the modification of side-wall injector systems", *Processes*, https://www.mdpi.com/2227-9717/8/10/1202, (2020).
29. BEIS Committee, "Liberty Steel", 30.
30. British Steel, "HNZ0098", https://committees.parliament.uk/writtenevidence/36264/pdf/, (2021).; Tata Steel Europe, "HNZ0096" https://www.google.com/url?q=https://committees.parliament.uk/writtenevidence/36262/pdf/&sa=D&source=docs&ust=1656695674470467&usg=AOvVaw3myM8bDNuBbikJXuzrtwVa, (2021).; Outokumpu, "Committed to carbon neutrality by 2050", https://www.outokumpu.com/en/expertise/2020/committed-to-carbon-neutrality-by-2050.
31. Liberty Steel, "HNZ0097", https://committees.parliament.uk/writtenevidence/36264/pdf/, (2021).; Celsa "HNZ0100", https://committees.parliament.uk/writtenevidence/36662/pdf/, (2021).
32. WSP Parsons Brinckerhoff & DNV.GL., "Industrial Decarbonisation & Energy Efficiency Roadmaps to 2050", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416667/Iron_and_Steel_Report.pdf, (2015), 38.
33. Ibid., 38.
34. Port Talbot's Blast Furnace 5 was partially relined in 2019 and is expected to run until ~2027/28. Port Talbot's Blast Furnace 4 was relined in 2012 and is expected to be capable of operating until the early 2030s. British Steel's Scunthorpe site was operating two of its four blast furnaces when Jingye took ownership of the plant in 2020. One of Scunthorpe's blast furnaces was relined in 2014 and plant owner, Jingye, planned to reline a second furnace as part of a series of planned upgrades to the site which have yet to be enacted.

their existing capacity. This leaves a brief window of opportunity over the coming years in which to influence steel companies' long-term investment decisions.

To meet the Government's climate targets, the UK's steelmakers will actually need to make investments worth billions in 'clean steel' technologies on a relatively short timescale. This is challenging for several reasons.

First, many of the technologies involved are not yet commercially available and developing them carries a significant risk.

Second, steelmakers face a number of current challenges unique to the UK which have raised the cost of doing business and sapped the industry of investment at a time when it is needed for developing 'clean steel' technologies.

Third, existing public policy for decarbonising the steel sector is lagging behind the UK's net zero ambitions, and the resulting lack of clarity surrounding the future direction of policy governing the industry threatens to delay action to reduce emissions.

Solving these challenges is key to the development of 'clean steel' in the UK, and the very survival of UK steelmaking. And decarbonising the UK steel industry will be of strategic value to the UK as all markets become increasingly climate-regulated, helping to secure new investment and skilled jobs in UK manufacturing and supply chains.

## Focus of this report

In this report, we explore and explain the pathways, policies, challenges and objectives for the development of 'clean steel' in the UK. We conclude by offering original and credible policy recommendations for deepening the decarbonisation of UK steel in the years ahead.

The report seeks to answer the following research questions:

- What are the viable processes and technologies to support the development of 'clean steel'?

- How effective are existing policies at decarbonising the UK steel industry?
- What are the key challenges for building a 'clean steel' market in the UK?
- How can policy enable the transition to 'clean steel' in the UK by the mid-2030s?

The report is structured as followed:

- **Chapter Two** defines 'clean steel' and outlines the methodologies used in developing this report, including a literature review and stakeholder consultation.
- **Chapter Three** describes the potential pathways for transitioning to 'clean steel' in the UK.
- **Chapter Four** examines the current policy landscape for UK steelmakers and its influence on the 'clean steel' transition.
- **Chapter Five** outlines the key challenges in developing business models for 'clean steel' production.
- **Chapter Six** puts forward new objectives to guide future policies for accelerating the transition to 'clean steel'
- **Chapter Seven** sets out a raft of new policy measures needed to deliver a sustainable 'clean steel' industry in the UK

# Chapter Two: **Methodology**

The previous chapter identified the importance of steelmaking to the UK economy, but also its substantial contribution to GHG emissions. To meet its climate targets, the UK will need to become a leading producer of 'clean steel'. This chapter explains what 'clean steel' is and details the research methodologies used to explore the technologies, challenges, objectives and policies for the development of 'clean steel' in the UK.

## What is 'clean steel'?

Steel produced with low or no direct or indirect greenhouse gas (GHG) emissions is sometimes referred to as 'clean steel'[35] or 'green steel'.

There is no commonly accepted standard that defines these terms and they are sometimes used to market steel products produced from EAFs which have a lower carbon footprint compared to blast furnace steel.

For the purposes of this report, we use 'clean steel' to refer to steel produced with no (or virtually no) scope 1, 2 or 3 emissions, as explained in Box 2.1 below, without preference to any particular technology.

35. Andrew Purvis and Nicholas Walters, "Blog: What we mean when we talk about low-carbon steel", https://worldsteel.org/media-centre/blog/2021/blog-low-carbon-steel-meaning/, (2021).

**Box 2.1. Scope 1, 2 and 3 GHG emissions**

The GHG Protocol's Standard, maintained by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), has developed an accounting standard to measure emissions throughout a product's full lifecycle.

The standard groups emissions into three categories:

**Scope 1:** Direct GHG emissions from owned or controlled sources.
Example: Emissions produced by the combustion of fossil fuels within a steel plant.
**Scope 2:** Indirect GHG emissions from the consumption of purchased energy.
Example: Purchase of electricity for use in EAF steelmaking.
**Scope 3:** Other indirect GHG emissions that occur in the value chain.
Example: Purchased goods and services, waste disposal, use of sold products, and transportation and distribution.

Understanding the full carbon footprint of steelmaking allows organisations involved in the value chain to target action to reduce emissions more effectively.

For steelmakers, scope 1 and 2 emissions account for the vast majority of their carbon footprint. Companies that buy steel would, on the other hand, account for the environmental impact of their use of steel under their scope 3 emissions since it forms part of their supply chain.

## Research techniques

We employed two research techniques in this project:

- **Literature review.** We conducted an extensive literature review which examined the role of current public policies in decarbonising the UK's steel industry, the core challenges facing the steel sector today, and the implications of net zero for the steel industry. The literature was informed by relevant academic journals, think tank reports, publications from industry groups and trade bodies, and government policy documents and datasets.

- **Stakeholder consultation.** Bright Blue consulted a number of senior representatives from organisations in the UK steel value chain, including: three UK steelmakers, a steelmaking equipment supplier, an original equipment manufacturer (OEM), and an energy company.

# Chapter Three: **Pathways to clean steel**

Efforts to develop clean steel production routes have advanced significantly over the last decade. The most promising processes and technologies – or what we call pathways – for decarbonising steelmaking are explained and evaluated in detail in this chapter.

The key pathways include: increasing scrap utilisation; hydrogen substitution; biomass substitution; electrowinning; Carbon Capture and Storage (CCS); and Carbon Capture and Usage (CCU).

## Increasing scrap utilisation

Every tonne of scrap steel ('scrap') recycled in an EAF reduces emissions by up to 90% compared to manufacturing steel from iron ore. As a well-established technology, EAFs are expected to contribute significantly to reducing the carbon footprint of steelmaking in the UK in the short-term. However, additional measures are needed to mitigate residual emissions from the use of coal and gas in EAF steelmaking for the process to become carbon neutral. The scale of EAF production is also limited by the price, quantity and condition of scrap available to produce secondary steel.

Approximately 11Mt of scrap is generated in the UK each year[36] but, at present, the vast majority of it is exported to third countries

36. Russell Hall, Wanrong Zhang, & Zushu Li, "Domestic Scrap Steel Recycling–Economic, Environmental and Social Opportunities (EV0490)", https://warwick.ac.uk/fac/sci/wmg/research/scip/reports/defra_scrap_recycling_report_wmgfinal.pdf, (2021), 3.

(8.1Mt in 2019) to be processed back into crude steel.[37] The tendency to export scrap has come about due to a lack of alignment between UK steelmakers and scrap merchants: UK steelmakers face challenges in obtaining scrap of suitable condition to use in their steelmaking processes, owing to a lack of consistency in the standards used by UK scrap merchants to sort and grade scrap steel.[38] While scrap merchants at present have a stronger financial incentive to export their scrap overseas than to process it in the UK.

Of the total volume of scrap generated each year, approximately 1Mt is scrap that is in good condition, which is required for high-end steels.[39] Scrap that is in poorer condition may also be recycled in an EAF to produce commodity steels, although these have a lower market value and a limited range of applications. According to one estimate, UK steelmakers could recycle up to 6.1Mt of scrap each year utilising their existing capacity, compared to the 2.1Mt that is used in domestic steelmaking at present.[40] This estimate is close to the total amount of steel the UK produces each year.

## Hydrogen substitution

Hydrogen can replace coal, both as an energy source and as a reducing agent in primary and secondary steelmaking.[41] Hydrogen direct reduced iron (DRI) offers an alternative to processing iron ore in a conventional blast furnace. The process involves reacting pelletised iron ore with hydrogen to produce DRI. The technology has proven popular among European steelmakers looking to decarbonise their sites, with some 23 hydrogen-based steelmaking projects active in EU Member States.[42] In 2021, Swedish consortium HYBRIT became the

37. World Steel Association, "World Steel in Figures", https://worldsteel.org/wp-content/uploads/2021-World-Steel-in-Figures.pdf, (2021), 22.
38. Hall, Zhang, W., & Li, "Domestic Scrap", 3.
39. BEIS Committee, "Oral evidence: Liberty Steel and the Future of the UK Steel Industry, HC 118", https://committees.parliament.uk/oralevidence/2248/html/, (2021).
40. Hall, Zhang, & Li, "Domestic Scrap", 3.
41. A reducing agent is used to strip oxygen atoms from iron ore or oxidised scrap to produce iron or steel.
42. Energy & Climate Intelligence Unit, "Stuck on the starting line", https://ca1-eci.edcdn.com/reports/ECIU_stuck_starting_line.pdf, (2021).

first steelmaker to produce iron using fossil-free hydrogen.[43]

Although hydrogen-DRI has yet to be trialled in the UK, the technology is very similar to the well-established natural gas-DRI process and involves reducing iron ore to sponge iron in a shaft furnace or fluidised bed reactor using hydrogen. The technique can lower direct CO2 emissions from iron production by as much as 89–99%.[44] A combination of hydrogen-DRI and EAF or H-DRI-OBF (open bath furnace) processing could be used to convert iron ore into crude steel and therefore holds potential to displace BF-BOF as a means of primary production.

However, the transition from BF-BOF production to DRI-EAF/OBF is not without challenges: aside from the significant investment required to create an entirely new production process, there are logistical challenges to contend with, such as the sourcing of raw materials and low-carbon energy inputs, along with developing expertise in these technologies.[45,46]

Hydrogen can also displace coal and natural gas in EAF production, which are currently the main sources of direct emissions from secondary steelmaking.

The use of hydrogen-based steelmaking technologies is contingent on hydrogen being made available and affordable to steelmakers, an issue we return to later in this report. At present, UK producers of crude steel do not have access to hydrogen in large quantities and it may take many years for 'green hydrogen' – that is, hydrogen produced without GHG emissions from renewable electricity – to become widely available. However, Northern Gas Networks and Cadent Gas have announced plans to develop dedicated hydrogen network infrastructure along the northeast coast of England which,

43. Michael Holder, "A major breakthrough for the clean steel industry" https://www.greenbiz.com/article/major-breakthrough-clean-steel-industry, (2021).
44. Fabrice Patisson, & Olivier Mirgaux, "Hydrogen ironmaking: How it works", *Metals*, *10*(7), 922, https://www.mdpi.com/2075-4701/10/7/922/htm, (2020).
45. An equipment manufacturer Bright Blue spoke with suggested a capital investment on the order of €1 billion would be required for the installation of an HDRI-EAF or HDRI-OBF to replace a 300 tonne capacity BF-BOF plant.
46. Hall, Zhang, W., & Li, "Domestic Scrap", 3.

it is anticipated, will connect Scunthorpe steelworks to the hydrogen network in the mid to late 2020s, with other steelmaking sites being connected soon after.[47]

## Biomass substitution

Coking coal may be substituted for biomass-based reducing agents such as charcoal or wood pellets in primary and secondary steelmaking, indirectly displacing emissions from the manufacture and burning of coke. Moreover, biomass substitution can be done without major modification to conventional steelmaking equipment, making it an attractive GHG emissions abatement solution in the short-term. However, some analysts argue that emissions savings from burning biomass are overstated.[48]

While there is anecdotal evidence of biomass being used or trialled at individual steelmaking sites,[49] little is known about the current scale of biomass usage in the steel sector in the UK or elsewhere. One UK EAF operator has plans to trial a biomass-coke blend in their furnaces with a view to eventually switching to a 100% biomass-based reducing agent.

The potential of biomass substitution to reduce emissions from steelmaking is linked to the amount of coke that can be displaced. Coal and coke make up 89% of energy inputs in BF-BOF steelmaking and it is reported that substitution of coal and coke biomass at integrated steelworks could reduce emissions by up to 42%.[50] However, doing so would also significantly increase production costs.[51]

47. East Coast Hydrogen, "East Coast Hydrogen Feasibility Report", https://www.nationalgrid.com/gas-transmission/document/138181/download, (2021), 5.
48. Ember, "UK biomass emits more CO2 than coal", https://ember-climate.org/insights/research/uk-biomass-emits-more-co2-than-coal/, (2021).
49. Reuters, "Rio Tinto seeks to produce low-carbon steel with biomass in pilot trial",
https://www.reuters.com/business/sustainable-business/rio-tinto-seeks-produce-low-carbon-steel-with-biomass-pilot-trial-2021-10-13/, (2021).
50. Chinedu Maureen Nwachukwu, Chuan Wang, & Elisabeth Wetterlund, "Exploring the role of forest biomass in abating fossil CO2 emissions in the iron and steel industry–The case of Sweden", *Applied Energy*, *288*, 116558, https://www.sciencedirect.com/science/article/pii/S0306261921001069, (2021).
51. Hana Mandova, Sylvian Leduc, Chuann Wang, Elisabeth Wetterlund, Piera Patrizio, William Jeffery Gale, & Florian Kraxner, "Possibilities for CO2 emission reduction using biomass in European integrated steel plants", *Biomass and Bioenergy*, *115*, 231-243, (2018).

## Electrowinning

Electrical energy can be used to displace fossil fuel inputs both in the reduction of iron ore and as a heat source in steelmaking. Electrowinning uses an electrochemical process to transform pulverised iron ore into reduced iron which can then be processed into crude steel in an EAF.

The technology is at an early stage of development, but is reported to offer an 87% reduction in direct CO2 emissions and a 31% reduction in direct energy use compared to BF-BOF steelmaking.[52] A pilot project is underway in Europe[53] although it is unclear when the process will become commercially available to steelmakers.

## Carbon Capture and Storage (CCS)

CCS is a process that involves retrofitting existing steel plants with equipment to capture CO2 emissions from exhaust gases which are then transported away from the site to be permanently sequestered in geological storage reservoirs. CCS is only possible at sites that have access to CO2 transportation infrastructure linked to suitable long-term storage sites.

Due to economies of scale, CCS is better suited to large integrated BF-BOF steelworks than EAF sites which produce much lower volumes of direct emissions. One estimate suggests that up to a fifth of the world's steelmaking capacity may require the technology to decarbonise by 2060.[54]

However, there are actually signs that the momentum is shifting away from CCS steelmaking, particularly in Europe and the UK[55], a trend that may in part be linked to a greater focus by policymakers on

52. European Commission, "Horizon 2020: Development of new methodologies for industrial CO2-free steel production by electrowinning", https://cordis.europa.eu/project/id/768788, (2021).
53. Siderwin-spire.eu, https://www.siderwin-spire.eu, (2021).
54. Global CCS Institute, "CCS: a necessary technology for decarbonising the steel sector", https://www.globalccsinstitute.com/news-media/insights/ccs-a-necessary-technology-for-decarbonising-the-steel-sector/, (2017).
55. Howard Mustoe, "Sparks fly as levelling up and going green collide at JLR owner's steel plant", *The Telegraph*, 13 November 2021.

expanding hydrogen production capacity. In 2020, Tata Steel announced plans to capture CO2 from its blast furnaces in IJmuiden, Netherlands, and transport it for storage in empty gas fields under the North Sea. The project was expected to reduce emissions by 30% from their steelmaking site.[56] However, the project was scrapped less than a year later, with Tata citing its decision to develop a hydrogen-DRI process instead.[57]

In 2012, the UK Government pledged to support the development of CCS in the UK through a £1 billion competition.[58] The scheme was established to provide funding for the development of a pilot CCS project for the power sector which could be linked to industrial clusters.[59] This would have provided an avenue for capturing CO2 directly from a steel plant or to produce 'blue hydrogen',[60] which could be used as a low-carbon input to steelmaking. However, the Government cancelled the competition in 2015, six months before the final award decision was due.[61]

The prospects of CCS have since been revived in the UK's *Net Zero Strategy*, in which the Government pledged to deliver four CCUS clusters, capturing 20-30 MtCO2 across the economy per year by 2030.[62] It is anticipated that at least one of these clusters will provide a source of hydrogen to steelmakers in the north of England and East Midlands.

