

Written evidence submitted by UK Steel (GST0011)

About UK Steel

UK Steel, a division of Make UK, is the trade association for the UK steel industry. It represents all the country's steelmakers and a large number of downstream steel processors.

Submission to the Inquiry on Green Steel

The technologies there are to produce “green steel”; how close they are to commercialisation; and the benefits and challenges involved with each.

There are three main technologies to produce steel with significantly fewer GHG emissions: Electric Arc Furnaces, Carbon Capture and Storage (CCS), and hydrogen-based steel production. Below is an overview of these production methods and the challenges present in implementing them.

Electric Arc Furnace

The scrap-based steelmaking process melts recycled steel in an electric arc furnace by heating the metal via an electric arc that is struck between the bottom of the electrode and the scrap. If the power used in EAFs is decarbonised, they become a highly cost-effective way of producing low-emission steel. Additionally, there are relatively small amounts of emissions from EAF steelmaking related to natural gas consumption that will need to be addressed through the electrification of alternative fuels.

The UK already has four EAF plants, one in Cardiff, one in Rotherham, and two in Sheffield. Ore-based and scrap-based production routes are broadly comparable in terms of costs per tonne of steel for basic steel grades, although fluctuations in ore, coal, and scrap prices (broadly set at a global or regional level) will make one production route more cost-effective than the other at any one time, as too will national variations in electricity prices.

EAFs are evidently an existing/proven technology that is widely in use producing around one-quarter of the world's steel. The challenges to further implementation in the UK are therefore not comparable to hydrogen-based steelmaking, but nonetheless, there are a number to consider:

- Globally, EAF steel production is limited by the production/availability of scrap. Today, this global scrap market stands at around 550 million tonnes (MT), and whilst expected to grow substantially in the years ahead¹, it will still be well under half of the global steel demand, which will continue to grow. Therefore there will be a clear need for ore-based steel production in 2050. In short, EAFs and scrap recycling is an important part of the solution but far from the entire solution.
- As there is a finite amount of steel scrap available worldwide, increasing scrap-based production in the UK would displace scrap-based production abroad and, to an extent, only reduce territorial, not global, emissions. That being said, scrap-based production in the UK is far less emission-intensive than the global average due to progress that has already been made in decarbonising UK power generation.
- The UK produces around 10MT of scrap each year, compared to the current annual steel production of 7MT, 'apparent consumption' of 10MT of steel, and actual consumption of 16MT of steel². Purely on volumetric terms, the UK could both match its current steel production and meet UK 'apparent demand' entirely from EAFs. However, we would still rely on around 6MT of tonnes of steel imported in various consumer products, and therefore the requirement for virgin/ore-based steel production is still clear.
- There have been big movements on which grades EAF furnaces can make over the past years, especially in North America, as there were previous major limitations in the types of steel that can be produced through the scrap-based/EAF route. Certain steel customers have strict requirements for impurity for particular steel grades (such as nitrogen content introduced by EAF steelmaking or residual elements present in scrap), which would presently be uneconomical with existing scrap sorting technologies. There are opportunities to address these issues through improved scrap sorting technologies and EAF processes, which will

¹ Global scrap market expected to grow to 748 MT by 2026 https://www.reportlinker.com/p05205337/Global-Steel-Scrap-Industry.html?utm_source=GNW

² Apparent consumption to the demand for steel products used in manufacturing, construction and other sectors in the economy. Actual consumption also includes all the steel imported in products like cars, washing machines etc..

likely need Government intervention to ensure an increased incentive to salvage scarce metals from the scrap stream, which today end up as contaminants in steel production.

