HILT CRC

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program

RP3.004
ECONOMIC AND EMISSIONS ANALYSIS OF AUSTRALIA-CHINA GREEN STEELMAKING VALUE CHAINS

Policy brief

AUTHORS:

Jorrit Gosens, Alireza Rahbari, John Pye, Fiona Beck, Frank Jotzo
Heavy Industry Low-carbon Transition Cooperative Research Centre, ANU

Augustine Ntiamoah, Wahidul Biswas, Michele John
Heavy Industry Low-carbon Transition Cooperative Research Centre, Curtin University

DATE: AUGUST 2025
HILT CRC REPORT 2025/199

HILTCRC.COM.AU

HILT CRC

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program

Policy brief

RP3.004 ECONOMIC AND EMISSIONS ANALYSIS OF AUSTRALIA-CHINA GREEN STEELMAKING VALUE CHAINS

PROJECT

RP3.004 Intermediate product exports for Australia-China green steel

AUTHORS:

Dr Jorrit Gosens, Professor Frank Jotzo
Heavy Industry Low-carbon Transition Cooperative Research Centre & Centre for Climate and Energy Policy, The Australian National University

Dr Alireza Rahbari, Associate Professor John Pye, Associate Professor Fiona Beck
Heavy Industry Low-carbon Transition Cooperative Research Centre & School of Engineering, The Australian National University

Dr Augustine Ntiamoah, Professor Wahidul Biswas, Professor Michele John
Heavy Industry Low-carbon Transition Cooperative Research Centre & School of Mechanical & Civil Engineering, Curtin University

ADDRESSES:

Crawford School of Public Policy, 132 Lennox Crossing, J.G. Crawford Building, The Australian National University, Canberra ACT 2600

School of Engineering, 35A Science Road ACT 2600 Australia, Craig Building, The Australian National University, Canberra ACT 2600

Sustainable Engineering Group, School of Mechanical & Civil Engineering, Curtin University, Perth

Heavy Industry Low-carbon Transition Cooperative Research Centre, Lot Fourteen, Corner North Terrace and Frome Road, Adelaide SA 5000

ACKNOWLEDGEMENTS:

The work has been supported by the Heavy Industry Low-carbon Transition Cooperative Research Centre whose activities are funded by its industry, research and government Partners along with the Australian Government's Cooperative Research Centre Program. Jorrit Gosens and Frank Jotzo's involvement in this project were made possible through co-sponsoring by an anonymous private donor, and by a grant from the National Foundation for Australia-China Relations (NFACR220265). The purchase of CRU data was made possible by a grant from the research spoke on Energy Transition of the Australian Centre on China in the World (CIW). This is HILT CRC Document 2025/199

OTHER MATTERS:

EXECUTIVE 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 steelmaking 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 H_2.
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.
4. Green steel production routes could cut lifecycle greenhouse gas (GHG) emissions to about 0.6 to 0.7 t CO2/t crude steel, or a reduction of about 70% compared with conventional fossil fuel pathways. Shifting green processing to Australia could reduce overall lifecycle emissions by a further 10 to 15%, though it would shift emissions into Australia's emissions inventory.

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.

CONTENTS

1. CONTEXT

Global plans for decarbonisation will inevitably have to deal with steelmaking emissions, which make up about 7 to 9 per cent of global emissions[1]. China is by far the world's largest producer and consumer of steel, responsible for well over half of global production and consumption[2]. Because China relies on production of steel via the emissions heavy blast furnaces to a much higher degree than other major steelmaking nations, Chinese emissions from steelmaking account for as much as 16-18 per cent of total domestic emissions[3].

China is also the largest consumer of Australian iron ore, being the destination for a little over 80% of Australian iron ore exports[4]. 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[5].

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[3], the supply of which is expected to grow significantly over the next few decades[6]. 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[3].

Whilst the production of steel with recycled steel scrap is a mature and economical technological pathway to produce green steel[1], 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 steelmaking[8,9].

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 steelmaking 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[10]. 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[11]. It is possible to upgrade the iron content in beneficiation processes[2] 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.

---

[1] 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[7]. This would necessitate the use of renewable energy and possibly other measures to reduce emissions.

[2] 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.

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[11,12], however.

