Decarbonising Australia-China steel making with reorganised value chains

Policy Brief

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Summary:

China is responsible for over half of global steel production, and consumes a little over 80% of Australia's iron ore exports. Our techno-economic and life-cycle assessment (LCA) models consider how iron ore composition affects capital and operating costs, including energy use and iron losses, as well as emissions, in both conventional and a number of promising alternative green steel production routes. We find that:
(1) China's plans for decarbonisation, with reduced steel demand and increasing use of scrap recycling, put strong downward pressure on iron ore consumption. As a result, China's ore consumption is expected to fall to about 950 Mt by 2035 and 650 Mt by 2050. A shift to green steel making further affects demand for Australian iron ores most strongly, as these ores as less suited to the H_2-DRI-EAF pathway, relative to high-grade ores from Brazil, Guinea, and elsewhere.
(2) Australia's competitiveness as a supplier of green iron into Chinese markets hinges on achieving green hydrogen production costs of A$0.50/kg hydrogen below Chinese production costs. At such a cost differential, our model suggests Australia would supply 320 Mt green iron to China in a 2035 scenario where China demands 100% green steel. This would grow to about 430 Mt if the cost differential is as large as A$1.25/kg H2.
(3) The Electric smelting furnace (ESF) technology is pivotal for the use of Pilbara ores in green steel production routes. In a 2035 scenario where China demands 100% green steel, our model suggests Australian iron ore consumption would climb together with ESF capacity, from 130 Mt in a scenario with 100 Mt of ESF capacity, to 420 Mt of Australian iron ore consumption in a scenario with an ESF capacity of 400 Mt or above.
These results should motivate policy makers to help accelerate development of low-cost renewables and hydrogen, de-risk ESF demonstration and early deployment, and pursue targeted Australia–China supply-chain configurations that align competitiveness with decarbonisation.

Keywords:
Steel sector decarbonisation, Green iron trade, Economics of supply chain analysis, Cost-optimisation, Australia, China.

JEL Classification:
L52, Q28, Q31, Q37, Q38, Q43, Q48, Q52, Q54, Q56, Q58

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1. Background

Global plans for decarbonisation will inevitably have to deal with steelmaking emissions, which make up about 7 to 9 per cent of global emissions (IEA, 2020). China is by far the world's largest producer and consumer of steel, responsible for well over half of global production and consumption(World Steel Association, 2025). Because China relies on production of steel via the emissions heavy blast furnaces to a much higher degree than other major steel making nations, Chinese emissions from steelmaking account for as much as 16-18 per cent of total domestic emissions (Zhou et al., 2022).

China is also the largest consumer of Australian iron ore, being the destination for a little over 80% of Australian iron ore exports (DISR, 2022). It is difficult to overstate the importance of this trade relation to the Australian economy. Exports of iron ore to China have made up between 20 to 25% of total Australian exports (of all goods, to all countries) in recent years (UN Trade Statistics Branch, 2025).

The Chinese have implemented emissions targets of achieving peak emissions before 2030 and net-zero emissions by 2060; it is expected that these economy-wide targets will be replicated for a number of heavy industry sectors, including the steel sector. China's plans for decarbonisation for the steel sector include a reduction in steel demand and a greater use of recycled steel scrap (Zhou et al., 2022), the supply of which is expected to grow significantly over the next few decades (Xuan & Yue, 2016). These two developments can be expected to put pressure on demand for iron ore consumption and therefore imports, including from Australia. Further pressure on demand for Australian iron ore can be expected to come from a greater diversification of suppliers, including towards newly developed deposits in Guinea (Zhou et al., 2022).

Whilst the production of steel with recycled steel scrap is a mature and economical technological pathway to produce green steel[a], limits to scrap supply will likely mean there is remaining demand for primary steel (made with iron ore), which will need to be decarbonised too, in order to meet net-zero targets. Both in China and globally hydrogen-based production routes are generally considered the most viable pathway for decarbonising such primary steel making (Rumsa et al., 2025; Venkataraman et al., 2022).