- Significant quantities of our steel requirements can currently be met entirely through EAF/scrap-based steelmaking. Where this applies, there are no technical limitations to their deployment, and therefore the timelines for advancing scrap-based are purely based on securing a viable business environment for further investment. Should this be provided, new EAF capacity could be deployed within 5-10 years, and the steel sector's emissions could be significantly reduced much sooner than 2035.
- The biggest barrier to this transition is the UK's uncompetitive electricity prices which are 60% higher than our competitors in Europe³. Converting the current ore-based production to EAFs would lead to an estimated doubling of electricity consumption in the sector as blast-furnace plants moved from a reliance on coal to grid electricity. The business case for investment in highly electro-intensive production methods is a very difficult one to make in the UK at present, given how uncompetitive our electricity prices are. If the UK Government wants to aid the transition to 'green steel', it is vital it urgently addresses this problem.

Carbon Capture and Storage

The other route that would enable decarbonisation by 2035 would be Carbon Capture and Storage (CCS), which is the main option to reduce emissions from ore-based steelmaking rapidly. It can be applied to the current production method or new forms of ore-based steel production. CCS captures the CO₂ from the industrial process and transports it for storing underground in depleted gas and oil fields or deep saline aquifer formations. In the case of South Wales, with no storage immediately available off the coast, CO₂ shipping to storage elsewhere would be required, as would utilisation of some of the capture CO₂.

CCS can capture 80-90% of ore-based steelmaking emissions and thus have an excellent decarbonisation potential. However, initial retrofitting of CCS to the blast furnaces without any capture from the sinter plant and coking stoves would likely lead to a 50-70% capture rate. Maximising the capture rate would require a significant rebuilding of the blast furnaces (such as HIsarna⁴) and include capture from the sinter plant and coking stoves, significantly increasing capital and operational costs.

It is worth emphasising that within a 2035-timeframe, CCS is the only available technology to reduce the majority of ore-based production emissions significantly. This will be especially true for producing specific steel grades, which require ore-based production. As outlined above, ore-based production is essential to meeting global steel demand and will continue to be beyond 2050. To prevent significant climate change, the world has to solve the decarbonisation of ore-based steel production. There will be significant commercial opportunities from the associated intellectual properties with any decarbonised ore-based production – giving the UK a substantial advantage.

Deployment of CCS is very dependent on broader infrastructure and cluster development, as it will require either CCS pipelines or shipping facilities to receive the captured carbon. As CCS is a more developed technology than hydrogen-based steelmaking, deployment timelines would be shorter. As such, it would theoretically be possible to deploy CCS (with the capture rates of 50-70%) within this decade, but higher capture rates would require a significant rebuild of blast furnaces and would push timelines into the early 2030s. This would, of course, be entirely dependent on the right business environment being created.

The electricity consumption associated with CCS operations at steel sites would also be immense, as it is an incredibly energy-intensive process to capture emissions. Therefore, competitive electricity prices also become very important to unlocking CCS for the steel sector.

The lack of widespread deployment of CCS at steel production sites globally is a key limitation, making feasibility, requirements, costs, and performance more difficult to assess. In addition to the requirements for capital investment and increased operational costs, there are numerous unknown risks from increased operational complexity and plant integration; high levels of uncertainty regarding costs and budgeting; a general lack of staff familiarity and operating expertise; in addition to consideration for availability of space onsite for CCS plant and any impact on the product quality.

³ <https://www.makeuk.org/insights/reports/a-barrier-to-decarbonisation-industrial-electricity-prices-faced-by-uk-steelmakers>

⁴ <https://www.tatasteeleurope.com/sites/default/files/TS%20Factsheet%20Hisarna%20ENG%20jan2020%20Vfinal03%204%20pag%20digital.pdf>

These barriers likely also apply to hydrogen-based production, which is also untested commercially and is not isolated to CCS. There will also be site-specific barriers to CCS deployment, which limits its applicability at scale.

Estimates for cost per tonne of carbon captured vary depending on capture technologies and storage costs, but for retrofit of OPEX is estimated to be around £61-101/tCO₂e, including transport and storage. OPEX of £61-£101/tCO₂e would roughly lead to a 16%-26% increase in the cost of producing a finished steel product, depending on the product and overall efficiency of the steel plant. Since profit margins of 6% are used as a benchmark for long-term viability for steel companies within EU trade remedies investigations, it is evident that trying to accommodate a 16-26% increase in costs will not be possible without government intervention. There are multiple options for supporting CCS deployment in the steel sector, including the Government's current CCS business models.