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[11,12]. How this would affect the competitiveness of low-grade Pilbara ores in the novel green steelmaking processes, versus higher grade ores from Brazil, Guinea, or elsewhere, requires investigation.

A second issue requiring further investigation is how global steelmaking 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 HILT research project RP3.004 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 HILT RP3.004 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.

The project also conducted a lifecycle analysis (LCA) to evaluate greenhouse gas emissions arising from different configurations of the Australia-China steelmaking value chain, including for conventional and emerging green steel production pathways. This has contributed to the understanding of lifecycle GHG emissions implications of developing downstream processing or iron ore including the production of iron or steel in Australia.

This policy brief provides a non-technical synthesis of the project outcomes, summarising results from two HILT-CRC reports with technoeconomic and lifecycle emissions analysis.

2. KEY RESULTS

2.1 CHINESE GREEN STEEL DEMAND AND AUSTRALIAN IRON ORE CONSUMPTION

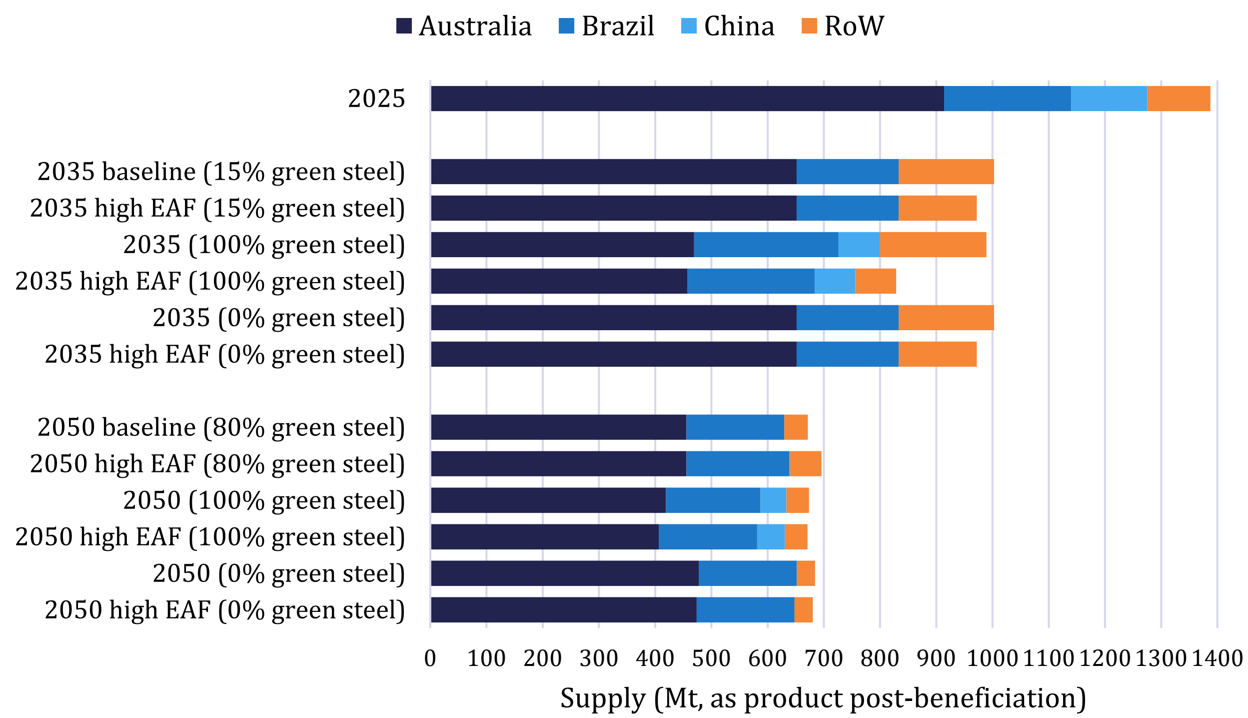
Chinese consumption of iron ore is expected to fall to about 950 Mt by 2035, and to about 650 Mt by 2050, compared to about 1,400 Mt today. This is due to combined trends of falling demand for steel and increased supply of scrap, which will reduce demand for primary steel production. In scenarios with 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 (EAFs). 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 that 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.

