STEELWATCH

Why green iron trade will catalyse steel industry decarbonisation

What needs demystifying?

Ironmaking and steelmaking often go hand in hand, occurring in the same place in 'integrated steel plants', where iron ore is reduced to iron, and molten iron is used to make steel. The shift to a decarbonising, renewable energy-based economy creates drivers that will transform how and where iron is made.

Transporting green iron between countries is relatively new and under-valued contribution to decarbonising the steel industry. Some steel industry actors perceive it as a risk. The benefits - to companies, to countries, and for addressing the climate crisis - need more attention as a viable step toward decarbonising the steel industry.

This SteelWatch Explainer sets out:

- Why decarbonising ironmaking will change how and where some of the iron is produced;
- What transportable green iron is, where it might be produced or used;
- The advantages that transportable green iron can deliver; and
- Common concerns, and solutions to them.

Getting clear on a few things first:

- The climate impact of the steel industry is mostly driven by coal-based ironmaking in blast furnaces. Blast furnaces represent around 90% of global virgin iron production and underpin 70% of global steel production.
- Ironmaking and steelmaking are distinct processes; iron feeds steelmaking.
- Iron is an intermediate product that sits in the transformation chain between iron ore (extracted from mines) and steel (the metal present everywhere in our lives from buildings to vehicles to cutlery).
- Iron is made in different ways, and as a result different terms are applied: virgin iron (iron made from iron ore, as opposed to scrap) is mainly 'pig iron' or 'direct reduced iron' (see Glossary). 'Transportable green iron' here refers to iron briquettes made via direct reduction using green hydrogen.

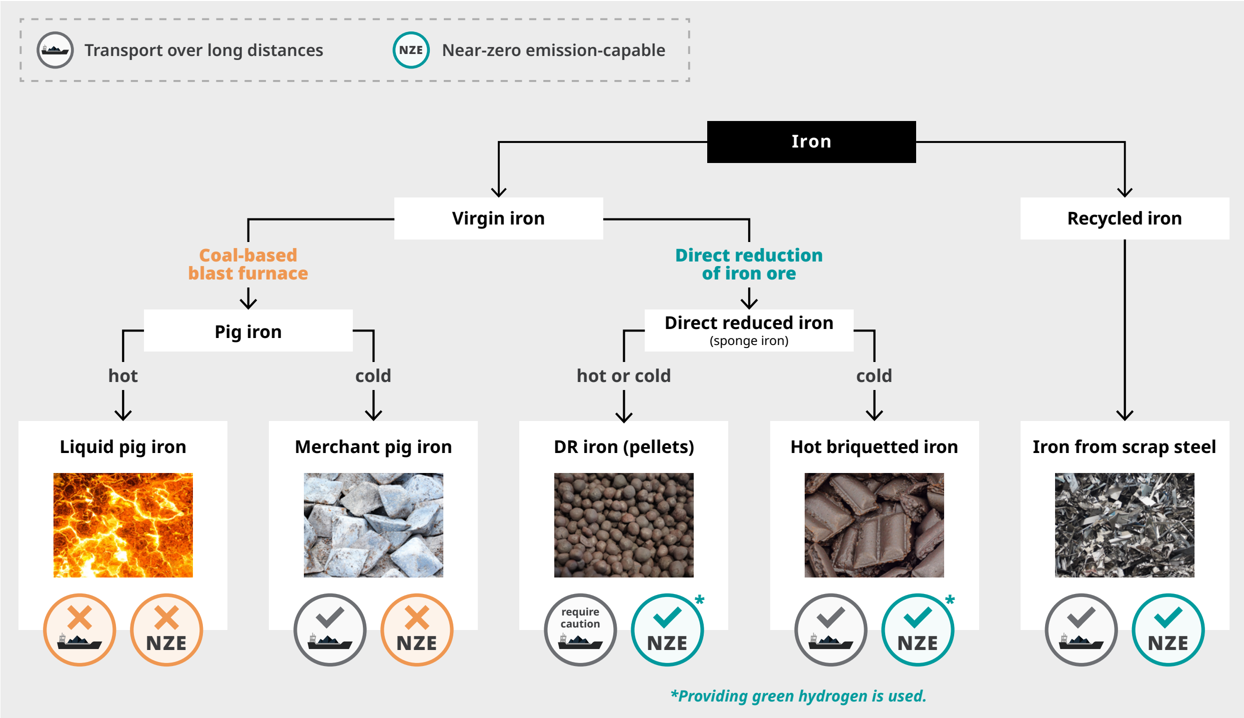
What is transportable green iron?