56. Tata Steel, "Tata Steel plans to develop largest CO2 capture installation in the world", https://www.tatasteeleurope.com/corporate/news/tata-steel-plans-to-develop-largest-CO2-captur-installation-in-the-world, (2020).
57. S&P Global, "Dutch CCS project scrapped after Tata Steel opts for hydrogen DRI production route", https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/092121-dutch-ccs-project-scrapped-after-tata-steel-opts-for-hydrogen-dri-production-route, (2021).
58. Department of Energy and Climate Change, "CCS competition launched as government sets out long term plans", https://www.gov.uk/government/news/ccs-competition-launched-as-government-sets-out-long-term-plans#:~:text=3%20April%202012-,3%20April%202012,energy%20security%20and%20reduce%20emission, (2012).
59. Element Energy, "Demonstrating CO2 capture in the UK cement, chemicals, iron and steel and oil refining sectors by 2025: A Techno-economic Study", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/311482/Element_Energy_DECC_BIS_Industrial_CCS_and_CCU_final_report_14052014.pdf, (2014).
60. *Blue hydrogen* is produced through a process of steam methane reforming where natural gas is decomposed into hydrogen and CO2. The CO2 is then captured and permanently stored.
61. Damian Carrington, "UK cancels pioneering £1bn carbon capture and storage competition", *The Guardian*, 15 November 2015.
62. HM Government, Net Zero Strategy: Build Back Greener", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf, (2021), 21.

## Carbon Capture and Utilisation (CCU)

CCU uses waste gases from fossil fuel-based steelmaking processes to produce fuels or feedstocks for the chemicals industry. Unlike CCS, CCU converts waste gases into useful products, instead of sequestering them underground.

The emissions savings that can be achieved with CCU vary according to the process and product(s) developed as a result. ArcelorMittal is piloting bio-ethanol production at their steelworks in Ghent, Belgium, supported by the EU's Horizon 2020 funding programme.[63]

UK steelmakers have not shown a strong interest in pursuing CCU technologies at their sites and this may be due in part to there being a limited market for CCU products at present. As such, it is unclear what impact CCU technologies might have on GHG emissions from UK steelmaking.

## Pathways for the UK

A decade ago, the technological solutions proposed for decarbonising steel were based on theoretical knowledge of low-carbon steelmaking processes with little experimental data to draw on. Today, there are dozens of clean steel pilot projects underway or planned in Europe alone[64] and the results gleaned from these trials have vastly improved knowledge of the potential, limitations, and costs of decarbonisation pathways for the steel industry.

A consensus view is emerging around which technological approaches will be necessary for decarbonising the UK steel industry.[65,66] They are:

- Increased scrap utilisation and EAFs

63. ArcelorMittal, "Capturing and utilising waste carbon from steelmaking", https://corporate.arcelormittal.com/media/case-studies/capturing-and-utilising-waste-carbon-from-steelmaking.
64. ECIU, "Stuck on the starting line", https://ca1-eci.edcdn.com/reports/ECIU_stuck_starting_line.pdf, (2021).
65. Frank Aaskov, "Oral evidence: Technological innovations and climate change: green steel, HC 1093, Q4", https://committees.parliament.uk/oralevidence/10109/html/, (2022).
66. Sian Burkitt, "The huge challenge the Port Talbot steelworks faces as Wales brings in tough new legally-binding carbon emissions targets", *Wales Online*, 1 March 2021.

- Hydrogen based steelmaking
- Conventional (primary) steelmaking with CCS.

Improvements in energy and material efficiency, driven by competitive pressure to reduce costs, will result in further reductions in energy use and emissions from steelmaking, particularly as older furnaces and processing equipment are replaced or augmented with more efficient technologies that can operate more flexibly. EAFs, for example, use around half the energy of the BF-BOF process while hydrogen-based steelmaking (H-DRI) will be considerably more efficient than coal-based steelmaking, requiring between one third to a half of the energy input needed to produce the same quantity of crude steel via the BF-BOF route.[67]

Technological limitations are no longer as significant a barrier to the development of clean steel as economic considerations.[68] The technologies required to produce clean steel are ready for deployment and, while hydrogen and CCS-based steelmaking techniques have not reached the technological maturity of EAF steelmaking, evidence from pilot projects demonstrates that both approaches and the underlying technologies are viable at scale and effective in reducing direct emissions. One steel equipment manufacturer already has the capability to design and supply large-scale hydrogen-based steelmaking technologies for integrated steelmaking operations on a 24 to 36 month lead time.[69]

For the UK's two primary steelmaking sites, the transition to clean steel will involve a diversification away from BF-BOF steelmaking. In the coming months and years there will be a need to test and prove technologies for displacing BF production at industrial-scale in order to enable funding for larger-scale deployment. This process appears to

67. Morris, A.E. 2014 states that the BF-BOF steelmaking route consumes 19.8–31.2 GJ energy per tonne of crude steel. Chris Goodall estimates that about 90 kilogrammes of H2 would be required to produce one tonne of crude steel via the H-DRI process, equating to an electricity demand of 10.8 GJ per tonne.
68. Philip Dunne, "Technological Innovations and Climate Change inquiry: Green Steel", https://committees.parliament.uk/publications/22480/documents/165697/default/, (2022).
69. Based on written evidence submitted to Bright Blue.

now be in its initial phase, with British Steel having secured funding from the government for a 6-month feasibility study into the use of green hydrogen in reheating furnaces.[70] If successful, this study will be followed by a full-scale technology demonstration. In the short-term, some existing BF capacity may be augmented to enable syngas injection and higher scrap ratios, leading to an immediate reduction in emissions intensity at relatively low cost.

However, to continue primary steel production while meeting emissions reduction targets, both Port Talbot and Scunthorpe sites will require new clean steel equipment to replace their blast furnaces in the 2030s. One option will be to install natural gas-based DRI-EAF or DRI-OBF capacity, which is capable of being converted to run on hydrogen at a later date. Alternatively, CCS may be installed on new or refurbished blast furnaces.[71] Tata has yet to express a preference for decarbonising its Port Talbot site.[72] However, British Steel's *Low-Carbon Roadmap* envisages a portfolio approach combining EAF, hydrogen-based steelmaking and CCS.[73] This suggests that Scunthorpe will retain capacity to produce primary steel through its transition.

EAF site operators have indicated that short-term emissions reductions would arise from improvements in plant energy efficiency and from switching to 100% renewable electricity. Indeed, this will almost completely eliminate scope 2 emissions. Biomass and/or hydrogen – which is expected to become available from the late 2020s – will be necessary to displace coal and natural gas inputs, bringing direct plant emissions close to zero. Some residual emissions that are difficult to eliminate – for example, from carbon in electrodes – will likely be offset until suitable alternatives are found.

70. Mike Hughes, "British Steel launches major study into use of green hydrogen", *The Northern Echo*, https://www.thenorthernecho.co.uk/news/20187921.british-steel-steps-hydrogen-plans/, (2022).
71. These decisions will be dictated in part by site conditions: the UK's integrated steelworks are currently optimised for BF-BOF production and existing on-site upstream and downstream processing facilities may not be interoperable with technologies for clean steel production.
72. Howard Mustoe, "Sparks fly as levelling up and going green collide at JLR owner's steel plant", *The Telegraph*, 13 November 2021.
73. British Steel (n.d.), Low-Carbon Roadmap, https://britishsteel.co.uk/who-we-are/sustainability/low-carbon-roadmap/.

## Conclusion

A range of processes and technologies are available to decarbonise steel production. There is no one clean steel process or technology that is suited to both primary and secondary steelmaking; each presents its own challenges and the solutions will need to be tailored accordingly.

However, hydrogen-based DRI-EAF steelmaking is emerging as the promising route to net zero primary steelmaking in the UK, although there remains significant uncertainty within industry over the future availability and cost of hydrogen. For secondary steelmaking at EAF sites, a switch from coal and natural gas to hydrogen and biomass, coupled with access to renewable electricity, can reduce emissions to very low levels.

Having identified in this chapter the principal processes and technologies to support the deep decarbonisation of both primary and secondary steelmaking in the UK, the next chapter explains the principal policies from the current UK Government to support the development of clean steel.

# Chapter Four: **Policies for clean steel**

The last chapter described the leading pathways to support the necessary development of clean steel in the UK. This chapter now outlines the intention and impact of the current UK Government's principal policies for supporting the development of and investment in clean steel.

The current UK Government has three main types of policies for decarbonising steel: carbon pricing; industrial policy; and public funding.

## Carbon pricing

UK steelmakers are regulated by the UK's new Emissions Trading System (ETS), a cap and trade carbon market which covers EIIs, the power sector, and aviation. The rationale behind the ETS is that by putting a price on CO2 emissions, it creates a financial incentive for regulated companies to lower their emissions which, in turn, reduces their carbon costs.

The design of the UK ETS largely mirrors Phase IV of the EU ETS,[74] the EU's carbon market which the UK exited in January 2021. Each year, the operators of installations regulated by the ETS are required to surrender one emission allowance for every tonne of CO2 emitted by their installation(s). Operators receive free allowances and/or

74. International Carbon Action Partnership, "ETS Detailed Information: United Kingdom", https://icapcarbonaction.com/en?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=99, (2021).

purchase emission allowances at auction or on the secondary market which they can trade with other participants as needed. There are various mechanisms to stabilise the price and supply of allowances on the market.

EIIs such as steelmakers receive a large portion of their allowances for free since they operate in globally competitive markets, are trade-exposed, and therefore have limited ability to pass carbon costs onto their buyers. This free allocation is calculated as a function of historic production levels at each regulated installation, multiplied by a product benchmark. A product benchmark reflects the average performance of the 10% most efficient installations in a particular sector or product category. That is to say – an installation that is among the most efficient of its kind will receive around 100% of the allowances needed to cover its annual emissions for free. Although, in reality, the supply of free allowances is constrained and installations covered by the same product benchmark are, to some extent, in competition with each other for free allowances.

For the steel industry, benchmarks are complicated by the diverse routes for producing crude steel. There are three benchmarks that apply to the BF-BOF route: coke, sintered ore, and hot metal. There are two benchmarks covering EAF steel: EAF carbon steel, and EAF high alloy steel.[75] These different benchmarks produce mixed incentives for plant operators to reduce their emissions. For example, both BF-BOF and EAF routes can produce crude steel of similar specification, yet the benchmarks applied to each route set a very different standard for the amount of free allocation that can be given to the respective operators of the BF-BOF and the EAF.[76] As the steel industry adopts clean steel processes, the application of multiple benchmarks to the same product (or products that can easily be substituted) will increasingly undermine

75. European Commission, "COMMISSION IMPLEMENTING REGULATION (EU) 2021/447", https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0447&qid=1615797821614, (2021).
76. Sandbag, "Benchmarks for free allocation of emission allowances 2021-25", https://sandbag.be/wp-content/uploads/2021/01/Sandbag-feedback-on-benchmarks-implementing-regulation.pdf, (2021), 1.

the role of the ETS in reducing emissions from the sector.[77]

Furthermore, the benchmark trajectories for the current phase of the ETS – which is, in essence, the implied rate at which industries are expected to reduce their emissions – are incoherent with the UK's net zero target, as they imply a much slower emission reduction, dampening the ETS' already weakened price signal.

Another pitfall of using free allowances to protect trade-exposed industries from carbon leakage is that it largely removes the very incentive carbon markets provide for industries to reduce their emissions. This proved to be the case for the EU ETS, in which UK steelmakers participated, when there was little discernible impact on the emissions-intensity of steelmaking in the period from 2005 to 2018.[78,79] However, with the price of allowances in the EU ETS and UK ETS having risen sharply since 2018 to around £80/tonne,[80] there are signs that carbon costs have become an increasingly important part of long-term business decision-making.[81]

## Industrial policy

The current Government has produced a number of strategies outlining policy and regulatory frameworks designed to support industrial decarbonisation.

First, the Government's *Ten Point Plan for a Green Industrial Revolution*, published in 2020, highlighted proposals to establish 5GW of low-carbon hydrogen production capacity by 2030, and invest £1 billion in

77. For further discussion of UK carbon pricing see Bright Blue's 2021 report: Josh Buckland, "Green Money" http://www.brightblue.org.uk/portfolio/green-money-a-plan-to-reform-uk-carbon-pricing/ (2021).
78. Agnese Ruggiero, "Why we need more than just the EU carbon market to tackle industrial pollution", *Euractiv*, https://www.euractiv.com/section/emissions-trading-scheme/opinion/why-we-need-more-than-just-the-eu-carbon-market-to-tackle-industrial-pollution/, (2019).
79. Pierre Andurand, "Windfalls for heavy industry in EU carbon scheme are a moral hazard", *Financial Times,* 4 November 2021.
80. Ember-climate.org, "Daily Carbon Prices", https://ember-climate.org/data/data-tools/carbon-price-viewer/, (2022)
81. A senior figure in the parent company of one steelmaker, which operates several plants in the UK, told Bright Blue that carbon pricing had, only within the last two years, started to be incorporated in European steel companies' financial planning.

developing 4 CCS clusters by 2030.[82] As discussed in Chapter Three, hydrogen will be an important low-carbon energy source for the steel industry as it shifts away from fossil fuels and the proposed CCS clusters will enable steelmaking sites to connect to hydrogen networks. A report by the Mission Possible Partnership suggested that "the scale of investment needed in accompanying [low-carbon energy] infrastructure will ultimately dwarf the needs of steel plants themselves".[83]

However, there are many other economic sectors too that plan to use hydrogen to decarbonise. It is unclear how much of the proposed new hydrogen production capacity will be made available to the steel industry and at what price – both key considerations for steelmakers choosing which technologies to invest in.

Next, 2021 saw the publication of this Government's *Plan For Growth*, which replaced the 2017 *Industrial Strategy: building a Britain fit for the future*.[84] In it, the Government reiterated its commitment to developing CCS and hydrogen infrastructure in the UK.[85] While these initiatives have been broadly welcomed by the steel industry generally, there has been criticism of the apparent lack of clear goals or coordination across government departments to deliver the *Plan For Growth*.[86]

Shortly after, the Government launched the *Industrial Decarbonisation Strategy* (IDS), setting out its approach to aligning industry generally with net zero. In addition to proposals outlined in the *Plan For Growth*, specific actions put forward in the IDS included plans to align the ETS with net zero and to provide funding for the research and development of low-carbon technologies for industry.[87] The IDS also acknowledges

82. BEIS, "The Ten Point Plan for a Green Industrial Revolution", https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title#point-6-jet-zero-and-green-ships, (2020).
83. Mission Possible Partnership, "NET-ZERO STEEL", https://missionpossiblepartnership.org/wp-content/uploads/2021/10/MPP-Steel_Transition-Strategy-Oct19-2021.pdf, (2021).
84. HM Government, "Industrial Strategy: building a Britain fit for the future", https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future, (2017).
85. HM Treasury, "Build Back Better: our plan for growth", https://www.gov.uk/government/publications/build-back-better-our-plan-for-growth/build-back-better-our-plan-for-growth-html#net-zero, (2021).
86. BEIS Committee, "Post-pandemic economic growth: Industrial policy in the UK", https://publications.parliament.uk/pa/cm5802/cmselect/cmbeis/385/385.pdf, (2021), 13.
87. HM Government, "Industrial Decarbonisation Strategy", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970229/Industrial_Decarbonisation_Strategy_March_2021.pdf, (2021).

the CCC's advice that iron and steel production should be largely decarbonised by the mid-2030s, but does not adopt it officially, instead committing to "consider the implications of the recommendation of the Climate Change Committee to set targets for ore-based steelmaking to reach near-zero emissions by 2035" and "support increasing amounts of fuel switching to low carbon hydrogen during the 2020s."[88]

Many of the initiatives announced in the IDS, however, lack detail on the timing or scope of government action on steel. While those that do are, to a large extent, a reiteration of previously announced policies.