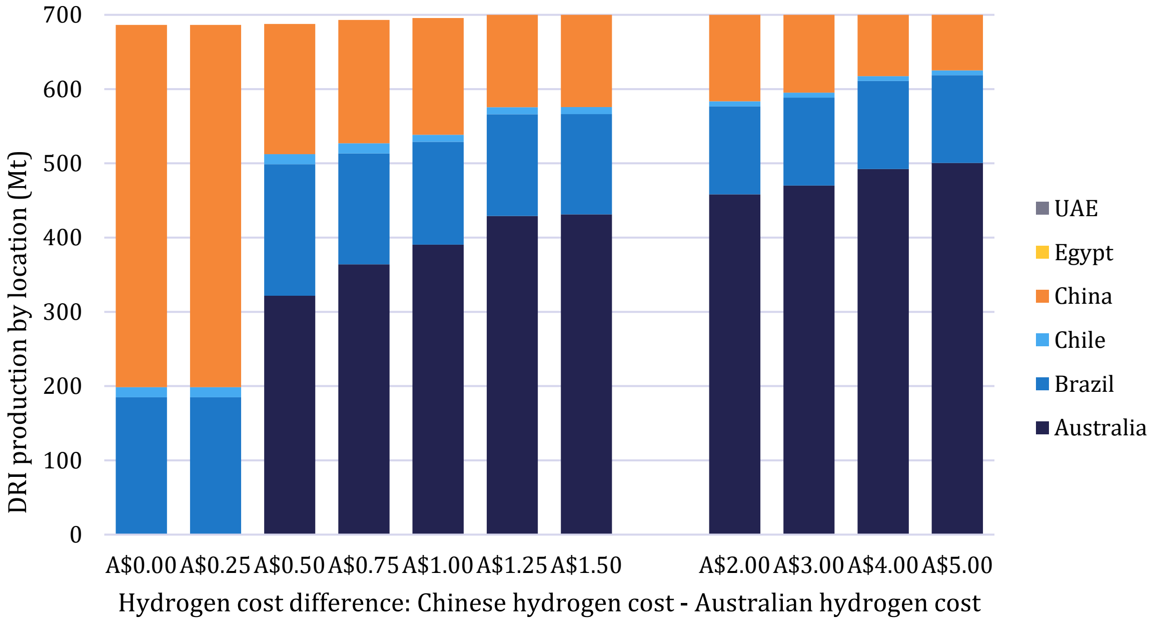
Our analysis indicates that no production of iron would occur in Australia if Australian hydrogen production costs would be at parity or above Chinese hydrogen production costs. The same analysis shows however, that if Australian producers could bring hydrogen costs down to as little as A$0.50/kg[3] (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 PRODUCTON 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.

[3] 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

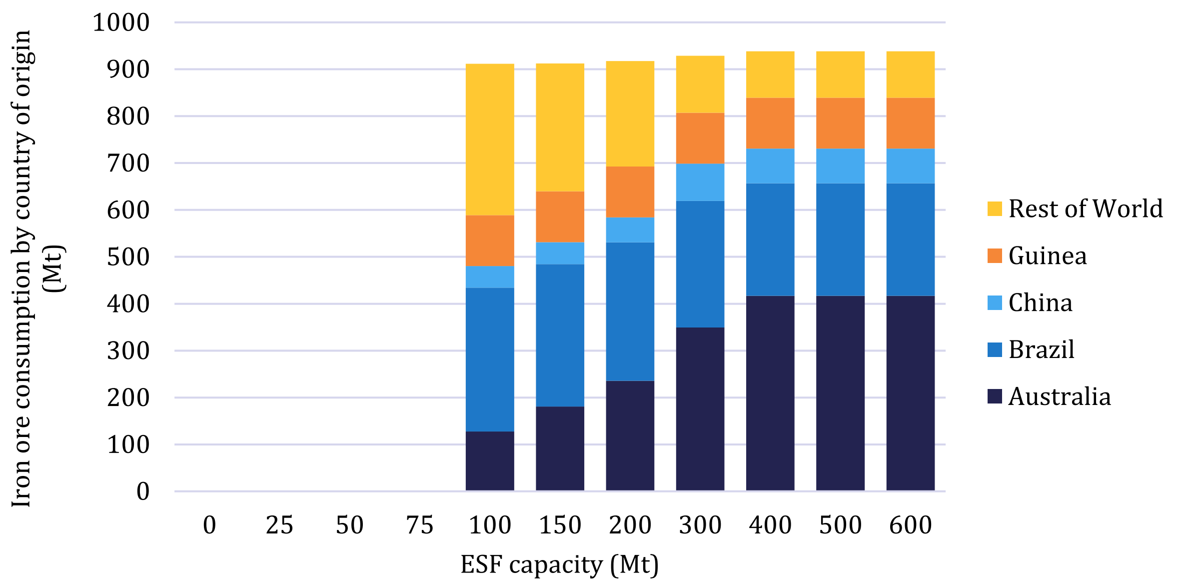
Our model results show that the electric smelter furnace (ESF) will be of key importance to the cost-competitiveness of Australian iron ore in future green steel value chains. This is regardless of whether the production of iron occurs in Australia or China.