Traditionally, virgin iron is made in a coal-based blast furnace. Molten pig iron emerges at around 1500˚C, along with tonnes of CO_2. The more recent approach is the direct reduction of iron ore (DRI) process using gasses in a furnace or a kiln, producing what is known as sponge iron or direct reduced (DR) iron. Though still very hot (600-700°C), it is solid in the form of pellets.

Over recent decades, the DRI process has reached around 10% of global virgin iron production, but has run on fossil fuels.[1] Recently, to drive decarbonisation, green hydrogen has started to be used instead. This process - termed H2-DRI (direct reduction of iron oxides with green hydrogen[2]) - is today the only available near-zero-emissions ironmaking technology. **The product of H2-DRI is referred to as 'green iron', technically called near-zero-emissions DR iron.**[3]

DR iron, if not used on site, is transported as briquettes. They are melted, then processed into steel, either in an electric arc furnace (EAF) or in a combination of electric smelter and basic oxygen furnace (BOF). **Near-zero-emissions DR iron in forms of briquettes is what we refer to as "transportable green iron".**

Figure 1: Classification of different types of iron used for steelmaking

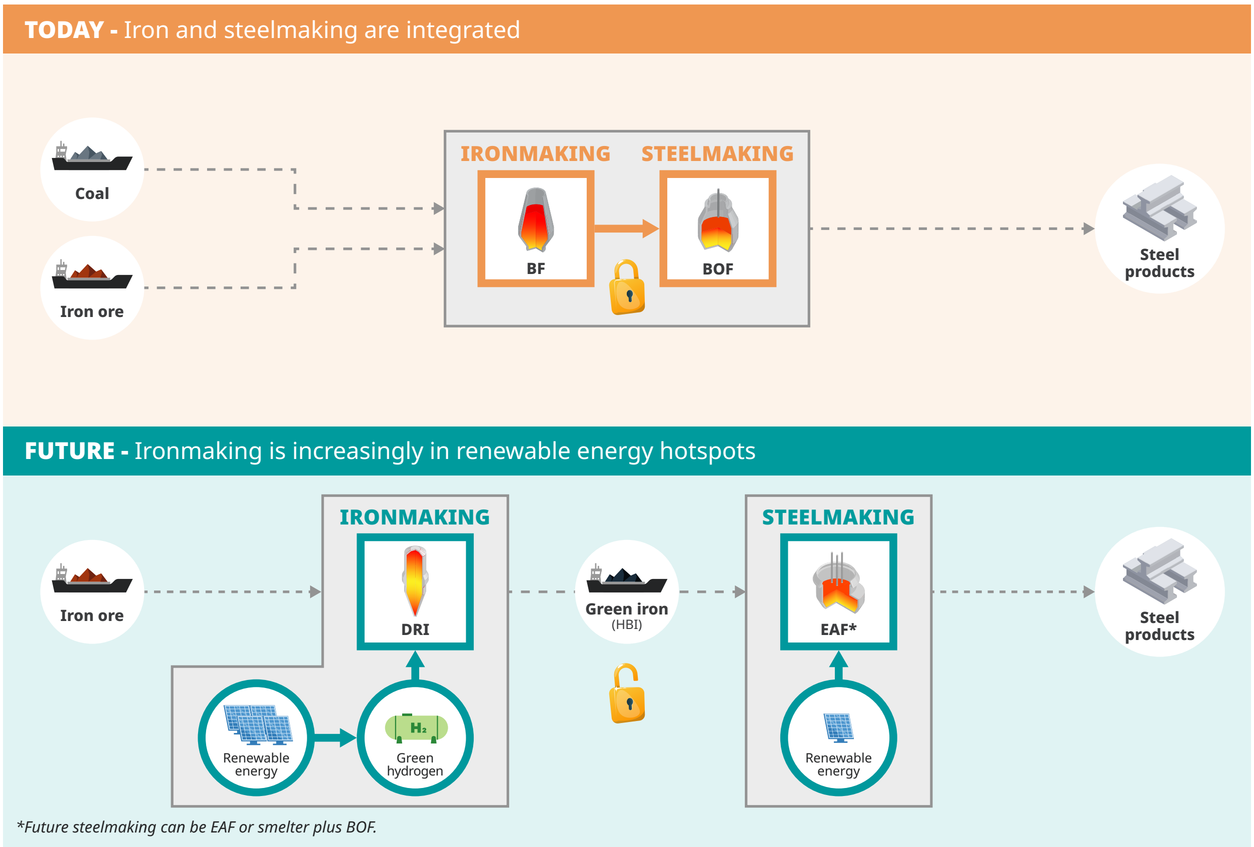


Maximising renewable energy use means decoupling ironmaking and steelmaking

Historically, ironmaking and steelmaking have been done on the same site, known as an 'integrated steel plant' and energy considerations help explain why. Proximity to coal or gas suppliers has mostly driven the location of many coal-based blast furnaces and fossil gas-DRI plants. Locating the steelmaking directly onsite with the ironmaking enables energy savings[4]: the hot iron coming out of ironmaking goes straight to steelmaking, avoiding the need for reheating. In the case of coal-based blast furnaces, they also release excess energy which steel plants have learned to capture and reuse.

