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Australia's path to green iron

Conventional technologies and transformation in balance for ironmaking

- *Australia is expected to play roles both as a supplier of suitable feedstock and as a green iron producer. Yet Australian miners are missing the first wave of low-emissions iron production, supplied by Vale, Rio Tinto's IOC in Canada and LKAB in Sweden.*
- *Australia must pursue two parallel options: Leverage its vast magnetite deposits to join existing suppliers of higher-grade iron ore, and develop new pathways and technologies to upgrade Pilbara's low-grade iron ore for use in low-emissions ironmaking.*
- *New technologies that make Pilbara iron ore suitable for low-emissions ironmaking are essential for the wider decarbonisation of the global steel industry. But Australia can begin with existing technology if it aspires to become a green iron superpower.*

Introduction

Australia has long discussed developing a green iron industry, and Prime Minister Anthony Albanese stepped up efforts by attending high-profile meetings during his recent trip to China.

While this appears to be a promising opportunity for Australian iron ore miners, companies such as BHP have made it clear they will not pursue this path, saying the production of green iron in Australia is commercially unfeasible. The company maintained that the most effective approach to lowering emissions is by targeting reductions from coal-consuming blast furnaces in China. These notions come as no surprise from BHP, which lags its peers in its commitment to decarbonisation, as IEEFA has pointed out.

Rio Tinto seems to be concentrating more on other markets to produce suitable feedstocks for low-emissions iron, mostly based on hydrogen direct reduced iron (H2-DRI), rather than Australia. The company has underlined that producing green iron in Australia is expensive.

Fortescue remains optimistic and has set ambitious targets for the transition; however, it is pursuing only a very small-scale pilot plant at Christmas Creek. "We're also looking to what's next for green iron and how we can scale it to meet the demand from China and our customers," noted Agustin Pichot, Fortescue's CEO for growth and energy.

Australia has a world-leading opportunity, and while international competition is growing, there are still opportunities for progress and further pursuit.

If Australia aims to position itself as a global leader in the emerging green iron market, it must first assess whether it has the essential ingredients and whether it is on track to leverage its resources to meet long-term targets. There are several pathways to producing low-emissions iron. Some of Australia's initiatives, mostly backed by big miners, wait for technological breakthroughs to make their lower-grade hematite and goethite ores suitable for low-emissions and green iron production. Others are pursuing conventional magnetite processing to produce iron ore concentrate and pellets suitable for DRI.

IEEFA's new Australian Green Iron Tracker has been developed to monitor progress in these initiatives, alongside the development of magnetite mines, using the latest publicly available data.

Green iron ambition starts with building an ironmaking value chain

Australia is expected to play two roles: supplying suitable feedstock for green iron plants worldwide, and emerging as a green iron producer itself.

However, as the world's biggest iron ore producer and exporter, Australia has no standalone iron production plants. Its iron ore mining has historically been dominated by direct shipping ore (DSO) for blast furnaces. With little incentive to build domestic high-grade feedstock capacity, the entire value chain has never developed at scale.

Australia wants to change that and expand its presence downstream in the ironmaking value chain (Figure 2, Current operations in Area 1, with Area 2 planned for addition) .

The steps in this transition could involve supplying suitable iron ore for various ironmaking technologies or even producing iron for export. Whether Australia wants to produce iron or export raw material, it needs to reconfigure the value chain and set up a new system.

When it comes to supplying high-grade materials, Australia is not yet ready to meet the needs of the evolving green iron industry. The first wave of low-emissions iron production initiatives is being supplied by Vale, Rio Tinto's Iron Ore Company (IOC) of Canada and LKAB in Sweden, with Australian iron ore miners notably absent.

There are plans to use Karara magnetite iron ore concentrate for Progressive Green Solutions (PGS)'s upcoming pelletising facility in Western Australia, and to source magnetite DR-grade pellet from South Australia's Middleback Ranges for future green iron plants at Whyalla. However, it is clear Australia is not among the iron ore suppliers of the first movers in the low-emissions iron and steel market. This is partly due to the fact Australia's iron mining industry has never developed an ironmaking value chain at scale for export.