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 H_2DRI-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.

2.4 EMISSION IMPLICATIONS OF DIFFERENT POSSIBLE SUPPLY CHAIN CONFIGURATIONS

We evaluated lifecycle GHG emissions resulting from possible conventional production routes including BF-BOF and natural gas based DRI-EAF production routes, with different configurations of these supply chains, i.e. with different processing steps across Australia and China, and corresponding exports of different products.

Our LCA suggests emissions as occurring from the currently dominant supply chain, with Australia shipping iron ore to China for processing via the BF-BOF route (scenario SC07 in Figure 4) are about 2.05 t CO_2/t crude steel. Given the dominance of emissions in the energy intensive Blast Furnace step, almost all of these emissions occur in China, with about 10.8% in shipping, and only 1.05% of total lifecycle emissions occurring in the mining and beneficiation steps in Australia. The results in Figure 4 further show that emission may be reduced by about 15% by switching to natural gas based DRI-EAF production routes in China (1.70 t CO_2/t steel; SC6 in Figure 4), and even as much as 35% when switching to Australian based natural gas DRI-EAF production (1.29 t CO_2/t steel; SC2 in Figure 4). This is mainly because the carbon emissions of Western Australia's electricity mix are around half of the emissions produced in Hebei province in China, and because transportation emissions are reduced as less material (1 t of steel product vs almost 2 t of iron ore) is shipped to China.

A shift to green steel, with all of the iron and steelmaking processes occurring in China, could lower lifecycle GHG emissions to 0.70 t CO_2/t crude steel if processing occurs via the H_2DRI-EAF route, and to about 0.62 t CO_2/t crude steel if processing occurs via the H_2DRI-ESF-BOF route. This would represent emission reductions of about 65 or 70% versus current emissions.

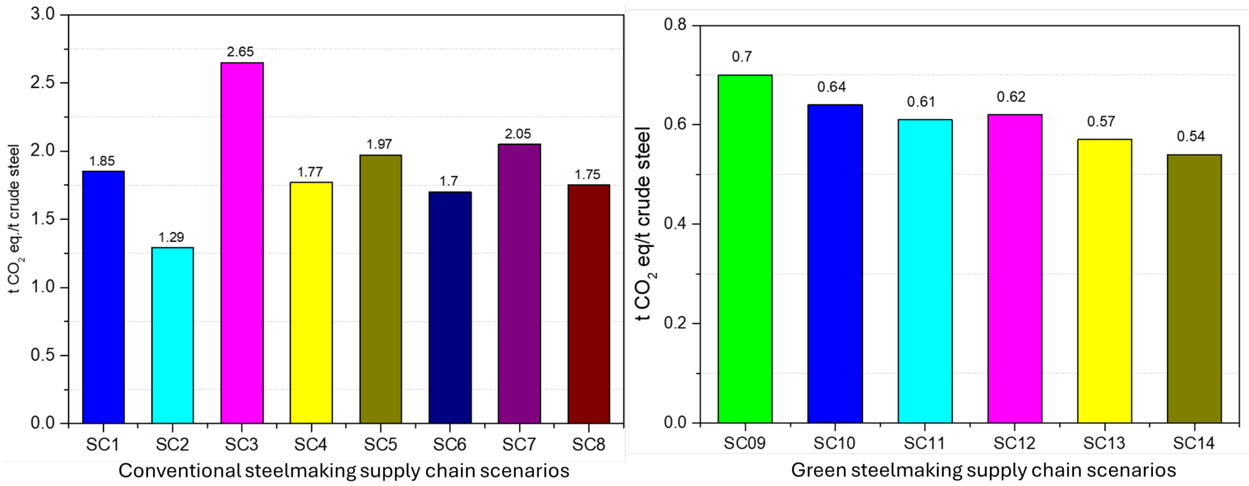
Moving all or part of the iron or steel processing steps to Australia would reduce emissions further. In a scenario where Australia produces green iron and exports this as HBI to China for steelmaking through the ESF-BOF pathway using renewable electricity, lifecycle emissions would fall to 0.57 t CO_2/t crude steel (SC13 in Figure 4). This would be 0.54 t CO_2/t crude steel in a scenario where all of the processing would occur in Australia, via the H_2DRI-ESF-BOF pathway, with exports of green steel to China (SC14 in Figure 4). As such, shifting processing to Australia could reduce lifecycle emission by about 10 to 15% versus scenarios where green iron and steel production occurs predominantly in China.

