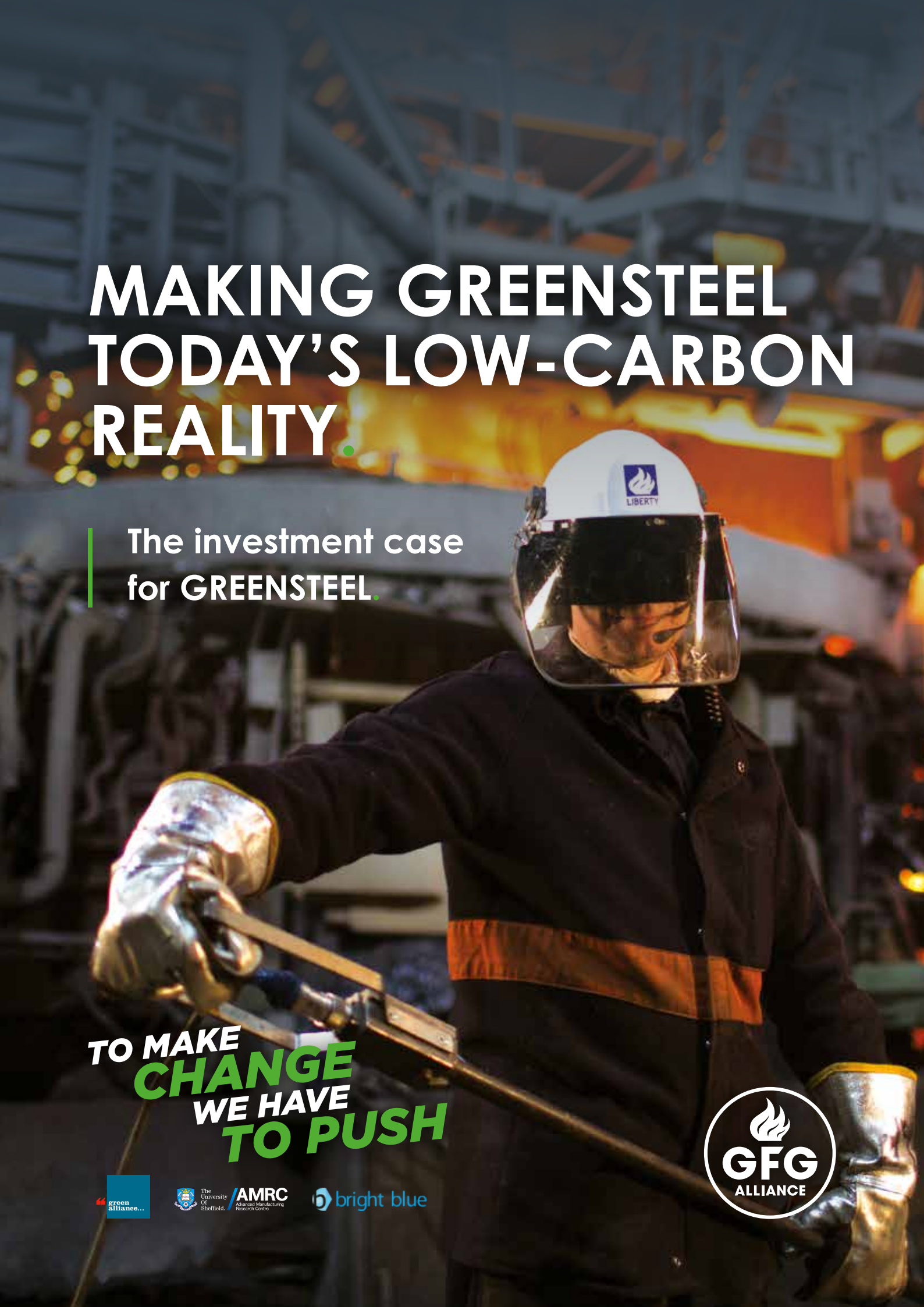


MAKING GREENSTEEL TODAY'S LOW-CARBON REALITY.

The investment case for GREENSTEEL.

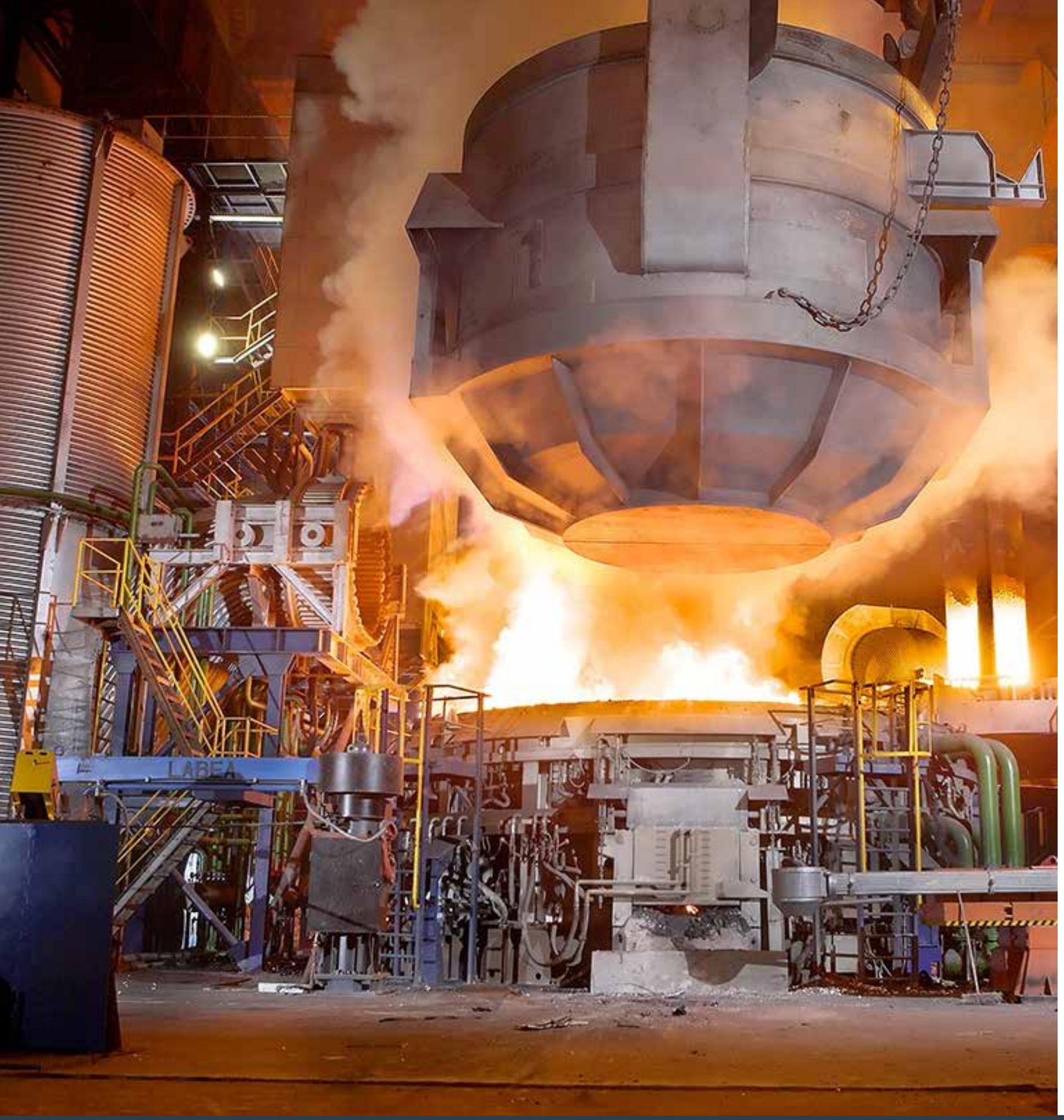
TO MAKE CHANGE WE HAVE TO PUSH

green alliance...

The University Of Sheffield. AMRC Advanced Manufacturing Research Centre

bright blue

GFG ALLIANCE



TO MAKE CHANGE WE HAVE TO PUSH

Introducing the GREENSTEEL Prospectus.

The idea

This prospectus is the first output of a unique, new policy partnership convened by GFG Alliance with three leading research groups to drive sustained change in the UK steel sector.