Table 1: First green iron initiatives and high-grade iron ore suppliers

Green iron initiative	DRI/HBI* capacity (Mtpa)	Iron ore supplier
Stegra (Sweden)	2.1	Rio Tinto's IOC, Vale and LKAB
GravitHy (France)	2	Rio Tinto's IOC, Vale
Meranti Green Steel (Oman)	2.5	Anglo American
Hydnum (Spain)	1.5 HRC*	Vale
Blastr (Finland)	2.5	Cargill

*Sources: IEEFA, company reports. *Note: HBI = hot briquetted iron; HRC = hot rolled coil.*

As the global DRI capacity expands, Australia is still contemplating entering this space, with a few proposed facilities and no track record in producing iron for export. Australia's ambition to become a green iron producer must begin with developing the entire value chain domestically, or it will lose ground to competitors.

Where Australia is positioned in the global competition

As IEEFA highlighted in previous reports, Australia faces growing competition to supply suitable feedstocks (concentrate or pellet) for low-emissions iron production. Other nations, however, can provide these feedstocks at scale, and are expanding their capacities as they advance into low-emissions iron production themselves. Among them, Brazil and Canada are the best positioned for this transition.

Canada

Canada is poised to play a significant role in the future of green iron. Its iron ore production primarily originates from the Labrador Trough, a geological formation spanning the Quebec-Labrador border. Almost all of Canada's 72Mtpa iron ore capacity is considered high-grade. Yet, despite having domestic ore-based steelmaking, it exported 80% of its 69Mt iron ore production in 2022. Nearly all of its operational iron ore deposits can produce high-grade ore (hematite and magnetite), with the majority already capable of delivering DR-grade concentrate. In 2024, the Canadian government designated high-purity iron ore as a critical mineral.

Canada holds the world's largest magnetite deposit, surpassing those found in Western Australia (WA) and South Australia (SA).

Table 2: Canada's iron ore producers

Mine	Capacity (Mtpa)	Location	Owner	Iron ore content
Fire Lake	4	Quebec	ArcelorMittal	DR-grade
Mont Wright	22	Quebec	ArcelorMittal	DR-grade
Bloom Lake	15	Labrador	Champion Iron	DR-grade
Scully	4	Labrador	Tacora Resources	65.9%
Carol Lake	17	Labrador	Rio Tinto	65%
Menihek region	4	Labrador and Quebec	Tata Steel Minerals Canada	64.5%
Mary River	6	Baffin Island	Baffinland Iron Mines	DR-grade

Sources: Lund University and SteelWatch

Both Quebec and Labrador offer round-the-clock access to clean hydropower, complemented by vast wind energy capacity. This makes them ideal locations for green iron production.

