Forging our **Future**

10 requirements to build an export-scale green iron industry in Western Australia

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Credits

Written by Springmount Advisory 2024

I Summary

Standing up an export-scale green iron industry in Western Australia will safeguard Australia's iron export industry, create tens of thousands of secure jobs, and significantly reduce global emissions. But it won't happen by chance.

Western Australia is the world's largest iron ore producer, mining more than 860 million tonnes of iron ore in 2023 equivalent to 39% of global supply.[1] Royalties from the iron ore industry account for 85% of WA's royalty revenue[2] and for a quarter of the WA government's general revenue. Nationally, iron ore is Australia's single largest export, worth $136bn in 2023 - 20% of Australia's exports by value[3] and 33% of resource and energy commodity exports in 2023-24[4].

However, iron ore mining, processing, and manufacturing into iron and steel products is extremely emissions intensive. Global steel-making emissions contribute 7-9% of total global emissions in any given year.[5] A net zero world will need to have almost completely decarbonised steel production. Because of this, international steelmakers are investing in new non-WA supplies of ore as the bulk of what is exported from the Pilbara is not compatible with the predominate existing green steel technologies.

The world must urgently decarbonise, but this puts Australia's largest export industry, in its current form, at risk. Without policy support and targeted investment by the Commonwealth and Western Australian governments, the backbone of our export economy is likely to collapse. If the WA iron ore industry isn't properly prepared for the fast-arriving low-emissions economy, Australians risk significantly lower standards of living and our country becoming a poorer place.

Almost every major iron and steel producer in the world today was initially established as a state-owned enterprise with a clear national objective underpinning their creation. The speed and scale of industrial development required to reduce emissions and secure a green iron industry in Australia means we need to look at what has worked in the past and build on those successes to meet the challenges of today.

Australia becoming the world's top green iron producer will require the Commonwealth and Western Australian governments, industry and workers to apply the lessons of how rapid industrialisation has been achieved in the past.

We have to partner together to achieve scale quickly.

If we fail to do so, Australia's prosperity and continued high standards of living are at risk, and the world will likely fail to keep global warming below 1.5C.

Forging Our Future sets out the ten requirements needed to build a green iron industry in WA quickly.

Importantly, we show how the establishment of a major new joint venture, the Australasian Green Iron Corporation, as a 21st-century partnership between the Western Australian and Commonwealth governments, iron ore miners, the steel industry, and our key trading partners is the fastest and lowest-risk route to a large-scale green iron industry in WA.

Forging Our Future includes 3 complementary scenarios that can enable the building of a large-scale green iron industry:

1. Domestic green iron consumption

The first scenario sees green iron production commence in 2026 with a goal to provide 100% green iron for Australia's steel production within 10 years. This will create an immediate green iron market and demonstrate Australia's capacity to produce green iron for investors and trading partners.

2. Green iron exports for South Korea, Japan and Taiwan

Starting with initial green iron exports in 2028 to South Korea, Japan and Taiwan. This scenario builds to meet 70% of the green iron demand of our renewable energy-constrained trading partners by 2040.