In this paper, Green Alliance, the University of Sheffield Advanced Manufacturing Research Centre and Bright Blue kick off a programme of activity into 2022 that will build out an investment case for the decarbonisation of steel production in the UK.

The move has been timed to coincide with the COP26 summit in Glasgow. GFG Alliance, a lead sponsor of the World Climate Summit, has for over a decade led the debate on the need for a transition to GREENSTEEL, and is demonstrating an industry-leading commitment to transforming steelmaking.

The challenge

Steel's past is one of high emissions, high energy use and hard to abate processes. With the right policy and investment environment, steel's future is at the heart of a low-carbon response to the challenge of climate change.

The UK steel sector has been under enormous strain in recent years due to global competition and an unlevel competitive playing field, which has limited its ability to invest. Yet the opportunity to demonstrate leadership and innovation in GREENSTEEL is there to be grasped.

The response

As environmental, technical and political experts provide their expertise, Green Alliance, the University of Sheffield AMRC and Bright Blue are ideally placed to map the immediate road ahead.

Here, the three organisations set out their initial thinking on the challenges and policies required to develop a sustainable future for steel, and embed investor support for the decarbonisation of steel production.

Over the next 12-18 months, more will follow as ideas and practical steps accelerate the pace of change needed to deliver a sustainable UK steel industry and a less carbon-intensive economy.

GFG Alliance

GFG Alliance is a collection of global businesses and investments, owned by Sanjeev Gupta and his family.

The Alliance is structured into three core industry brands: LIBERTY Steel Group, ALVANCE Aluminium Group and SIMEC Energy Group. Independent of each other yet united through shared strategy, values and purpose to create a sustainable future for industry and society.

GFG Alliance employs 35,000 people across 30 countries and has revenues of USD $20bn. It is the leader in sustainable industry with a mission to become Carbon Neutral by 2030.

LIBERTY is a fully integrated steel and mining business, with capabilities ranging from liquid steel making, from raw and recycled materials, through to high-value precision engineered products and associated services, sold around the world.

With a total rolling capacity of 20 million tonnes, 200+ manufacturing locations globally across 12 countries and more than 30,000 people, our comprehensive product range includes iron ore and coking coal, recycled steel as well as semis, long and flat steel products and value added services.

LIBERTY is seeking to transform steel manufacturing into a global product and technology leader through its GREENSTEEL strategies.

Advanced Manufacturing Research Centre

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) is a network of world-leading research and innovation centres working with manufacturing companies of any size from around the globe.

They specialise in carrying out world-leading research into advanced machining, manufacturing and materials, which is of practical use to industry.

They transform industrial and economic performance by making changes in productivity, increasing competitiveness, developing new products, processes and training new talent and skills.

Their 125+ industrial partners range from global giants like Boeing, Rolls-Royce, BAE Systems and Airbus to small companies.

The AMRC now employs over 500 highly qualified researchers and engineers from around the globe, on the Advanced Manufacturing Park and Sheffield Business Park in South Yorkshire, as well as in Broughton and Preston.

Bright Blue

Bright Blue is an independent think tank for liberal conservatism. They defend and improve liberal society.

Their primary role is to create and vet government policy.

Established by Ryan Shorthouse in 2014, they are today a respected and leading think tank – as well as a membership organisation – which delivers an extensive programme of research, publications and events.

Bright Blue's thinking and ideas have had significant influence on public debate and government policy. Over 30 original Bright Blue policies, especially environmental policies, have been adopted by the UK Government over the past seven years.

Bright Blue was shortlisted for the 2016, 2017, 2018 and 2019 UK social policy think tank of the year and UK environment and energy think tank of the year in the prestigious Prospect Magazine annual awards. Bright Blue is a not-for-profit organization.

Green Alliance

Green Alliance is an independent think tank and charity focused on ambitious leadership for the environment.

Since 1979, they have been working with the most influential leaders in business, NGOs and politics to accelerate political action and create transformative policy for a green and prosperous UK.

Their projects involve in depth research and advocacy by our experts, often in partnership with other organisations and interests. This work has received widespread interest from business and government.

Green Alliance has a proven ability to convene senior, expert figures from the NGO, political, business and academic sectors and regularly hold events with senior political figures. Their high-profile events and specialist seminars provide important opportunities for dialogue with key decision makers.

Green Alliance have a track record of 45 years generating new thinking and dialogue to secure ambitious leadership for the environment.

GFG ALLIANCE HAS PLEDGED IT WILL BE CARBON NEUTRAL BY 2030.

TO MAKE CHANGE WE HAVE TO PUSH

The way the world makes and uses steel has to change, argues Executive Chairman and CEO of leading global steelmaker GFG Alliance, Sanjeev Gupta. Here he introduces the launch of a unique partnership of three expert organisations who will be working with GFG Alliance over the next 18 months to force the pace of change.

To secure our collective sustainable future, steel must change and GFG will be at the heart of that change.

As a business, we have already adapted our operations to reduce their carbon impact. But more needs to be done.

To push the pace, we have convened a policy partnership with three leading organisations: Advanced Manufacturing Research Centre, Bright Blue and Green Alliance with the relevant expertise to drive forward industrial transformation across our sector, and critically to advance the case for investment in it.

As such, it is my pleasure to introduce our GREENSTEEL prospectus, to kick off the partnership which will identify policy and investment solutions to unlock a sustainable steel industry.

At GFG Alliance, we want to turn steelmaking – which is currently the biggest industrial carbon emitter - into one of the cleanest, low-carbon industries.

Decarbonisation of the steel industry is both a necessity and an opportunity. Traditional steel production uses carbon – in the form of coal – in blast furnaces to strip the oxygen from iron oxide (iron ore). As a result, steelmaking accounts for 9% of global CO2 emissions. As the world's economies develop further, the need for foundational materials will keep growing: it is currently estimated that global consumption of steel will double in the next 30 years. According to the Net Zero Steel Initiative, which LIBERTY Steel is part of, early progress on steel decarbonisation could unlock 1.3Gt of CO2 emissions reductions by 2030, helping to achieve the target of limiting global warming to 1.5 degrees. In short, no plan for net zero can be achieved without a plan for steel.

“ THERE IS NO ONE SIZE FITS ALL SOLUTION

FOR THE GLOBAL STEEL INDUSTRY, BUT WE RECOGNISE LOCAL MARKET DYNAMICS AND DEVELOP STRATEGIES WHICH REFLECT THEM.

We predict that those operations which are the first to decarbonise their steel making will gain market share, meeting demand from customers across the globe for cleaner, low carbon, steel. With the right operating and investment environment steel can once again become an engine for growth, job creation and sustain vibrant industrial communities around the world.

GFG has pledged it will be carbon neutral by 2030 (CN30) through its GREENSTEEL and GREENALUMINIUM strategies, underpinned by major renewable energy projects under SIMEC Energy. This does not mean we will have no emissions nor that we will abandon traditional practices overnight. But the transition can begin in earnest today with existing technologies – and take place more quickly than some may think.

We have already begun the reinvention of our sectors, based on new technologies, new business models and new ways of working together. Using our current capabilities, we can offer solutions to address some of today’s most pressing challenges. For example, Electric arc furnaces use a significant amount of electricity to melt scrap – but with a growing portion of the UK’s grid power coming from renewables (30% today) and coal phasing out, we can further reduce total emissions compared with traditional steel making.

With relatively modest investment and the right policy framework, we can expand Rotherham’s capacity to two million tonnes per annum, which presents a real, achievable and low-carbon way to answer 30% of domestic demand currently imported, using existing technology and using steel scrap constantly generated in the UK.

Our CN30 pledge, announced in October 2019, is now shaping everything we do. GREENSTEEL is a manufacturing approach which involves greater use of steel recycling, development and application of low carbon technologies and renewable energy to power processes and, the UK, which imports 6m tonnes of steel and exports around 8 million tonnes of the scrap steel it generates each year, is currently suffering supply chain issues. In October we have restarted production at our GREENSTEEL electric arc furnace in Rotherham, UK, which will aim to be producing 500,000 tonnes of recycled steel per annum. Making steel through electric arc furnaces generates just 10% of the direct emissions compared with traditional coal-based blast furnaces which produce the vast majority of the UK’s steel output today.

soon, the application of emerging technologies such as hydrogen steelmaking. We have developed two strategies that can bring about our GREENSTEEL vision. In the UK, Poland, Australia and in the US – mature economies with an abundance of steel scrap – we are combining scrap recycling with renewable power.