Looking ahead, access to renewable energy will increasingly shape locations of green iron production. **Since green H2-DRI relies on the availability of green hydrogen made with renewable electricity, ironmaking will be pulled to regions with greater renewable electricity generation capacity, particularly those that also have iron ore.**

Figure 2: Decoupling iron and steel production by transporting green iron

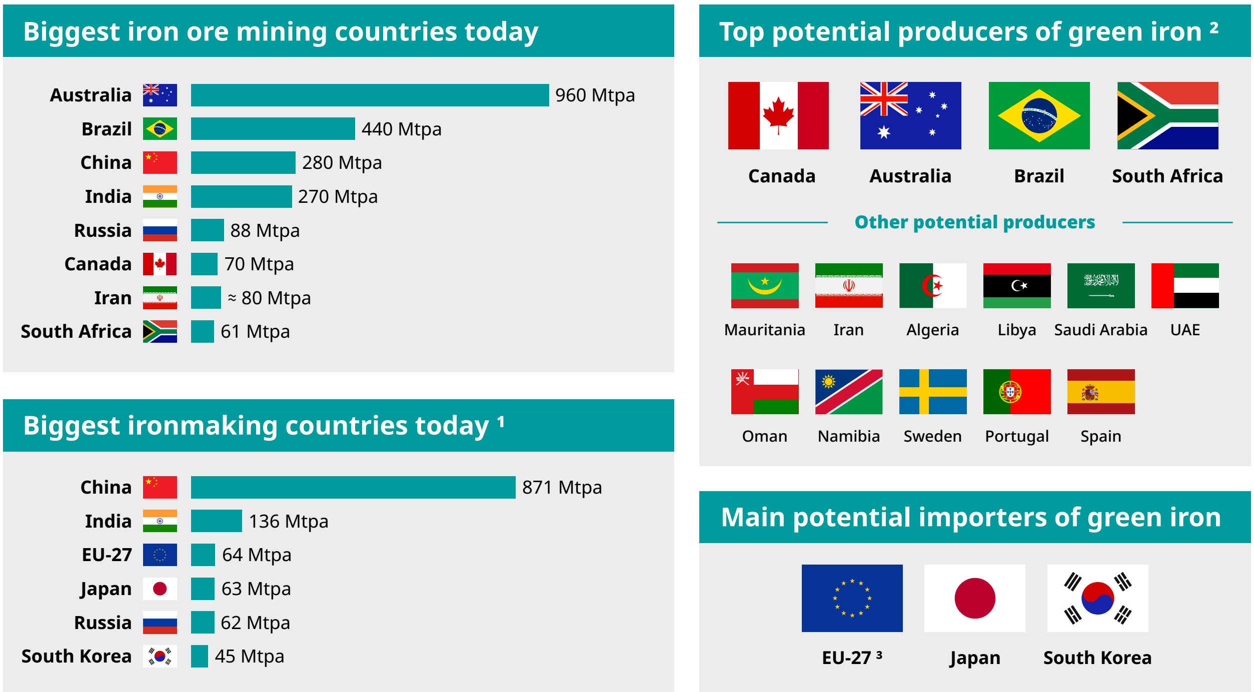


At the same time, steelmaking is less likely to relocate because steelmakers want to stay close to their end-users such as carmakers or appliance producers. **The shift to low-emissions DRI ironmaking is made easier by decoupling iron- and steelmaking.** Transportation[5] of green iron reconnects the two.

Today, the largest steelmaking countries tend to be the largest ironmaking countries (see Figure 3). Some steelmakers will continue to make iron. H2-DRI-based ironmaking reduces, but does not eradicate, the benefits of producing iron and steel in one place, particularly in terms of energy efficiency.

How much ironmaking shifts location will vary by market context. But with a growing share of H2-DRI in global virgin iron production, more standalone ironmaking will emerge in renewable electricity-rich locations, shipping green DR iron to steelmaking plants located near their end-users.

Figure 3: Iron ore mining, ironmaking, and green iron potential by country



[1] *Today, the biggest steelmakers tend to be the main iron makers, with the exception of the US due to higher scrap use.*
[2] *Potential producers based on information from RMI, Agora, IEEFA, and recent news items.*
[3] *Particularly Central and Eastern Europe*

Based on multiple sources[6] .