The Government further elaborated on its plans for growing the hydrogen economy by 2030 in the *UK hydrogen strategy*, published in 2021. The *UK hydrogen strategy* provides details of the size and locations of proposed hydrogen production projects in the UK and a delivery timeline that implies industrial users will have access to hydrogen by the late 2020s.[89] It also set out a 'Hydrogen Business Model', designed to provide "revenue support to hydrogen producers to overcome the cost gap between low carbon hydrogen and higher carbon counterfactual fuels".[90] The cost of hydrogen is a significant uncertainty for industrial users and the ability of steel producers to use hydrogen will be heavily influenced by the distribution of costs between the taxpayer and the private sector.

Finally, the *Net Zero Strategy*, published in 2021, detailed this Government's strategy to fully decarbonise the economy by 2050. It includes plans to deliver 6 MtCO2 per year of industrial CCUS by 2030, and 9 MtCO2 per year by 2035, and outlines a number of mechanisms for supporting CCS and hydrogen infrastructure along with fuel-switching technologies.[91]

88. Ibid.,10.
89. HM Government, UK hydrogen strategy",https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf, (2021), 25.
90. Ibid", 74.
91. HM Government, "Net Zero Strategy: Build Back Greener", https://www.gov.uk/government/publications/net-zero-strategy, (2021),120.

## Public funding

The current Government has established a number of public funds to overcome investment barriers to decarbonising steelmaking and providing low-carbon infrastructure. These funds offer support for low-carbon technologies and finance for innovation and demonstration of new technologies that carry higher risks and which might otherwise fail to attract private investment.

In 2019, the then Government launched the Industrial Energy Transformation Fund (IETF) with £315 million available in grants to fund the commercial demonstration of fuel switching technologies for EIIs and to help businesses cut their energy costs through increasing energy efficiency. In its first phase, the IETF granted £3 million to Celsa for efficiency upgrades at its Cardiff steelworks, introduced in Chapter One.[92] The second round of funding allocation is currently underway.

The £250 million Clean Steel Fund was also announced in 2019 to support initiatives to decarbonise steelmaking. The fund will provide support for switching to lower carbon fuels such as hydrogen, biomass and renewable electricity, as well as carbon capture usage and storage, and energy and material efficiency.[93]

However, grants of up to £30 million will only become available to steelmakers from 2023, leading to concerns that this will delay investment in upgrading UK steel plants at a time when the EU is already investing large sums of public money in decarbonising its steel industry – through programmes such as Horizon 2020 and the Innovation Fund – and attracting private capital that might otherwise have been invested in UK steelmaking.[94]

In 2021, BEIS published a consultation on a planned £240 million Net Zero Hydrogen Fund, which was first trailed in the 2020 *Ten Point Plan*

92. S&P Global, "UK expands IETF funding to steelmakers; to launch Clean Steel Fund", https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/092221-uk-expands-ietf-funding-to-steelmakers-to-launch-clean-steel-fund, (2021).
93. Green Alliance, "Making the UK a world leader in the production of clean steel", https://green-alliance.org.uk/wp-content/uploads/2021/12/Making_the_UK_a_world_leader_in_clean_steel.pdf, (2021), 6.
94. Energy & Climate Intelligence Unit, "Stuck on the starting line", https://ca1-eci.edcdn.com/reports/ECIU_stuck_starting_line.pdf, (2021).

*for a Green Industrial Revolution*. As already discussed in Chapter Three, the availability of hydrogen will be essential to fully decarbonising steelmaking in the UK. The fund was launched in June 2022 and will support initiatives that contribute to meeting the Government's target of developing 10GW of hydrogen production capacity by 2030.[95] Part of the fund will be used to provide support for the engineering design of hydrogen production projects while the remainder of the fund will support capital expenditure on projects that will produce low-carbon hydrogen at scale by 2025.

The UK's *Net Zero Strategy*, published in 2021, committed £1 billion to delivering "four carbon capture usage and storage (CCUS) clusters, capturing 20-30 MtCO2 across the economy, including 6 MtCO2 of industrial emissions, per year by 2030".[96] Two initial clusters will be located in the northwest of England and along the northeast coast

Senior figures in the UK steel industry have raised concerns that the public funding being offered is not sufficient to attract the "billions of pounds" of investment needed to transform the industry, with Gareth Stace, Director General of trade body UK Steel warning that "much more will be required and in short order".[97]

Steelmakers with international parent companies – which is the case for five of the six UK steelmakers, as illustrated in Chapter One – are particularly sensitive to the local investment environment since they are often vying with other parts of the business for investment. Jingye, which owns the British Steel plant at Scunthorpe, pledged investment worth £1.2 billion in the site and planned to construct a new EAF when it took over in 2020.[98] However, that investment has since remained on hold with high energy prices and a lack of clear direction from the Government being cited by the company's leadership as key reasons for

95. BEIS, "Net Zero Hydrogen Fund strand 1 and strand 2",https://www.gov.uk/government/publications/net-zero-hydrogen-fund-strand-1-and-strand-2, (2022).
96. BEIS, "Net Zero Strategy",https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf, (2021), 21.
97. Jim Pickard & Sylvia Pfeifer,, "Pressure grows to accelerate £250m green fund for UK steel industry", *Financial Times*, 15 February 2021.
98. Matthew Moggridge, "Jingye outlines plans for British Steel", *Steel Times International*, 9 March 2020.

its decision.[99]

It is important to view investment in the UK steel industry in a wider context: UK steelmakers are in competition for investment with international markets, particularly in Europe. The technologies involved in clean steel production are still under development, making investments in clean steel inherently risky. To make these projects attractive to the private sector, it is incumbent on government to establish policy frameworks that promote investments in UK clean steel relative to alternatives. A recent inquiry conducted by the House of Commons Environmental Audit Select Committee into clean steel technologies heard evidence that "[UK] Government initiatives to decarbonisation steel production lacked ambition compared with other countries".[100]

## Conclusion

This current Government has set out a broad vision and set of principles for decarbonising UK industries, key to which is the development of low-carbon infrastructure and cost-effective emissions abatement technologies for industry.

However, there is so far no specific commitment from the government to delivering clean steel within a clearly defined timeframe. Indeed, the IDS only promises to "consider the implications of the recommendation of the Climate Change Committee" for the UK to reach near-zero emissions from ore-based steelmaking by 2035.

Government has also launched a series of public funds that will enable steelmakers to invest in efficiency improvements and clean steel technologies. Taken together, BEIS will provide £2 billion in funding

99. Alan Tovey, "Pressure grows to accelerate £250m green fund for UK steel industry", *The Telegraph*, 15 February 2021.
100. Environmental Audit Committee, "UK steelmaking could be jeopardised unless new, clean technologies are progressed, EAC argues",https://committees.parliament.uk/committee/62/environmental-audit-committee/news/171214/uk-steelmaking-could-be-jeopardised-unless-new-clean-technologies-are-progressed-eac-argues/, (2022).

between 2020 and 2028 to support industrial decarbonisation.[101]

However, the published Government strategies appear to rely extensively on the UK ETS to support clean steel business models and do not address the higher operating costs of producing clean steel, which represent a fundamental barrier to investment in commercial scale projects.

Adding to the uncertainty is the lack of clarity over the availability and cost of hydrogen for industry generally.

The business case for clean steel remains highly uncertain due a lack of clarity on what action the government is willing to take to ensure that UK companies can manufacture clean steel competitively. Without a firmer commitment to clean steel from the government, steelmakers may be unwilling to commit to investments in the necessary clean steel processes and technologies detailed in Chapter Three. With net zero now a relatively short-term prospect for the steel industry, it is vital that new investments in the industry align with the UK's climate ambition. The UK Government should urgently look at how it can use public policy to promote new business models for clean steel.

This chapter has highlighted that current public policy regarding the steel industry has developed significantly in recent years but is still insufficient to support the necessary transition to clean steel. The next chapter outlines all the key challenges, including inadequate public policy, to the growth of a clean steel market in the UK.

101. BEIS, "The Industrial Energy Transformation Fund: Summary of responses to consultation", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/895759/ietf-finalising-design-summary-of-responses.pdf, (2020), 5.

## Chapter Five:
# Challenges for clean steel

Chapter Four outlined the principal policies of the current UK Government to support the development of clean steel, exposing their inadequacy. Alongside poor public policies, there are other major challenges for the maturing of a market for clean steel. Ultimately, decisions around investments in clean steel, and the sector more broadly, will be shaped by companies' ability to navigate these challenges. In this chapter, we explain in detail the key current challenges for steelmakers as they attempt to reach net zero.

The UK steel industry has already faced a series of challenges in recent years. Between 2015 and 2016, global overcapacity in the sector pushed down steel prices[102] which saw UK steel output fall by 30%, leading to a wave of steel plant closures – including the Redcar steelworks, home to Europe's second largest blast furnace – and the loss of an estimated 7,000 jobs.[103]

Then, in early 2020, UK steelmakers experienced a 45% drop in demand for steel[104] due to the effects of the COVID-19 pandemic on the wider economy. Steelmakers reportedly sought government aid totalling £1 billion to stabilise their balance sheets.[105] A number of

102. Commons Library, "UK Steel: Decades of decline", https://commonslibrary.parliament.uk/uk-steel-decades-of-decline/, (2017).
103. Commons Library, "UK Steel Industry: Statistics and policy", https://researchbriefings.files.parliament.uk/documents/CBP-7317/CBP-7317.pdf, (2021), 12.
104. Ibid., 18.
105. Sky News, "Coronavirus: British Steel's Chinese owner seeks £100m state loan", https://news.sky.com/story/coronavirus-british-steels-chinese-owner-seeks-100m-state-loan-11989311, (2020).

UK steelmakers were able to secure loans or other financing facilities under the Coronavirus Large Business Interruption Loan Scheme (CLBILS),[106] the Coronavirus Job Retention Scheme (CJRS), and Project Birch – a bespoke government support scheme targeted at strategically important industries whose failure would "disproportionately harm the economy." Although some applicants and recipients of funding are known, neither government, nor the British Business Bank which administered some of the schemes, have published data that provide a complete picture of how many specific steelmakers secured financing under these initiatives, and how much.

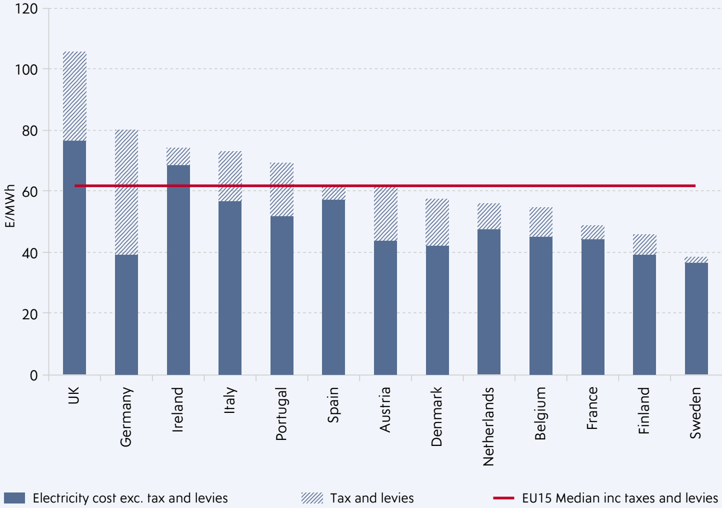
In addition to these economic disruptions, UK steelmakers face a series of ongoing and well-documented challenges that limit their ability to raise the capital needed to transition to commercial clean steel production. The House of Commons Business, Energy and Industrial Strategy Select Committee's 2021 report on the future of the UK steel industry highlighted three key issues facing UK steelmakers on the path to net zero: high energy prices, lack of visibility around opportunities to bid for public contracts, and global trade pressures.[107] We would also add inadequate public policy, which was outlined in Chapter Four. These additional key challenges are discussed in further detail below.

## High energy prices

UK steelmakers have faced persistently higher electricity prices than their counterparts in Europe and elsewhere. Analysis by Ofgem shows that electricity prices paid by the UK's energy intensive industries (EIIs), including steel, are consistently above the EU average and the highest overall, even when excluding environmental levies[108], as Figure 5.1 below shows.

106. BEIS Committee, "Liberty Steel and the Future of the UK Steel Industry", https://publications.parliament.uk/pa/cm5802/cmselect/cmbeis/821/report.html, (2021), 22.
107. BEIS Committee, "Liberty Steel and the Future", 29-30.
108. Ofgem, "Research into GB electricity prices for Energy Intensive Industries", https://www.ofgem.gov.uk/sites/default/files/2021-07/Final%20report-%20Research%20into%20GB%20electricity%20prices%20for%20EnergyIntensive%20Industries.pdf, (2021), 8.

**Figure 5.1. Average electricity prices for EIIs in Europe, 2016-2020**




Notes: data represents consumers with an annual consumption between 70-150GWh. The total for each column includes all environmental taxes and levies, and excludes VAT. 2020 data is only up toand including June 2020. There was insufficient data for Greece and Luxembourg.

*Source: Ofgem, "Research into GB electricity prices for Energy Intensive Industries", https://www.ofgem.gov.uk/sites/default/files/2021-07/Final%20report-%20Research%20into%20GB%20electricity%20prices%20for%20EnergyIntensive%20Industries.pdf, (2021), 8.*

The discrepancy between UK electricity prices and those elsewhere in Europe is due to a combination of factors which, according to Ofgem, include:

- An electricity generation mix that relies on natural gas
- The additional cost of the Carbon Price Support (CPS)[109]
- Comparatively low levels of interconnection[110]

109. The CPS is a levy on fossil fuels used in power generation that is additional to the carbon price. For the year 2022-2023 this price will be £62.10/tCO2.
110. Ibid., 8. Interconnection refers to the network of high-voltage cables that connect the electricity system of the UK with those of neighbouring countries. For further information, see Ofgem's summary of interconnectors https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/interconnectors

Since steel is a globally traded commodity, UK producers have no means of passing higher energy costs onto consumers without losing market share. According to industry trade association, UK Steel, this "price gap has cost the sector over £250 million since 2016-17".[111]

Evidence submitted by UK Steel to the House of Commons Business, Energy and Industrial Strategy Select Committee shows that while the policy cost (taxes and levies) component of energy prices is higher for UK steelmakers relative to many European counterparts, wholesale energy prices actually account for the majority of the price gap between the UK and Europe.[112]

During the gas price spikes seen in September and October of 2021, average electricity prices paid by UK steel companies reportedly rose to £182/MWh[113] from a level of between £80-90/MWh in summer.[114] The war in Ukraine has further exacerbated volatility in natural gas markets[115] due to the ongoing disruption to gas supplies from Russia's, previously a major exporter of natural gas to Europe. As of June 2022, wholesale electricity prices remain high at around £195/MWh (not accounting for relief given to steelmakers).[116]

High electricity prices pose a barrier to investment for decarbonising the steel industry since every technological option available for manufacturing clean steel – as outlined in Chapter Three – will increase electricity consumption significantly.[117] In terms of electricity requirement, UK Steel estimates that replacing blast furnaces with EAFs would require two to three times more electricity; for hydrogen-based

111. UK Steel, Written evidence submitted by UK Steel", https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/interconnectors, (2021).
112. UK Steel, "Written evidence submitted by UK Steel (EPM0007)".
113. UK Steel, "A barrier to decarbonisation: Industrial electricity prices faced by UK steelmakers", https://www.google.com/url?q=https://www.makeuk.org/-/media/eef/files/reports/industry-reports/uk-steel-a-barrier-to-decarbonisation---main-report---dec-21.pdf&sa=D&source=docs&ust=1656697236850008&usg=AOvVaw1fkhVyYcaZQWtHGSAj4x32, (2021), 7.
114. Maria Tanatar, Carrie Bone, Julia Bolotova, "FOCUS: Steel producers express concerns over rising energy costs ahead of winter", *Fast Markets*, https://www.metalbulletin.com/Article/4009250/FOCUS-Steel-producers-express-concerns-over-rising-energy-costs-ahead-of-winter.html, (2021).
115. Rob Davies, "Gas prices hit record high again as Ukraine invasion disrupts markets", *The Guardian*, 4 March 2022.
116. Ofgem. (n.d.), "Wholesale market indicators", https://www.ofgem.gov.uk/wholesale-market-indicators, (2022).
117. UK Steel, "Written evidence submitted by UK Steel" (2021).

steel production the electricity requirement increases to six or seven times; while for carbon capture and storage the energy requirement would increase 'significantly'.[118]

Consequently, production costs are also likely to increase as a result of decarbonising the industry, by 35-100% per tonne of steel by 2050 (relative to conventional steelmaking routes) according to one estimate,[119] while another estimate suggests an increase in costs of between 20% and 50%.[120]

In its 2020 *Energy White Paper*, the current Government committed to engaging with industrial energy users to "identify existing distortions in the system and gain insights into the trade-offs involved in the distribution of energy costs", and to have a dialogue with the "energy industry about the fairness and affordability of the cost of moving to clean energy over the long-term".[121]

Earlier this year, the Secretary of State for Business, Energy and Industrial Strategy noted that government has provided "over £600 million in relief to the steel sector since 2013 to make electricity costs more competitive".[122] However, this figure also includes indirect support given to electricity generators in addition to relief given to steelmakers. Analysis by UK Steel indicates that, while exemptions and compensation given to the steel sector have reduced the *effective* price they paid for electricity prior to the ongoing energy crisis from £71/MWh to £19/MWh, this was at the time approximately double the net

118. UK Steel, "Written evidence submitted by UK Steel" (2021).
119. Materials Processing Institute, Decarbonisation of the Steel Industry in the UK, https://www.mpiuk.com/downloads/industry-papers/SI-Series-Paper-05-Decarbonisation-of-the-Steel-Industry-in-the-UK.pdf, (2021), 3.
120. World Economic Forum, "This is how the steel industry is forging a path to net-zero", https://www.weforum.org/agenda/2021/05/green-steel-forging-a-path-to-net-zero/, (2021).
121. BEIS, "Energy white paper: Powering our net zero future", https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future/energy-white-paper-powering-our-net-zero-future-accessible-html-version, (2020).
122. BEIS, "Final Steel Procurement Taskforce sets out recommendations to support continued competitiveness of UK steel sector", https://www.gov.uk/government/news/final-steel-procurement-taskforce-sets-out-recommendations-to-support-continued-competitiveness-of-uk-steel-sector, (2022).

electricity prices paid by steelmakers in Germany and France.[123]

In April 2022, the Government published the *British energy security strategy* (BESS) which contains a series of energy policy changes designed to address the short-term effects of the 2021-2022 global energy crisis while reducing the UK's dependence on imported energy in the longer-term. Among the new measures announced was the renewal of the Energy Intensive Industries (EII) Compensation Scheme for a further three years,[124] a move welcomed as a "major step forward" by industry association UK Steel.[125] The scheme allows large energy users including steelmakers to claim an exemption of up to 100% of indirect carbon costs[126] of the UK Emissions Trading Scheme and the Carbon Price Support (CPS) mechanism. It does not specifically address high wholesale energy prices but, instead, reduces the carbon costs passed through to industrial energy users from electricity they consume.