The risks associated with product ranges and the global need for ore-based steel production do not apply to CCS, as it will allow the continuation of ore-based production.

Hydrogen-based steel production

If the target of significantly reducing most emissions from the steel sector were pushed beyond 2035, hydrogen-based steelmaking could also become an option. Hydrogen-based steelmaking is an emerging ore-based production method, essentially a low-carbon modification of a lesser-used, but established, steelmaking technique known as direct reduced iron (DRI). This novel form of DRI uses hydrogen, instead of natural gas, as the reductant to reduce the oxygen in the iron ore, with water as a by-product. It produces an intermediate product, sponge iron or DRI, which can be melted in an electric arc furnace (EAF) together with recycled scrap, reducing the volumes of ore-based steel. Using hydrogen as the reductant in the DRI plant would lead to near-zero process emissions, and the need for oxygen blowing eliminated or very much reduced, significantly reducing the CO₂ emissions. However, this is wholly dependent on how the hydrogen is produced and its emission intensity.

Hydrogen-based steel production has been performed in test labs but not at a commercial scale. The first full demonstration plant is not expected to be ready until 2025, with the commercial plant ready in 2026-35. Few OPEX estimates are available, but the Swedish HYBRIT project estimates a 20-30% increase in the cost of producing crude steel in Sweden, dependent on the prices of coking coal, electricity, and emission rights. It is difficult to compare this to potential hydrogen-based steelmaking in the UK, as Swedish hydrogen would be produced through electrolysis of water using very low-cost hydropower, where British hydrogen would need to be created through steam reformation with CCS. A UK OPEX would thus be much higher. Estimates for hydrogen productions range around £50/MWh when through steam reforming, which is twice as expensive as natural gas, although it has been projected to decrease to £40/MWh in 2030 and £20/MWh in 2050, at which point it would be competitive with natural gas.

For ore-based steel production, more energy is required to reduce the iron, which has already been reduced in scrap-based steel production. A blast furnace consumes about 3.68MWh per tonne of steel, mainly in the form of coal and coke, compared to hydrogen-based steelmaking's energy consumption of 3.48MWh/t (excluding secondary metallurgy, pelletising, casting, and rolling). Therefore, there would be a significant increase in grid electricity consumption if switching to hydrogen-based steel production due to the removal of onsite generation, EAF use, and indirectly through hydrogen production.

There are several technical challenges, including risks associated with using a more combustible fuel; the lack of understanding of how hydrogen reacts in different environments; HSE familiarity; and NO_x emissions when combusted. It will likely require several proven trials to resolve some of these issues, and, thus, large pilots or small commercial sizes will be invaluable to progressing hydrogen-based steelmaking. It is not expected that any of these will be showstoppers, however, this is difficult to estimate as the production route is still in its infancy, with no demonstration plant yet fully commissioned. It is also worth considering the limitation of suitable iron ore for DRI.

It is worth emphasising that hydrogen-based steelmaking is technical feasible sooner than 2035 but not commercially feasible. Original Equipment Manufacturers (OEMs) are starting to offer DRI infrastructure, which can handle hydrogen later. However, the main barrier is access to cost-competitive hydrogen, which the industry does not expect to be available until after 2035 at the very earliest in the UK. Hydrogen may only become competitive towards 2050 unless substantially subsidised by the Government. It would be possible to commission DRI natural gas-based steelmaking in the UK earlier than 2035, followed by a switch to hydrogen when the hydrogen is

commercially available. This would allow the UK sector to make earlier investments until hydrogen was widely available at competitive prices. A DRI plant using natural gas could likely see carbon reductions of over 50% compared to conventional coal-dependent BOF ore-based production depending on the scrap/DRI mix, so it could also be an important step in terms of cumulative emissions.