At our primary steel operations in Australia and parts of Europe, rich with iron ore and significant renewable energy potential, we are introducing breakthrough technologies to address emissions from traditional steelmaking with hydrogen and Direct Reduced Iron (DRI).

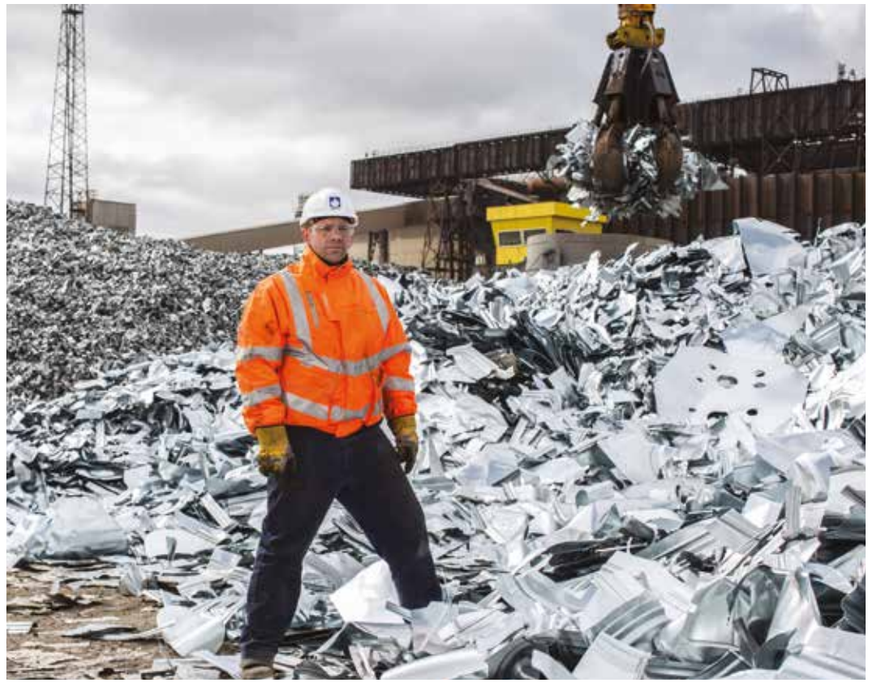
There is no one size fits all solution for the global steel industry, but at GFG we have already recognised local market dynamics and have developed specific strategies which reflect the underlying economics and structure of the markets in which we operate.

We have transformational GREENSTEEL plans for each of our traditional steelworks we own – these account for 90% of our scope 1 emissions. For example;

At LIBERTY Whyalla in South Australia, we are already transforming our site to create one of the first global scale commercial Hydrogen Direct Reduction Iron production facilities. We are building a new DRI plant and electric arc furnace to produce GREENSTEEL from abundant South Australian magnetite resources, alongside a 280MW solar farm. Eventually, we will use cheap, clean renewable energy to produce hydrogen from water without CO2 emissions, and feed it directly into a steel plant, bypassing the problems of hydrogen storage and transportation.

In Czech Republic, we plan to replace the four existing tandem furnaces at LIBERTY Ostrava with two state of the art hybrid furnaces, which will allow the facility to vary the mix of liquid metal and steel scrap used in the steel making process. These furnaces are expected to reduce Scope 1 emissions by 50% by 2026, and eventually achieve full carbon neutrality. We are also developing a DRI plant at LIBERTY Galați in Romania, with a 2.5 million tonne capacity and two electric arc furnaces, supported by a major wind and solar renewable energy programme. This will reduce CO2 emissions per tonne of steel produced by up to 80%, with emissions dropping to minimal levels once the DRI plant uses hydrogen rather than natural gas as the reductant fuel.

Our industry offers relatively high wages for skilled jobs and has a high multiplier effect - each job supports six or seven more in the wider economy. Around the world, our industries are vital to growth in regions that may otherwise struggle to provide economic security for local communities. By transforming the steel industry, we can provide



quality jobs for generations to come and modernise industrial sites and communities that have been neglected in recent times.

The responsibility that comes with this transition is immense, and we need to be mindful of the impact it will have on the lives of our communities. At GFG, we will play our part in ensuring our current and future employees have the right skills to be part of a net zero steel workforce through the rollout of GREENSTEEL Academies, the first one of which has already been launched in Romania. It is our duty to protect industrial futures by delivering sustainable profits and securing long-term employment which supports local economies and enables societies to live well and thrive.

The radical change that is needed cannot be achieved by one trailblazing organisation. Private sector collaborations are required to spread costs, share knowledge and accelerate change. But even that is not enough. In order to reinvent the industry, steel producers, policymakers and the financial community need to work together to push for change. GFG believes net-zero steelmaking will soon be competitive, but transitioning to net-zero compatible technologies globally will require tens of billions in additional CAPEX compared to baseline investment plans. Firm commitments and rapid actions from stakeholders across the value chain are needed to stimulate demand for low-emissions steel and financial flows toward this transition.

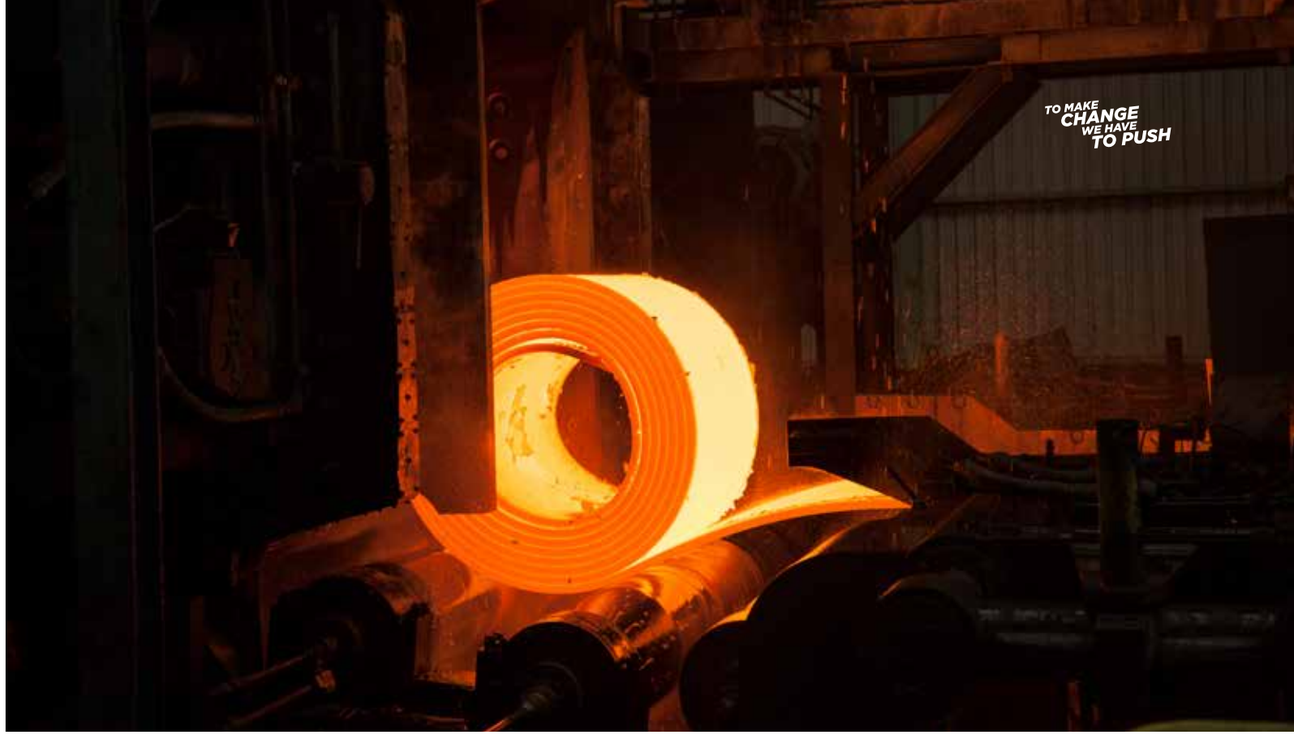
Over the past twenty years many countries have made huge progress in decarbonising energy generation. This progress was underpinned by a policy framework that reduced risk and encouraged investment. In the next few years we need to address industrial emission with equal muster, to create new fiscal and policy frameworks that give competitive advantage to players who move faster in the transition to low-carbon steel, rewarding innovation instead of propping up a polluting model that has no place in a net zero future.