Note that in this analysis, we have considered decarbonisation of mining with e.g. electric mining trucks, of shipping with green methanol or other zero carbon fuels, of electricity used in the EAF or ESF processing steps with dedicated renewable electricity. Remaining emissions are mostly from transport, iron making in the H_2DRI process, and either the ESF or EAF process, each accounting for roughly 20 to 35%. Remaining emissions are largely from production of burnt lime, international shipping and electricity production.

It is important to note that any re-configuration of steelmaking supply chains between Australia and China will affect national greenhouse gas emissions inventories. In the current conventional configuration where Australia ships iron ore to China for processing in the BF-BOF pathway (SC7 in Figure 4), Australian emissions from mining and beneficiation add up to just 21.6 kg CO_2/t crude steel. In the scenario with lowest overall emissions, where Australia exports steel produced via the H_2DRI-ESF-BOF pathway (SC14 in Figure 4), Australian emissions would increase to 378 kg CO_2/t crude steel.

Note that below emissions figures may not be directly comparable with emissions assessment in other reports, depending on whether similar study boundaries and scope have been applied. In the analysis reported here, the cradle-to-gate system boundary was limited to the production of crude hot steel, excluding subsequent processes such as alloying, casting and rolling, which also occur before export. Some Scope 3 emissions, including emissions related to off-site waste disposal, transportation of coal and other raw materials from suppliers to production sites, and employee commute (e.g. fly-in-fly-out, or FIFO), were omitted due to data constraints. Additionally, emissions generated during plant construction and the manufacturing of processing equipment and machinery were not considered in this analysis. For power production, for production in Australia, the emission factor for Western Australia's electricity mix in the AusLCI database was used as the default value, while China's electricity mix was modelled with 53% coal and the balance from renewables. When companies generate their own electricity or use different emission factors, it can lead to variations in emissions results. For green steelmaking scenarios, it was assumed all energy demand was met with renewable energy.

FIGURE 4. GREENHOUSE GAS EMISSIONS IN DIFFERENT SUPPLY CHAIN CONFIGURATIONS



Legend:

SC01- Australia produces steel through BF-BOF process and exports it to China
SC02- Australia produces steel through NGDRI-EAF method and exports it to China
SC03- Australia produces BF pig iron and exports it to China for BOF steelmaking
SC04- Australia produces HBI using natural gas DRI and exports it to China for EAF steelmaking
SC05- Australia exports sinter for steelmaking through the BF-BOF process in China
SC06- Australia exports pellets for steelmaking using the NGDRI-EAF method in China
SC07- Australia exports beneficiated ore for iron and steel production using the BF-BOF process in China
SC08- Australia exports beneficiated ore for iron and steelmaking through the NGDRI-EAF method in China
SC09 - Australia exports beneficiated ore to China for iron and steel production using the H_2DRI-EAF route
SC10 - Australia exports green HBI to China for steel production in an EAF using renewable electricity
SC11 - Australia produces steel via the H_2DRI-EAF route and exports it to China
SC12 - Australia exports beneficiated iron ore to China for processing via the H_2DRI-ESF-BOF pathway
SC13 - Australia exports green HBI to China for steelmaking via the ESF-BOF process with renewable electricity
SC14 - Australia exports steel produced by the H_2DRI-ESF-BOF route to China