Transportable green iron can decarbonise steelmaking

Decarbonisation of the global steel industry is a huge undertaking that is proceeding too slowly in the face of climate change. Lack of availability of green hydrogen - in part due to shortage of renewable energy - is one major constraint. **Tapping into renewable energy hotspots for iron production is invaluable to address that feasibility constraint and speed up change.**

When compared with relying solely on H2-DRI done at existing steel plants, green iron trade offers several advantages: it can boost feasibility, reduce costs, cut transport needs for materials and bring a range of benefits to different actors.

Green iron trade can save costs

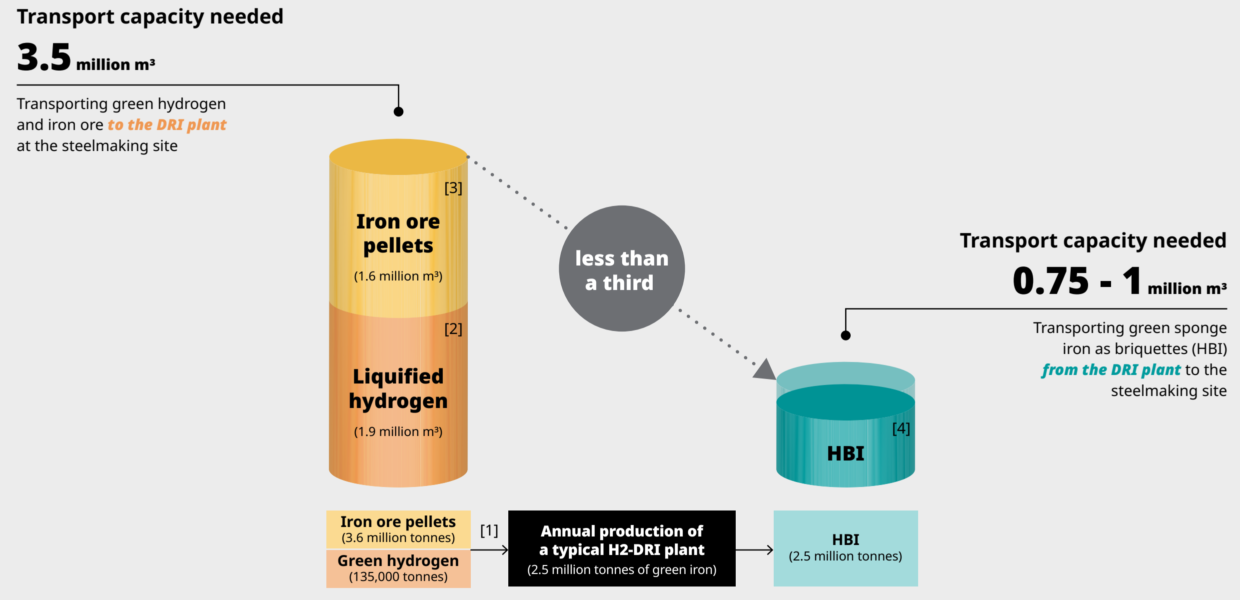
There is emerging evidence on cost savings to be achieved by producing green iron in renewable energy hotspots. One study estimates global steel production costs can be cut by 2-4% using green iron trade compared with a scenario in which DR iron and steel production continue to be co-located.

Cost savings are highest in countries with the most limited access to renewable energy. In the case of Japan, studies[7] estimate the steel production cost gap between steel made with locally-produced H2-DR iron vs H2-DR iron imported from either Australia or Canada would be around 30%. In Western or Central Europe or in South Korea, the production cost per tonne of steel would be around 20% cheaper with H2-DR iron imported from Canada than with locally produced H2-DR iron. Similar results emerge when comparing the production costs of steel made in Germany with H2-DR iron made locally versus H2-DR iron made in Australia.[8]

Shipping green DR iron requires less transport capacity

Feeding a typical 2.5 Mtpa capacity DRI plant with iron ore and green hydrogen shipped separately from overseas would imply transporting 3.5 million m^3 of materials annually, and would come with technical challenges and climate risks associated with transporting hydrogen over long distances. Conversely, shipping only the plant's output - 2.5 million tonnes of green DR iron in the form of hot briquetted iron (HBI) - would require a transport capacity of 0.75-1 million m^3, less than a third of the volume,[9] as outlined in Figure 4.