The BESS also plans an acceleration in the deployment of domestic low-carbon electricity generation, driven by security of supply concerns amid the ongoing global energy crisis. It is envisaged that offshore wind capacity will increase from 40GW to 50GW by 2030. A five-fold growth in solar energy is expected by 2035 from the current installed capacity of 14GW. While up to 24GW of nuclear capacity is set to be installed by 2050. It is expected that this additional capacity will help reduce renewable electricity prices in the longer-term.

UK interconnector capacity is also scheduled to more than double by 2025 from an existing capacity of 7.4 GW,[127] and further increase

123. UK Steel, "Closing the Gap: How competitive electricity prices can build a sustainable low-carbon steel sector", https://www.google.com/url?q=https://www.makeuk.org/-/media/files/insights/publications/uk-steel---closing-the-gap---february-2021.pdf&sa=D&source=docs&ust=1656697338058075&usg=AOvVaw3cBKWZUKwl3xmwJLZNnGka, (2021), 12.
124. BEIS, 10 Downing Street, "British energy security strategy", https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy, (2022).
125. Make UK, "News from UK Steel – Reaction to Energy Security Strategy", https://twitter.com/UKSteel__/status/1512065277109760006?s=20&t=MMvVLlJ9riUf9aKVUW2dlw, (2022).
126. Indirect carbon costs refers to the carbon price component of electricity costs that is passed onto electricity consumers by greenhouse gas-emitting electricity generators regulated under the UK ETS.
127. Ofgem. (n.d.), "Interconnectors", https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/interconnectors, (2022).

to 20 GW by 2030.[128] This will improve liquidity in the UK electricity market and bring UK and European electricity wholesale prices into closer alignment. Analysis by UCL and the Aldersgate Group suggests that each GW of interconnection can reduce UK wholesale electricity prices by 1-2%.[129]

The Government is also due to consult on a series of electricity market reforms as part of the Review of the Electricity Market Arrangements (REMA). The consultation is widely expected to include a proposal to create parallel markets for renewables and fossil power generation as a means of decoupling electricity prices from wholesale gas prices, thereby reducing costs for power consumers.[130]

In essence, UK steelmakers have faced high electricity prices relative to their counterparts in Europe and elsewhere, in spite of a number of policies from successive Governments to alleviate high energy costs for EIIs. With electricity demand from steelmaking expected to at least double as the sector decarbonises, UK Steel has suggested that the UK's high electricity prices will have a negative impact on investments in UK clean steel.[131] While the growth of low-carbon electricity generation and interconnectors is expected to lower electricity prices in the long term, indications that the Secretary of State for Business, Energy and Industrial Strategy may consider network charge relief for EIIs suggests that the Government now recognises the need for more immediate solutions to the issue of

128.NationagridESO, "Downloadable Future Energy Scenarios Resources", https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2021/documents.
129. UCL Sustainable Resources Institute, commissioned by the Aldersgate Group, "Delivering competitive industrial electricity prices in an era of transition", https://www.aldersgategroup.org.uk/content/uploads/2022/03/DELIVERING-COMPETITIVE-INDUSTRIAL-ELECTRICITY-PRICES-IN-AN-ERA-OF-TRANSITION-policy-briefing.pdf, (2021), 5.
130. Molly Lempriere, "Government could decouple wholesale gas and power prices in 'urgent' market reforms", *Curent±*, https://www.current-news.co.uk/news/government-to-consult-on-market-reform-with-urgency, (2022).
131. UK Steel, "Closing the Gap", https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj9naG1-9D4AhWDg1wKHaRcD-gQFnoECA8QAQ&url=https%3A%2F%2Fwww.makeuk.org%2F-%2Fmedia%2Ffiles%2Finsights%2Fpublications%2Fuk-steel---closing-the-gap---february-2021.pdf&usg=AOvVaw0WNH8B7LRwTTqyB9bmovrA, (2022).

high electricity prices.[132,133] This matters because, at a global level, the steel industry is not operating under free market conditions due to the prevalence of state intervention globally, as explained later in this chapter. This wider context should be taken into consideration by the Government as it seeks to align the UK's steel industry with net zero and drive adoption of clean steel technologies.

## Lack of visibility around opportunities to bid for public contracts

The market for clean steel products is undeveloped and at present consists of a small number of companies and 'buyers clubs' – that is, groups of companies that commit to procuring or stocking net zero steel according to a particular standard.[134] UK steelmakers report that buyers have shown strong interest in clean steel products, but have not yet seen that translate into significant demand.

The challenge for steelmakers is in developing a business case for producing clean steel. As described earlier in this chapter, the increased cost of manufacturing clean steel makes it uncompetitive to produce on a commercial basis[135] and this poses a significant barrier to the deployment of clean steel production technologies.[136] Even with government support for capital and energy costs, along with carbon pricing, there remain enormous uncertainties over whether UK-manufactured clean steel will be competitive in the short-term in domestic or overseas markets. While there are signs that a handful of buyers in the automotive, construction, renewable energy and white goods sectors are willing to commit to purchasing clean steel at a price

132. Helen Cahill, "Energy subsidy lined up for struggling steelmakers", *The Telegraph*, 4 June 2022.
133. The UK Chancellor has previously voiced scepticism around extending corporate subsidies. See Rishi Sunak, "Chancellor Rishi Sunak's Mais Lecture 2022", GOV.UK., https://www.gov.uk/government/speeches/chancellor-rishi-sunaks-mais-lecture-2022, (2022).
134. Chris Bataille, "Low and zero emissions in the steel and cement industries", https://www.oecd.org/greengrowth/GGSD2019_Steel%20and%20Cemement_Final.pdf, (2019), 31.
135. World Economic Forum, "This is how the steel industry is forging a path to net-zero", https://www.weforum.org/agenda/2021/05/green-steel-forging-a-path-to-net-zero/, (2021).
136. Material Economic, "Steeling Demand: Mobilising buyers to bring net-zero steel to market before 2030", https://materialeconomics.com/latest-updates/steeling-demand#:~:text=the%20report%20here, (2021), 5.

premium, these buyers represent a small fraction of the total market for steel products.[137,138]

The taxpayer is a major purchaser of steel products. Steel is used in central and local government projects, including for defence equipment, rail infrastructure, hospitals and flood defences. A recent publication from the Department for Business, Energy and Industrial Strategy (BEIS), *Steel procurement pipeline*, showed that public authorities will require an estimated 7.6Mt of steel over the next decade[139] – equivalent to 10% of current UK steel output over the same period.[140] This spending power could be harnessed to create markets for clean steel.

As a major purchaser of steel, the government can play a pivotal role in creating a domestic market for clean steel and, indeed, has already committed to achieving net-zero in major public construction projects by 2050.[141] However, it is unclear what this means in the short-term. The government's *Net Zero Estate (NZE) Playbook*, published in November 2021, states that accounting for net zero carbon construction "is not in scope for the NZE Playbook as the concept is currently in its early stages of development".[142]

HM Treasury's *The Green Book* provides guidance to public authorities on how to appraise project procurement options relative to current government policy objectives. The guidance – which was recently updated to promote great emphasis on the environmental

137. S&P Global, "Europe's steel buyers ready to buy low-emissions steel at higher prices: Austria industry group", https://www.spglobal.com/commodityinsights/en/market-insights/topics/lme-week, (2021).
138. Material Economics, Steeling Demand: Mobilising buyers to bring net-zero steel to market before 2030", https://www.google.com/url?q=https://materialeconomics.com/material-economics-steeling-demand.pdf?cms_fileid%3Db5f87ce120230f7f8d2b3c413a6c28c9&sa=D&source=docs&ust=1656697561496512&usg=AOvVaw0fYYzeInA3MbET9ORm4fBb, (2021), 4.
139. BEIS, "Steel public procurement 2021", https://www.gov.uk/government/publications/steel-public-procurement-2021#:~:text=their%20major%20projects.-,Steel%20procurement%20pipeline%202021,of%20the%20UK%27s%20motorway%20network, (2021).
140. BEIS Committee, "Liberty Steel and the Future of the UK Steel Industry", https://publications.parliament.uk/pa/cm5802/cmselect/cmbeis/821/report.html, (2021), 36.
141. S&P Global Commodity Insights, "COP26: Five developed nations commit to support low carbon steel, cement sectors", https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/110921-cop26-five-developed-nations-commit-to-support-low-carbon-steel-cement-sectors, (2021).
142. Government Property Function, "Net Zero Estate Playbook", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1035417/Net_Zero_Estate_Playbook__1_.pdf, (2021), 10.

and social impact of projects, following a review in 2020[143] – is not mandatory but, rather, provides a toolkit for government officials to evaluate and monitor the outcomes of policy or procurement decisions.

Guidance on public procurement of steel is also set out in Procurement Policy Notice (PPN) 11/16, which is designed to aid contracting authorities in accounting for 'social and environmental benefits' when evaluating project bids.[144] The guidance does not specify the degree to which environmental outcomes should influence bid selection, only that social and environmental benefits are secondary to the Government's overarching value for money policy.[145] However, in recent years there have been moves to amend procurement criteria in line with government policy with greater weighting now being given to the environmental and social value in government tender processes.[146]

The Government does publish annual statements detailing compliance with the PPN. The most recent of these shows that for the year 2020-21, the value of steel sourced from the UK was £268 million, or 58% of the total value of steel contracts reported by public authorities that disclosed details of where steel was sourced from.[147] However, these annual statements appear to provide an incomplete picture of steel procurement. The reported 456,631 tonnes of steel procured by public authorities in the 2020-21 PPN statement is substantially lower than the estimated 800,000 to 900,000 tonnes of steel required by the government each year.[148] It would appear that PPN guidance has not

143. HM Treasury, "Green Book Review 2020: Findings and response", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/937700/Green_Book_Review_final_report_241120v2.pdf, (2020).
144. Crown Commercial Service, "Procurement policy note 11/16: procuring steel in major projects – revised guidance", https://www.gov.uk/government/publications/procurement-policy-note-1116-procuring-steel-in-major-projects-revised-guidance, (2016/17).
145. Crown Commercial Service, "Procurement policy note".
146. Cabinet Office, "New measures to deliver value to society through public procurement", https://www.gov.uk/government/news/new-measures-to-deliver-value-to-society-through-public-procurement, (2020).
147. BEIS, "Steel public procurement 2022: compliance with the steel procurement guidance (PPN 11/16)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987147/steel-procurement-data-2021.pdf, (2022), 4.
148. BEIS Committee, "Liberty Steel and the Future of the UK Steel Industry", https://publications.parliament.uk/pa/cm5802/cmselect/cmbeis/821/report.html, (2021), 38.

been applied consistently across the board and, consequently, that little is publicly known about the origin of around half the amount of steel used in public sector projects.

The Government's Steel Procurement Taskforce was established in March 2021 to explore the current challenges the steel sector reported they were facing in accessing opportunities to supply major public projects.[149] The Steel Procurement Taskforce's final report, published earlier this year, made a series of recommendations designed to promote better visibility of tender applications that require steel, and increased transparency over the sourcing of steel used in public projects, including that: "HMG should set a requirement for all new qualifying contracts, where steel may be purchased directly or via any sub-contract, for the origin of this steel to be recorded and reported".[150]

In June 2021, the Government announced that businesses wanting to bid for government contracts worth more than £5 million per year would need to publish credible plans for achieving net zero emissions by 2050.[151] The requirement came into force in late 2021 and covers scope 1, 2 and 3 GHG emissions – described in Box 2.1 much earlier – and will therefore include carbon in bidders' supply chains. However, as we discuss in the following chapter, the broad requirements set by this rule may do little to encourage companies to procure clean steel in the short-term.

In November 2021, at COP26, the UK along with India, Germany, Canada and the United Arab Emirates committed to supporting markets for low carbon steel, cement and concrete, and to achieve net zero in major public construction steel and concrete by 2050 – known as the Industrial Deep Decarbonisation Initiative (IDDI).[152] In early 2022,

149. BEIS, "Steel Procurement Taskforce. Final Report", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055762/steel-procurement-taskforce-report.pdf, (2022), 6.
150. BEIS, "Steel Procurement Taskforce", 7.
151. Cabinet Office, "Firms must commit to net zero to win major government contracts", https://www.gov.uk/government/news/firms-must-commit-to-net-zero-to-win-major-government-contracts, (2021).
152. S&P Global Commodity Insights, "COP26: Five developed nations commit to support low carbon steel, cement sectors", https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/110921-cop26-five-developed-nations-commit-to-support-low-carbon-steel-cement-sectors, (2021).

the UK Government launched a consultation on developing markets for low emissions industrial products and was, at the time of writing, analysing the feedback received.

Ultimately, a regulatory framework exists to promote public procurement of UK steel and which can be used to create a market for clean steel. However, current guidance on the treatment of social and environmental outcomes is complex and adherence is not mandatory. It would also appear that, in many cases, guidelines on reporting steel procurement in public projects are not being followed consistently by contracting authorities.

## Global trade pressures

Steel is a globally traded commodity with one quarter[153] of the 1.95Gt[154] of steel produced worldwide each year being moved across borders. In 2020, the UK exported 4.4Mt[155] of steel, 53% of which went to EU countries.[156] UK imports in 2020 stood at 5.3Mt, three quarters of which came from the EU.[157]

The ability of steelmakers to sell their products overseas has led to a highly competitive marketplace for steel. While this has benefitted buyers, it has also exposed UK steelmakers to competition from non-UK producers that are heavily subsidised, or that operate in non-market economies,[158] or which are located in regions where requirements for environmental and social compliance are less stringent, enabling them to produce steel at lower cost than would be possible in the UK. Differences in political and economic regimes that steelmakers operate under have created trade distortions in global

153. UK Steel, "Written evidence submitted by UK Steel".
154. Worldsteel.org, "Total production of crude steel: World total 2021", https://worldsteel.org/media-centre/press-releases/2022/december-2021-crude-steel-production-and-2021-global-totals/#:~:text=Total%20world%20crude%20steel%20production%20was%201%2C950.5%20Mt%20in%202021,3.7%25%20increase%20compared%20to%202020., 2021.
155. Commons Library, "UK Steel Industry: Statistics and policy",https://researchbriefings.files.parliament.uk/documents/CBP-7317/CBP-7317.pdf, (2021), 13.
156. Ibid., 14.
157. Ibid., 14.
158. UK Steel, "Written evidence submitted by UK Steel", https://committees.parliament.uk/writtenevidence/36107/pdf/, (2021).

steel markets that have a detrimental impact on the ability of UK steelmakers to compete for market share.