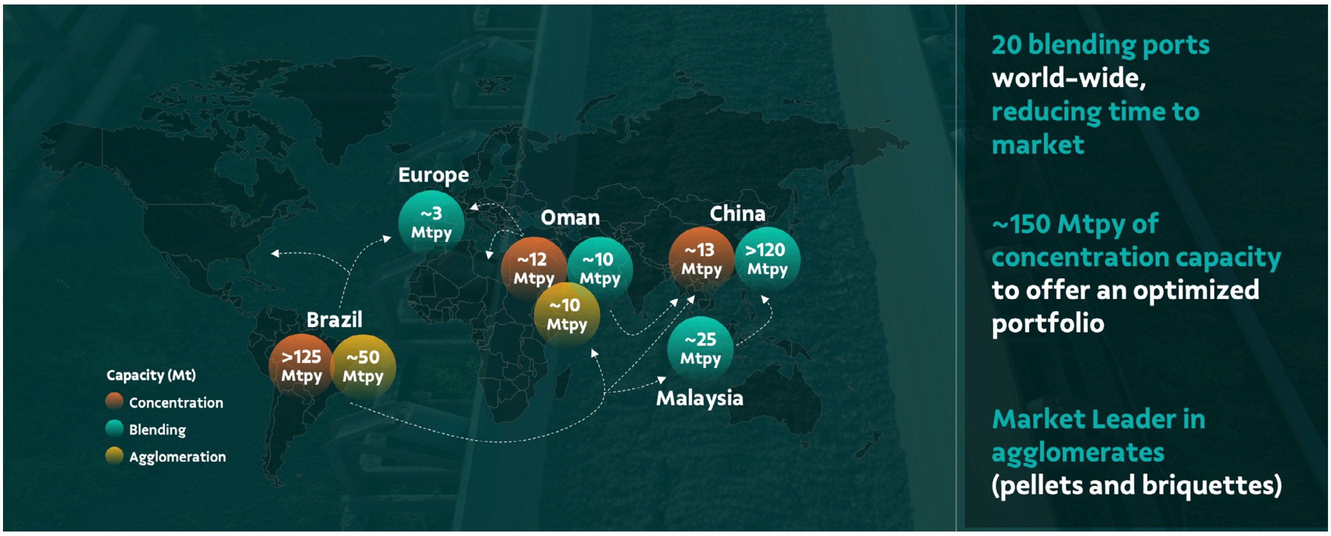
Brazil

Brazil is another major contender in the emerging green iron market. Backed by high-grade iron ore, large-scale hydropower and vast renewable energy potential, capable of producing green hydrogen, the country is actively targeting the global low-emissions iron market. Brazil's iron ore deposits are concentrated in two regions: Minas Gerais in the south-east, which typically yields mid-grade ore (40-50% Fe), and the Carajas mountains in the north-east state of Para, known for higher-quality ore (~66% Fe).

The largest iron ore producer in Brazil, Vale, has more than 125Mtpa of concentration capacity and about 50Mtpa of agglomeration capacity (pellets and iron ore briquettes combined). The company is pursuing a clear pathway to strengthen its leadership in the high-grade iron ore market through its global Mega Hub concept and domestic capacity expansions.

Vale is seeking to shift part of its processing to other regions while focusing on supplying raw materials, a strategy that lowers its direct investment and expands the availability of high-grade feedstocks for lower-emissions steel. It is in advanced discussions with seven customers, with two final investment decisions (FIDs) anticipated this year. With Brazil hosting COP30 in November, Vale may announce updates on these FIDs and project progress.

Figure 1: Vale's global iron supply chain



Source: Vale

Other than Brazil and Canada, several other countries and companies are working to produce iron ore feedstocks and green iron. WA's PGS plans to produce 7Mtpa of iron ore pellets and 2.5Mt of green hot briquetted iron (HBI). The company has signed a 100% offtake agreement with Germany's Thyssenkrupp Materials Trading for its green iron output.

The technology adoption dilemma

Two major pathways are at the centre of Australia's green iron transition:

1. Enhancing feedstock supply for conventional shaft furnace DRI production (Figure 2, Pathway 2).

This pathway with mature technology focuses on expanding the supply of high-grade iron ore concentrate and pellets, primarily magnetite-based, to feed into DR shaft furnaces. For this route to work, pellet quality is critical. Once the ore is reduced, the impurities (gangue) content must fall within a range suitable for electric arc furnaces (EAFs). Excessive impurity levels compromise EAF performance, leading to lower efficiency and reduced steel quality.

Large-scale, low-emissions iron projects worldwide, such as Stegra and Meranti Green Steel, are opting for conventional DR shaft furnaces. The two dominant technologies in this field, Midrex and Energiron, demonstrate that green hydrogen can be used to reduce iron ore and produce green steel. In Australia, initiatives such as POSCO's Port Hedland Iron and PGS's Mid-West Iron are following this pathway.

