Low embodied carbon steel

Reinforcing a low carbon future or pipe dream?

MECLA

The issue

The iron and steel industry contributes approximately 7-9% of global greenhouse gas emissions.

In order to ensure a sustainable future, the industry must find ways to cut emissions in line with international goals to limit climate change.

What is 'green steel'?

Does green steel mean low embodied carbon, near zero embodied carbon, net zero embodied carbon, 100% recycled content, ethically sourced, responsible steel or simply steel that painted green?

The truth is there is no commonly used definition of 'green' steel.

'Green' can have multiple positive environmental impact meanings and, like most claims, the devil is in the detail. So, check with the claimant to see what they meant when they said 'green steel'.

The following organisations and initiatives are useful information sources on the decarbonisation of the steel industry.

worldsteel

worldsteel defines low-carbon steel as steel that is manufactured using technologies and practices that result in the emission of significantly lower CO_2 emissions than conventional production. It also notes there is no single solution to reducing CO_2 emissions from the steel industry. The worldsteel paper on Climate change and the production of iron and steel provides an overview of key technologies and timelines for decarbonisation of the steel industry.

Net Zero Steel Pathway Methodology Project

A project established by the global steel industry, including BlueScope and GFG Alliance to enable the steel sector to support the achievement of the Paris Agreement objectives through a credible, well informed sectoral decarbonisation approach ; and resolve the challenges by defining what is expected from a steelmaker to make a realistic and credible commitment to the Paris Agreement, with a net zero or 'science based target'. The project identifies distinct decarbonisation pathways for EAF and BF-BOF steelmaking (refer p3).

ResponsibleSteel™

ResponsibleSteel is the steel industry's first global multi-stakeholder standard and certification initiative. The site standard comprises 12 'Principles', including Climate Change and GHG emissions (Principle 8). Requirements include a corporate commitment to achieve the goals of the Paris Agreement and site level GHG reduction targets, planning and disclosure.

A site must meet the requirements of all relevant Principles, including but not limited to, Biodiversity (Prinicple 11), Human rights (Principle 5) and Labour rights (Principle 4), to achieve certification.

Will specifying low embodied carbon steel drive the steel industry to speed up its efforts to reduce emissions?

Specifying low embodied carbon steel from an EAF for a particular building or project does not change the overall emissions profile of the steel industry.

Rather, doing so shifts the burden around the value chain, and may actually increase the burden, as scrap, and the final product, may be transported around the globe.

How can industry support the steel sector to decarbonise?

- Consider climate change commitments of the steelmaker and ask to see the decarbonisation pathway that supports targets
- Support manufacturers who are transparent e.g. have a product-specific Environmental Product Declaration (EPD)
- Specify steel from manufacturers who are certified to a credible stewardship scheme e.g. ResponsibleSteel™
- Understand the role of primary and secondary steelmaking in meeting overall steel demand and their differentiated decarbonisation pathways via the Net-Zero Steel Pathway Methodology Project
- Support manufacturers who are participating in emissions reduction and research and development activities e.g. Australian Industry Energy Transitions Initiative / worldsteel StepUp™ Program
- Consider offsetting as part of a broader program of decarbonisation e.g. products with Climate Active certification.

If steel is 100% recyclable, why can't we stop making virgin steel today, and only make net-zero steel with 100% recycled content steel using 100% renewable energy?

Most steel products remain in use for decades before they can be recycled. Currently there is not enough recycled steel to meet growing world demand using the EAF steelmaking method alone and there is a need to produce primary steel from raw materials. Overall steel demand is met through a combined use of the ~70% BF-BOF and ~30% EAF production methods.

The Blast Furnace – Basic Oxygen Furnace (BF-BOF) can't eliminate its emissions by switching to renewable electricity alone. The process utilises carbon (most commonly from metallurgical coal) as the key element in the chemical reaction to extract iron from iron ore. Emissions of carbon dioxide are a byproduct of this chemical reaction.

In addition to scrap supply issues, steel production is very capital intensive, with assets that have long (often multi-decade) lifetimes. More than half of global iron and steelmaking capacity is in developing countries, with much of it only installed in the last 10 to 20 years. Accordingly, there is significant sunk investment in existing technology.