UK steelmakers are not alone in facing these trade pressures. Since 2016, governments in advanced economies around the world have taken measures to insulate their domestic steel industries from the effects of overcapacity in global steel markets which has driven down the cost of many steel products. The increased prevalence of trade barriers, such as tariffs and quotas, marks a shift away from free trade towards 'managed trade' as advanced economies have sought to limit external threats to their domestic industries.

In May 2016, the US doubled tariffs on imports of Chinese cold-rolled steel[159] and, in December that year, the European Commission introduced levies on a range of steel imports from China and Russia.[160] These were followed by EU tariffs on Chinese hot-rolled steel in April 2017.[161] And, in March 2018, the United States announced a blanket tariff of 25% on all steel imports (excluding Canada and Mexico), citing national security concerns.[162] The EU responded swiftly by introducing tariff rate quotas, applying a 25% levy on imports of steel (and other goods) that exceeded historic import levels.

While the UK has not been a target of trade tariffs, the largely indiscriminate application of trade safeguarding measures has nonetheless reduced the competitiveness of UK steel in those markets. Indeed, since the UK's departure from the EU in 2020, EU tariffs have applied to UK steel products sold in EU Member States.

In March 2022, the UK did secure a resolution with the US,[163] which resulted in blanket tariffs on steel imports to the US being replaced by

159. Sky News, "US Raises Tax On Chinese Steel Imports By 522%", https://news.sky.com/story/us-raises-tax-on-chinese-steel-imports-by-522-10286559, (2016).
160. EUObserver, "EU imposes anti-dumping duties on China and Russia",https://euobserver.com/green-economy/134586, (2016).
161. Emre Peker,, "EU Ramps Up Anti-Dumping Duties on Chinese Steel", *Wall Street Journal*, 6 April 2017.
162. Peter Baker and Ana Swanson, "Trump Authorizes Tariffs, Defying Allies at Home and Abroad", *The New York Times*, 8 March 2018.
163. Department for International Trade, "UK and US resolve steel and aluminium tariffs issue",https://www.gov.uk/government/news/uk-and-us-resolve-steel-and-aluminium-tariffs-issue#:~:text=The%20UK%20has%20secured%20a,aluminium%20tariffs%20with%20the%20US.&text=International%20Trade%20Secretary%20Anne%2DMarie,around%20steel%20and%20aluminium%20tariffs, (2022).

tariff rate quotas, which allow a certain weight of steel to be exported to the US duty free each year.[164]

Following its departure from the EU, the UK also instituted its own protections through the new Trade Remedies Authority (TRA), a body that advises the Secretary of State for International Trade on measures to protect sectors against unfair trading practices post-Brexit. At the start of 2021, the TRA transitioned over tariff rate quotas for 19 steel product categories in alignment with EU safeguarding measures,[165] although protections for some products have since been removed. In June 2021, the then Secretary of State for International trade extended a number of safeguard tariffs for steel products, against the advice of the TRA.[166] The extension was due to expire on 30th June 2022 although, earlier the same month, the Prime Minister committed to an extension of the tariffs for a further two years.[167]

Essentially, UK steelmakers have historically faced competition from overseas steelmakers that benefit from generous state support and have taken advantage of the UK's (and previously the EU's while the UK was a Member State) relatively light trade protections. Trade remedies put in place by the UK's new TRA offer short-term protection to UK steelmakers in domestic markets, but do not address the major underlying causes of trade distortions that put them at a competitive disadvantage.

164. Department for International Trade, "US tariff rate quotas (TRQs) for UK exports of steel and aluminium", https://www.gov.uk/government/publications/us-tariff-rate-quotas-trqs-for-exporters-of-steel-and-aluminium/us-tariff-rate-quotas-trqs-for-uk-exports-of-steel-and-aluminium, (2022).
165. House of Commons International Trade Committee, "UK trade remedies policy: Third Report of Session 2019–21",https://committees.parliament.uk/publications/5168/documents/51061/default/, (2021), 20.
166. Trade Remedies Authority, "TRA Report of Findings to the Secretary of State as Directed Under Call-In of the Transition Review of Safeguard Measures on Certain Steel Products Reconsideration. Case TF0006", https://www.google.com/url?q=https://www.trade-remedies.service.gov.uk/public/case/TF0006/submission/8d7c7071-a400-456f-b301-36c72df0c01a/&sa=D&source=docs&ust=1656698307302488&usg=AOvVaw0WPfb00DUklE8S01y3r7Hj, (2022), 8.
167. Edward Malnick, "Boris Johnson imposes steel tariffs to win back Red Wall", *The Telegraph*, 25 June 2022.

## Conclusion

The three challenges outlined in this chapter – high energy prices, lack of visibility around opportunities to bid for public contracts, and global trade pressures – along with an inadequate public policy framework described in Chapter Four, have contributed to a business environment that is unfavourable to the development of clean steel in the UK.

To overcome these challenges and enable UK steelmakers to invest, a new set of objectives and policies is needed. In Chapter Six, we put forward new objectives to guide the future direction of policy towards a clean steel industry in the UK.

# Chapter Six:
# Objectives for clean steel

The previous chapter unearthed the main challenges thwarting the development of clean steel in the UK. Technological readiness is no longer a significant barrier to deep decarbonisation. Instead, steelmakers need the support and confidence to invest in new technological approaches and develop clean steel business models. In this chapter, we identify five overarching objectives to support commercial-scale clean steel production in the UK.

We consider that the five overarching objectives for clean steel should be:

1. Ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity
2. Making hydrogen available and affordable to steelmakers in sufficient quantities to enable clean steel production in the 2030s
3. Establishing a policy framework to overcome investment barriers to producing clean steel
4. Enabling access to suitable raw materials, particularly scrap steel
5. Developing a market for clean steel products, backed by appropriate regulations

## Ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity

Access to affordable electricity is critical to reducing emissions from steelmaking. As described in Chapter Five, UK steelmakers face higher electricity costs relative to those in neighbouring jurisdictions, which presents a challenge both to steel recycling at UK EAF sites and longer-term investments in clean steel capacity.

We think there are three components of the UK electricity market that strongly influence how much UK steelmakers pay for electricity and where there are different approaches that affect decarbonisation.

- **Supply-side approaches.** Wholesale costs.
- **Demand-side approaches.** Plant efficiency and demand response.
- **Policy approaches.** Costs and relief.

### Supply-side approaches

Wholesale electricity prices and network (or distribution) charges account for close to three quarters of steelmakers' electricity costs.[168] With the expansion of low-carbon electricity generation in the UK and increasing interconnection with Europe, UK and European wholesale electricity prices are expected to become more closely aligned in the medium to long-term. Keeping wholesale costs affordable for steelmakers is important since, as they decarbonise, they will become increasingly dependent on electricity as an energy source, both directly through electrification and indirectly through the use of hydrogen.

In the short-term, several steelmakers have sought to reduce their exposure to price risks associated with rising wholesale electricity prices, as detailed in Chapter Five. At least two steelmakers – one primary and one secondary – have explored power purchase agreements (PPAs), or installing on-site renewables, as a means of

168. UK Steel, "Written evidence submitted by UK Steel (EPM0007)", https://committees.parliament.uk/writtenevidence/43487/html/, (2022).

controlling electricity costs. However, one EAF steelmaker believes that pursuing either option would, at the time, have resulted in their business paying a higher price for electricity compared to purchasing electricity directly from the grid, an assessment that was also echoed by a major UK energy supplier.

Hedging is another strategy that EIIs such as steelmakers can use to reduce their exposure to fluctuations in wholesale electricity prices. This involves the forward purchase of electricity to manage the risk of future price rises. One EAF steelmaker under normal circumstances would expect to hedge up to 30% of their electricity needs. Although some do not hedge at all.

UK steelmakers not only have limited capacity to manage the risk of price fluctuations in wholesale electricity markets, but will also become increasingly susceptible to electricity price risks as they transition to using clean steel technologies. Even as the UK seeks to expand its domestic renewable energy capacity, the growing demand for electricity in many other sectors of the economy – including from electric vehicle users and electrified domestic heating, especially heat pumps – will exert upward pressure on electricity prices.

The evolution of electricity prices will be a key determinant of when, or even whether, clean steel business models become viable in the UK. Having acknowledged the key role that steelmaking will play in delivering net zero, this Government needs to establish policy and guidance to secure affordable electricity prices for critical industries such as steelmaking in a manner which reflects the relative risks that electricity price volatility poses to investments in low-carbon technologies for different sectors.

## Demand-side approaches

Steelmakers can optimise electricity demand in order to reduce costs while maintaining productivity, either through making improvements to plant efficiency or by shifting production to periods of the day when electricity prices are lower.

Recent energy efficiency improvements carried out by steelmakers include installing LED lighting and variable speed drives, which are typically used to control electric motors for industrial fans. While these may sound trivial, the savings that can be generated through efficiency gains are significant. For example, a static VAR compensator due to be installed at Celsa's Cardiff steelworks,[169] with support from the UK's Industrial Energy Transformation Fund (IETF), described in Chapter Four, is expected to yield 36,500 MWh per year in energy savings. This is equivalent to the electricity consumption of 1,260 UK homes. The savings will be mostly from reduced electricity consumption, resulting in £2.5 million in annual cost savings from a capital investment of around £8.6 million.[170]

Thermal batteries provide another example of an efficiency technology that can play a role in reducing electricity demand through the recovery and reuse of thermal energy that might otherwise be lost in waste gases. However, it has been suggested that customers typically require payback periods to be less than three years and this presents a hurdle to investment in efficiency improvements that deliver less immediate benefits.

EAF steelmakers can reduce their electricity costs even without investing in new technologies, by shifting electricity use to periods of the day when power is cheaper or by temporarily adjusting electricity consumption in response to incentives from the network operator, a method known as 'demand-side response' or DSR. DSR is also possible for BF-BOF sites which generate their own electricity that can be fed into the grid. In the UK, National Grid is responsible for managing DSR incentives. We are aware of at least one EAF steelmaker having shifted production to night-time in order to reduce electricity costs.

169. UK Research and Innovation (n.d.), "Celsa Cardiff Steelworks Static VAR Compensator", https://gtr.ukri.org/projects?ref=97426#/tabOverview, (2022).
170. KTN, "Industrial Energy Transformation Fund Phase 2 Competition Briefing", https://www.slideshare.net/KTNUK/industrial-energy-transformation-fund-phase-2-competition-briefing, (2021), 58.

## Policy approaches

Policy costs make up around one quarter of the price UK steelmakers pay for electricity.[171] These include indirect costs associated with policies such as the UK ETS, Carbon Price Support (CPS) mechanism, Contracts for Difference, the Renewable Obligation, and Feed-in Tariff schemes[172] that are passed on to steelmakers from electricity suppliers. Steelmakers are insulated from some of these costs through the EII Compensation Scheme, as detailed below.

Network charges, which are regulated by Ofgem, make up another component of policy costs that apply to electricity prices. These are expected to increase for steelmakers due to changes to network charges introduced in the *Targeted Charging Review* which came into effect in April 2022.[173]

As described in the last chapter, UK steelmakers face greater exposure to policy costs than their counterparts in many other parts of the world and rely on free allocation, policy exemptions, and compensation for indirect carbon costs to remain competitive.

Since the start of the energy crisis in 2021, UK steelmakers and their trade representatives have urged the government to reduce or temporarily remove electricity network and policy costs in order to alleviate extremely high electricity prices.[174] Indeed, UK steelmakers seem to be unequivocal in their view that the Government should take action to ensure electricity prices do not exceed those paid by European industries. Thus far, government support during the current energy crisis has so far included renewing the EII Compensation Scheme until

171. UK Steel, "Written evidence submitted by UK Steel (EPM0007)", https://committees.parliament.uk/writtenevidence/43487/html/, (2022).
172. The UK ETS was described in detail in Chapter Four. The CPS is a levy on fossil fuels used in power generation that is additional to the carbon price; Contracts for Difference (CfDs) are contracts offered by the Government to support renewable electricity generation in the UK; the Renewable Obligation (RO) is a requirement on UK licensed electricity suppliers to source a proportion of their supply to customers from eligible renewable sources; and the Feed-in Tariff is a government scheme that aims to encourage people to use renewable energy to power their homes by offering them payments for electricity supplied back to the grid.
173. UK Steel, "Ofgem reforms set to further increase steel producers' electricity costs", https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjDvevnhtT4AhUhS0EAHd1DAugQFnoECAUQAQ&url=https%3A%2F%2Fwww.makeuk.org%2F-%2Fmedia%2Fuk-steel-press-release--targeted-charging-review--221119.pdf&usg=AOvVaw1CCGLKGhpPpBU1rezM75gn, (2019).
174. Make UK, "Commenting on the Energy Security Strategy", https://www.makeuk.org/news-and-events/news/make-uk-comment---the-energy-security-strategy (2022).

2025,[175] which provides up to 100% relief on indirect policy costs from electricity usage.

The EII Compensation Scheme is, however, only a temporary measure and enacted at the Government's discretion. As such, it does not provide long-term certainty or predictability for industry, in contrast to similar policies for steelmakers operating in Germany and France, which provide consistently high levels of relief from network costs and Germany's renewables levy.[176] However, there are suggestions that the UK Secretary of State for Business, Energy and Industrial Strategy is considering exemptions for heavy industries from Ofgem's network charges,[177] indicating that the Government is now looking for more long-term solutions, rightly.

In essence, electricity prices will play an important role in the path to clean steel. Competitively priced electricity incentivises lower-emissions steelmaking in EAFs and can support longer-term investments in clean steel technologies that utilise electricity and green hydrogen. For steelmakers, demand response, energy efficiency and price hedging will continue to be important strategies for minimising their electricity costs, but are not a substitute for adequate policy protections.

## Making hydrogen affordable and available to steelmakers in sufficient quantities to enable clean steel production in the 2030s

As outlined in Chapter Three, hydrogen is an integral part of the UK's clean steel transition. For steelmakers looking to invest in hydrogen-based technologies, the key considerations are timing, scale, and price.

Published details of the Hynet and East Coast Hydrogen networks suggest that Scunthorpe's integrated steelworks is expected to be among the first to gain access to the hydrogen network in the late 2020s. EAF

175. BEIS, 10 Downing Street, "British energy security strategy", https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy, (2022).
176. Ulrich Scholz, and Hendrik Wessling, "Electricity regulation in Germany: overview" https://uk.practicallaw.thomsonreuters.com/5-524-0808?transitionType=Default&contextData=(sc.Default).
177. Louise Clarence-Smith, "Business secretary Kwarteng considers aid for steelmakers", *Financial Times*, 6 June 2022.

sites operated by Liberty Steel, Outokumpu and Sheffield Forgemasters also lie within close proximity to hydrogen networks planned for the early stages of these projects.

The question of scale has only been partially addressed in the Government's commitment, through its *The Ten Point Plan for a Green Industrial Revolution*, to delivering 10GW of low-carbon hydrogen production capacity by 2030. This is because achieving a level of production capacity does not guarantee that capacity will be running continuously. Furthermore, analysis carried out by BEIS indicates that demand from industry for low carbon hydrogen could range from around 10TWh per year by 2030 if supply is limited to clusters up to around 20TWh per year if some dispersed sites are connected to hydrogen networks.[178]

Given the UK is at an early stage in developing hydrogen production and infrastructure at scale, there are significant uncertainties around demand for hydrogen and the price at which it will be offered to steelmakers. Hydrogen is expected to be expensive and many steelmakers plan to use hydrogen in commercial steel production only once other lower cost emissions reduction options have been exhausted.

Hydrogen supplied via both aforementioned network projects is initially likely to be 'blue' – that is, hydrogen produced from natural gas via a process of steam methane reforming where emissions are mitigated using CCS – with 'green' hydrogen, produced via electrolysis using renewable energy, being supplied to the network as renewable generation increases. Modelling of the levelised cost of hydrogen production (LCOH) – that is, the cost of electricity generation over the project's lifetime – carried out by BEIS suggests that for blue hydrogen this will range from £56-66 per MWh of H2 in 2030.[179] However, this analysis predates the ongoing volatility in energy markets. While the costs of CCS are likely to reduce over time as technologies scale and mature, and steelmakers will increasingly be exposed

178. BEIS, "Hydrogen Analytical Annex", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011499/Hydrogen_Analytical_Annex.pdf, (2021), 11.
179. BEIS, "Hydrogen Production Costs 2021", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011506/Hydrogen_Production_Costs_2021.pdf, (2021), 28.

to carbon pricing, there is no certainty that blue hydrogen will become cost competitive with natural gas as an energy source in steelmaking in the 2030s. For blue hydrogen to play a role in decarbonising UK steelmaking, it will need to be made available at a competitive price and appropriate policies will need to be put in place to ensure this happens.