The DRI plant could also deploy CCS at the site to reach over 80% emission reductions in the time until hydrogen was cost-competitive. However, DRI plants are currently not operating widely in the UK and the rest of Europe as it is dependent on the cost of natural gas, which is relatively more expensive in Europe than elsewhere globally. This would make using natural gas-based DRI commercially unattractive in the UK unless the Government intervened to support it. The Russian invasion of Ukraine and the impact on gas prices makes this even more difficult.

The relationship between low-carbon steelmaking technologies and the development of other decarbonising technologies

Decarbonisation of steel production will be dependent on several other technologies and developments provision of necessary infrastructure:

- Renewable electricity generation to power EAF, CCS, and hydrogen-based production with zero indirect emissions.
- Hydrogen production to fuel hydrogen-based steel production and replace natural gas for rolling and heating of steel. This will include the necessary infrastructure to deliver the hydrogen to site
- CCS infrastructure and storage – while the GHG emissions can be captured on site, they need to be transported and stored elsewhere, which requires the necessary infrastructure

The timescales needed to achieve fossil fuel feedstock replacement and fossil fuel-free energy throughout the supply chain for steel products

As outlined above, the timelines for the different decarbonisation routes vary and are wholly dependent on the right business conditions/policy support being introduced by the Government. Assuming that this is in place (see below for which policies would need to be introduced), the sector would be able to switch to scrap-based, electric arc furnaces within 5-10 years and apply CCS within the next 10 years. As described above, hydrogen-based steelmaking would likely take longer than 15 years due to costs and technology readiness, but the sector could switch to DRI before 2035 and increase the amount of hydrogen used as costs decline.

However, these are highly ambitious timelines, which would only be enabled by a willing government, which provides the necessary support mechanisms, introduces new regulations, and implements new trade policies. It would be possible to meet the Climate Change Committee's recommendations in such a scenario, with the remaining emissions phased out gradually between 2035 and 2050.

The targets the Government should set for low-carbon steelmaking in the UK

We note that the Government's advisor, the Climate Change Committee, has recommended a target of decarbonising ore-based steel production in the UK by 2035. The Government's adopted target, for now, denotes decarbonisation for industry by 2050 with an ambitious interim staging post set out in the Industrial Decarbonisation Strategy. In the scenarios where vital policy changes were introduced, the steel sector would aim to decarbonise over an ambitious timeline. However, it would only be suitable to set targets for the sector to decarbonise if the right policy interventions and support was provided.

The steel industry can only decarbonise in partnership with the UK Government. This is evident from other countries where substantial and significant support to the steel industry is planned:

- French government support EAF investment with £1.4bn
- Canadian Government £230 million investment in Arcelor Mittal plant
- Canadian Government £420 million investment in Algoma Steel plant
- German Government commits to £48 million investment in ArcelorMittal Hydrogen based steel production
- German Government puts forward 'industrial CfD' plans
- Spanish Government signs MOUS with ArcelorMittal for Hydrogen based steel plant
- Swedish SSAB (Steel producer) joint venture in hydrogen-based steel making with Swedish State-owned Vattenfall and LKAB
- Belgian and Flemish Governments investment in ArcelorMittal DRI Plant

The above is in addition to more generous programmes for hydrogen production, more competitive electricity prices, and the development of CBAM policies in the EU.

The policy support for low-carbon steelmaking in the UK provided in the Industrial Decarbonisation Strategy and the Net Zero Strategy

The Industrial Decarbonisation Strategy outlined the Government's overall ambition, set a clear direction of travel, and outlined the Government's existing programmes to support industrial decarbonisation. In general, there were no significant new spending commitments, schemes, or new policies announced in the Strategy document. However, we noted the announcement of a call for evidence on low-emission industrial products, which has recently closed and the consultation on UK ETS free allocations, which the Government has yet to respond to despite closing last year.