We cannot wait. Long investment cycles mean delays to the development of critical technologies or to the build-out of zero-carbon electricity and hydrogen infrastructure would throttle the pace of the sector's transition. This is the critical decade, both steelmaking technologies and enabling infrastructure will need to be ready in the 2020s.

The steel industry cannot afford to be complacent and carry on as before. Only by decarbonising steel can we secure the ultimate prize – a sustainable and competitive future.

Sanjeev Gupta
Executive Chairman

WE MUST CHANGE THE WAY WE USE RAW MATERIALS.



If we are to achieve our Net Zero ambitions, then we must move UK steelmaking away from production using virgin material, towards recycled steel made with sustainable power, argues Peter Osborne, Senior Research Fellow at the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

In June 2019 the UK became the first major economy to pass a net zero emissions law, committing the UK to bring all greenhouse gas emissions to net zero by 2050. Without significant action on climate change we all face a hotter planet, rising sea levels and more extreme weather that threatens many different forms of life.

If we as a nation are to accomplish our net zero objective, we are going to have to make some significant changes to our lifestyles, the products that we use and the way that we create the raw materials that go into them. Air travel is often held up as one of the activities that we should curb. It is important to remember that flying is not the issue; emissions are, therefore the problem that we must solve is how to do it while not creating emissions

The foundation industries: Cement, glass, ceramics, paper, metals and bulk chemicals, play a significant role in underpinning the productivity of the UK by producing the raw materials which go on to be used in a wide range of different products which we all use each day. Sustainable metal production is as much part of our future as battery-powered automotive technology. Whatever powers cars, planes and trains will need to be made of new high performance specialist metals, and our capacity to participate in a low-carbon supply for those products will be critical to the UK economy's future. Steel is essential, we just need to work out how to create it in the cleanest, most sustainable way.

Sheffield and Rotherham, where the AMRC is based, owe much of their history and development to the growth of the steel industry. This growth came about as a direct result of the development of new processes, such as crucible steel and the Bessemer converter, which allowed the manufacture of better-quality steel than had previously been possible.

Today's industrial processes have largely been designed without resource constraints and with only limited consideration for the impact of emissions on the environment. Demand for products made from steel is only going to increase - whether for defence, urban regeneration, SMRs or offshore wind - as we transition to more sustainable technologies which emit less through there lifecycle or help us to generate clean electricity. With 'green' steel we have the opportunity to take the lead and ensure that the steel inputting into these lifetime infrastructure assets is both sustainable and auditable and potentially produced in the UK - particularly if we mandate that steel has to come from green sources.

The phrase *Reduce*, *Reuse*, *Recycle* is often used when we talk about how to be more environmentally friendly, how to be greener, how to be ecologically sound and live sustainably.

Equally, this logic can be applied to the manufacture and use of steel, and we must focus on each if we are to reduce the impact of steel manufacture on the environment.

Reducing emissions by fuel switching

There are two main processes for making crude steel: the blast furnace-basic oxygen furnace (BF-BOF) process and the electric arc furnace (EAF) process. Table 1 shows, in bold, the approximate direct CO2 emissions per ton of steel for the BF-BOF and EAF steel manufacture routes respectively. When added together, the BF-BOF process steps total more than ten times the carbon dioxide emissions of the EAF process. This difference is significant and meaningful reductions in emissions can be made by switching from BF-BOF to EAF for crude steel production.

After crude steel manufacture the processing steps taken for steel are the same regardless of the crude steel processing route taken. Steel products may go through one or several of the secondary processing steps before becoming a finished product. A key point to note is that the bulk of emissions take place as a result of the primary processing, and the relatively small impact from the secondary steps means that it should not be the initial focus of measures to curb steel's impact on the climate.

Table 1: Direct CO2/t emission comparison between BF-BOF and EAF manufacturing routes [1]

BOF PROCESS STEPS	DIRECT CO^2 EMISSION (tCO^2/t)	EAF PROCESS STEPS	DIRECT CO^2 EMISSION (tCO^2/t)
Coke Plant	**0.794**	**Electric Arc Furnace**	**0.24**
Sinter Plant	**0.2**		
Pellet Plant	**0.057**		
Blast Furnace	**1.219**		
BOF Plant	**0.181**		
Bloom, slab and Billet Mill	0.088	Bloom, slab and Billet Mill	0.088
Hot Strip Mill	0.082	Hot Strip Mill	0.082
Plate Mill	0.098	Plate Mill	0.098
Section Mill	0.084	Section Mill	0.084
Pickling Line	0.004	Pickling Line	0.004
Cold Mill	0.008	Cold Mill	0.008
Annealing	0.049	Annealing	0.049
Hot Dip Metal Coating	0.059	Hot Dip Metal Coating	0.059
Electrolyptic Metal Coating	0.046	Electrolyptic Metal Coating	0.046
Organic Coating	0.003	Organic Coating	0.003

Table 2 shows the energy sources used for the BF-BFOF and EAF processes. The EAF process mostly uses electricity for its power source, with its carbon emissions caused by the consumption of the electrodes, oxidised scrap, and the injection of coal into the process to assist with slag foaming. Currently around 30 % of UK energy comes from renewable sources. The EAF process is already a mature technology with 29 % or 1.8 billion metric tons of steel produced globally using this method in 2019.

Using EAFs in greater volume opens the possibility of making steel with less than half the emissions of the BOF process, and with more renewable power in the future this should drop even further. As such it provides a real opportunity to reduce emissions when combined with green electricity derived from renewable energy. One of the most important barriers to the wider adoption is that the UK has comparatively high industrial electricity costs to competitor nations, it has been reported that UK steelmakers pay around 80 % more for electricity than French steelmakers [2].

Table 2: Energy sources for the BF-BOF and EAF processes [1, 3]

ENERGY SOURCE	BF-BOF ROUTE	EAF ROUTE
Coal	**89%**	**11%**
Electricity	**7%**	**50%**
Natural Gas	**3%**	**38%**
Other Gases and Sources	**1%**	**1%**
Total Energy / Ton	**24.5 x 10^9 J**	**2.25 x 10^9 J**

Reducing virgin material usage

In 2019 the UK consumed 11.9 million tons of steel [4] and produced 11.3 million tons of scrap steel, of which 8.7 million tons was exported and the remainder was consumed in UK crude steel making [5]. UK steelmakers can use up to 6.1 Mt of scrap steel in the current steel manufacturing plants [6].

Another factor in the favour of the EAF process is its ability to use recycled material. The BF-BOF process relies on the production of pig iron from coke and iron ore, which is then reduced into crude steel. This limits it to use only around 30 % scrap steel. The EAF process by contrast can use almost 100 % scrap steel to produce crude steel.

Steel will play a key role at the heart of the circular economy and decarbonisation will change the way that steel is used. As a material, steel can be easily reused and remanufactured before being recycled. It has a high yield when recycled, there is very little wastage during the steel recycling process.

The impact of the circular economy on steel production will mean less crude steel production as steel will stay in service for longer, potentially seeing several lives before finally being scrapped for recycling. The circular economy presents new industrial market opportunities for steel grade design, manufacture, recycling, and application. The exact impacts of the circular economy on steel markets and the industry are currently unknown as the research and work is only just beginning [7].

Reducing material wastage

Roughly two thirds of today's liquid steel is made from iron ore, with the rest made from scrap, but at present more than half of this scrap is from the manufacturing process itself, rather than from end-of-life goods.

A quarter of the finished steel made each year (including half of all sheet steel) never makes it into a product but is cut off in manufacturing because final users want components (such as car doors) that do not closely match the intermediate products (coils of strip steel) or require a shape which is difficult to produce.

