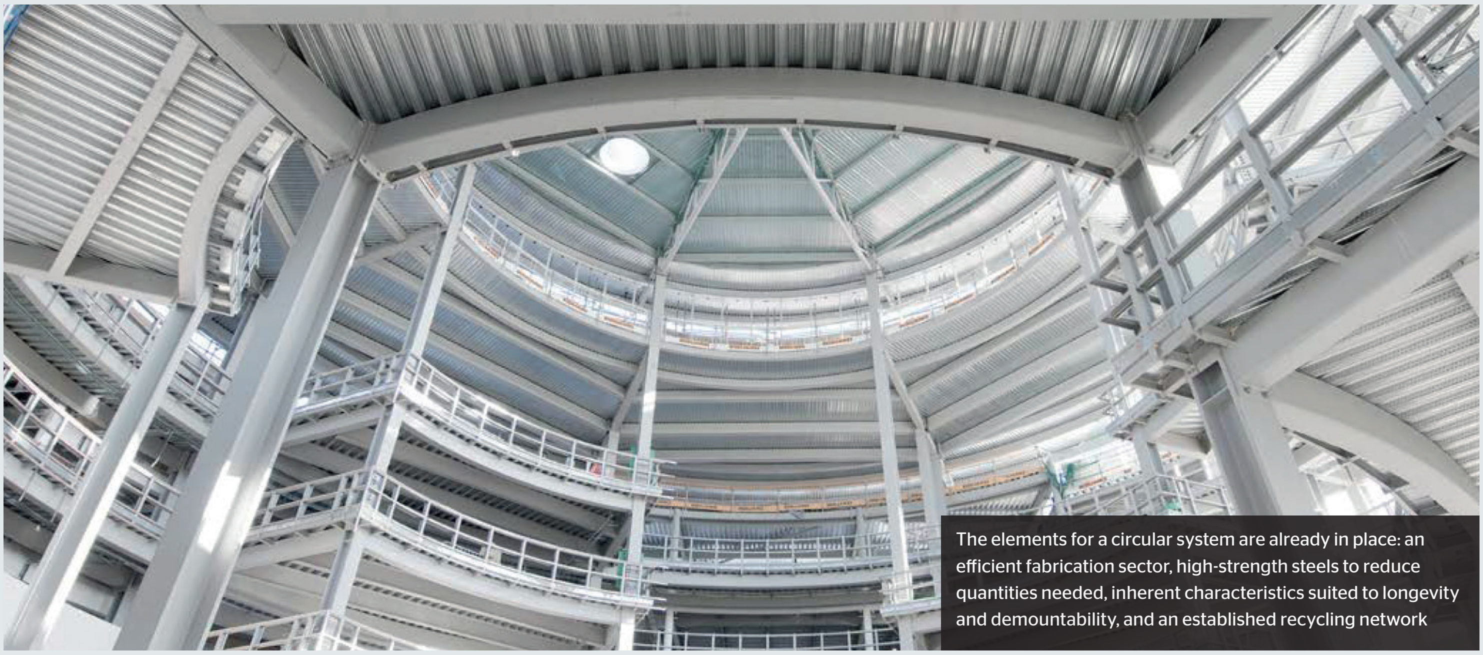
CPD 1

DECARBONISING STRUCTURAL STEELWORK

This Steel for Life sponsored CPD explains the roadmap produced by the BCSA to decarbonise the UK structural steelwork sector to meet the UK net zero carbon target by 2050



The elements for a circular system are already in place: an efficient fabrication sector, high-strength steels to reduce quantities needed, inherent characteristics suited to longevity and demountability, and an established recycling network

Introduction

A new roadmap setting out how the UK structural steelwork industry will decarbonise to meet the UK's net zero carbon target by 2050 has been assembled by companies working in the sector, together with the BCSA.

While much progress has been made in recent decades to reduce the energy and carbon intensity of steelmaking, more needs to be done to meet climate targets. Action is required from all parts of the supply chain: designers, steelwork contractors, steel producers and stockholders, and demolition contractors, all working closely together on both demand-side and supply-side reduction measures.

The scale of the challenge is considerable, but given the right policies, incentives and financial support, the technologies outlined in this roadmap can deliver decarbonised steel structures by 2050. The breadth of available technologies and other measures is a major strength of the plan to decarbonise. It gives flexibility to respond and react to enabling policies as they are developed and implemented, and as new technologies are commercialised at different timescales.