The Government is intending for at least half the 10 GW hydrogen capacity planned for 2030 to be green.[180] BEIS' model shows that the LCOH for green hydrogen is dominated by electricity costs, making production from 'curtailed electricity' – where electrolysers can take advantage of free electricity during periods when renewable generation exceeds demand on the grid – the lowest cost route overall. The LCOH from curtailment is approximately £60/MWh H2 in 2025, and is projected to fall to less than £50/MWh H2 by 2030 as the capital costs of proton exchange membrane (PEM) electrolysis come down.[181] However, this route assumes frequent periods of excess renewable electricity generation.[182] The LCOH for green hydrogen produced from dedicated offshore wind capacity running at typical load factors is estimated to be close to £110/MWh in 2025 and around £90/MWh in 2030.[183] Hydrogen production from grid electricity, running at baseload, is projected to be considerably more expensive, with a LCOH of between £130-180/MWh in 2030.[184] Recent analysis by McKinsey suggests that renewable electricity prices will need to fall below €0.027/ per kilowatt-hour to ensure cost-effective production of green hydrogen.[185]

The curtailment business model for hydrogen production may be well suited to EAF steelmakers since furnace operation can be scheduled in response to periods of excess renewable generation when hydrogen can be produced at lower cost. Hydrogen-based primary steelmaking (H-DRI) sites,

180. BEIS, 10 Downing Street, "British energy security strategy", https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy, (2022).
181. BEIS, "Hydrogen Production Costs 2021", https://www.gov.uk/government/publications/hydrogen-production-costs-2021, 29.
182. BEIS' analysis assumes a 25% load factor for hydrogen production from curtailment.
183. BEIS, "Hydrogen Production Costs 2021", https://www.gov.uk/government/publications/hydrogen-production-costs-2021, 29.
184. Ibid.,
185.Christian Hoffman, Michael Van Hoey, Benedikt Zeumer, "Decarbonization challenge for steel", https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel, (2020).

on the other hand, will require a more or less continuous supply of hydrogen to operate efficiently and profitably. Some network or on-site hydrogen storage may be required to smooth out intermittency of hydrogen supply and to avoid the need to use more expensive modes of hydrogen production.

Box 6.1 is an example of how green hydrogen is being used in the decarbonisation transition of a German steel plant.

### Box 6.1. ThyssenKrupp's H2Stahl project

In November 2019, ThyssenKrupp Steel became the first steelmaker to inject hydrogen into an operating blast furnace.[186,187] The company is aiming to become climate neutral by 2045, with an interim 2030 target to reduce emissions by 30% (from 2018) across their entire business.[188]

The initial phase of its 'H2Stahl' project involved the trial injection of hydrogen into an existing blast furnace at the company's Duisburg site in Germany. Duisburg steelworks currently produces almost 11 million tonnes of steel per year, making it Europe's largest steel production site. According to ThyssenKrupp, the injection of hydrogen into the conventional BF can reduce emissions by approximately 20%.[189]

The second part of the project will involve the construction of an entirely separate DRI furnace, which will be supplied with green hydrogen produced from a nearby electrolyser constructed by STEAG, a German power company. DRI furnaces are capable of eliminating emissions entirely from the iron reduction process. Currently at the feasibility stage, with an expected financial investment decision (FID) in 2023 and anticipated operation in 2025, the 500 MW electrolyser will be constructed to initially supply ThyssenKrupp with 75,000 tonnes of hydrogen a year – enough to operate ThyssenKrupp's first DRI furnace, the first in fact of a planned four.[190]

186. Energieforschung.nrw., "On the way to a climate-neutral industry", https://www.energieforschung.nrw/erfolge-und-stories-aus-nrw/h2bf, (2020).
187. bmwk.de., "Green hydrogen could replace coal in steel production", https://www.german-energy-solutions.de/GES/Redaktion/EN/News/2021/20211208-hydrogen-replaces-coal-in-steel-production.html (2021).
188. ThyssenKrupp. (n.d.), "thyssenkrupp Steel's climate strategy Premium flat steel, less of CO2", https://www.thyssenkrupp-steel.com/en/company/sustainability/climate-strategy/
189. Energie System Forschung. (n.d.), "Blast furnace uses hydrogen in industrial practice", https://www.energiesystem-forschung.de/forschen/projekte/reallabor-der-energiewende-h2-stahl
190. ThyssenKrupp, "Green hydrogen for green steel: Paving the way to Hydrogen Valley", https://engineered.thyssenkrupp.com/en/green-hydrogen-for-green-steel/, (2021).

Conversion of the steel mill will require 20,000 tonnes (0.67 TWh) of hydrogen per year in the initial phases and up to 720,000 (23.3 TWh) tonnes by 2050 if all BFs are replaced with DRI furnaces.

ThyssenKrupp will partially fund the development of the electrolysis plant by placing it in a separate company and inviting investors to fund the project in return for equity.[191]

There is little publicly available information regarding project financing although the company states that the total cost of the project is "a high double-digit million figure".[192] The H2Stahl project consortium of ThyssenKrupp Steel, BFI and Air Liquide have received €37 million from the German Ministry for Economic Affairs and Climate Action.[193] To secure future cash flows the project partners will also apply for public subsidies permitted within the scope of EU State aid rules for climate-neutral technologies.[194]

The project is also expected to benefit from a German scheme to promote investments in hydrogen supply which was announced in 2021. The 10 year scheme, worth EUR 900m, will support investments in green hydrogen production in Germany, awarding aid in the form of long-term green hydrogen purchase and resale contracts through competitive tenders.[195]

Ultimately, hydrogen will be essential to the long-term decarbonisation strategies of most UK steelmaking sites, which are not well suited for the development of CCS. The first hydrogen network projects – HyNet and

191. ThyssenKrupp. (n.d.), "Green hydrogen for green steel made in Duisburg: STEAG and thyssenkrupp are planning joint hydrogen project" https://www.thyssenkrupp.com/en/newsroom/press-releases/pressdetailpage/green-hydrogen-for-green-steel-made-in-duisburg--steag-and-thyssenkrupp-are-planning-joint-hydrogen-project-91317.
192. ThyssenKrupp, "Climate-neutral future of steel production: Real-world laboratory of the energy transition H2Stahl project to start at Duisburg site of thyssenkrupp Steel", https://www.thyssenkrupp.com/en/newsroom/press-releases/pressdetailpage/climate-neutral-future-of-steel-production--real-world-laboratory-of-the-energy-transition-h2stahl-project-to-start-at-duisburg-site-of-thyssenkrupp-steel-129078, (2021).
193. ThyssenKrupp, "Climate-neutral future of steel production: Real-world laboratory of the energy transition H2Stahl project to start at Duisburg site of thyssenkrupp Steel", https://www.thyssenkrupp.com/en/newsroom/press-releases/pressdetailpage/climate-neutral-future-of-steel-production--real-world-laboratory-of-the-energy-transition-h2stahl-project-to-start-at-duisburg-site-of-thyssenkrupp-steel-129078, (2022).
194. Renewables Now, "Steag to supply green hydrogen to Thyssenkrupp Steel plant", https://renewablesnow.com/news/steag-to-supply-green-hydrogen-to-thyssenkrupp-steel-plant-777845/, (2022).
195. European Commission, "State aid: Commission approves €900 million German scheme to support investments in production of renewable hydrogen", https://ec.europa.eu/commission/presscorner/detail/en/ip_21_7022, (2021).

East Coast Hydrogen – are beginning to take shape and the Government has recently pledged to double planned hydrogen production capacity to 10 GW by 2030.

Having timely access to low-carbon networks, including for supplying hydrogen, is a concern shared by most steelmakers. The hydrogen economy will take many years to grow and mature as new networks are built, production sites added, and businesses are connected.

There remain uncertainties over the future availability and price of hydrogen for steelmakers who are likely to face competition from other sectors that also need hydrogen to decarbonise.[196] To manage these risks, some steelmakers may initially replace coal-based steelmaking equipment with natural gas-based technologies that can subsequently be converted to run on hydrogen without significant modification. Indeed, such investments are already being made. As the experience of European steelmakers shows, early hydrogen-based steelmaking projects will rely on government support, both for capital and operating costs, a topic we explore further in the final chapter.

## Establishing a policy framework to overcome investment barriers to producing clean steel

Clean steel technologies, particularly those used to convert iron ore, are capital intensive to develop and have higher operating costs compared to conventional steelmaking routes. We now examine in greater detail why this is the case and the extent to which economic circumstances pose a barrier to commercial clean steel production in the UK.

Capital requirements for the transition to clean steel vary enormously from site to site. This is to be expected, given the differences in the scale of deployment (or plant capacity), the technologies involved, and geographic context.

196. Yet to be published analysis carried out by the author shows that using hydrogen to displace coal in steelmaking is among the most effective uses of hydrogen for lowering emissions.

At the upper end of the cost range is the transition to clean steel at Port Talbot, the UK's largest site, which is expected to require between £1.6 billion and £2 billion in new investment.[197] For EAF sites, capital requirements are expected to be significantly lower as the furnace can be more readily modified for low-carbon inputs. The total cost of delivering new assets to decarbonise the UK steel industry may come to between £4 billion and £6 billion.[198]

As described in Chapter One, much of the UK's existing steelmaking capacity is reaching the end of its operational lifespan and will soon either need to be upgraded or replaced. Investments of this kind fall within steelmakers' long-term financial planning and are, to a certain extent, already accounted for. Indeed, fulfilling capital requirements is less of a concern for steelmakers than risks around infrastructure and business models. Two EAF steelmakers have noted that their plans for developing clean steel capacity are not contingent on receiving public funding but that, in order for them to commit to such investments, solutions will need to be found for electricity pricing, connecting steelmaking sites with low-carbon infrastructure, and developing markets for clean steel. While these issues remain at large, the risks associated with clean steel development are high, leaving public funding as the main driver of investment decisions in clean steel.

Raising capital for the clean steel transition appears to be more challenging for the UK's BF-BOF steelmakers. In addition to measures that address anticipated increases in operating costs, senior industry figures have called for measures to help manage the risk around capital expenditure at the UK's primary steelmaking sites.[199]

The competitive nature of investments in clean steel should also be viewed in the wider context of efforts to decarbonise steel globally. The UK

197. Burkett, "The huge challenge the Port Talbot steelworks faces as Wales brings in tough new legally-binding carbon emissions targets", *Wales Online*, 1 March 2021.
198. Chris McDonald, "Oral evidence: Liberty Steel and the Future of the UK Steel Industry, HC 118, Q44", https://committees.parliament.uk/oralevidence/2248/html/, (2022).
199. Burkett, "The huge challenge the Port Talbot steelworks faces as Wales brings in tough new legally-binding carbon emissions targets", *Wales Online*, 1 March 2021.

is one of many countries concerned with the transition to clean steel and most steelmakers operating in the UK are owned by international groups that have a presence in Europe and/or other markets where steelmakers are also being incentivised to cut GHG emissions. The balance of government incentives and market conditions in each region has a strong influence on where companies will choose to invest in new clean steel capacity.

Other major steel-producing regions have already invested heavily in EAF steelmaking. China, for example, approved the construction of 43 EAFs in 2021 which, once installed, will result in half of their steel production coming from EAF routes[200] while more than two thirds of US-made steel is already produced at EAF sites.[201] The French Government has allocated €5.6 billion to decarbonising its industries under the *France 2030* investment programme.[202] Most of this sum will go towards supporting the deployment of new technologies on industrial sites, including backing for a €1.7 billion investment in transforming Arcelormittal's Fos-sur-mer and Dunkirk sites.[203] The former will switch to EAF production while the latter will see two of its three coal-fired furnaces replaced with hydrogen-fueled furnaces from 2027.[204] The Belgian Government has signed a letter of intent that could see it fund half of the €1.1 billion investment in a new gas DRI furnace and two EAFs at Arcelormittal's Ghent site.[205]

These international examples represent a significantly larger commitment on the part of national governments to delivering net zero steel than the UK's £2 billion worth of investment, as outlined in Chapter Four, in decarbonising all its industries.[206]

200. Kshitiz Goliya, "ANALYSIS: China's EAF steelmaking capacity on rise amid decarbonization goals", *S&P Global*, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/011122-analysis-chinas-eaf-steelmaking-capacity-on-rise-amid-decarbonization-goals, (2022).
201. World Steel Association, "2021 World Steel in Figures", https://worldsteel.org/publications/bookshop/world-steel-in-figures-2021/, (2021), 10.
202.Nelly Moussu, "France to invest €5.6bn to decarbonise industry", *Euractiv*, 7 Feb 2022.
203. RFI, "French government helps ArcelorMittal speed up shift to more green energy", *RFI*, 4 February 2022.
204. Petya Trendafilova, "France Will Invest $6.2 Billion In Decarbonization Technologies", *Carbon Herald*, 2 March 2022.
205. Arcelormittal, "ArcelorMittal signs letter of intent with the governments of Belgium and Flanders, supporting €1.1 billion investment in decarbonisation technologies at its flagship Gent plan", https://corporate.arcelormittal.com/media/press-releases/arcelormittal-signs-letter-of-intent-with-the-governments-of-belgium-and-flanders-supporting-1-1-billion-investment-in-decarbonisation-technologies-at-its-flagship-gent-plant, (2021).
206. Both France and the UK derive a similar proportion of their GDP from industrial output.

## Enabling access to suitable raw materials, such as scrap steel

Alongside access to low-carbon energy sources, steelmakers will require suitable raw materials in order to produce low or zero-emissions steel.

Initiatives to decarbonise steelmaking will drive up the costs of raw materials for steel production as increased rates of steel recycling lead to greater competition for scrap from both EAF and BF-BOF plants. Since scrap metal is an internationally traded commodity, there is competition for UK scrap from overseas steelmakers too. Regional policies for recycling in other parts of the world also create incentives for exporting UK scrap overseas and, at present, the economics of scrap processing appear to favour scrap steel leaving the UK, rather than being used by domestic steelmakers.

UK steelmakers advocate for export licensing and/or controls for scrap steel, as well as support for R&D to promote better segregation of scrap, with one steelmaker suggesting that the UK should only permit exports of scrap that cannot be processed domestically.

From a decarbonisation perspective, increasing scrap utilisation in the UK is attractive for a number of reasons. First, it helps retain steel in the UK economy, a material that underpins a broad suite of technologies needed to achieve net zero emissions. Second, higher rates of domestic scrap processing will improve material circularity leading to a significant and rapid reduction in emissions from domestic steelmaking.

However, a balance does need to be struck between reducing exports of scrap that might otherwise be recycled in the UK and maintaining the basic value of scrap so as not to jeopardise investment in scrap collection and processing infrastructure. A combination of export controls to avoid scrap going to countries or companies with a poor track record of environmental performance, and incentives to process scrap in the UK are needed to support emissions reductions in UK steelmaking.

## Developing a market for clean steel products, backed by appropriate regulations

There is growing interest in the role that clean steel will play in decarbonising the wider economy. Voluntary initiatives such as SteelZero – a group of companies who have committed themselves to targets for purchasing clean steel – are evidence that businesses from a range of sectors recognise the importance of clean steel to meeting their own emissions targets.

Steelmakers point to the construction and automotive sectors where a small, but increasing, number of companies have shown interest in the carbon footprint of steel they purchase – and, in several cases, a willingness to pay above market rates for steel products that have demonstrably reduced emissions.[207] However, these companies represent a small fraction of the total market for steel products: for most buyers, product price takes priority over environmental credentials. As such, current levels of demand for clean steel simply cannot sustain the enormous investments required to develop clean-steel capacity. However, with clearer direction from the government, demand for clean steel could be accelerated.

There are lessons from the UK's success in enabling the decarbonisation of its power sector – which saw total GHG emissions fall by 62% between 2008 and 2018, largely due to a shift from coal to renewable energy generation.[208] In particular, there is learning for UK steel on the use of policy to direct investment to meet government objectives and market regulation to support low-carbon business models.