Smarter manufacturing processes, enabled by digital technologies which provide greater control and which are leaner and more energy efficient, will play a key role in the future. Making condition of supply (CoS) parts which are closer to net shape is not without its challenges. Forged parts can include significant residual stress, which must be released during final machining and care must be taken to ensure that the final parts have the desired microstructure if they are to have the performance characteristics which are required.

These challenges can be solved, however, with sufficient thought about what CoS material is required at an early enough stage in the design process. New high-performance alloys also have the potential to help reduce emissions by lightweighting. A lighter vehicle structure requires less energy to move - either extending range or requiring smaller batteries with correspondingly lower embodied emissions.

Valorisation of scrap material

Sustainable processes which make greater use of recycled materials will be reliant on the effective segregation and valorisation of scrap. Some industries have already made significant steps towards this with almost 95% of the material used in an aerospace engine able to be recovered and reused. To do this effectively however relies on our ability to segregate the different material types, enabling them to be returned and safely reused in the same grade of material rather than mixed with significant virgin material or turned into a lower grade of steel.

Digital technologies will be key to understanding what a particular product is made from and technologies like blockchain will provide the digital ledger audit trail that describes a product's full lifecycle and unlocks its value at the end of life.

Anchoring innovation in the UK

In his recent book [8] Lord Sainsbury introduced a new capability/market opportunity theory for high tech clusters. In it he described how innovation clusters take off in a particular location when two conditions are met.

- A market-opportunity is created by a technology becoming available and that,
- Firms exist or are created that have the capability to take advantage of it.

We already have some of the keys to unlocking this market opportunity. To do this will require the correct market conditions to be in place which allow firms to take advantage of the technology at our fingertips today. Part of these conditions, however, will be ensuring that businesses have access to a workforce with the correct skills and competencies to take advantage of them.

Steel making contributes £1.6 Bn to the UK economy and directly employs 32,000 people – the indirect contribution to the UK economy is hard to calculate, but a conservative estimate is that there are a further 96,000 people in the steel industries supply chain. [9]

Summary

If we are to achieve our Net Zero ambitions, then we must move UK steelmaking away from production using virgin material, towards recycled steel made with sustainable power. Much of what is required technologically is already possible. However, it relies on the correct market conditions for firms to take advantage of it. The UK, with its strong climate policy, mature stocks of steel and great history of innovation in materials science and processing is perfectly placed to be world leading again if we can rethink and redevelop a sustainable steel industry which takes advantage of a circular economy model for steelmaking. If we can achieve this it will not only create long term green jobs within the UK but also lead to the development of world-leading exportable skills and technologies and allow us to transform the highly valuable scrap that we currently export at low value, into a strategic high-value asset.

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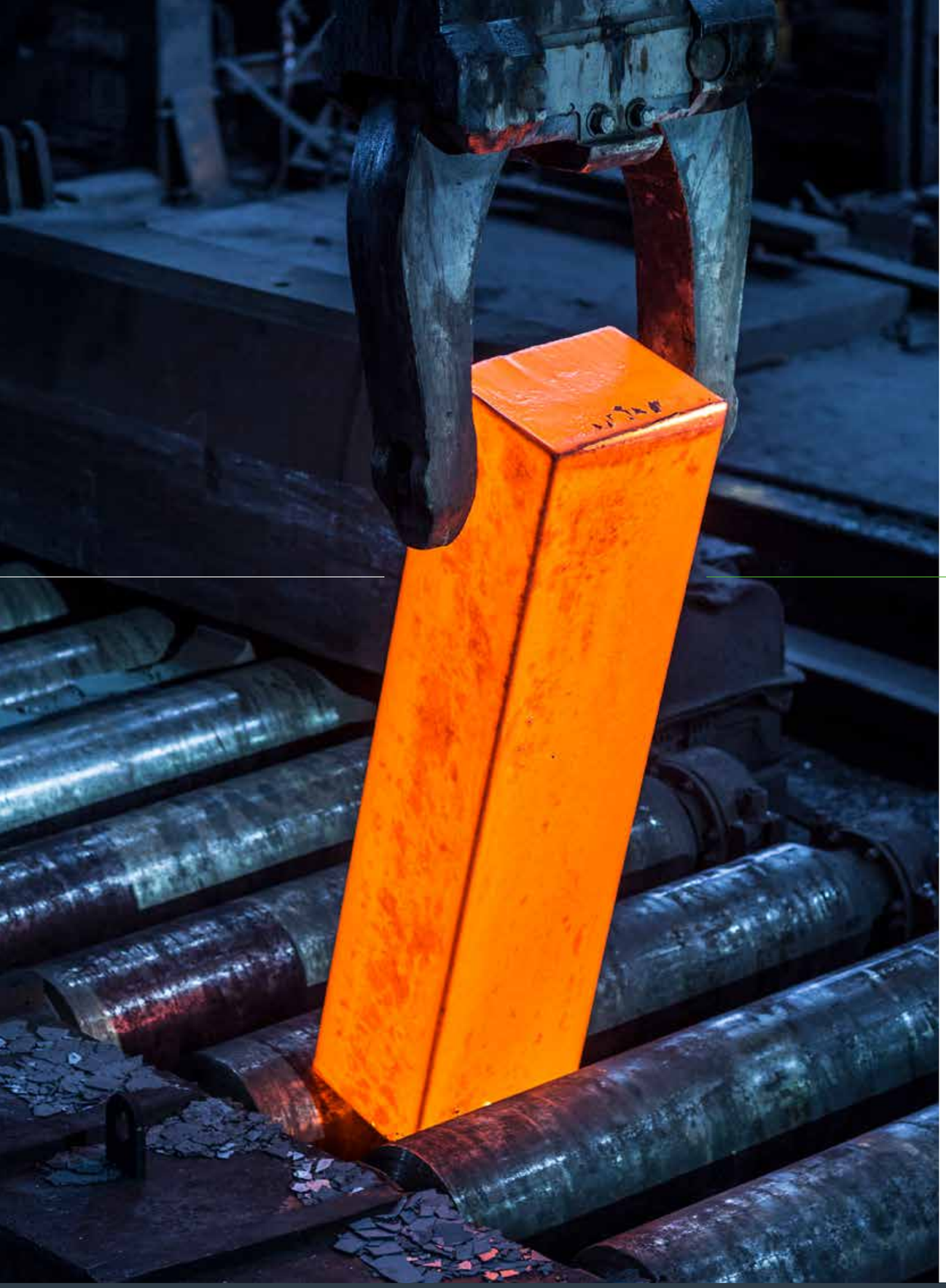


POLICY MUST FOCUS ON DELIVERING GREEN STEEL IN THE UK BY 2035.

bright blue

Clean steel is a prize that the UK cannot afford to let slip from its grasp, argues Wilf Lytton, Associate Fellow at the leading centre-right think tank, Bright Blue. To secure the opportunity for change, governments must do more to incentivise investment in green steel production.

Green steel is an indispensable building block of the net zero future we are heading towards, and the UK's steelmakers are poised to play a leading role in producing it. The Government too has signalled its intent to decarbonise the sector quickly and cost-effectively with plans to "align existing [industrial] policy with net zero and invest in critical shared infrastructure". [1] These plans build on analysis published by the Climate Change Committee, which presents a clear case for bringing emissions from the UK's iron and steel industry close to zero by 2035[2] to meet the UK's interim carbon budgets. Doing so will be of strategic value to the UK as markets become increasingly climate-regulated, and will also help secure new investment and skilled jobs in UK manufacturing.

Yet, the promise of a net zero future does not guarantee the role of UK steelmakers in delivering it. Indeed, having lurched from one crisis to another, optimism of a green future within the industry is fragile: a decade of overcapacity in the sector has depressed steel prices globally, wiping out UK steelmakers' margins, while the recent US-China trade war and uncertainties around Brexit undermined UK exports. As the Covid-19 pandemic began to bite in the first half of 2020, steel demand dropped, forcing plants to cut production, furlough workers and take on mounting debt. Now, with energy prices at several times average levels[3], many UK steelmakers have again been forced to suspend production and face losing market share to rivals in Europe and elsewhere where foreign governments have already moved to insulate their industries from the energy price spike.[4]

If the entire UK steel sector is to decarbonise within the next 15 years, steelmakers will need to move quickly to transform their business models and invest in new technologies. This will be much harder to achieve so long as the sector remains on a crisis footing. Therefore, it is vital that emissions policy goes hand in hand with addressing the structural challenges facing the sector to avoid delaying the net zero transition.