The prize is a big one, namely a truly circular and sustainable model in which steel structures are constructed, adapted and extended to prolong building lifetimes and, ultimately, routinely deconstructed and reused. Where this is not possible, in the new model the steel is recycled in electric arc furnaces (EAFs) powered using zero carbon renewable energy, to be used again in the same or a new application.

The importance of steel

Steel is the backbone of modern economies and underpins many industrial sectors, including construction, which accounts for more than half of all steel use globally. The material also has a vital role to play in facilitating the transition to a zero carbon economy, along with the industrial and infrastructure revolution that will be required if the UK is to decarbonise by 2050. Such infrastructure will include wind turbines, solar harvesting and other renewable energy technologies including tidal, hydrogen production facilities and networks, nuclear power and biomass plants.

Using current commercial technology, steelmaking is carbon-intensive. Globally, steel production accounts for around 8% of all greenhouse gas emissions, according to the International Energy Agency. But steel is also the world's most recycled material, with excellent circular economy credentials. By delivering this roadmap, steel construction can offer a net zero, sustainable and truly circular future.

Significant progress has already been achieved in decarbonising the steelmaking process. For example, the carbon intensity of UK steel production has been reduced by around 60% since 1960 and by 20% since 1990; the baseline for the UK's 2050 net zero reduction targets, according to the World Steel Association.

More needs to be done, however, and this roadmap shows how the UK structural steelwork sector will substantially reduce emissions by 2030 and be net zero by 2050, while continuing to deliver safe and sustainable buildings.

While reducing greenhouse gas emissions »

» amid the threat of climate change is a priority and is the focus of this roadmap, the benefits of steel and steel construction systems within a broader sustainable context should not be forgotten. These benefits include:

- Steel structures are lightweight and structurally efficient.
- Fabricated offsite, steel offers quality assured, fully tested and traceable products.
- Steelwork design and fabrication is BIM-led, providing a digital-twin enabling future reuse.
- On-site construction is safe and fast, with minimal local adverse environmental impacts.
- Structural steel is fully recyclable and many structural elements are reusable.
- Steel-framed buildings are flexible to change of use and steel structures are easily adapted.

The constructional steelwork market

The UK constructional steelwork market is worth approximately £1.6bn per year and employs about 60,000 people in fabrication and erection.

Steel's market share of UK buildings, compared with other constructional materials, has increased significantly since the 1980s and is now the highest in the world. Steel's market share of the single-storey (shed-type) buildings market is 98%, and it has approximately 65% of the multi-storey non-domestic buildings market. This is the result of a combined push in market development, new construction solutions and improvements in efficiency and productivity.

The industry is now applying the same determination, innovation and expertise to the climate emergency and believes it will meet the government's carbon challenge to be net zero before the 2050 deadline.

The scope of products in the roadmap includes:

- Hot-rolled steel sections
- Steel plate
- Structural hollow sections.

Although these products are globally traded, currently more than 90% are supplied to the UK market by UK and European producers. This is important because, underpinned by EU and national legislation, most UK and EU steelmakers have already committed to decarbonising steelmaking by 2050.

A range of technologies underpin the roadmap, most of which are proven and many already at the pilot and demonstration stage. Their technology readiness level is provided as evidence that the sector is already engaged, committed and investing in the transition to net zero by 2050.

Steelmakers and steelwork contractors can choose from a variety of decarbonisation strategies to implement these different technologies at varying timescales. Which strategy they opt for depends on factors such as geography, local infrastructure and synergy with other industries, cost and available finance, national and international policy and commercial readiness.

However, such technologies are only part of the plan. It is vitally important that the right incentives, policy, infrastructure and funding are created and put in place so that the technologies outlined are commercially deployed to the required timescales. These are required both nationally and internationally in order that there is a level playing field for decarbonising steelmaking.

The sector's vision for a zero carbon future

The role of structural steel in the circular economy is already proven, through a well-established scrap network that today recovers 99% of all UK structural sections, 86% of which goes for recycling while 13% is for reuse.

Fast forward to the end of the century. All the blast furnaces, equipped with carbon capture, use and storage (CCUS) technologies, have now been decommissioned and replaced with EAFs for primary steelmaking using hydrogen-DRI (direct reduced iron) where required.

Throughout this century, global scrap supply has steadily increased and reduced the demand for DRI and iron ore. By 2100, the availability of scrap means that DRI is no longer required, and the industry now operates in a truly circular way based on 100% scrap feedstock using EAFs powered by zero carbon renewable energy.