For clean steel to capture market share, one or both of the following must occur:

- Clean steel becomes less expensive to produce and source than steel

207. William Boston, "Green steel becomes a hot commodity for big auto makers", *The Wall Street Journal*, 13 September 202., https://www.livemint.com/industry/manufacturing/green-steel-becomes-a-hot-commodity-for-big-auto-makers-11631538978370.html.
208. Climate Change Committee, "The Sixth Carbon Budget: Electricity generation", https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Electricity-generation.pdf, (2020), 5.

with a high carbon footprint
- Users of steel are compelled to specify and purchase clean steel, even while cheaper, more polluting alternatives are available.

Below, we discuss how both these requirements could be met.

## Clean steel as the lowest cost option

At present, the production of clean steel via any route is more expensive than producing steel with a higher carbon footprint. The Government acknowledged this in its recent consultation on low emissions industrial products.[209] However, as clean steel technologies mature and the industry becomes more exposed to carbon pricing, clean steel products will become more affordable.

Carbon pricing, discussed in Chapter Four, could play a crucial role in tipping the balance of costs in favour of clean steel. In principle, the ETS carbon price should act as a counterbalance to the increased costs of manufacturing clean steel. However, with the steel industry receiving most of its allowances for free, the carbon price signal has been weakened such that the risks for companies wanting to invest in clean steel technologies continue to outweigh the opportunity cost of delaying those investments and incurring carbon costs as a result.

The proposed tightening of the industry cap for free allocation, as set out in the Government's recent consultation on changes to the UK Emissions Trading System,[210] will be largely inconsequential for the steel industry in the context of it achieving net zero emissions by the mid 2030s. This is because the impact of reducing free allocation to industry will be largely offset by plans to use unallocated allowances to mitigate the application of the cross sectoral correction factor, a mechanism that

209. BEIS, "Call for Evidence: Towards a Market for Low Emissions Industrial Products", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1038546/towards-market-for-low-emissions-industrial-products-cfe.pdf, (2021), 22.
210. HM Government, "Developing the UK Emissions Trading Scheme (UK ETS)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067125/developing-the-uk-ets-english.pdf, (2022).

would otherwise reduce free allocation to industry in line with the cap.

Full exposure to carbon prices from €70 per tonne, combined with trade protections, could make clean steel investments viable. Others have suggested that investment in hydrogen DRI processes would require carbon prices on the levels of €100-€160/tonne in 2030.[211] Analysis carried out by McKinsey found that hydrogen-based steelmaking could become cost competitive with conventional steelmaking at carbon prices as low as €55 in 2030, assuming a very low electricity price of €0.027 per kilowatt-hour.[212] At the time of writing, the price of one UK ETS allowance stood at £81 per tonne (€94).

To limit the risk of carbon leakage when fully exposing domestic steelmakers to the UK carbon price, an equivalent levy would need to be applied to carbon emissions from imported steel. One such approach, often referred to as a carbon border adjustment mechanism (CBAM), enables steelmakers to pass their carbon costs onto customers while remaining competitive – a policy that UK steelmakers have broadly advocated for. A CBAM is briefly explained in Box 6.1 below.

**BOX 6.1. What is a Carbon Border Adjustment Mechanism (CBAM)?**

Carbon border adjustments are mechanisms through which jurisdictions that operate carbon pricing schemes can ensure equal treatment of embodied emissions in goods imported from third countries that apply different carbon constraints.

In practice, CBAMs may take the form of a tariff on imports, or a requirement for importers to purchase emissions allowances to cover the embodied emissions. They may also provide equivalent levels of carbon pricing relief or rebates on exported goods.[213]

211. Cristina Brooks, "EU carbon price yet to move needle for steel, chemicals, cement", *IHS Markit*, https://cleanenergynews.ihsmarkit.com/research-analysis/eu-carbon-price-yet-to-move-needle-for-steel-chemicals-cement-.html, (2022).
212. Hoffman, Van Hoey, Zeumer, "Decarbonization challenge for steel", https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel, (2020).
213. Sandbag, "The A-B-C of BCAs: An overview of the issues around introducing Border Carbon Adjustments in the EU", https://sandbag.be/wp-content/uploads/2019/12/2019-SB-Border-Adjustments_DIGI-1.pdf, (2019).

CBAMs provide certain advantages in that they avoid the need for free allocation to protect trade-exposed industries from carbon leakage, they support higher carbon prices and investment in low-carbon technologies, they are useful in creating markets for low-carbon products, and they can raise additional revenue for governments.[214]

Despite these advantages, CBAMs have seen little use globally to date. The reasons for this include opposition from industry and exporting countries, the administrative burden of operating such schemes, and the potential for perverse outcomes such as resource shuffling, where exporters reroute supply chains in order to circumvent carbon pricing. These issues often arise due to poorly designed CBAM policies.

However, the EU Commission recently put forward a proposal to introduce a CBAM for trade-exposed industrial sectors, commencing in 2026.[215] This would, in effect, extend the EU ETS to cover emissions from the manufacture of imported goods. Under the scheme, importers of regulated commodities would be required to purchase certificates according to the carbon content of their product. At the same time, sectors covered by the EU's CBAM would see a reduction in their free allocation until it reaches zero in 2035.

While the EU is at present the only region with plans to implement a comprehensive CBAM for industry, other large economies such as the US and Canada are actively exploring similar policy approaches.[216] The emissions trading systems of both California and New York State contain provisions for levying carbon adjustments on electricity imported from other US states that do not have a carbon market framework.[217]

214. Ibid.,
215. European Commission, "Carbon Border Adjustment Mechanism: Questions and Answers", https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661, (2022).
216. Ben McWilliams, Simone Tagliapietra, "Carbon border adjustment in the United States: not easy, but not impossible either", *Bruegel*, https://www.bruegel.org/2021/02/carbon-border-adjustment-in-the-united-states-not-easy-but-not-impossible-either/, (2021, February)
217. ECRST, "Status of the Border Carbon Adjustments' international developments", https://ercst.org/wp-content/uploads/2021/08/Update-on-developments-in-the-international-jurisdictions-on-the-Border-Carbon-Adjustments-part-3.pdf, (2021), 6.

There has also been considerable interest in CBAMs among UK policymakers. The Government recently announced that it will consult on proposals around implementing a domestic CBAM to address carbon leakage[218] in response to a report published earlier in 2022 by the House of Commons Environmental Audit Select Committee which recommended the UK establish a CBAM to support the Government's approach to decarbonising the economy.[219]

As carbon pricing schemes become more prevalent globally, there is a risk that continued use of free allocation and exemptions or rebates from carbon pricing for UK steelmakers could come to be perceived by other jurisdictions with carbon pricing schemes as grounds for raising tariffs or additional carbon taxes on imports of UK steel. To avoid this possibility and the negative impacts it would have on UK steel exports, the Government should consider alternatives – specifically a CBAM – to its current approach towards managing carbon leakage.

Finally, the EU ETS, upon whose architecture the UK ETS is based, has established a precedent of setting different product benchmarks for the same product according to the process used to manufacture it.[220] This has given rise to instances of low-carbon manufacturing technologies facing a higher bar for receiving free allocation than more-polluting equivalents.[221] Those developing clean steel technologies therefore face the risk of their technology being treated under a less favourable benchmark within the UK ETS than would be the case for conventional steelmaking processes.

218. Environmental Audit Committee, "Ministers to consult on implementing CBAM following EAC recommendation", https://committees.parliament.uk/committee/62/environmental-audit-committee/news/171544/ministers-to-consult-on-implementing-cbam-following-eac-recommendation/, (2022).
219. Environmental Audit Committee, "Greening imports: a UK carbon border approach", https://committees.parliament.uk/publications/9570/documents/162115/default/, (2022).
220. An example of this can be found in the different ETS product benchmarks applied to pig iron manufactured from sintered iron-ore, compared to pig iron produced from iron ore pellets.
221. For example, see Sandbag's 2018 report on industrial decarbonisation https://sandbag.be/index.php/2018/05/15/launching-sandbags-report-on-barriers-to-industrial-decarbonisation/.

## Demand creation

Bringing down the cost of clean steel will take time but, in the short-term, other approaches can be used to rapidly expand markets for clean steel and to displace cheaper but more polluting steel products.

Setting requirements for steel users to purchase low- or zero-emissions steel is one way to generate demand at little or no additional cost to the taxpayer. This approach is analogous to the UK's Renewables Obligation (RO), which requires electricity generators to obtain a certain proportion of the electricity they supply to customers from renewable sources. One advantage to this approach is that it allows for price discovery, enabling markets to find the lowest cost clean steel products. And while it does not guarantee demand for UK steel, it would nonetheless establish domestic markets for clean steel that UK companies can supply to.

The UK Government has already set requirements for companies that bid for large taxpayer-funded contracts to align with the UK's 2050 net zero target.[222] For businesses that use or specify steel in their projects, this creates an implicit requirement to source clean steel in order to reduce supply chain emissions. However, it is likely that companies subject to these rules will initially pursue lower cost mitigation options before decarbonising materials in their supply chains. Indeed, this is the case for a number of firms that regularly carry out work on taxpayer-funded projects: Kier Group's *Carbon Reduction Plan*, for example, foresees the company achieving net zero in its supply chain (scope 3) emissions by 2045,[223] while Balfour Beatty, Lendlease, and renewable energy supplier Ørsted have more ambitious targets of zero emissions (scope 1, 2 and 3) by 2040.[224.225.226]

There is an opportunity for the government to leverage both public

222. Cabinet Office, "Companies bidding for major government contracts face green rules", https://www.gov.uk/government/news/companies-bidding-for-major-government-contracts-face-green-rules, (2021).
223. Kier Group, "Carbon Reduction Plan", https://www.kier.co.uk/media/6899/kier-group-carbon-reduction-plan-ppn06-21-final-2021.pdf, (2021), 6.
224. Balfour Beatty. (n.d.), "Beyond Net Zero Carbon" https://www.balfourbeatty.com/sustainability/beyond-net-zero-carbon/.
225. Lendlease. (n.d.), "Mission Zero", https://www.lendlease.com/missionzero/.
226. Adnan Durakovic, "Ørsted Joins SteelZero Initiative. *Offshorewind.biz*, https://www.offshorewind.biz/2020/12/02/orsted-joins-steelzero-initiative/, (2020, December).

and private sector spending to bring forward demand for clean steel through the introduction of specific requirements for the carbon content of steel used in UK projects. Indeed, there are indications that mandatory standards, which define an upper limit on the carbon footprint of industrial products marketed in the UK, could be introduced as early as the mid-2020s as part of plans to stimulate demand for low-carbon industrial products, and the Government is expected to launch a public consultation on policy design later this year.[227]

UK steelmakers are eager to see procurement rules favour clean steel to create an incentive to fulfil demand for clean steel alongside requirements for the disclosure of country of origin data for steel used in public projects. There is also the possibility of embedding 'green' criteria in quality and certification processes that form part of the tender process on public projects.

Discussions around low-carbon procurement often focus on the construction sector, which accounts for roughly 50% to 60% of all the steel used in the UK.[228] However, renewable energy is an area of steel demand that is set to grow significantly under the Government's plans to increase wind power generation. This is because up to 80% of a wind turbine's mass is typically composed of steel parts.[229]

At present, the Contracts for Difference (CfD) – explained earlier in this chapter – application process requires generators bidding for capacity contracts to submit supply chain plans (SCP) detailing specific actions they have taken, or plan to take, to develop their supply strategy in line with government policy, including the green growth and net zero agendas specifically.[230] This enables contracting authorities to monitor whether project developers that bid for capacity contracts are aligning their businesses

227. HM Government, "Developing the UK Emissions Trading Scheme (UK ETS)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067125/developing-the-uk-ets-english.pdf, (2022), 35.
228. Barbara Rossi, "Oral evidence: Technological innovations and climate change: green steel, HC 1093, Q3", https://committees.parliament.uk/oralevidence/10109/html/, (2022).
229. USGS. (n.d.), "What materials are used to make wind turbines?" https://www.usgs.gov/faqs/what-materials-are-used-make-wind-turbines?qt-news_science_products=0#qt-news_science_products
230. BEIS, "SUPPLY CHAIN PLAN GUIDANCE", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/999779/scp-guidance-ar4.pdf, (2021)

with the government's decarbonisation programme. However, the criteria for scoring project developers' commitments to reducing their supply chain carbon footprint in the SCP are very broad and there appears to be no requirement for bidders to submit standardised information about the environmental footprint of their proposal, such as would enable authorities to perform an objective comparison between individual applications.

Furthermore, while project developers are responsible for preparing CfD bids, it is their original equipment manufacturers (OEMs) that are ultimately responsible for sourcing the steel used in wind turbines. This does not prevent project developers from specifying clean steel or higher domestic supply chain content in their wind turbines though, in reality, the competitive tension in the CfD scheme makes imposing such requirements challenging as they may increase the project's cost.

## Conclusion

In this chapter we have identified and explained the key objectives to enable steelmakers to transition to the commercial production of clean steel.

Managing energy costs at various levels will improve the business environment for EIIs such as steelmaking, giving companies the confidence to make long-term investments. Relief from network charges would be a welcome move in this regard, particularly while electricity prices remain inflated. The long-term evolution of UK electricity prices will, however, largely depend on how successful the UK is in expanding renewable generation and interconnector capacity.

Second, low carbon hydrogen will be necessary for displacing coal in steelmaking but its use by the sector will depend on whether it is available in sufficient quantities and at a price steelmakers can afford. Plans to develop hydrogen networks are beginning to take shape but the lack of a hydrogen delivery plan or price signal means that steelmakers cannot at present plan investments on the basis of having access to hydrogen at a given time in future.

Third, a policy framework is needed that attracts investment in clean steel. While UK steelmakers are largely able to fulfil the capital requirements for deploying clean steel technologies, they are unlikely to risk committing to such investments until viable business models for producing and marketing clean steel can be developed. UK policymakers should also be aware of how other countries' efforts to lead the clean steel transition affect the investment environment in the UK.

Fourth, greater utilisation of scrap steel within the UK is crucial to decarbonising the steelmaking by the mid-2030s and is low risk compared to alternative strategies for emissions abatement. However, new measures are needed to stem exports of scrap metal from the UK and divert it back into domestic steelmaking.

Finally, stimulating demand for low-carbon products will support business models for clean steel, and lower risks to investment in new clean steel capacity. Both the public and private sector have a role to play in supporting markets for clean steel particularly in construction and energy projects. However, existing requirements for the use of low carbon materials are vague and will have limited impact in the short-term. More targeted measures will be needed to expand markets for clean steel and to displace cheaper but more polluting steel products

Led by these objectives, we can develop specific, original and credible policy recommendations to facilitate the growth of clean steel in the UK.

# Chapter Seven: **New policies**

Despite the UK Government's recent efforts to support the decarbonisation of the steel industry, existing and insufficient public policy is still one of the key challenges that is holding back private investment in UK clean steel. This chapter sets out original and credible policy recommendations to steer investment towards clean steel.

The previous chapter outlined five overarching objectives for the maturing of the market for clean steel. We propose new policies that further those objectives, but are also guided by five key principles:

- **Enables deeper decarbonisation.** Promotes public and private sector behaviour that is consistent with the Government's net zero target, ultimately establishing a policy framework that supports the transition to clean steel in the UK by the mid 2030s, as advised by the CCC.
- **Fair treatment across economic sectors.** Avoids policy approaches that lead to an undue advantage or burden for any particular industry.
- **Technologically neutral.** Driving markets for low-carbon materials while preserving flexibility in how the companies choose to do that in terms of the technologies they invest in and deploy.
- **Politically implementable.** Accords with the UK's current policy approach and which can, to a large extent, be implementable without the need for new primary legislation.

- **Fiscally responsible.** Creates value for the taxpayer both directly or indirectly: taken together, the policy measures we propose are expected to be revenue neutral for the government and do not shift the burden of decarbonising steelmaking onto the taxpayer.

Underpinned by these principles, we propose policies that further the overarching objectives introduced in Chapter Five:

1. Ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity
2. Making hydrogen available and affordable to steelmakers in sufficient quantities to enable clean steel production in the 2030s
3. Establishing a policy framework to overcome investment barriers to producing clean steel
4. Enabling access to suitable raw materials, such as scrap steel
5. Developing a market for clean steel products, backed by appropriate regulations

## Ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity

### Recommendation one: Extend the EII Compensation Scheme until 2030, with the level of compensation reviewed annually

The UK Government recently renewed the EII Compensation scheme which, as described in Chapter Five, provides relief to steelmakers from indirect carbon costs in the electricity they use. The Government also recently announced that it would consider whether to exempt steelmakers from network charges, although this is unlikely to be implemented before 2024. While planned electricity market reforms show that the Government is also working to reduce wholesale electricity prices. These represent important steps towards creating a more competitive electricity market that will benefit steelmakers and other consumers.