Having acknowledged the need to "change the policy landscape to overcome these issues"[5], the focus of government efforts in the near-term should be on creating a policy landscape that supports business models for UK green steel production - that is, steel produced without emissions, using clean energy and high recycled metal content. Recently-announced policies are laying the foundations of a UK green steel sector with the Industrial Energy Transformation Fund, Industrial Decarbonisation Challenge, and Clean Steel Fund to support the development of homegrown green steel technologies. However, we now need to go further and bring those technologies into full-scale deployment.

However, three key challenges need to be solved before green steel can become a commercial success in the UK. First, the country's steelmakers must be able to compete on a level playing field, both internationally and within the UK. Second, steelmakers will need access to low-carbon infrastructure in order to produce green steel. And finally, there will need to be markets for green steel.

The creation of a level playing field that addresses competitive distortions in energy costs, carbon and trade policy is vital to rebuilding confidence in the sector and supporting investment in UK steelmaking. The transition to green steel will see steelmakers rely increasingly on low-carbon electricity - both directly in the smelting of steel and indirectly through hydrogen production. UK steelmakers have historically faced higher electricity prices than their counterparts in other parts of the world[6] and, if UK steelmakers are to remain competitive, managing energy costs must form an essential plank of industrial and energy policy going forward. Regulations that govern carbon pricing and trade will also need to be geared towards encouraging the cleanest forms of steelmaking. The Government's Industrial Decarbonisation Strategy nods to reform of the UK Emissions Trading Scheme (ETS). The design of benchmarks in particular will be an important tool for incentivising the least polluting modes of steelmaking. To be an effective instrument, carbon pricing will also need to be reflected in UK trade policy to account for the embedded carbon of imported goods and ensure equal treatment of the carbon content of products sold in the UK.

The level playing field principle should also apply domestically, taking account of the geographic diversity of steelmaking sites across the UK. In developing low-carbon industrial clusters, policy must not neglect the sizeable portion of UK industry that operates outside the five or six industrial clusters identified in the Government's

"THE UK CAN BE A LEADING MARKET FOR GREEN STEEL.

Net Zero Strategy[7] (NZS). Managing the net zero transition at dispersed sites which represent approximately half of industrial emissions will be critical to the overall success of the NZS.

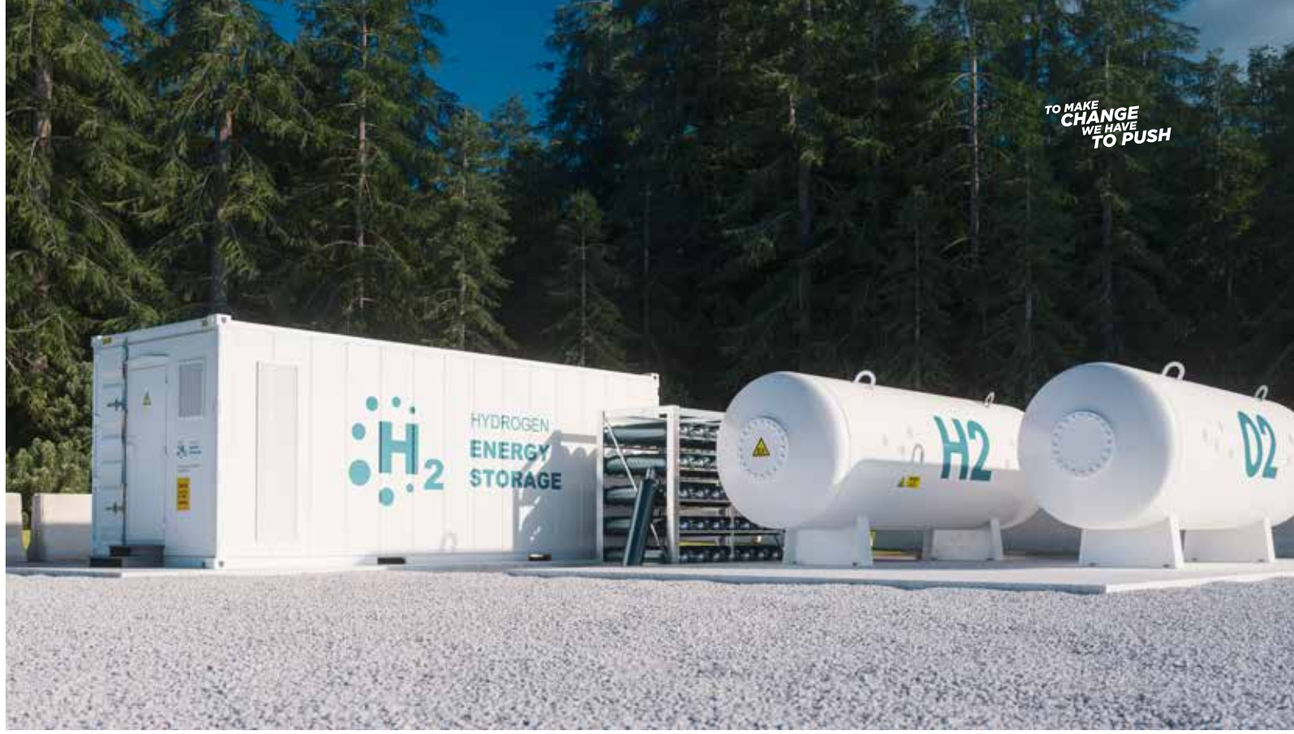
Second, production of green steel will depend on access to affordable electricity and hydrogen. As one analyst observed, "the scale of investment needed in accompanying [low-carbon energy] infrastructure will ultimately dwarf the needs of steel plants themselves".[8] The 5GW of low-carbon hydrogen by 2030 proposed in the Government's Hydrogen Strategy marks a step in the right direction, but the quantities required by the steel industry alone to decarbonise will far exceed this amount. Greater clarity is also needed over the amount and cost of hydrogen that will become available to the steel industry, specifically over the next decade.

Finally, the market for green steel products is undeveloped and, to date, consists of a limited number of companies and buyers clubs with differing levels of commitment and varying definitions of green steel. Earlier this year, the Government announced that firms bidding for large contracts will need to have a credible plan to reach net zero in order to be considered[9], expanding on the 2020 review of public procurement guidance set out in The Green Book. As part of the tender process, the Government might also consider the environmental credentials of suppliers to bidding firms that might otherwise have limited incentives to decarbonise. The Competition and Markets Authority (CMA) also recently launched a consultation on the role that competition law can play in supporting net zero. These initiatives are encouraging and can be complemented by other measures to stimulate demand for green steel.

With COP26 underway, the UK will have an opportunity to work with international partners who share our ambition for clean steel in developing protocols for trade and carbon taxation, bringing green steel closer to becoming a commercial proposition. As such, we urge the Government to **commit to delivering a fossil-free UK steel sector by the mid-2030s**, in line with the CCC's projections for the least-cost pathway to meeting net-zero emissions across the whole economy by 2050. This will provide an unambiguous direction of travel for the sector and a timeframe against which other policies can be measured, while signalling to markets globally that the UK is committed to green steel.

1 HM Government. (2021). Industrial Decarbonisation Strategy p20
2 Climate Change Committee. (2020). Sixth Carbon Budget
3 BBC. Energy prices: Steel boss says government offers no solution
4 Reuters. Factbox: How is the EU responding to record-high energy prices?
5 HM Government. (2021). Industrial Decarbonisation Strategy p19
6 MakeUK. (2021). UK Steel Electricity Price Report
7 HM Government. (2021). Net Zero Strategy: Build Back Greener
8 Mission Possible Partnership. (2021). NET-ZERO STEEL
9 HM Government. Firms must commit to net zero to win major government contracts (2021)

OPTIONS FOR ZERO CARBON STEEL HOLD HUGE PROMISE.



green alliance...