Figure 4: Savings in transport capacity from shipping green iron



[1] *Assume 1.45 tonne of iron ore pellets and 54 kg of pure H2 (for reduction purposes only, heating not included) per tonne of DRI.*
[2] *Assume hydrogen is transported as liquid hydrogen, with density of 0.07 tonne / m3.*
[3] *Assuming iron ore density of 2.2 tonnes / m3 of iron ore pellets.*
[4] *Assuming HBI density of 2.5-3.3 tonnes / m3.*

A higher-value export commodity for green iron producers

The largest iron ore exporting countries today may have the greatest advantages[10] because they tend to also be rich in renewable electricity potential. So they have opportunities to climb up the value chain and export a more processed product - iron instead of iron ore.

A study by Deloitte and WWF Australia considers that *"developing green iron manufacturing capacity offers the clearest avenue for Australia to competitively move up the green steel value chain"* and represents an opportunity estimated between 60 and 185 billion USD per year.

Countries of the Middle East and North Africa (MENA) region have less iron ore but have potential as green iron producers due to significant renewable electricity potential. This could be leveraged by importing iron ore, and producing green DR iron for export to steelmaking countries.

Today's steelmakers can gain from green iron

For some iron and steel producers (Japan, South Korea and certain European countries) where renewable electricity and green hydrogen production are limited, fully converting existing blast furnace-based ironmaking capacity into green H2-DRI may be challenging. Importing green DR iron will therefore be an essential contribution for decarbonising the iron and steel sector.[11]

In the US and China, sector decarbonisation might rely less on *imported* green DR iron, but can still benefit from decoupling ironmaking and steelmaking *within* the country, with transportable green iron provided by regions offering better conditions for renewable electricity and green hydrogen production.

Losing some ironmaking capacity does not mean relinquishing steel production. Importing green DR iron from more favourable locations actually reduces the cost of decarbonisation and of producing green steel, strengthening the competitiveness of local green steel production.

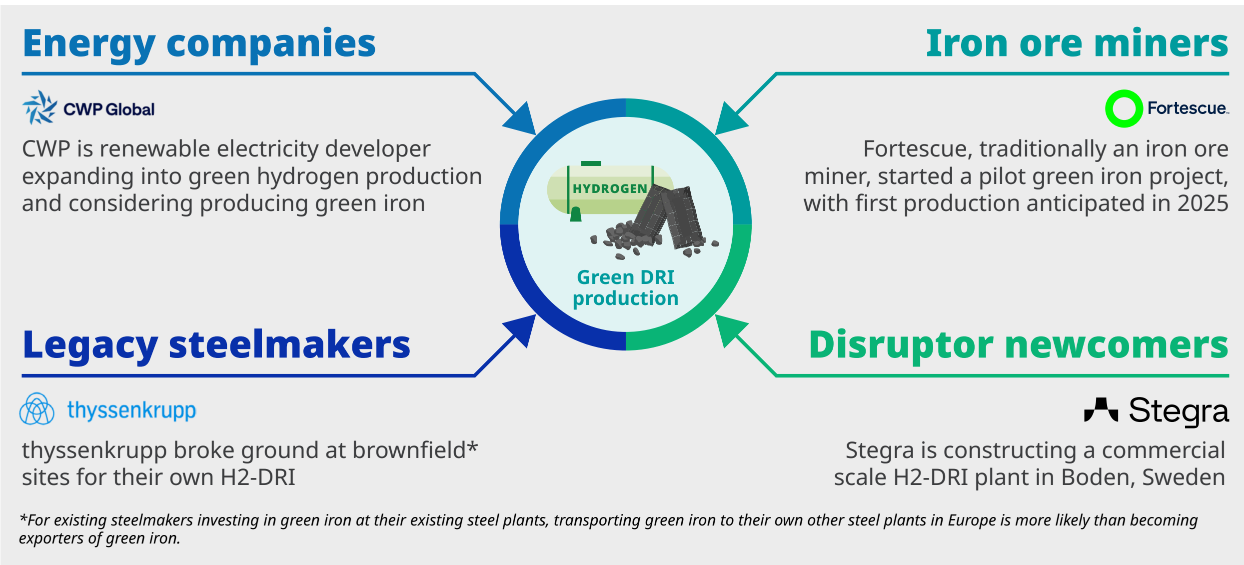
Several steelmakers, particularly in industrialised nations, are already shifting to EAFs, which rely primarily on scrap, but require some amount of virgin iron for optimal quality. Transportable DR iron can feed EAFs, complementing scrap, ensuring high quality, low-emissions production (provided renewable energy is used). So as EAF steel production advances, access to supplies of transported green iron will be increasingly important.