However, these pathways still require high-grade iron pellets as feedstock. This presents two key challenges for Australia: producing high-grade ore, and processing it into pellets. Major Australian iron ore miners are seeking technological solutions to these challenges.

2. Developing solutions for low- to mid-grade iron ore in the direct reduction pathway (Figure 2, Pathways 3 and 5).

The second pathway targets Australia's abundant but lower-grade iron ore resources. It explores innovative technologies capable of upgrading ore quality and managing higher levels of impurities. Many of these approaches involve a smelting stage after iron ore reduction for further impurity removal. This pathway addresses two key challenges facing ironmakers: the quality and particle size of Australian ores, and the technology required to manage higher impurity levels.

If successful, these technologies could enable direct reduction of lower-grade ores; in some cases without the need for agglomeration (Figure 2, Pathway 5). The results of initial studies using Pilbara hematite and goethite/limonite ores are promising, and pilot-scale plants are under construction in Australia and elsewhere to verify the viability of this pathway.

However, scaling this approach requires breakthroughs in two critical areas:

a) Continuous smelting technologies

These processes remove impurities from iron ore before the steelmaking stage. This could enable a wider range of ore types (including hematite and goethite) to enter the green iron value chain. Although continuous smelting has long been applied in other metals processing (e.g., ferroalloys), it has never been proven at scale for steel. Initiatives include:

- SMS's DRI-Smelter project at ThyssenKrupp
- Tenova's iBLUE Ironmaking
- Metso's Outotec pilot DRI Smelting Furnace
- Primetals' HYFOR (hydrogen-based fine-ore reduction)
- Neosmelt, an Australian initiative led by BlueScope, and Fortescue's Christmas Creek pilot facility.

In addition, BHP, in partnership with China's Baowu, trialled its fine ore in the DRI-electric smelting furnace (ESF) process.

b) Direct use of fines in direct reduction pathway (Figure 2, Pathway 4 (high grade) and 5 (all grades)).

Some pathways focus on using low- to mid-grade fines directly, eliminating the pelletising step. For miners, this would mean portions of existing production could be redirected into green steelmaking without major changes.

Beyond the large shaft furnace providers that dominate the DRI space, other players, mostly focused on fine iron ore reduction (non-agglomerated iron ore), are moving quickly to keep pace with the transition. Metso has launched its hydrogen-based Circored pilot plant, while Primetals is advancing its HYFOR industrial-scale prototype plant and POSCO is developing HyREX technology. Fortescue is also trialling this technology at its Christmas Creek pilot plant. Each follows a different technical approach but shares the same goal: integrating hydrogen into the reduction process of fine iron ores. In coming decades, more technological pathways are likely to emerge as leading providers compete to position themselves at the forefront of this transition.

Figure 2: Pathways for iron and steel production

Pathway	Iron Ore Feedstock	Ironmaking	Smelting	Steelmaking	Ironmaking Technologies	Readiness Level
1	AREA 1: Sinter feed fines (Fe: 58-62%); Lump (Fe: 62%); BF-Pellet (Fe: 63-65%)	BF		BOF		Commercial Scale
2	AREA 2: Lump (Fe>67%); DR-Pellet (Fe>67%)	SF DRI		EAF	Midrex Energiron	Commercial Scale
3	AREA 2: Lump (High Grade); BF-Pellet (Fe: 63-65%)	SF DRI	Smelter	EAF/BOF	Midrex Energiron	Pilot and Demonstration
4	AREA 2: Fines (Fe>67%)	FB DRI		EAF	FINMET FINEX Circored	Demonstration and smaller-scale plants
5	AREA 2: Fines (Fe: 58-67%)	FB DRI	Smelter	EAF/BOF	Circored HyREX HyFOR	Pilot and Demonstration

Source: IEEFA. Notes: SF = shaft furnace, FB = fluidised bed, BOF = basic oxygen furnace, BF = blast furnace, EAF = electric arc furnace. Area 1: grey, represents the focus of Australia's iron ore mining. Area 2: light green marks the area targeted for green iron development. For more information on the range of accepted materials feedstock in the market, see Fastmarkets and S&P Global. In addition to the pathways above, other emerging technologies include direct electrolysis of iron ore and the use of biomass as a substitute for coal to reduce emissions, although these are still at very early stages of development.