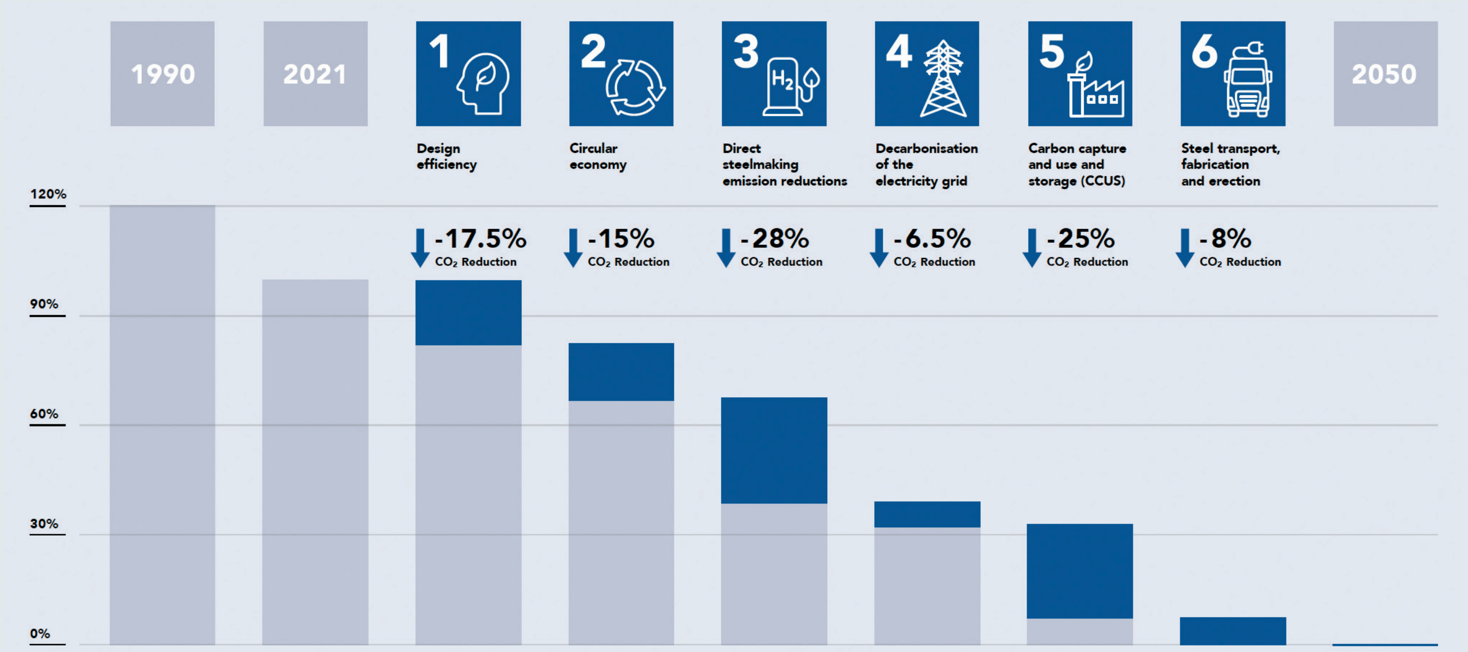
But that is only half of the story. In the second quarter of the century, designers and the supply chain capitalised on the inherent demountable attributes of steel structures to enable mainstream reuse of structural elements.

Some may regard this as fantasy, but according to the World Steel Association, 37% of steel globally is already made from scrap, limited only by current availability, suggesting that a truly circular system is achievable.

The six levers of steel's decarbonisation

The 2050 roadmap is based on six decarbonisation strategies or "levers" which the sector plans to develop and deploy concurrently. The diagram below shows the absolute carbon reductions

Absolute carbon reductions attributable to each of the six decarbonisation strategies (levers) in the 2050 roadmap



attributable to each lever leading up to 2050. While levers are presented as distinct steps, the transition to net zero by the middle of the century will be a complex journey involving a diverse mix of technologies.

The roadmap represents the most likely route to this outcome, based on the current state of development of steelmaking technologies and the various pilot and demonstration studies already under way in the EU and the UK as well as other planned initiatives, for example relating to reuse.

Some will be more successful than others. Similarly, some will be commercialised sooner than others. Nevertheless, the range of technological options available, coupled with their technology readiness, provides flexibility and multiple options to achieve the 2050 net zero target.

The six decarbonisation "levers" are as follows:

1. Design efficiency

Demand reduction through greater design efficiency is an important component of the roadmap. In the short term, while new steelmaking technologies are further developed and commercialised, material efficiency gains will deliver early, significant carbon reductions. Demand reduction does not mean fewer steel buildings but rather involves smarter, more efficient design, allowing the same structural function to be performed using less steel.