Most of Australia's iron ore exports consist of direct shipping hematite ore, with a relatively low iron content, ranging from 56 to 62%. The current competitiveness of Australian iron ore exports is largely because the dominant process route, the Blast Furnace - Basic Oxygen Furnace (BF-BOF) route, can effectively and efficiently remove impurities (or gangue) by melting the iron ore fed into it, separating it into hot metal (pure iron) and liquid slag (impurities).

The green steel making pathway with the highest Technological Readiness Level (TRL) currently is the hydrogen direct reduced iron (DRI) – Electric Arc Furnace (H_2DRI-EAF) pathway, though this route requires DRI with very low gangue content, i.e., made with ores with very high iron grades, typically at least 65% Fe (Daisy Summerfield, 2019). DRI with lower Fe grade ores will, amongst other problems, lead to higher power consumption, and can lead to increased losses of iron to slag in the EAF steelmaking step, making the process uneconomical (Rahbari et al., 2025). It is possible to upgrade the iron content in beneficiation

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[a] There are no universally accepted standards for green steel. The IEA uses definitions of low-emissions or near-zero emissions steel. The IEA definition of near-zero emission steel depends on the level of scrap use, at 400 kg CO_2/t for steel made with 0% scrap, falling to 50 kg CO_2/t for steel made with 100% scrap (IEA, 2024). This would necessitate the use of renewable energy and possibly other measures to reduce emissions.

processes[b] but Australian hematite ores in particular are not amenable to beneficiation to the very high Fe grades required, with current beneficiation technologies. Australian ores will therefore likely face competition from existing high grade iron ore producers in Brazil, domestic supply in China, and new suppliers in Guinea, which are more suited to this most developed green steel production pathway.

A promising alternative pathway, a two-step ironmaking process via the hydrogen DRI - Electric Smelter Furnace (H_2DRI-ESF) pathway can handle iron ores with high gangue content, as the melting step separates iron and gangue, similar to what happens in the blast furnace process. The hot metal produced in the ESF can be processed into steel in either an EAF or a BOF plant. This ESF technology is currently at a lower TRL, however (Rachel Wilmoth, Quailan Homann, Chathurika Gamage, Lachlan Wright, Kaitlyn Ramirez, Sascha Flesch, Thanh Ha, Joaquin Rosas, Natalie Janzow, 2024; Rahbari et al., 2025).

A switch to green steelmaking could therefore have an impact on demand for iron ores with different compositions, as iron ore composition will affect energy consumption, flux requirements, and iron losses either in the beneficiation step or to slag in the steelmaking step, amongst others (Rachel Wilmoth, Quailan Homann, Chathurika Gamage, Lachlan Wright, Kaitlyn Ramirez, Sascha Flesch, Thanh Ha, Joaquin Rosas, Natalie Janzow, 2024; Rahbari et al., 2025). How this would affect the competitiveness of low-grade Pilbara ores in the novel green steel making processes, versus higher grade ores from Brazil, Guinea, or elsewhere, requires investigation.

A second issue requiring further investigation is how global steel making value chains for green steel may be re-organised in an attempt to drive down green steel production cost, with energy intensive steps moved to locations with abundant low-cost renewable energy. There are several different possible configurations of the Australia-China green steel value chain, with different process steps occurring either in Australia or China, and corresponding exports of different intermediate products. Moving from exports of iron ore as is currently the case, to a situation where Australia could export green iron or green steel, could generate substantial downstream economic activity. It would also affect how much and in what location remaining greenhouse gas emissions occurring in green steel production processes would occur.

The aim of this research project was to assess the implications of decarbonising the Australia-China steel supply chain on the cost-competitiveness of, and greenhouse gas emissions associated with, Australian exports of direct shipping ore, beneficiated ores, iron (either in the form of Hot Briquetted Iron (HBI) or pig iron), or steel.

This was achieved by developing a model that considered how different ore types and composition affect CAPEX and OPEX including energy and material input requirements in different processing steps, a key oversight in much earlier work. As such this research has contributed to a much-improved understanding of the relative competitiveness of Australian iron ores in green production routes for the Chinese market. Model results offered additional insight on the relevance of different green production pathways for cost-competitive processing of Australian iron ores, and the production cost of green hydrogen required to make Australian green iron competitive in Chinese value chains.