The capacity for producing reduced iron from fine iron ore is minimal compared with shaft furnaces, which remain the dominant DRI technology. According to the Midrex 2024 report, more than 114 shaft furnaces are operating worldwide, with a combined DRI production capacity exceeding 110Mtpa. In contrast, only one FINMET facility in Venezuela processes fine iron ore, with four modules and a total capacity of 2.2Mtpa. Other technologies and plants, such as the Circored facility in Trinidad and the FIOR plant in Venezuela, are reportedly idle. The FINEX process, operating at POSCO's 2Mt plant in Pohang, South Korea, is another advanced fine ore processing technology, and HyREX is being developed based on this platform.

So, while fine ore solutions are advancing, shaft furnaces remain the backbone of global DRI production, which is almost entirely pellet-based today. Shaft furnaces are expected to remain dominant in the short term, meaning pellet supply will continue to play a critical role both DR grade and BF grade. (Figure 2, Pathways 2 and 3)

The way forward for Australia

With Australia's mining and ironmaking industry at a crossroads, which pathway should it take: enhance feedstock supply for conventional shaft furnace DRI production? Or develop solutions for low- to mid-grade iron ore in the DR pathway?

The short answer is both, although the required priorities vary in their significance.

Many, including major technology providers, believe the breakthrough technologies already exist for the transition to green iron, but need time to become commercially viable at scale. While these solutions are being developed, it is equally important to continue investing in mature technologies. History shows the risks of relying on a single pathway. Australia has twice failed in pursuing new pathways for iron production: first with BHP's Boodarie HBI plant based on FINMET technology in 2005, and later with Rio Tinto's HIsmelt plant in Kwinana in 2011. The ironmaking industry has always evolved through competing processes, with some scaling to millions of tonnes of production while others never move beyond pilot scale.

Vale's executive vice president for commerce and development, Rogerio Nogueira, said, "You may think about different routes being developed – one which is more proven for the usage of high-grade ores [beneficiation] and the other for the usage of lower-grade ores, … My sense is that with the technology we can see right now, it will be less capital intensive ... and more competitive to use higher grade ores in the newer but more traditional steel-making."

Nogueira also emphasised the need "to find solutions that are more applicable to the characteristics of our iron ore and so will the Pilbara". He added, "I don't see a world where steel is produced without Pilbara ore. So, in order for steelmaking to decarbonise, Pilbara needs to find a solution."