A rapid transition to green steel can make a big contribution to curbing rises in global temperatures, argue Dustin Benton and Roz Bulleid, Policy Director and Deputy Policy Director of the leading independent environmental research and policy think tank, Green Alliance.

Steel is all but essential to modern life: in advanced economies, every one of us benefits from 10 tonnes of steel embodied in all the infrastructure we use: buildings, trains, electricity pylons – even toasters. The vast array of kit that we use in our daily lives is full of steel.[i] Emerging economies are catching up in their use of steel as they grow.

China's stock of steel per capita is 4 times larger in its wealthier urban areas than its rural ones, and India has a policy goal to double steel consumption per capita in rural areas because of the benefits that infrastructure brings to people's lives.[ii] We should expect our use of steel to grow: It, alongside aluminium, is at the heart of the clean energy and transport technologies that are essential to limiting global heating.

However, steel is responsible for 7-11% of global CO^2 emissions.[iii] It and aluminium (representing 2% of global GHG emissions) are the most commonly used metals: we can't do without them but they are also at the heart of the climate crisis. Emissions from steel need to fall by at least 90% globally by 2050, but the challenge of decarbonising steel isn't something that can be put off. Limiting temperature rises to 1.5c means acting now: emissions across the economy need to fall by an average of 7.5% per year over the next decade to stay on track to 1.5c and steel will have to play its part.[iv]

This urgency is new, we've known steel is a large emitter for at least two decades, but it hadn't received much attention because it seemed hard to decarbonise. The challenge of net zero makes it impossible to ignore but over the past decade we have discovered technological options for zero carbon steel that holds huge promise for a rapid transition. This can only be a good thing, as steel is not just an input into our infrastructure, it has a special hold on the imagination. Steel making is deep in industrial culture. Making it is a source of pride for workers, and its production is a status symbol for regions and countries. If you can make high quality steel, you can count yourself amongst the countries that matter. For some countries, steel production is even seen as a question of national economic security.

Steel is essential, a source of pride, a status symbol, and perhaps seen as a security matter. But the way we make and use it must be transformed this decade. This will be no easy task, which is why Green Alliance has partnered with LIBERTY Steel, the University of Sheffield's Advanced Manufacturing Research Centre, and Bright Blue to address the industrial, technical, political and environmental challenges to investing in a new generation of green steel.

An outline of the transition

The basic architecture of the transition is clear. Demand for steel seems to plateau at around 10 tonnes per capita. Wealthy markets have reached this level and so a large fraction of their demand for steel can be satisfied through recycling: extracting old steel from decommissioned infrastructure and

then remelting and reforming it for repurpose can be done in electric arc furnaces (EAFs). Because they run on electricity, innovation in renewables – now the cheapest form of electricity across most major markets in the world[v] – can power them with cheap, zero carbon energy. This transition is well underway - globally, it's easy to foresee steel scrap recycling with EAFs powered by clean electricity doubling. This is the first step in the transition.

Even if secondary steelmaking can lower emissions rapidly in a first big wave of steel decarbonisation, it cannot solve the whole carbon challenge alone. Today, new steel is mostly produced using coal in blast furnaces from iron oxide ore. The carbon in the coal is essential to the process because it is what turns iron oxide into iron, the precursor to steel. Several routes exist to decarbonise this process but none is as easy as plugging clean power into an EAF – they involve hydrogen reduction, carbon capture and storage, or electrolysis and all currently command a price premium compared to traditional, and polluting blast furnaces. Recent evidence suggests that green hydrogen reduction combined with electric arc furnaces can outcompete coal fired primary steel production at an electricity price of $20-$40/MWh. These costs are already being achieved by renewables in the lowest cost markets, but the business case for this approach to steel production depends on assumptions about carbon pricing, coal costs, and finance amongst others. The second step in steel decarbonisation needs innovation and investment, under conditions of uncertainty.

There is a third part of the transition: the shift to a circular economy. Better design, digital tracking, higher grade steel, and measurement of steel condition enable us to keep each tonne of steel in use for longer, and use less steel to make the same infrastructure. For example, improved steel beams and better design can cut steel demand in buildings by 25-45%[vi], and advanced construction techniques using hybrid steel and cross-laminated timber construction look promising.[vii]

The challenges

However, digging into the detail of these three strands of the transition reveals challenges.

The seemingly easy first step of powering EAFs with clean electricity isn't straightforward. EAFs employ fewer people than blast furnaces, posing questions about how to make a clean steel transition just. Harnessing cheap renewables also means operating when the wind is blowing – LIBERTY's Rotherham plant has switched to overnight production to capture lower electricity prices.[viii] Part of the reason is that, despite the UK's rapid shift toward renewable power, a small number of gas power stations set the price for the whole electricity system, and the world is seeing a massive gas price spike. Beyond electricity, making high quality secondary steel means accessing well separated, low-cost scrap – scrap with impurities is expensive to refine. Steel companies can go some way to securing low-cost clean electricity and good quality scrap, but not if the policy environment makes it difficult. The rules on recycling, carbon pricing, energy markets that are set by governments are often the decisive factor.

Obvious circular economy opportunities pose challenges too: the first material efficient building products on the UK market cut steel rebar demand by up to 30% and were cheaper to install than their conventional counterparts. They launched in 1998 but by 2009 had only been used in around 60 products.[ix] Good technologies don't automatically win in the market. Part of the future for the circular economy may involve steel companies collaborating with construction companies to produce lower volume, but higher function (and therefore value) steel products. A sensible industrial policy for net zero would encourage these partnerships, with public procurement leading the way in growing the market. The EU's European Green Deal could be the home for such an integrated approach.

The big, technical challenge of making primary steel without fossil fuels looms large in all of this. It's certainly possible, but nobody knows which route will be cheapest or most scalable. Hydrogen looks like a strong bet, and at least six countries (including the UK) have meaningful public and private funding commitments to hydrogen clusters and hydrogen steel plants, with smaller scale trials becoming increasingly common. What's needed to progress these is a mechanism to accelerate projects that can plausibly produce commercial zero carbon steel, and to ensure that projects that are stalling or unlikely to be commercially or technically successful are not approved or supported via public money – the UK's example of a new metallurgical coal mine which could be 'net zero' through unsustainable offsets is a good if obvious example of the latter.

Whichever route is chosen, there are terrifying transition risks. The steel sector globally is oversupplied already, and the "majority of operating steel plants facing repowering or retirement this decade, the steel sector is poised to either lock in continued emissions or put an estimated $70bn of investment at risk of stranding."[x] The sums and jobs involved, never mind the national pride and security questions outlined above, are large enough that the state will be drawn into the transition. The question is whether it engages intelligently and early, enabling a rapid and profitable move to clean steel production, or whether it engages late, in which case clean steel pioneers will be hampered even though they will probably outcompete climate laggards over the course of the decade.

Building a rapid transition

Good policy will need to secure investment and the prospect of profit through the coming clean steel transition. There are some ready lessons to learn from the UK's energy transition over the last decade, which enabled clean energy pioneers to build a robust investment case by combining:

- **A rapid phase out of the worst:** for energy, regulation made coal the producer of last resort – a potential future for high carbon steel producers will be one in which they cling on in booms and become terrifyingly expensive stranded assets in busts, with major consequences on employment in countries that don't act quickly to decarbonise. The worst may even find themselves excluded from markets entirely, initially via carbon border adjustments and then via global sectoral agreements, like those that covered CFCs in 1989, HFCs in 2016, and are shaping up for methane. [xi]

- **A major public commitment to R&D, with deployment forming as important a public policy goal as research: for energy, this approach enabled the offshore wind sector to go from high cost, high subsidy operation to providing subsidy-free power in less than a decade.** The experience shows that public support will and should be time limited and designed to enable innovation. Doing so means being alive to detail: support for steel will need to map onto the diversity of the technology improvements and innovations needed – from H2 production in DRI to advanced EAF practice (to deal with excess nitrogen) to more efficient scrap steel separation (to avoid excess copper).