This policy brief is a non-technical summary of a forthcoming journal article that will present methodological detail, assumptions, and data sources underpinning these results.

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[b] A collection of technologies to separate impurities (gangue) and iron, in order to increase the iron grade of the resulting product. Any such process will result in some losses of iron to waste streams, and Australian hematite ore are prone to high losses with current beneficiation technologies, making them uneconomical to upgrade to high levels of purity.

2. Key results

2.1 Chinese green steel demand and Australian iron ore consumption

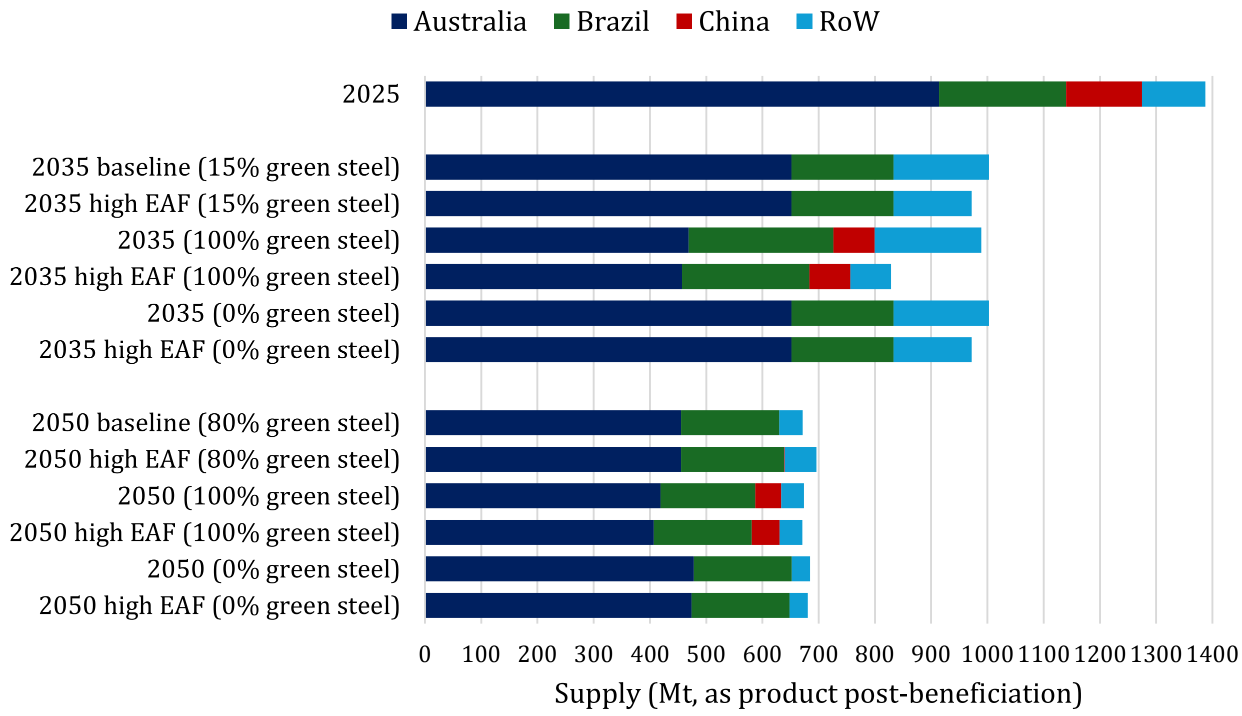
Chinese consumption of iron ore is expected to fall to about 950 Mt by 2035, and to about 650 Mt by 2050, compared to about 1,400 Mt today. This is due to combined trends of falling demand for steel and increased supply of scrap, which will reduce demand for primary steel production. In scenarios with high EAF capacity, demand for iron ore further falls as more of the available scrap supply is consumed in the scrap-EAF pathway, replacing the need for primary steel production (this effect is most visible in the 2035 scenarios).