Steel making overview

worldsteel.org

Blast furnace-basic oxygen furnace

AKA: BF-BOF steelmaking

Market: ~70% global production

AU producer: BlueScope (Port Kembla, NSW), InfraBuild (Whyalla, SA)

Input materials: iron ore, metallurgical coal, recycled steel (up to max 30%)

Process: iron ores are reduced to iron in the blast furnace. Then the iron is converted to steel in the BOF.
After casting and rolling, the steel is delivered as coil, plate, sections or bars.
Currently, the only technically and commercially feasible way to produce steel from iron ore is through the use of fossil fuels as reducing agents.
The blast furnace is the dominant technology used to reduce iron ore today.
The modern blast furnace is continually being developed and refined and currently operates close to the efficiency limit of the reduction process.

Electric arc furnace steelmaking

AKA: EAF

Market: ~30% global production

AU producer: InfraBuild

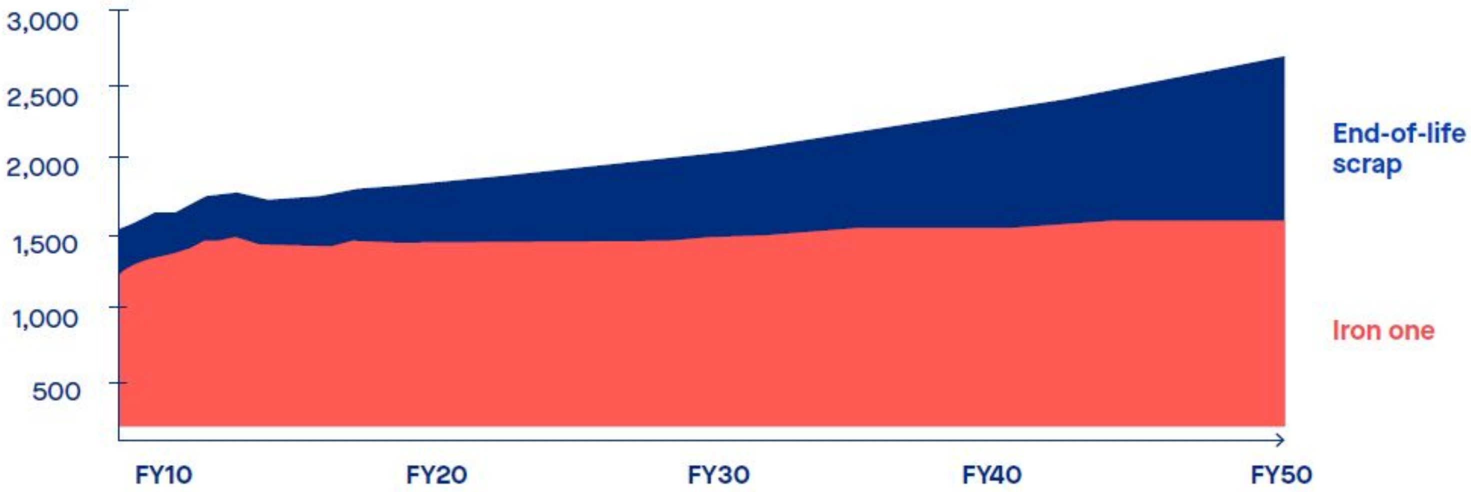
Input materials: recycled steel (up to 100%). Depending on the plant configuration and availability of recycled steel, other sources of metallic iron such as direct-reduced iron (DRI) or hot metal can also be used

Process: electricity used to melt recycled steel. Additives e.g. alloys, are used to adjust to the desired chemical composition. Electrical energy can be supplemented with oxygen injected into the EAF. Downstream process stages, such as casting, reheating and rolling, are similar to those found in the BF-BOF route.

Scrap steel market

STEEL DEMAND OUTLOOK (million tonnes)

Source: Material Economics (2018), The Circular Economy – a Powerful Force for Climate Mitigation.



The IEA predicts that EAF production will only satisfy 45% of future steel demand due to limited scrap availability and quality issues.
IEA Iron and Steel Technology Roadmap

Global scrap steel market

“The future expansion of scrap-based steel production will depend on the availability of high-grade scrap. While iron ore supply can flex with demand, global scrap availability is a function of steel demand and the arising of scrap when steel-containing products reach the end of their life.

“Every steel plant is also a recycling plant, and all steel production uses scrap. All scrap that is collected is recycled, and the overall recycling rate today is estimated to be about 85%. This high level of recycling means that there is limited room for improvement.” worldsteel

Not all scrap is created equal

Not all scrap is suitable for making all grades and types of steel in Australia. There is an important distinction between ‘prime’ or ex-manufacturing scrap and post-consumer recycled scrap. Greater proportions of post-consumer recycled scrap can be used in long steel products (reinforcing, wire, etc), whereas the impurities often present in this type of scrap steel have to be managed carefully when utilised in the production of flat steel products such as roofing and cladding.