The current provisions of the EII Compensation Scheme are set to last until 2025. However, it is likely that the scheme will be required on a longer-term basis, not least because French and Germans steelmakers are expected to benefit from equivalent exemptions indefinitely. As such, the change is not expected to increase costs for the government or billpayers overall since the current scheme would likely be extended anyway. Government should therefore extend the scheme at least until 2030 to provide a longer-term signal to steelmakers that reduces uncertainty around the level of compensation available after 2025.

The level of compensation provided by the scheme should, however, be reviewed annually by the government in line with the latest available evidence. Recommendations to the Secretary of State at the Department of Business, Energy and Industrial Strategy on whether to retain or adjust the level of compensation should also be made public.

## Making hydrogen available and affordable to steelmakers in sufficient quantities to enable clean steel production in the 2030s

**Recommendation two: Publish a list of priority users for low-carbon hydrogen supplied through the UK's planned hydrogen networks and ringfence a proportion of low-carbon hydrogen purchase contracts for those sectors**

As explained in Chapter Three, hydrogen is vitally important to the clean steel transition and indeed to decarbonising many other industries that produce goods of strategic importance to the UK economy. The Government has committed through its *Ten-point plan for a green industrial revolution* to developing 10GW of low-carbon hydrogen production capacity by 2030.[231] While it has not yet provided

231. BEIS, 10 Downing Street, "British energy security strategy", https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy, (2022).

details of how markets for low-carbon hydrogen will operate, the *Hydrogen Strategy* indicates that supply-demand coordination will be an important feature of the Government's approach to developing the market initially.[232]

We consider that this will be achieved most effectively through establishing two-way CfDs that allow hydrogen producers and purchasers to competitively bid for long-term government contracts to supply and purchase low-carbon hydrogen, with contracts awarded through a competitive bidding process. The scheme will require taxpayers (via the Low Carbon Contracts Company) to fund the difference between supply and purchase contracts but we believe this offers better value for the taxpayer than alternative forms of subsidy.

To ensure value for money and compatibility of the scheme with UK policy objectives, access to low-carbon hydrogen purchase contracts should be prioritised for certain sectors, taking account for:

1. How effectively the sector's use of hydrogen contributes to meeting the Government's net zero target, measured in terms of emissions savings generated;[233]
2. The ambition of sectoral emissions targets set by government; and
3. The availability and cost of alternatives to hydrogen for decarbonising the sector.

We therefore urge government to publish a list of sectors that are eligible for priority access to low-carbon hydrogen and to ringfence a proportion of low-carbon hydrogen purchase contracts for those sectors, commensurate with their needs.

Prioritising sectors that have a clear need for hydrogen means that low-carbon hydrogen can be directed to where it is most useful to meeting

232. HM Government, "UK hydrogen strategy" https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf, (2021), 15.
233. Analysis carried out by the author on the displacement of fossil fuel inputs with renewable energy sources shows that using hydrogen to displace coal in steelmaking is one of the most efficient uses of hydrogen in terms of emissions reductions achieved per kWh of hydrogen.

decarbonisation objectives, rather than being contracted on a purely commercial basis. It also provides greater certainty around investments in low-carbon industrial processes that are contingent on having access to hydrogen.

## Establishing a policy framework to overcome investment barriers to producing clean steel

**Recommendation three: Introduce a carbon border adjustment mechanism (CBAM) by or before 2026 whilst phasing out free allocation from the UK ETS for sectors covered by the CBAM**

The UK ETS, described in detail at the start of Chapter Four, could play an important role in supporting commercial clean steel production, but existing provisions for free allocation undermine the carbon price signal for EIIs.

Proposals to align the UK ETS with the UK's net zero target, as set out in a recent government consultation,[234] do little to address this issue. Retaining free allocation will be damaging to investment in low-carbon industries. However, the UK cannot risk exposing its domestic industries to the full carbon price without alternative safeguarding measures.

With the Government due to consult on a UK Carbon Border Adjustment Mechanism (CBAM) – explained earlier in Box 4.1, to strengthen domestic carbon pricing and fulfil a Government pledge to support markets for low-carbon industrial products – we urge the Government to implement a UK CBAM as an extension of the UK ETS carbon price. This can be done with a view to expanding cooperation with other carbon pricing jurisdictions that share the UK's ambition on climate change, many of which such as the EU, Canada and United States are already considering similar trade-based policies that can

234. HM Government, "Developing the UK Emissions Trading Scheme (UK ETS)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067125/developing-the-uk-ets-english.pdf, (2022).

support greater climate ambition within their own economies while safeguarding the competitiveness of domestic industries. To reduce trade barriers, the UK CBAM should broadly align with similar schemes being considered by its trading partners.

The CBAM should initially cover products regulated by the UK ETS that are at risk of carbon leakage and take effect by or before 2026, when the EU plans to introduce its own CBAM.[235] This will allow trade in low-carbon goods with the UK's largest steel export market to continue with minimal disruption. The introduction of a CBAM should be followed by the rapid phase-out of free allocation in the UK ETS for industries covered by the scheme.

To maintain compliance with WTO rules, the UK CBAM should form an extension of the UK ETS, with importers required to adopt the same compliance standards as UK manufacturers, and to pay a levy on embodied carbon in their products at a rate pegged to the UK carbon price. This is different from an import tax which sets a fixed price of embodied carbon emissions.

As part of ongoing reform of the UK ETS, the Government should, as a minimum, introduce a mechanism through which free allocation can be reduced more rapidly for products covered by a CBAM. This will enable government to generate additional revenues from carbon pricing which can be used to fund policy interventions that support the net zero transition for EIIs.

The UK ETS Auction Reserve Price – the minimum price for which emissions allowances can be sold at auctions – of £22 per tonne should also be retained as it brings stability to the secondary carbon market – that is, where entities trade UK ETS allowances – and creates a backstop which can be priced into financial models that inform low-carbon investment strategies.

235. European Commission. (n.d.), "Carbon Border Adjustment Mechanism", https://ec.europa.eu/taxation_customs/green-taxation-0/carbon-border-adjustment-mechanism_en

## Enabling access to suitable raw materials, such as scrap steel

### Recommendation four: introduce a cap – reducing over time – on the total weight of scrap metal exports, with the intention of at least halving scrap exports by 2030

High levels of scrap exports are unsustainable in the context of decarbonising the UK's steel industry, as explained in Chapter Five. Indeed, improving supply chain resilience and processing infrastructure is a key element of the *Resources and waste strategy* (RWS)[236] introduced under the previous Conservative Government.

Increasing scrap retention and processing within the UK will enable faster emissions reductions, continued investment in secondary steelmaking within the UK, the supporting of jobs in domestic supply chains, and the reduction of the UK's dependence on imported steels. To promote these desirable outcomes, new measures should be introduced as part of government plans to support markets for low-carbon industrial products.

This could include implementing a cap on total UK scrap exports by weight, rather than an export ban as some have proposed[237] which might lead to unintended consequences such as scrap metal losing its value. The export cap should be set at historic average levels initially and reduce over time with the intention of at least halving scrap exports by 2030. This will allow time for companies within the UK scrap processing industry to align their business models with the RWS.

### Recommendation five: Provide total VAT relief on the purchase of low-residual scrap to offset the increased costs of scrap processing

Large quantities of poor condition scrap are produced in the UK, in excess of what UK steelmakers require for their own production.[238]

236. HM Government, "Our waste, our resources: a strategy for England", https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england, (2018), 131.
237. Antonia Grey, "Banning exports is not the panacea for waste crime", *British Metals Recycling Association*, https://www.recyclemetals.org/newsandarticles/banning-exports-is-not-the-panacea-for-waste-crime.html, (2022).
238. Hall, Zhang, W., & Li, "Domestic Scrap", 3.

Scrap that is in poor condition can, however, be upgraded to low-residual scrap, which has greater value to UK steelmakers, if processed to remove contaminants.

As explained in Chapter Five, scrap processing requires capital investments and uses additional energy and, since energy is relatively expensive in the UK, scrap is often sent for processing in third countries.

To offset some of the additional costs associated with processing and upgrading scrap metal in the UK, the Government should zero rate VAT on the purchase of low-residual scrap.[239] This will help ensure that scrap retains its value in the supply chain, even with a cap scrap exports.

## Developing a market for clean steel products, backed by appropriate regulations

**Recommendation six: Introduce new mandatory carbon footprint standards for large construction projects from 2026 that require a certain proportion of construction materials used to be low-carbon, and expand both the scope products covered by the standard and the required proportion of low-carbon materials over time**

The construction sector is the largest consumer of steel products in the UK – representing some 50-60% of total steel demand[240] – the majority of which are also manufactured in the UK. Publicly funded construction projects account for a significant portion of this demand, as detailed in Chapter Five. There is an opportunity to use both private and public procurement to stimulate markets for clean steel.

The UK Government has established guidance on public procurement for construction projects via the PPN, explained in Chapter Five, and the Treasury's *The Green Book*, which contains guidance on how to evaluate the environmental credentials of policies, programmes and projects.

239. Low-residual scrap refers to scrap steel containing very few impurities which tends to be better suited for high-end engineering steel products.
240. See discussion on *Demand Creation* in Chapter Six.

Both include specific guidance to public authorities on appraising carbon reduction plans of companies that bid on public projects and are useful models in evaluating environmental credentials of bids, if applied consistently. However, both are advisory and require extensive training and resourcing at central and local government levels to be applied effectively owing to their complexity. As described in Chapter Five, PPN reporting suggests that guidance is not at present being followed in the majority of public procurement processes.

New rules introduced by the Cabinet Office, requiring private businesses bidding for large UK government contracts to demonstrate alignment of their business with the net zero agenda have, on the other hand, prompted companies to scrutinise carbon in their supply chains, particularly those involved in construction and infrastructure development, as highlighted in Chapter Six. Interest from customers has, in turn, led some UK steelmakers to move towards disclosure of product environmental footprint (PEF) information for their products. However, this interest has yet to translate into commitments to purchase clean steel and, based on a review of some company net zero plans, may not do so for more than a decade in the current policy environment.

At COP26, the UK Government committed to supporting markets for low-carbon construction products with interim targets for achieving net zero in public construction by 2050 to be determined this year, alongside a commitment to disclosing the embodied carbon of major public construction by 2025.[241] The following recommendation builds on this pledge and proposals outlined in BEIS' recent consultation on developing markets for low-carbon industrial products.[242]

To deliver on its commitment to support markets for low-carbon products, Government should introduce a new policy requiring all large construction projects to incorporate a minimum percentage of

241. S&P Global Commodity Insights, "COP26: Five developed nations commit to support low carbon steel, cement sectors", https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/110921-cop26-five-developed-nations-commit-to-support-low-carbon-steel-cement-sectors, (2021).
242. BEIS, "Towards a market for low emissions industrial products: call for evidence", https://www.gov.uk/government/consultations/towards-a-market-for-low-emissions-industrial-products-call-for-evidence, (2021).

certifiable low-carbon materials.

The requirement should apply to the use of specific products in constructions, rather than to the project as a whole. That is to say, if a project specifies steel components that fall under the requirement, then a proportion of that steel will need to be certified clean steel, irrespective of the carbon footprint of the project as a whole. This sends a clearer signal to the market than applying carbon footprint standards to entire constructions as the CCC proposes in the Sixth Carbon Budget.[243]

The requirement should come into effect from 2026 to allow time for the development of product carbon footprint labelling standards that will enable project developers to more easily identify and specify low-carbon materials. To reduce administrative burden, the requirement could initially be applied to a selection of widely used and standardised construction products which, for steel, might include reinforcement bar, beams, columns, heavy sections, flat sections, angled sections, and hollow sections. The scope of materials covered by the requirement should be expanded over time to include steel products used outside the construction sector. The required percentage of low- and zero carbon products used in projects should also be increased over time in line with the UK Government's 2050 net zero target.

To promote compliance, a requirement to submit a sustainable procurement plan should be introduced in planning and tender processes for large projects. As part of these procurement plans, project developers would be obliged to demonstrate compliance with the requirement to source a certain percentage of low-carbon materials.

**Recommendation seven: Introduce mandatory carbon footprint requirements for Contracts for Difference (CfD) from 2024 and Capacity Market (CM) contracts from 2025, raised in each round until 2035 when embedded carbon content should be net zero**

243. Climate Change Committee, "The Sixth Carbon Budget Manufacturing and construction", https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Manufacturing-and-construction.pdf, (2020) 50-51.

In the power sector, the UK's Contracts for Difference (CfD) – explained in Chapter Six – and Capacity Market (CM)[244] schemes represent a major source of government-administered funding to support investments in low-carbon power generation and marginal capacity, respectively.

The fourth allocation round (AR4) for CfDs, which opened in December 2021, has a budget of £265 million for contracting low-carbon electricity generation, while £1,094.7 million of CM payments were made to electricity generators in 2021.[245]

Government is responsible for setting the rules that participants bidding for both CfD and CM contracts must adhere to, which already includes emissions performance standards for fossil power generation and Supply Chain Plans for renewables. A similar approach should be taken to setting standards for the embodied carbon – that is, the carbon dioxide emissions arising from the production of goods or materials – in generation assets contracted through these schemes.

Most forms of low-carbon power generation, and wind power in particular, require large quantities of steel and other carbon-intensive materials in their construction. There is an opportunity to use capacity procurement mechanisms to send a signal to markets that drives demand for clean steel and other low-carbon industrial products through establishing limits on the embodied carbon of power generation assets. This could be achieved either through establishing minimum requirements for the carbon content of materials used in contracted projects or by setting upper limits for embodied carbon emissions on a per kWh contracted basis.

We propose specific requirements for the use of materials with low or no carbon footprint should be introduced into bidding criteria for CFD and CM contracts (including for renewables, nuclear, dispatchable

244. The UK's Capacity Market is a mechanism for ensuring reliable electricity supply to the grid at an affordable price. It helps avoid the possibility of future blackouts due to unexpectedly low levels of generation or outages on the grid.
245. BEIS, "Contracts for Difference and Capacity Market Scheme Update 2021", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1040749/cfd-capacity-market-scheme-update-2021.pdf (2021) 3, 14.

power, storage and flexibility) starting with the 2025 T-4 auction for CM applications, and with the sixth allocation round (AR6) for CfDs, which is expected to open for applications in March 2024. These new requirements should be set in line with the Government's 2035 net zero target for the power sector and raised at each round such that newly contracted capacity is required to achieve net-zero embodied carbon emissions from 2035 onwards.

Mandating carbon footprint requirements for contracting of electricity generation has several advantages. First, it provides greater visibility and predictability around demand for clean steel in terms of volume and specification. Second, it uses the competitive bidding processes of CfD and CM mechanisms to ensure that low-carbon materials are procured at least cost such that billpayers are not excessively burdened. Finally, establishing carbon footprint requirements aligns with some energy companies' existing ambitions to decarbonise their own supply chains and the requirement therefore does not set an unreasonable expectation for generators.

## Conclusion

The UK's steel industry is poised to become the first of a new generation of net zero manufacturing industries. Clean steel – produced with no emissions – will form the backbone of the green economy, supplying key industries and levelling up communities across Northern England and Wales. Indeed, the Sixth Carbon Budget has specifically recommended that the UK Government decarbonise the steel industry by the mid-2030s. As such, the steel industry faces a unique set of challenges that call for a carefully coordinated policy response.

Existing UK policies intended to support decarbonisation of the steel industry will not deliver clean steel on a timescale consistent with the Government's emissions reduction targets. While a number of public policies affecting the industry have recently been, or are in the process of being, revised by the current Conservative Government – including electricity charging regimes, the UK ETS, and public procurement policies – new and ambitious policies are also needed to meet five key objectives.

First, ensuring steelmakers have access to suitable quantities of affordable low-carbon electricity.

Second, making hydrogen available and affordable to steelmakers in sufficient quantities.

Third, establishing a policy framework to overcome investment barriers to producing clean steel.

Fourth, enabling access to suitable raw materials, such as scrap steel.

Fifth, developing a market for clean steel products, backed by appropriate regulations.

By acting on the policy recommendations put forward in this report, the Government can enable the UK's clean steel transition to take place in a timely and cost-effective manner, and in doing so will create a policy model that can be applied to decarbonising other energy intensive industries.

Since the industrial revolution, steelmaking has formed a critical part of the UK economy. However, existing modes of steel production are carbon-intensive and will need to be rapidly decarbonised for the UK to reach net zero emissions by 2050.

UK steelmakers have faced significant challenges in recent years, especially higher energy prices and global trade distortions. But with the right policies and investment, the UK can have a competitive, world-leading 'clean steel' industry.

This report outlines the pathways, challenges and policies for the development of a commercial market for clean steel in this country.

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