Demand for Australian ores is most strongly affected by total Chinese primary steel demand and the ambition level for green steel as a percentage of total demand, across our selection of scenarios. The numbers for steel demand and scrap supply as used in this analysis are taken from the IEA's Stated Policies scenario; other forecast typically see lower Chinese demand for iron ore, which would impact demand for Australian iron ore further.

The effect of a push for green steel leading to reduced demand for Australian ores is explained in large part by reduced production via the BF-BOF route, where Australian ores appear more competitive versus supplies from other countries. In green steel production routes, large shares of demand are met with ore from Brazil, as well as from new production sites in Guinea. Our model suggests that the Simandou complex in Guinea may supply 18% of Chinese iron ore demand in 2035, in a scenario where all steel demand is met with green steel. Production of green steel via the H_2DRI-EAF pathway is predominantly with Brazilian and Guinean iron ores. The overall result is that Brazilian iron ore demand appears most resilient due its flexibility in both conventional and green production pathways, whereas demand for Australian ores appear most sensitive to such changes in production processes.

Figure 1 summarises how the supply of iron ore to China from different countries depends on these scenario assumptions on green steel and EAF processing capacity.

Figure 1. Consumption of ore by supplier: comparison over the different scenarios



Notes:

- The numbers in the bar 2025 are baseline model results used to compare what future development will mean for Australian and other iron ore exports to China
- The scenarios plotted include a baseline assumption of about 15% of steel demand having to be met with green steel by 2035, and 80% by 2050, which would be a trajectory in line with China's net-zero by 2060 goal. For comparison's purpose, we also include a scenario with 100% green steel demand and 0% green steel demand for either year
- The baseline scenario also includes assumptions on the processing capacity of Electric Arc Furnaces. This EAF capacity stood at 150 Mt at the start of 2025 in China; our baseline scenario presumes expansion of this capacity to 300 Mt in 2035 and 450 Mt in 2050. The 'high EAF' scenarios presume expansion of this EAF capacity to 450 Mt by 2035 and 900 Mt by 2050. In the baseline scenario, we further presume a maximum acid gangue content of material processed through the EAF of 3%, equivalent to the current market demand of DR grade pellets having an iron content of at least 67%. In the 'high EAF' scenario we presume a maximum acid gangue level of 7%, reflecting a change in EAF operator procedures to accept lower grade ores in a world where demand for green steel has increased. Acid gangue are silica, alumina, and other non-iron oxides which affect energy consumption and losses of iron to slag.

2.2 Australian Hydrogen production cost and resulting iron production

The production cost of green hydrogen is the dominant driver of competitiveness of different countries or sub-national regions in the production of green iron.

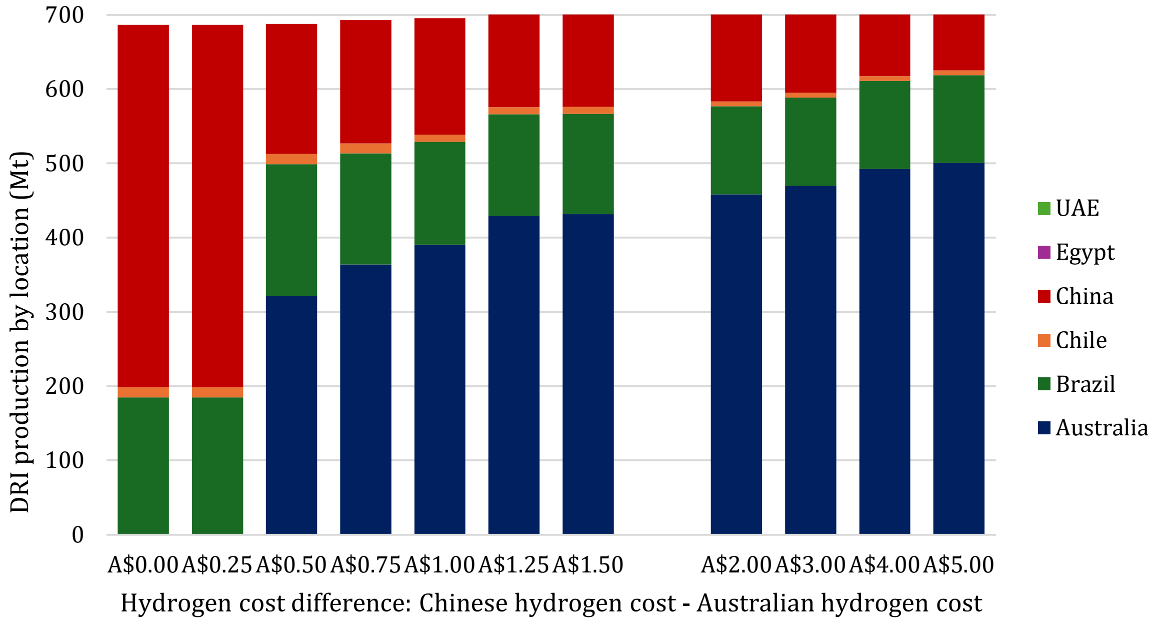
Our analysis indicates that no production of iron would occur in Australia if Australian hydrogen production costs would be at parity or above Chinese hydrogen production costs. The same analysis shows however, that if Australian producers could bring hydrogen costs down to as little as A$0.50/kg[c] (or US$0.33/kg) below Chinese production costs, substantial levels of iron production would be competitive in Australia (Figure 2). At that level, 320 Mt of iron would be produced in Australia, equivalent to about 47% of total Chinese demand for iron in 2035. This level of iron production in Australia would ramp up to about 430 Mt, or about 62% of total Chinese demand for iron in 2035 in a scenario where Australia could produce green hydrogen at a discount of A$1.25 (or US$0.83) per kg of green hydrogen.