So if we need both EAF and BF-BOF steelmaking, what is stopping BF-BOF production from reducing its carbon intensity?

In order to achieve emissions goals, the steel industry will need to adopt a combination of: breakthrough ironmaking technologies; major improvements in the emissions intensity of mature ironmaking technologies; and increases in secondary (scrap-based) steelmaking.

There is no single 'silver bullet' technology, and different countries and regions are likely to adopt different combinations of technologies to achieve climate goals, depending on local conditions. Factors that will influence the local take up of technologies include: the cost and availability of raw materials; the range and competitiveness of energy sources; consumer preferences; climate and energy policies; the age and condition of existing assets, and general economic conditions.

While encouraging work is being done globally on breakthrough 'green' iron and steelmaking technologies, which seek to replace carbon by using hydrogen or direct electrolysis-based processes, those that have the most potential to reduce GHG emissions are in the early stages of technology development.

Steel is a highly traded material, but markets are often distorted by subsidies, trade barriers and overcapacity. These factors mean that, along with technical barriers that will need to be overcome, the adoption of breakthrough technology will also need government, finance and industry support.

Solutions for reducing BF-BOF steel emissions intensity

Medium term

- Greater use of affordable, reliable renewable energy
- Increase scrap usage (dependent on availability of high grade scrap and ~30% limit)
- Optimise raw material mixes
- Capture and reuse a greater proportion of waste heat and gases
- Replace a proportion of coal with alternative reductants such as biomass or hydrogen-containing gas e.g. coke ovens gas.

Future / breakthrough technology

- Using carbon as a reductant while preventing the emission of fossil CO_2, for example using carbon capture, utilisation and storage (CCUS) and/or sustainable biomass.
- Using electrical energy through an electrolysis based process to reduce the iron ore
- Substituting hydrogen for carbon as a reductant in the ironmaking process, generating H_2O (water) rather than CO_2.

Factsheets on breakthrough technology and current pilots are available via worldsteel

What policy changes will accelerate action?

Ensure affordable and reliable low-emissions energy supply

Affordable firmed renewable energy is critical to reducing Scope 2 emissions from the BF-BOF process, to the competitiveness of EAF steelmaking, and to the introduction of breakthrough green steel technologies.

Natural gas will continue to play a role in iron and steelmaking in the short and potentially medium-term, with technology to electrify some processes or substitute green fuels not yet commercially available.

There is a key role for governments to ensure grid decarbonisation and competitive energy markets to help accelerate investment in breakthrough technologies.

Establish 'green' hydrogen supply chain

Competitive hydrogen iron and steelmaking (assuming successful commercialisation) will require ready access to a cost competitive low or zero emissions commercial-scale 'green' hydrogen supply chain.

Establishing a 'green' hydrogen supply chain is likely to be beyond the ability of any one sector and will require cooperation between industry sectors and facilitation by governments.

Co-invest with industry

Steel industry abatement projects typically have very large capital expenditure requirements, and often increase operating expenditure as well - so do not always meet investment hurdles.

Steel is a globally traded commodity. However, global steel markets are distorted by subsidies, overcapacity and dumping, and there is not a level playing field regarding the regulation of GHG emissions.

Accordingly, there is a key role for government and quasi government organisations such as the Clean Energy Finance Corporation, co-investment to help deliver abatement projects and support industry competitiveness, for the benefit of the whole community.

Support research and development

Further research and development is needed for breakthrough technologies (e.g. hydrogen DRI) and to commercialise established technologies in a local context (e.g. biochar).

BlueScope is working with a range of Commonwealth-funded agencies including CO2 CRC, ARENA and the University of Wollongong on opportunities to cut iron and steelmaking emissions.

References / Further Reading

Australian Industry Energy Transitions Initiative
https://energytransitionsinitiative.org/

BlueScope climate change action
https://www.bluescope.com/sustainable-steel/climate-change/

InfraBuild sustainability hub
https://www.infrabuild.com/en-au/technical-library/sustainability-hub/

International Energy Agency Iron and Steel Technology Roadmap
https://www.iea.org/reports/iron-and-steel-technology-roadmap

Net-Zero Steel Pathway Methodology Project https://netzerosteelpathwayproject.com/

ResponsibleSteel™
https://www.responsiblesteel.org/

SteelZero
https://www.theclimategroup.org/join-steelzero

worldsteel - breakthrough technology
https://www.worldsteel.org/steel-by-topic/environment-climate-change/climate-action/breakthrough-technology.html

worldsteel - Climate Change Policy Paper
https://www.worldsteel.org/publications/position-papers/climate-change-policy-paper.html