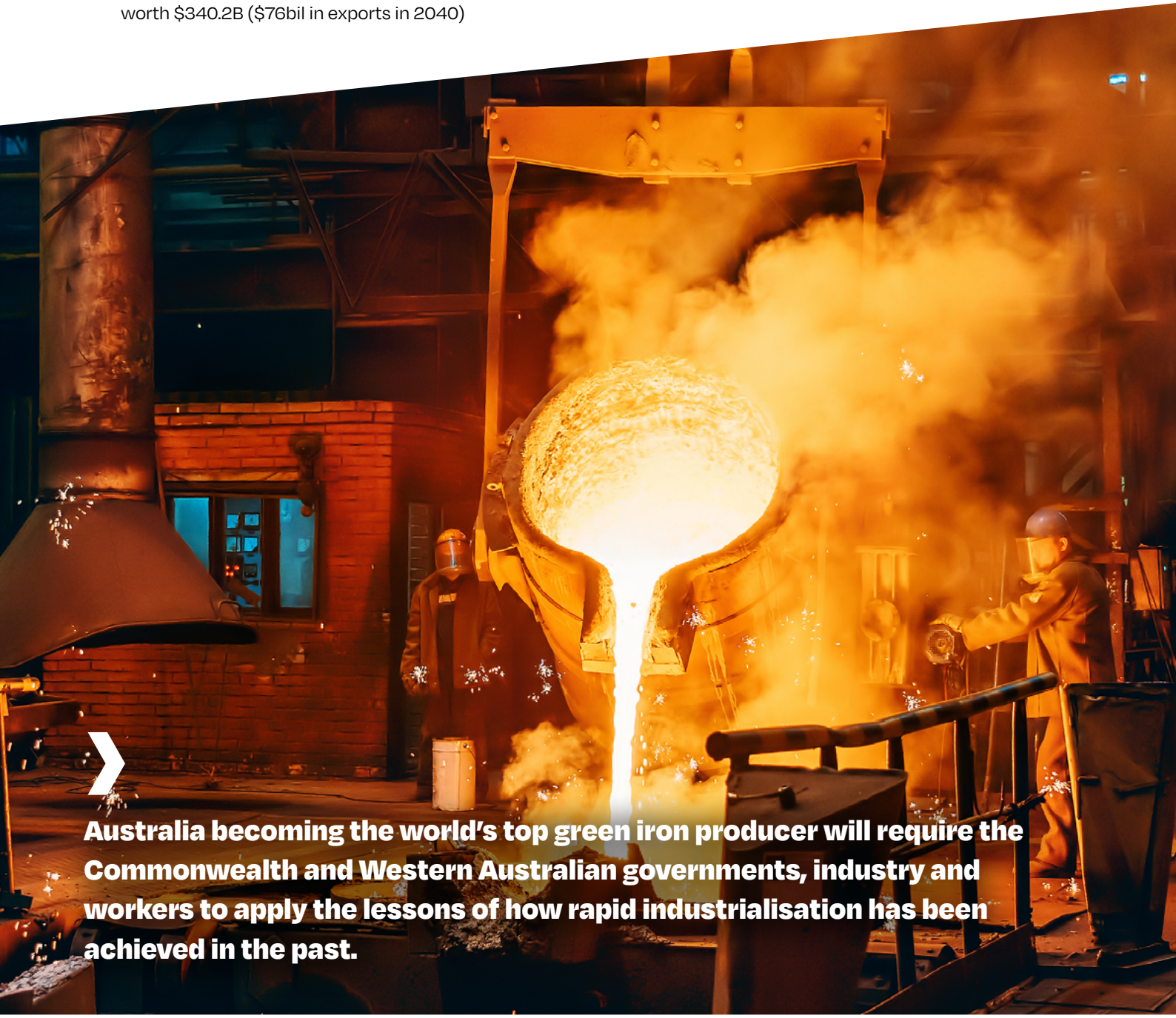
3. Top and tail China's green steel transition

Starting exports to China in 2033 will enable Australia to help provide top and tail green iron exports that will improve China's capacity to decarbonise its domestic steel industry, the largest in the world.

1 Department of Jobs, Tourism, Science and Innovation (JTSI), Western Australian Government, March 2024, 'Western Australia Iron Ore Profile – March 2024'.
2 https://www.watc.wa.gov.au/media/lbopz4i3/wa-iron-ore-profile-march-2023.pdf
3 https://www.dfat.gov.au/sites/default/files/australias-goods-and-services-by-top-25-exports-2023.pdf
4 https://www.industry.gov.au/sites/default/files/2024-06/resources_and_energy_quarterly_june_2024.pdf
5 https://worldsteel.org/publications/policy-papers/climate-change-policy-paper/

If delivered in parallel, these three scenarios would:

- **Produce 122 million tonnes of green iron per year by 2040 from approximately 40 DRI plants with an average capacity of 4 mtpa**
- **Over the 14 years produce:**
  - $380bil in GDP ($27bil per year)
  - $350bil in real income ($25bil per year)
  - $167bil in Commonwealth and WA state taxation, ($11.9bil per year)[6]
  - Develop a new Western Australian export industry worth $340.2B ($76bil in exports in 2040)
- **Create 24,000 ongoing jobs in WA, with an additional 150,000 construction jobs created over 14 years - or an average of 11,000 full-time construction jobs per year**
- **Drive down emissions from Australia's and our region's steel industry with a reduction of 274 MtCO2-e of emissions per annum in 2040 - equivalent to half of Australia's annual national emissions.**



Australia becoming the world's top green iron producer will require the Commonwealth and Western Australian governments, industry and workers to apply the lessons of how rapid industrialisation has been achieved in the past.