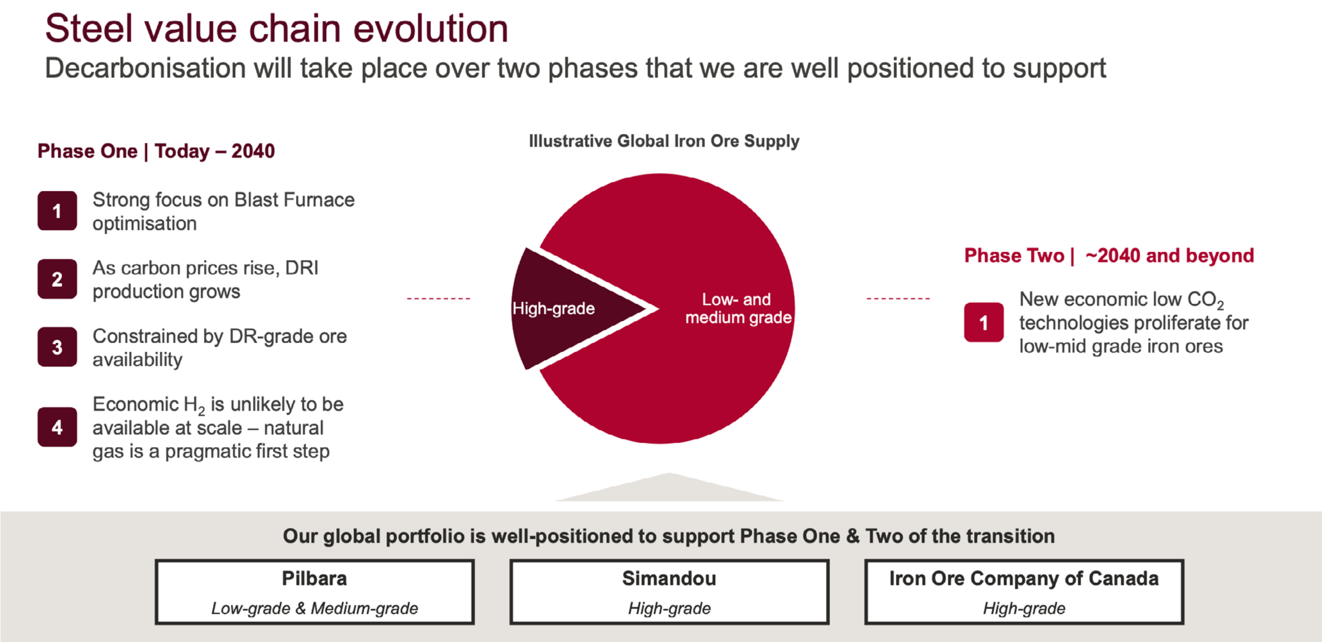
This raises a critical question whether Australia should wait for global technology providers to deliver breakthroughs before building its next generation of ironmaking. That is far too risky for a country aiming to be a major, if not leading, player in the green iron market. While new solutions such as DRI-ESF and direct electrolysis (e.g., Electra and Boston Metal) are being developed, Australia cannot overlook the proven technologies widely adopted in other countries.

Notably, many so called "next-generation" technologies remain dependent on conventional feedstocks such as iron ore concentrate and pellets. In other words, even the most advanced pathways are still tied to iron ore processing. Betting solely on new pathways also risks overestimating how quickly capacity can expand. Large-scale facilities may take decades to develop. Australia is not alone in this race, and competition for access to these technologies will only intensify.

Some trading partners may be better positioned to establish their own hydrogen-based ironmaking, such as China, which is forecast to be able to produce hydrogen at very low cost. This may increase their demand for high-grade feedstocks rather than reduced iron. In contrast, trade partners such as Japan and South Korea are likely to be more dependent on Australian reduced iron.

Rio Tinto estimates iron decarbonisation will occur in two phases: continued reliance on high-grade ores and conventional DRI technologies until the 2040s, when low- to mid-grade ores are expected to become technologically viable. Rio Tinto can produce high-grade ore from its IOC facility in Canada, and aims to capture a larger share of the market once its Simandou project in Guinea comes online.

Figure 3: Rio Tinto's two-phase iron ore transition



Source: Singapore Green Steel Forum 2024

Rio is also considering pellet production from Simandou iron ore, stating, "We are committed to working with our industrial partners and the [Guinea] government on a feasibility study for the construction of a pellet plant, which will help us understand the viability and options available together." However, Rio's Australian operations have no facilities to supply any products suitable for low-emissions iron and steel. Furthermore, the company is reportedly planning to blend higher-grade iron ores from Simandou with lower-grade ores from the Pilbara, as it faces a persistent decline in ore quality due to the depletion of higher-grade deposits.

A sensible approach for Australia is to maintain its focus on high-grade iron ore mining and processing while partnering with international players on technology development. Australia is well positioned to serve as a key supplier of the high-quality feedstocks needed for the green iron value chain. Taking a balanced approach, backing today's proven solutions while preparing for tomorrow's breakthroughs, will be essential to secure a role in the future green iron market.