Innovation by new players in the iron, steel and energy industries

Decoupling ironmaking and steelmaking opens opportunities for new players (see Figure 5). Innovation and increased competition can accelerate decarbonisation and reduce costs. New entrants like Stegra in Sweden are already leveraging renewable electricity to produce green iron for export.[12]

Iron ore miners like Fortescue (in Australia)[13] and renewable electricity and hydrogen developers like CWP are entering ironmaking to climb up the value chain. Green energy producers, usually limited by the difficulty of transporting electricity and hydrogen over long distances, gain export opportunities by embedding the hydrogen in green iron.

Figure 5: Likely new players in green iron production



Challenges for transportable green iron

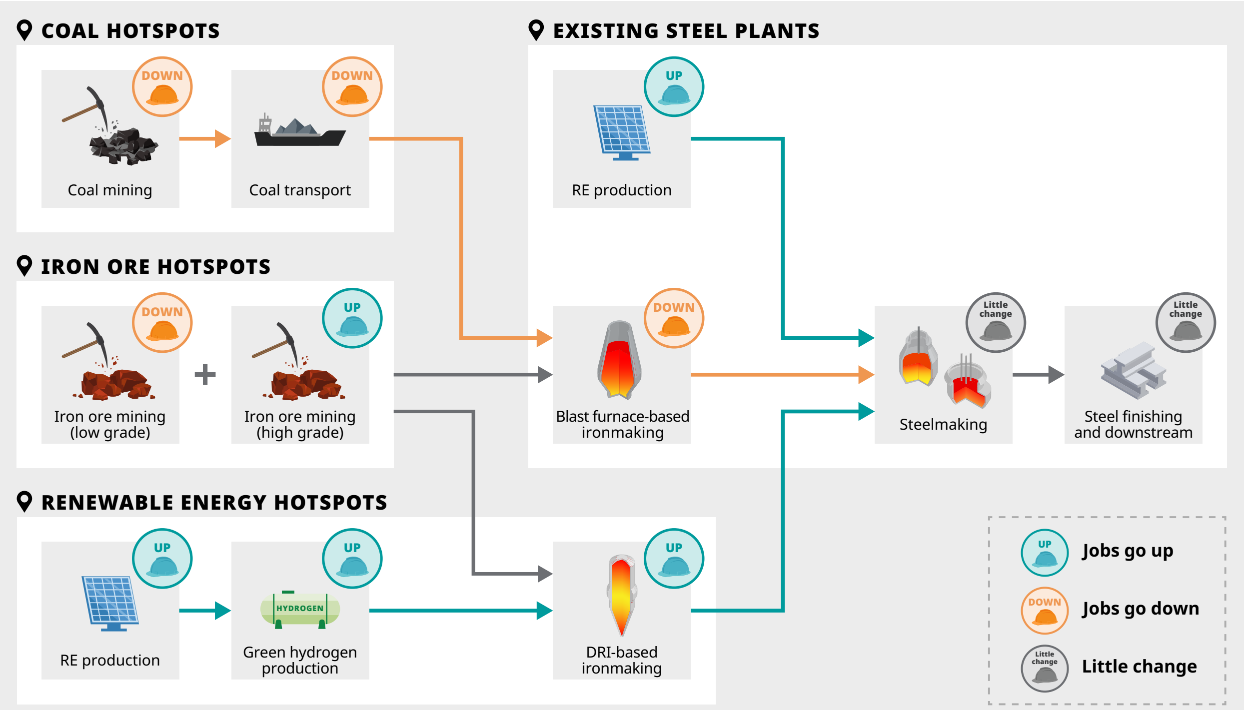
Perceived threat to national sovereignty, security and pride

In existing steelmaking countries, steel production is often seen as a foundation of national sovereignty and pride of an industrialised nation. It is also valued as an essential component for large manufacturing industries like the automotive sector, as well as strategic industries like defence. Shifting the ironmaking step overseas is seen as a potential threat and so is politically difficult to discuss. **However, since the largest steel producing countries today already rely on imported iron ore, trading green iron does not increase dependence on others.** Green iron imports are expected to come from current iron ore suppliers like Australia, Brazil, South Africa, and Canada. So current steelmaking countries can continue to make steel, while achieving decarbonisation and taking advantage of the new trade in green iron with longstanding trade partners.

Navigating job changes in ironmaking

Shifting to imports of green iron raises concerns about job losses. Ironmaking accounts for less than 10% of jobs in the steel value chain and it is these jobs that may shift. Net jobs will rise and fall at different points in the value chain and different locations (see Figure 6) and there are no robust estimates yet of total effect. There must be a just transition strategy to support affected workers. Long term, failing to transition would jeopardise the entire steel sector, including the steelmaking and finishing stages that represent over 90% of jobs.