Specific structural steel efficiency measures include:

- Reducing over-specification of structural steel, such as more efficient and less conservative design
- Reducing over-specification of design loads
- Reducing applied loads (although it must be noted that this may hamper future building flexibility)
- Section and profile optimisation that tailors components to their required functionality, using higher-strength steel to facilitate the use of lighter members (for example, an S460 grade column weighs 32% less than a standard S355 grade column of the same length and thickness)
- Extending building lifetimes by designing for adaptability and designing for internal flexibility, such as using long spans.

2. The circular economy

Steel in general, and structural steel specifically, is highly compatible with circular economic models. To drive optimum resource decision-making, it is important we look at whole-life impacts, including the whole-life benefits of our buildings and of the components used to construct them.

In the context of the new roadmap to decarbonisation, the circular economy delivers carbon emission reductions through demand reduction measures relating to extending building lifetimes and preserving the value of steel products through reuse and recycling.

Structural steel is fully recyclable and many elements are reusable, making the material naturally amenable to a circular economy

A whole-lifecycle assessment approach should be taken which considers all emissions produced over the entire life of the building, from sourcing through construction and use to disposal (cradle to grave). Delivering a low carbon building that requires significant maintenance during its lifetime or uses materials that cannot be reused or recycled can lead to future unintended consequences, which the whole-lifecycle assessment takes into account.

Steel structures can offer predictability on the reuse and recycling potential of building elements, helping to drive the circular economy. In terms of lifecycle assessment, the benefits of recycling and reuse are accounted for separately as beyond-life credits, technically referred to as Module D in European CEN standards.

For steel products, Module D generally gives a benefit by accounting for new material not needing to be manufactured in future, although for some less well-recycled materials, the opposite could be true.

In the context of structural steelwork, there are other circular economy attributes that yield further whole-life benefits. These include:

- Durability and resilience
- Flexibility and adaptability
- Versatility
- Reuse and remanufacture
- Recycling.

3. Direct steelmaking emission reductions

Steelmaking emission reduction technologies range from step-change technologies such as hydrogen to incremental performance improvements in energy/carbon intensity of specific furnace processes and include a range of best available technologies, many of which can be retrofitted to existing steel mills.

Emission reduction technologies deployed in many UK and EU steel mills include:

- Waste heat recovery systems in which heat is recirculated to preheat input streams and generate electricity
- Coke dry quenching, which recovers the latent heat from the hot coke output of coke ovens and uses it to generate electricity
- Top pressure recovery turbines, which use the pressure and heat of the blast furnace gas for electricity generation
- Injection of natural gas or process gases, such as coke oven gas, into the blast furnace in addition to or in place of pulverised coal injection
- Increased use of scrap in the basic oxygen furnace (BF-BOF) and EAF processes: in both production routes maximising scrap reduces CO_2 emissions
- Use of biomass and biowaste materials, such as sustainable forestry and agriculture residues, to produce bioenergy for steelmaking.

4. Decarbonisation of the electricity grid

Industrial decarbonisation, including steelmaking, requires clean electricity and so it is critical that the infrastructure is in place to deliver this. Decarbonisation of the UK electricity grid reduces the carbon intensity of both BF-BOF and EAF production. The impact of grid decarbonisation has a greater influence on scrap-based EAF production because electricity is the primary energy source and can contribute over 50% of a steel product's carbon footprint.

It is assumed that by 2050, and probably long before, the UK electricity grid will be almost decarbonised in line with national targets. For example, the UK National Grid estimates that the grid carbon factor (or carbon intensity) will have fallen to 47g CO_2/kWh by 2030, a reduction of 72% compared with 2019 emissions intensity. »

» The impact of grid decarbonisation on UK steelmaking is also heavily dependent on whether there is a shift from BF-BOF to scrap-based EAF steel production. In the UK, where there is currently more scrap steel available (currently around 10 million tonnes a year) than is used, then a shift from BF-BOF to scrap-based EAF production yields a greater benefit from grid decarbonisation.

Meanwhile, in order to facilitate a large-scale shift to scrap-based EAF there will be a need for an appropriate supply of affordable renewable energy.

5. Carbon capture and use and storage

Carbon capture and use and storage (CCUS) refers to a suite of technologies that involve the capture of CO_2 from large point sources, including power generation or industrial facilities that use either fossil fuels or biomass for fuel. If not being used on site, the captured CO_2 is compressed and transported by pipeline, ship, rail or truck to be used in a range of applications, or injected into deep geological formations (including depleted oil and gas reservoirs or saline formations) which trap the CO_2 for permanent storage.