Magnetite mining in Australia: The good, the bad and the ugly

Based on the available technologies at scale, the green iron transition will require higher-grade feedstock. While Australia's iron ore industry is dominated by low-grade hematite/goethite ores, pursuing green iron pathways will require a shift towards high-grade ores. High-grade hematite/goethite, such as that found in Simandou or Brazil's Carajas deposits, is scarce in Australia, if not entirely unavailable. But Australia does hold significant magnetite deposits, amenable to beneficiation, which could initially support the transition.

Good

Australia holds more than 66 billion tonnes of magnetite iron ore resources, with several deposits suitable for DRI production. The country is richly endowed with high-potential magnetite reserves, particularly in South Australia, where large-scale deposits are gradually advancing. Three of Australia's top 10 deposits – Hawsons Iron, Central Eyre Iron Project (CEIP), and

Razorback and Iron Peak – are moving towards FID, and could reshape Australia's role in the nascent global green iron supply chain.

Bad

The maze of regulatory approvals and permits remains a significant barrier. Securing all the necessary clearances before mining often takes close to a decade, a critical delay in a rapidly evolving market. While these processes serve important purposes, opportunities to streamline and modernise them must be considered. The scale of the challenge is clear: of 83 magnetite iron ore deposits listed in the Australian Green Iron Tracker, only six had reached the mining lease stage by August 2025, and none had achieved FID.

Many earlier magnetite projects in Australia made significant progress until challenges, particularly in securing approvals and navigating market volatility, led to cancellations or FID deferrals. This troubled history, combined with project timelines, highlights the prolonged and complex journey Australian iron ore miners face to bring magnetite operations to fruition.

For example, the Balmoral South project was halted in 2012 after failing to gain necessary approvals from the WA government. CEIP completed its first definitive feasibility study in October 2014, yet has not progressed to FID. Similarly, the Ridley project deferred its investment decision, citing "onerous" approval requirements and escalating costs. These are just a few of many large-scale magnetite projects that have encountered persistent hurdles despite considerable efforts to advance towards production.

Ugly

Many magnetite deposits lie in remote regions, requiring billions in new infrastructure before production is viable. Not all deposits are suitable for DR-grade feedstock; in many cases, impurities such as silica and sulphur must be reduced to levels that deposits struggle to achieve. Magnetite operations in Australia mainly produce BF-grade iron ore concentrate, and may require upgrades to deliver DR-grade material. These structural challenges present significant hurdles for miners aiming to supply the green steel industry.