Figure 6 : Likely net increase or decrease in jobs along the value chain



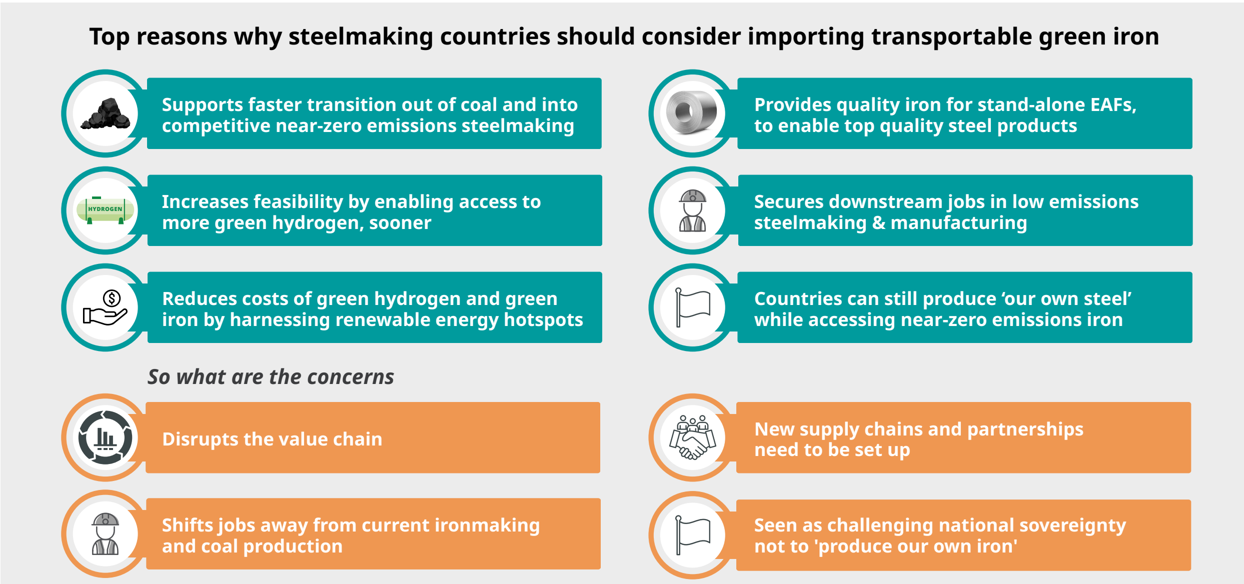
Note: *The diagram shows which locations in the value chain are likely to experience a net increase or decrease in jobs caused by a switch to a decoupled value chain using transportable green iron. Robust data estimates are not yet available.*

Practical concerns: Safety and energy efficiency

Concerns about the safety of transporting iron are common. DR iron risks reoxidation when exposed to air or water, leading to fire hazards and physical deterioration during transport. However, briquetting DR iron into HBI mitigates these risks, and HBI is already a traded commodity (although made with fossil gas). Projects like HBI C-Flex are exploring whether H2-DR iron requires additional safety measures for handling and transport.

Reheating cooled iron for steelmaking is also energy intensive, whereas feeding hot DR iron directly into steelmaking operations saves energy. However, the economic viability depends on the cost difference of renewable electricity and hydrogen between where the steel plant is located and the countries with optimal conditions to produce renewable energy and hydrogen. **Local circumstances will determine the most cost-effective approach.**

Figure 7: Pros and cons for steelmaking countries



Note: *These reasons apply to steelmaking countries that struggle to supply sufficient green hydrogen for ironmaking: such as UK, Japan, and many EU countries, particularly and central and eastern Europe.*

The future of green iron

Developing transportable green iron as a new commodity will require action across the industry. Existing steel producers should look to develop their supply chains through procurement or investment, while iron ore miners and green energy producers adapt to the new opportunities transportable green iron creates. Governments and policymakers will have a key role to play by supporting investment, trade policy, and diplomacy. Successfully driving this transition will depend on willingness to have honest conversations and negotiations that prioritise climate needs and resilience of future-fit industry.

Decarbonising iron and steelmaking means more than simply replacing coal-based blast furnaces with H2-DRI plants. It requires strategic thinking, and recognising that certain disruptions - like where iron is produced and by whom - are not just inevitable, but essential for accelerating decarbonisation.

Transformation should not be feared. In the face of the climate crisis, the question is not whether the industry can afford to change—but whether it can afford not to.

This is part of the SteelWatch Explainer series, which aims to demystify confusing issues and set the facts straight on common industry claims, so as to build understanding and momentum for transformative steel decarbonisation.

Thanks to Chris Vlavianos for editing, and to Bernt Nordman (WWF Finland) for having reviewed this SteelWatch Explainer.