Both carbon capture and use (CCU) and carbon capture and storage (CCS) will play an important part in the decarbonisation roadmap. Whereas CCS permanently stores captured carbon, CCU converts carbon into commercially viable products such as bio-oils, chemicals, plastics and fuels. These can be used in place of products made from fossil fuels, with the net effect of reducing greenhouse gas emissions.

A key attraction of CCUS technologies is that they can be retrofitted on existing BF-BOF steel plants without significant changes to existing equipment, which makes them easier and cheaper to deploy.

Carbon dioxide utilisation or "carbon recycling" technologies are also under development. These technologies use or convert CO_2 into new carbon-based products, including fuels such as methanol and chemicals such as ethylene.

In the UK, CCUS hubs or clusters are being developed including Zero Carbon Humber, which includes British Steel. The principal benefit of the hub approach to CCUS deployment is the possibility of sharing CO_2 transport and storage infrastructure for increased efficiency.

6. Steel transport, fabrication and erection

Some steelwork contractors are investing in renewable technologies such as wind turbines, biomass units that produce heat using locally sourced woodchips, and anaerobic digestion plants. Technologies used in the fabrication shop include simple ideas such as changing to LED lighting, compressed air leak detection and efficiencies to reduce leaks in compressed air and gas systems, power optimisation, inverters to control the speed of electrical drive motors so the speed is increased only when needed, and the use of new-generation weld sets.

Many steelwork contractors are also investing in hybrid or fully electric company vehicles, maintenance vans and electric equipment on site to reduce emissions. Steel is a valuable material and consequently most steelwork contractors have systems in place to minimise waste.

During procurement, steel sections are ordered by length to reduce the amount of waste material that will be generated, with any residual scrap being repurposed or recycled. Nesting techniques are used when cutting steel plates to minimise waste, and any temporary steelwork used during erection is recovered for reuse in future projects. Any material that cannot be reused is recycled.

Any unavoidable residual carbon emissions are offset through verified carbon offsetting schemes that are aligned to the UN Sustainable Development Goals. Recently some steelwork contractors announced that all their UK facilities are carbon neutral, and it is likely the majority (by tonnage) of constructional steelwork fabricated in the UK and Ireland will be carbon neutral by 2030.

The fabrication industry's reliance on offsetting will decrease over time as new and better technologies are employed to further reduce the remaining emissions. With more company-level roadmaps featuring science-based targets in the pipeline, it is anticipated that the industry will achieve net zero by or before 2050.

Conclusion

The UK structural steelwork sector is committed to delivering structural steel and sustainable steel buildings in line with UK net zero 2050 targets.

Decarbonisation is a significant challenge for steelmaking, just as for many industrial sectors. However, the new roadmap shows a credible pathway to transition to net zero by 2050. It demonstrates that the sector has multiple options, many of which are already at industrial pilot stage, for achieving net zero.

Steel is the cheapest "harder to abate" industrial sector to decarbonise, according to consultants McKinsey, with an average abatement cost estimated to be around £90 per tonne of steel.

Technologies are only part of this transition. Policies and frameworks, both nationally and globally, are needed to ensure a level playing field for steel producers and to provide the financing necessary to commercialise new, and to adapt existing, steelmaking technologies. Integration and co-operation with other sectors, notably renewable energy, CCUS and hydrogen, will also be vital.

The UK structural steelwork sector is addressing the urgent need to reduce carbon emissions in line with national targets and in doing so will transition to becoming carbon neutral, fully circular and truly sustainable.

QUESTIONS

1. The carbon intensity of UK steel production has been reduced by around what since 1960?
a. 40%
b. 50%
c. 60%
d. 70%
e. 80%

2. According to the World Steel Association, what percentage of global steel today is made using scrap?
a. 30%
b. 31%
c. 35%
d. 37%
e. 39%

3. A large-scale shift to scrap-based electric arc furnace (EAF) production of steel will require what?
a. A supply of affordable renewable energy
b. Legislation that mandates the use of scrap
c. Financial incentives
d. The agreement of customers to use EAF technology
e. Costs of raw materials to come down by more than half

4. The average abatement cost of decarbonising steel per tonne is what?
a. £80
b. £90
c. £120
d. £150
e. £175

5. A key attraction of CCUS technologies is what?
a. They are heavily backed by the UK government
b. It is easy to import the equipment necessary
c. They are made in the UK
d. Construction clients like them
e. They can be retrofitted onto existing BF-BOF steel plants easily and cheaply

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