In scenarios with even larger hydrogen production cost differentials, iron production in Australia only very slowly ramps up further; this is because additional Australian ores are relatively expensive to mine and/or beneficiate to required levels for processing.

Brazilian and a small fraction of Chilean iron production are resilient in any of these scenarios; their costs remain below that of Chinese domestic iron production. This also means that Australian competition over market share for supplying the Chinese market with green iron is mostly with Chinese domestic production of iron.

Figure 2 provides an overview of how Australian's supply of iron into a Chinese market would depend on Australian green hydrogen production cost.

Figure 2. Australian iron production as a function of hydrogen production cost difference with China



Note: the model includes potential production locations of Australia, China, Brazil, Chile, Egypt and the UAE. In any of the scenario settings presented above, there would not be any iron production in Egypt or the UAE.

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[c] All dollar values in this report as real 2025 A$, with a presumed exchange rate of 1 AUD : 0.66 USD.

2.3 Relevance of the Electric Smelter Furnace for Australian iron ore exports

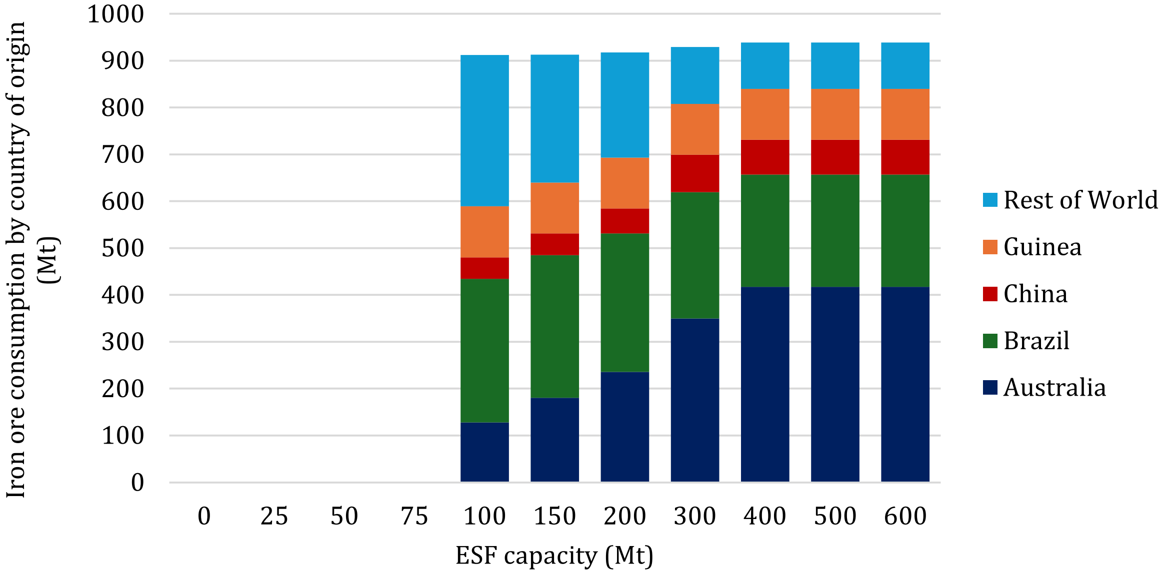
Our model results show that the Electric Smelter Furnace (ESF) will be of key importance to the cost-competitiveness of Australian iron ore in future green steel value chains. This is regardless of whether the production of iron occurs in Australia or China.