Magnetite processing an integral part of the green iron ecosystem

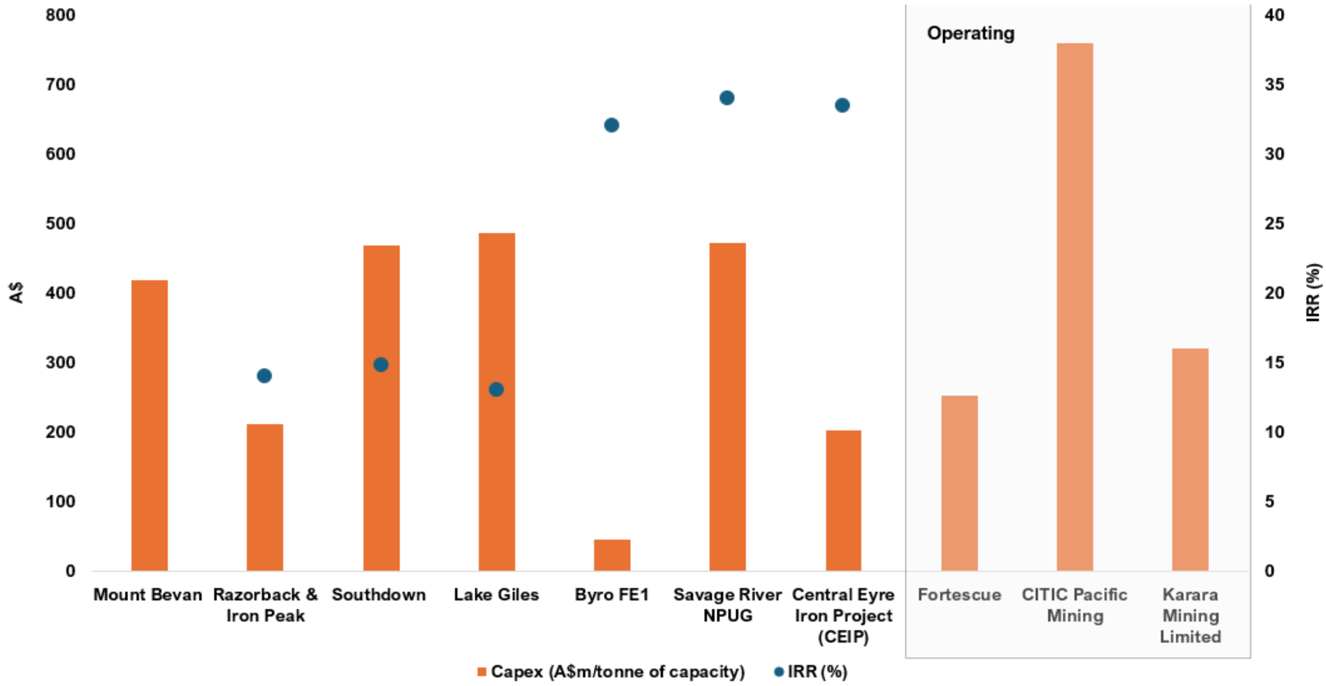
The cost of processing magnetite is higher than traditional direct shipping ore (DSO) operations. However, comparing magnetite economics directly with existing DSO business models is misleading. Magnetite concentrate and pellet production should be viewed as a foundational element of Australia's green iron strategy.

The capital expenditure (capex) and infrastructure requirements of magnetite projects vary significantly, depending on location, processing technology and capacity. However, evidence from past Australian projects and recent feasibility studies show that most large-scale developments demand billions in investment. Beyond the processing facility, critical infrastructure, such as ports, slurry pipelines and transport networks, is required. In 2019, CEIP revised the scope of its feasibility study from 24Mtpa to 12Mtpa to reduce the project's capex by 56% compared with the original studies in 2014 and 2015.

More recent feasibility studies show that a capex of A$300-A$400/tonne of concentrate is required for magnetite mines to produce iron ore concentrate.

Figure 4 presents the capex of selected operating projects as well as pipeline projects, together with their reported capex and internal rate of return (IRR) from feasibility studies.

Figure 4: Capex and IRR of Australian magnetite projects (proposed and operating)



Source: Australian Green Iron Tracker Dataset

Feasibility studies indicate magnetite mining is economically feasible in Australia. The IRRs of projects in the pipeline fall into two groups: 10-15% and 30-35%. For major magnetite iron ore concentrate projects, cash costs range from A$63-A$119/t of concentrate. It is worth noting that high-grade pellet feed has averaged US$120-US$140 for the past two years, and demand for this type of feedstock continues to grow.

Australia must also recognise that, as a newcomer in the agglomerated products market, its costs may be higher than those of long-established players. For instance, Vale's performance report for the second quarter of 2025 showed pellet cash costs of US$77.10/t against a realised price of US$134.10/t. Meanwhile, Australia's Grange Resources reported pellet cash costs of A$178.08/t for the same period.

Global capex in the iron ore sector has slowed. Since 2023, the primary driver has been Simandou, a multi-billion-dollar investment in one of the world's largest untapped high-grade iron ore deposits. S&P Global expects the margin of iron ore mining to come down, and Australian miners with low-quality ores will be affected intensively as the market seeks higher-grade iron ores and end users are more interested to pay for higher-grade feedstocks.

In Australia, magnetite ores appear to be the only viable source of high-grade iron ore capable of supporting an early transition and maintaining competitiveness in the global race.

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