GLOSSARY OF TERMS

Hydrogen / Green Hydrogen	Hydrogen (technically dihydrogen or H2) is a molecule that is both energy-rich and carbon-free. As hydrogen for the time being cannot be simply extracted, it must be produced from primary sources of energy such as fossil energy and renewables. The ultimate climate impact of hydrogen depends on how it is produced. For hydrogen to be a genuine decarbonisation tool, it must be produced in a near-zero-emission process: today that means hydrogen produced from water in electrolysers powered by renewable sources of electricity, and is known as green hydrogen or fossil-free hydrogen.
Iron	Iron is the prime ingredient of steel. It can be sourced from recycled iron and steel products (scrap), or produced from extracted iron ore.
Virgin iron or ore-based iron	This refers to iron that is produced directly from iron ore. It is contrasted with iron obtained by processing and melting scrap steel.
Pig iron	The product of a blast furnace in the ironmaking process.
DRI (direct reduced iron) / DR iron / sponge iron	Iron made through the direct reduction of iron oxides. DR iron is also called sponge iron, which refers to its porous structure.
HBI (hot briquetted iron)	A briquetted form of DR iron. It is more convenient to transport than DRI in the form of pellets, the more common form of iron produced in a DRI furnace. It is briquetted when hot and transported cold.
H2-DRI / H2-DR iron	DR iron made using hydrogen (H2) instead of fossil gas in the direct reduction process.
Green H2-DRI / Green H2-DR iron	H2-DR iron produced using green hydrogen, meaning hydrogen generated via electrolysis powered by renewable energy.
Transportable green iron	Green H2-DR iron that is briquetted into HBI form to make it suitable for transport. A technical term would be H2-DRI in HBI form.

Endnotes

1. Commonly used is fossil gas, or coal in the case of India.
2. Green hydrogen means hydrogen made in electrolysers powered by electricity from renewable sources.
3. Both incumbent steelmakers (thyssenkrupp, Salzgitter) and new entrants (Stegra) are investing in green H2-DRI-based ironmaking, with the first large-scale plants scheduled to enter production in 2026.
4. Iron ore is fed into the blast furnace which produces molten pig iron. At integrated steelmaking plants, molten pig iron is fed directly into the basic oxygen furnace (BOF), avoiding the need to remelt cold, solid pig iron. Coal-based blast furnaces also release excess energy, which steel plants have learned to capture and reuse.
5. The terms 'green iron trade' 'green iron transport' and 'green iron corridors' are all used. The green iron will not always be 'traded' in the sense of sold for export. Green iron may move within a country. Even if it moves across borders, it may stay within the same company and not be sold externally.
6. Identification of the top and 'other' potential green iron producers is based on RMI (2024) analysis and Agora Industry (2023) for the leading producers (Canada, Australia, Brazil, South Africa), plus information from IEEFA (2023) on Iran and from IEEFA (2024) on Algeria, Libya, Saudi Arabia, UAE, Oman (as hubs where iron ores would be imported and processed into DR iron with locally made green hydrogen); from Stegra (2024) on current and potential European locations (Sweden, Portugal), and from news items on current projects (Namibia and Spain).
7. By Rocky Mountain Institute (2024) and the Deloitte-WWF Australia (2025).
8. Estimates of cost savings vary depending on whether a global or country-specific lens is used, and depending on which assumptions are used, particularly around future carbon and green hydrogen prices - the latter remains highly uncertain and evolves with policy changes. A study that considers the global steel industry is likely to find smaller cost savings than one focused on a specific country, because steelmaking countries will vary in their use of imported green iron and the likeliest importers of green iron do not represent the majority of the world's iron and steel production.
9. Calculations by SteelWatch.
10. In 2023, the four largest iron ore exporting countries - Australia (891 Mt), Brazil (353 Mt), South Africa (59 Mt), Canada (45 Mt) - accounted for around 85% of total iron ore exports (exports not to be confused with production). They are identified by the Rocky Mountain Institute and Agora Industry as good candidates for green iron exports.
11. The Rocky Mountain Institute types them as green iron importer candidates.
12. The rebranding from H2 Green Steel to Stegra in 2024 was partly due to explicit plans to sell not just steel but also green iron to other steelmakers.
13. The majority of currently exported Australian iron ore is not 'DR-grade' and further innovation will be needed. This will either require developing new deposits, or upgrading the quality of the output of existing iron ore mines (beneficiation), or adopting technologies/processes at the stages of iron- and steelmaking that can work with a wider range of iron ore grades. Given iron ore mining drives around 14% of GDP, Australia has huge incentives to overcome these hurdles to protect it's future economy.