The ESF is a process step following the production of Direct Reduced Iron (DRI), where smelting the DRI separates it into hot metal (mostly iron) and impurities (the gangue components in the DRI), allowing the production of iron with low levels of impurities from iron ores with higher gangue content, as is typical for Pilbara hematite ores, which form the bulk of Australia's iron ore exports.

Our model suggests that in scenarios with high green steel demand in China, Australian iron ore consumption would climb together with ESF capacity, from 130 Mt in scenarios with 100 Mt of ESF capacity, to 420 Mt of Australian iron ore consumption in scenarios with ESF capacity of 400 Mt or above. At total ESF capacities of below 100 Mt the model does not produce a result, as there is simply not enough sufficiently high-grade iron ore available for processing via H2DRI-EAF pathway (the only alternative pathway for primary green steel in our model).

It should therefore be a priority of Australian industry and government to stimulate the technological development of the ESF, which is currently still in the demonstration stage, and help support their industrial-scale rollout. This may mean developing ESF processing capacity domestically, or convincing customers in China or other key markets that investments in ESF capacity are worthwhile.

Figure 3. Demand for ore by country of origin, as a function of Chinese ESF capacity



Note: Iron ore consumption as Mt of product (post-beneficiation) into green iron making processes. Scenario settings: results for 2035, with 100% of steel demand met with green steel; unlimited EAF capacity, 3% max acid gangue through the EAF pathway, and all ESF capacity in China.

3. Future model development and scenario analysis

The current model and results presented here focus on Australia-China value chains for iron ore and green iron, as this is by far the largest exporter-importer relationship in the global iron ore market.

Demand for imports of green iron, or of iron ore with composition that is suited to be processed in green steel making value chains, is likely strongly dependent on local conditions of the importing country, including local renewable energy resource quality and related green hydrogen production costs, as well as local availability of alternative iron ore, and policy settings for decarbonisation of the steel making sector.

Ongoing model development therefore includes expanding the geographical scope as a priority, including to key markets in Japan, Korea, Taiwan, and India. It will also include cost modelling for both natural gas DRI and green iron in key potential competitor locations such as Brazil, the MENA region, Guinea, Sweden, North America, etc. Lastly, it is clear that strong differences exist in green hydrogen and other production costs between different locations in Australia. Very remote regions such as the Pilbara in particular are faced with very high cost penalties (Aurecon Australasia Pty Ltd, 2024). This future model update will therefore consider local renewable energy quality and other relevant factors that influence final green iron production cost in regions across Australia, including the Pilbara, but also Geraldton, Whyalla, North Tasmania, Gladstone, and Port Kembla.

This model update will also incorporate costing models for renewable energy and green hydrogen developed at the ANU School of Engineering.

This model will be used to extend the testing of sensitivity of results to key model parameters and develop a set of different future scenarios and policy settings to be modelled based on the needs of key industry and government stakeholders.

This extended analysis will allow us to identify potential global markets in which different Australian green iron producers would be competitive. This could for example highlight that some markets are particularly dependent on green iron imports, or that specific regions in Australia have particular combinations of local green hydrogen production cost and local ore quality that promote strong global competitiveness.