2.5 FUTURE MODEL DEVELOPMENT AND SCENARIO ANALYSIS

HILT CRC project RP3.009 will expand and improve the modelling reported on here, specifically by:

- Expanding beyond the singular focus on the Chinese market, and evaluating the outlook for exports of iron ore and green iron to global markets, including key markets in Japan, Korea, Taiwan and India.
- Integrating outcomes of HILT CRC projects RP2.006 and RP3.007 to include region-specific hydrogen production costs for key Australian production locations (including the Pilbara, Geraldton, Kwinana, Whyalla, Northern Tasmania, Gladstone and Illawarra), and similar cost modelling for both natural gas DRI and green iron in key potential competitor locations (Brazil, MENA, Guinea, Sweden, North America, etc).

In addition, it will 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.
- identify critical points at which cost reductions or technology improvements could improve the competitiveness of Australian iron ore or green iron.
- interrogate how different policy mechanisms could improve the competitiveness of Australian iron ore and green iron in different global supply chains.

3. 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 steelmaking pathways, with green hydrogen-based direct reduction currently the most promising pathway to produce green iron.

Different green steelmaking 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 steelmaking 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.

Lifecycle GHG emissions in green production routes are evaluated to be about 0.6 to 0.7 t CO_2/t crude steel, or a reduction of about 70% compared with conventional fossil fuel pathways. Shifting green processing to Australia could reduce lifecycle emissions by a further 10 to 15%, though it would increase Australian GHG emissions.

REFERENCES

(1) IEA. *Iron and Steel Technology Roadmap*; Paris, 2020; p 190.

(2) World Steel Association. *World Steel in Figures 2025*; 2025. https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2025/.

(3) Zhou, T.; Gosens, J.; Xu, H.; Jotzo, F. *China's Green Steel Plans: Near-Term Policy Challenges & Australia-China Links in Decarbonization. ANU Policy Brief.*; 2022.

(4) DISER. *Resources and Energy Quarterly Q1 2022*; Canberra, Australia, 2022.

(5) UN Trade Statistics Branch. UN Comtrade Database, 2025. https://comtrade.un.org/data/.

(6) Xuan, Y.; Yue, Q. Forecast of Steel Demand and the Availability of Depreciated Steel Scrap in China. *Resources, Conservation and Recycling* **2016**, *109*, 1–12.

(7) IEA. *Definitions for Near-Zero and Low-Emissions Steel and Cement, and Underlying Emissions Measurement Methodologies*; 2024. https://www.iea.org/reports/definitions-for-near-zero-and-low-emissions-steel-and-cement-and-underlying-emissions-measurement-methodologies.

(8) Rumsa, M.; John, M.; Biswas, W. Global Steel Decarbonisation Roadmaps: Near-Zero by 2050. *Environmental Impact Assessment Review* **2025**, *112*, 107807. https://doi.org/10.1016/j.eiar.2025.107807.

(9) Venkataraman, M.; Csereklyei, Z.; Aisbett, E.; Rahbari, A.; Jotzo, F.; Lord, M.; Pye, J. Zero-Carbon Steel Production: The Opportunities and Role for Australia. *Energy Policy* **2022**, *163*, 112811. https://doi.org/10.1016/J.ENPOL.2022.112811.

(10) Daisy Summerfield. *Australian Resource Reviews*. https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/134851 (accessed 2025-07-27).

(11) Rahbari, A.; Shahabuddin, M.; Sabah, S.; Brooks, G.; Pye, J. Production of Green Steel from Low-Grade Ores: An End-to-End Techno-Economic Assessment. *Cell Reports Sustainability* **2025**, *2* (1). https://doi.org/10.1016/j.crsus.2024.100301.

(12) Rachel Wilmoth, Quailan Homann, Chathurika Gamage, Lachlan Wright, Kaitlyn Ramirez, Sascha Flesch, Thanh Ha, Joaquin Rosas, Natalie Janzow. *Green Iron Corridors: Transforming Steel Supply Chains for a Sustainable Future*; RMI. https://rmi.org/insight/green-iron-corridors/.

HILT CRC

hiltcrc.com.au

General enquiries
enquiries@hiltcrc.com.au

Connect with us
hiltcrc.com.au/connect

Australian Government
Department of Industry, Science and Resources

Cooperative Research Centres Program