While the former is welcome, we are concerned that it misses the mark by not focusing on carbon leakage, as it suggests implementing tough standards on UK industry but not on imported products, when one of the main barriers to decarbonisation is the threat of lower-cost, high-emission imported products. On the latter, free allocations are the key carbon leakage protection policy, which has effectively protected against significant direct carbon leakage. Reforming these will naturally be contentious and could, if implemented poorly, cause substantial damage to UK industries participating in the UK ETS.

From a steel perspective, the Industrial Decarbonisation Strategy had crucial gaps which need addressing. Key amongst them were a lack of a credible strategy to protect against carbon leakage and an absence of policies to address uncompetitive industrial electricity prices. On carbon leakage, the EU is moving fast to implement a Carbon Border Adjustment Mechanism (CBAM) to ensure that imported industrial products face a similar carbon price as domestic producers. The UK has not yet confirmed whether it will implement a similar scheme along the same timelines or implement other policies to achieve a similar outcome. Separately, there has been no movement on industrial electricity prices, with the disparity in electricity prices between the UK, France, and Germany growing substantially over the past year. This remains a key barrier to any investment in industrial decarbonisation.

The Net Zero Strategy referred explicitly to the CCC's recommendation for the steel industry to decarbonise by 2035 and referred to CBAMs as a policy tool. It did, however, not announce any details on specific policies relating to the steel sector apart from stating that the Government was working with the sector on understanding the implications of decarbonising by 2035. It did not address industrial electricity prices, carbon leakage, or CAPEX funding.

How effective the Clean Steel Fund is expected to be in helping to deliver decarbonised fuel capacity in the UK

The Governments introduced the £250 million Clean Steel Fund in 2019. While it was included in the Industrial Decarbonisation Strategy, it was conspicuously absent from the Spending Review/Budget in Autumn 2021. BEIS officials have since confirmed that its future was now under reconsideration. As such, unless confirmed otherwise, the Clean Steel Fund does not have a budget and will not be able to launch in 2023 as recommended.

As outlined above, other governments provide substantial CAPEX support, which dwarfs the Clean Steel Fund's budget. It is thus worrying that even a smaller fund as the Clean Steel Fund cannot secure a budget, and it emphasises the growing gap between the Government's public ambitions for steel sector decarbonisation and the policies required to deliver it. This gap must be closed during 2022.

Any additional policy support required to encourage the transition to low-carbon steelmaking

Several new policies must be introduced to enable the transition to low-emission steel production in the UK. First and foremost, the business environment needs to improve for the UK steel sector to put it in a sustainable position of growth and profitability, which will enable it to make significant investments in decarbonising its operations. This will involve parity of industrial electricity prices, energy efficiency funding, improved scrap utilisation and quality, and R&D funding, which should all be implemented in 2022. Subsequently, a market for low-emission steel must be created via either CBAMs or product standards, green public procurements, and appropriately levelled carbon pricing, which will be enforced from 2026 onwards to match EU policy development.

To enable each of the three different production methods (electrification, CCS, and hydrogen-based production), separate policies will be required. Electrification of steelmaking in the UK will require continued parity of industrial electricity prices, improved scrap utilisation and quality, support for decarbonising heat, and R&D funding. Carbon Capture & Storage will need a policy to ensure competitiveness (such as the CCS Business models being developed by BEIS), access to CCS infrastructure, support for decarbonising heat, R&D funding, and continued parity of electricity prices. Finally, hydrogen-based steelmaking will need continued parity of electricity prices, a policy to ensure competitiveness (whether that be CAPEX support, CfDs etc.), cost-competitive hydrogen, and R&D funding.

Provided the right policies and investment support are put in place to address the barriers to decarbonisation, there is a great opportunity to grow the domestic steel industry and be in the vanguard of industrial decarbonisation globally.

The consequences to the UK steel sector from a failure to invest in alternative technologies in a globally competitive market

The Government's Industrial Decarbonisation Strategy targets near-complete decarbonisation for the steel sector. This creates a binary choice for the sector: decarbonise or cease to exist. Therefore, the future of the steel sector relies on a major transition starting as soon as possible, not least concerning investment decisions in the next few years.

March 2022