A second focus of future analysis will be to identify critical points at which cost reductions or technology improvements could improve the competitiveness of Australian iron ore or green iron, for example in operational parameters of the Electric Smelter Furnace, or of novel beneficiation technologies for hematite ores.

Lastly, this future work will interrogate how different policy mechanisms could improve the competitiveness of Australian iron ore and green iron in different global supply chains.

4. Synopsis

China produces well over half of the world's steel and is the largest consumer of Australian iron ore, being the destination for a little over 80% of Australian iron ore exports. China's plans for emissions reductions of the steel sector include a reduction in steel demand and a greater use of recycled steel scrap, both of which can impact demand for (Australian) iron ore. Ultimately, meeting China's decarbonisation target of net-zero emissions by 2060 will require remaining demand for primary steel to be met through decarbonised steel making pathways, with green hydrogen-based direct reduction currently the most promising pathway to produce green iron.

Different green steel making pathways either require, or are more economical, with very high-grade iron ores (typically considered 65% iron content or more), in terms of reduced energy consumption, raw material inputs, or losses of iron. Australian Pilbara hematite ores, which form the bulk of current exports, are typically low-grade (56-62% iron) and cannot economically be beneficiated to higher grades, with current beneficiation technologies. Whether the low production cost of Pilbara iron ores is sufficient to offset this difference, and remain competitive in green steel production pathways with existing high grade iron ore producers in Brazil, domestic supply in China, and new suppliers in Guinea, is an issue that requires investigation.

A second issue requiring further investigation is how Australia-China steel making value chains may be re-organised, in order to utilise Australia's abundant low-cost renewable energy for green iron or steel production. Different configurations of this value chain will affect both resulting production cost and GHG emissions.

This research project assessed the implications of decarbonising the Australia-China steel supply chain on the outlook for Australian exports of iron ore, iron, or steel, into future Chinese green steel value chains, and the resulting lifecycle GHG emissions. The model does so with a techno-economic analysis and LCA that consider how ore composition affects costs, energy consumption and material inputs in different processing steps, a key oversight in much earlier work.

Model results show that Chinese consumption of iron ore is likely to fall substantially, to about 950 Mt by 2035, and to about 680 Mt by 2050, compared to about 1,400 Mt today. This is due to combined trends of falling demand for steel and increased supply of scrap, which will reduce demand for primary steel production. The scenario for steel demand and scrap supply used for this analysis is the IEA's Stated Policies scenario; other forecasts typically see lower Chinese demand for iron ore. Demand for Australian ores appear most strongly affected by total Chinese demand for steel, and by the Chinese ambition level for green steel. In green steel production routes, large shares of demand are met with high-grade iron ore from Brazil, as well as from new production sites in Guinea.

The cost-competitiveness of green iron production in Australia depends strongly on the relative production cost of green hydrogen. Our results suggest that green iron production would occur entirely in China at hydrogen cost parity between Australia and China. However, at a cost differential of just A$0.50/kg of green hydrogen, Chinese demand for Australian green iron increases to 320 Mt, slowly climbing to about 430 Mt if the cost differential is as large as A$1.25/kg H_2. The challenge then is for development of low-cost renewable energy projects, or for government assistance, including in the form of a Hydrogen Production Tax Incentive, to drive down the production cost sufficiently to realise such a cost differential.

Model results further show that the Electric Smelter Furnace (ESF) technology will be of key importance to the cost-competitiveness of Australian iron ore in future green steel value chains. Our model suggests that in scenarios with high green steel demand in China, Australian iron ore consumption would climb together with ESF capacity, from 130 Mt in a scenario with 100 Mt of ESF capacity, to 420 Mt of Australian iron ore consumption in a scenario with an ESF capacity of 400 Mt or above. At total ESF capacities of below 100 Mt the model does not produce a result, as there is simply not enough sufficiently high-grade iron ore available for processing via H_2DRI-EAF pathway. It is therefore imperative that Australian industry and government work to stimulate the technological development of the ESF, which is currently still in the demonstration stage, and help support their industrial-scale rollout. This may mean developing ESF processing capacity domestically, or convincing customers in China or other key markets that investment in ESF capacity are worthwhile.

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