  Smart policy operates like a savvy investor, looking at plant age profile; [xii] physical

opportunities (e.g. the prospect of on or offshore wind PPAs to provide cheap clean power, or CCUS cluster proximity for blue hydrogen and blast furnace abatement); the skill mix and research base a country has, because cheap raw materials alone don't make for a competitive steel business; and finally a country's economy-wide decarbonisation approach – not least because that will determine the demand for low and zero carbon steel.

Finally, good policy will have to attend to trade in ways it did not for the initial phase of the clean energy transition – electricity is largely consumed locally. A large share of steel is a commodity product with small margins, with state aid sometimes shielding polluters from more efficient international competition. But this situation is changing.

What can we do now

There's no question the steel sector is ready to decarbonise. Companies representing 80% of industrial sector emissions have now set net zero goals, with major steel producers including ArcelorMittal, China Steel, LIBERTY Steel, Nippon Steel, thyssenkrupp, and Tata amongst this group. It's now the norm to have a net zero goal – partly as a result of investor pressure, and partly as a social licence to operate.

Net zero – often by 2050 and therefore outside the immediate investment horizon – is no longer a differentiator. Increasingly focus will shift from target setting to the quality of action taken to achieve net zero in the near term, and therefore to the policy environment and business case for near term decarbonisation. It is easy to set long-term goals, and much harder to deliver on them with integrity.

Already, steel purchasers are beginning to insist on lower carbon steel to decarbonise their scope 3 emissions: Volvo and BMW are buying zero carbon steel, and the SteelZero group has begun to set out standards for their future steel purchases.[xiii]

COP26 can add to this momentum by building support for global zero carbon steel standards, encouraging more companies to commit to purchasing zero carbon steel this decade, and to begin a conversation about mandatory measures for both steel's carbon content and its use in a circular economy.

National governments can act in concert: the UK could adopt the advice of its Climate Change Committee and set a target for near zero carbon ore-based production by 2035 and build on demand-side policy hinted at in its Net Zero Strategy, with measures to address embodied carbon in cars and buildings. Countries in the EU could progress their collective carbon border adjustment mechanism. Our work over the next year will develop these ideas into policy that can be implemented quickly.

More than anything though, investors can begin to run the numbers on what a clean-energy style disruption would mean for high carbon steelmaking, and shift their investments to locations with near-term decarbonisation opportunities. The lesson of the past decade is that betting against new and clean technologies was bad business, and the success of the Paris climate conference was in how fast it helped the real economy decarbonise.

i An average of around 10 tonnes of steel in UK, USA, Japan, Australia: http://www.industrialecology.uni-freiburg.de/research/Documents/RECYCL-D-12-00359_Self_Archive.pdf

ii https://www.ibef.org/industry/steel.aspx

iii 11% of global CO2 emissions; 7% of global CO2e emissions: https://www.globalefficiencyintel.com/new-blog/2021/global-steel-industrys-ghg-emissions

iv https://www.unep.org/news-and-stories/press-release/cut-global-emissions-76-percent-every-year-next-decade-meet-15degc

v Wind and solar are cheaper than even existing coal power stations in China, Japan, Europe, and India. https://www.renewableenergyworld.com/solar/report-its-now-cheaper-to-build-new-solar-than-to-run-existing-coal-plants-in-china-india-and-most-of-europe/#gref

vi https://www.creds.ac.uk/wp-content/uploads/CREDS-Resource-efficiency-scenarios-UK-technical-report.pdf

vii See, for example, https://www.sciencedirect.com/science/article/pii/S235271022100406X

viii https://www.reuters.com/world/uk/liberty-steel-restarts-uk-plant-night-save-energy-costs-2021-10-28/

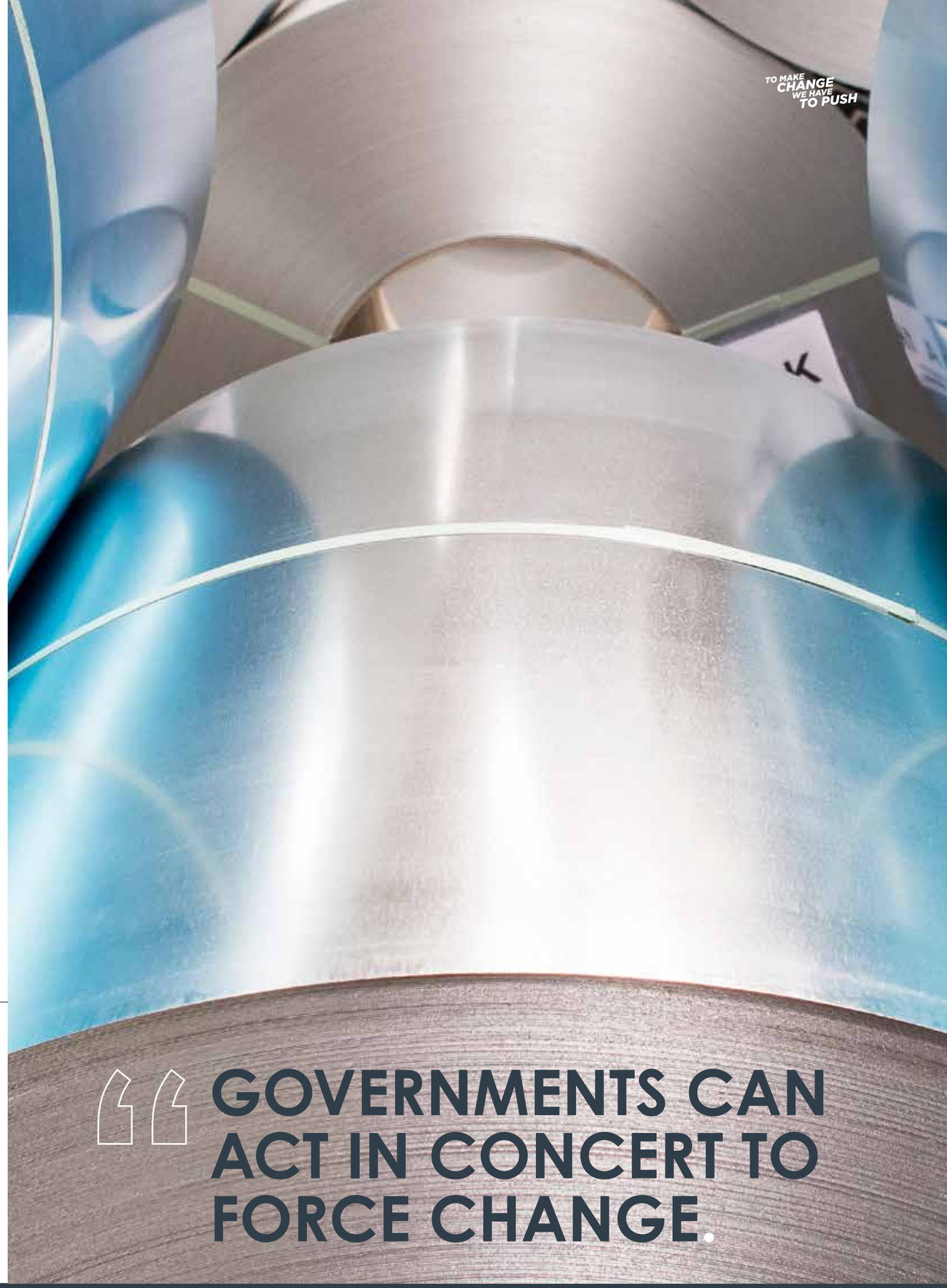
ix Ibid, https://www.creds.ac.uk/wp-content/uploads/CREDS-Resource-efficiency-scenarios-UK-technical-report.pdf

x https://www.carbonbrief.org/guest-post-these-553-steel-plants-are-responsible-for-9-of-global-co2-emissions

xi The US and EU announced they would cut methane emissions by 30% by 2030 and have since been joined by 20 other countries: https://www.reuters.com/business/environment/exclusive-us-eu-line-up-over-20-more-countries-global-methane-pact-2021-10-11/

xii https://www.iea.org/data-and-statistics/charts/age-profile-of-global-production-capacity-for-the-steel-sector-blast-furnaces-and-dri-furnaces

xiii SteelZero members | Climate Group (theclimategroup.org) https://www.theclimategroup.org/steelzero-members



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