6 Based of a MRWIA model https://www.mriwa.wa.gov.au/minerals-research-advancing-western-australia/focus-areas/green-steel/green-steel-resources/

II Requirements

Build industry - what we need to achieve scale quickly and responsibly.

Requirement 1:
Establish the **Australasian Green Iron Corporation** as a joint venture between the Australian and Western Australian governments, a key trading partner, a major iron ore miner, and steel makers.

Requirement 2:
Construct enabling infrastructure for green iron projects by activating **Renewable Energy Zones linked to WA's Strategic Industrial Areas** - in particular, the Boodarie and Oakajee Strategic Industrial Areas.

Requirement 3:
Build domestic demand for green iron and steel through **government green steel procurement** for civil and energy infrastructure, shipbuilding, rail expansion and other projects.

Requirement 4:
Create the **Perth Green Metals Exchange** to provide a distinct market for low-carbon and ethically produced metals, underpinned by Guarantee of Origin certification.

Requirement 5:
Establish **mutually complementary trade policies and incentives** to encourage the trade of green iron, and finished products constructed with green iron inputs. Prioritise establishing a common definition for green steel and the introduction of carbon border adjustment mechanisms with our trading partners in East and Southeast Asia.

Requirement 6:
Improve **Commonwealth and WA environmental laws** to set strong standards for environmental protection with a focus on waste management, air pollutants and minimising land clearing.

Work for workers - what we need to ensure secure jobs and a say for workers.

Requirement 7:
Work with the **Net Zero Economic Agency, WA worker transition programs and the Clean Energy Centre of Excellence** to create secure transition pathways for workers into the green iron industry.

Requirement 8:
Ensure **strong collective bargaining structures and union agreements** on all new green iron projects.

Ensure justice – what we need to guarantee benefits are shared fairly.

Requirement 9:
Prioritise **First Nations consent, participation and co-ownership** through all green iron industrial policy initiatives by adhering to the First Nations Clean Energy Network's Best Practice Principles for Clean Energy Projects.

Requirement 10:
Deliver outcomes for host communities by aligning all green iron project approvals and conditionality with the **Community Benefit Principles** detailed in the Future Made in Australia **Act.**[7]

7 https://treasury.gov.au/sites/default/files/2024-05/p2024-526942-fmia-nif.pdf

III Our green iron future

The majority of Australia's iron ore is exported to just four nations: China (84.9%), Japan (6.3%), South Korea (5.4%) and Taiwan (1.5%), each of which converts the iron ore into steel via a blast furnace–basic oxygen furnace (BF-BOF) pathway.

The BF-BOF process consumes 780 kg of coking coal for each tonne of steel[8] and generates 2.33 t CO2-e of emissions. It is the most common and most emissions-intensive form of steel production[9].

As a result, final emissions from Australia's iron ore exports are likely to be responsible for ~3.6% of total annual global emissions (1,353 mt CO2-e per annum) once converted into steel.

Not surprisingly, steel production is a major source of emissions for our key iron ore trading partners (see chart).[10] However, options for reducing steel's emissions footprint where it is produced are more limited.

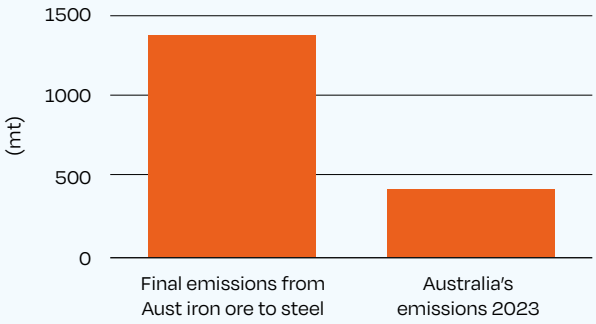
South Korea, Japan and Taiwan in particular are highly constrained geographically and have limited capacity to build sufficient new renewable electricity generation at the scale and speed to replace current fossil fuel electricity generation. This is before the additional renewable energy demand load of green iron production is even factored in.

Establishing a large-scale onshore green iron industry in Australia using our abundant renewable energy resources to process iron ore into iron, the most emissions-intensive part of the steelmaking process, would provide an opportunity to sustain the industrial ecosystems of our trading partners while enabling them to achieve their emissions reduction targets.

Our capacity to host large renewable energy projects should put Australia, and WA in particular, in a position to become a leading provider of a secure, high-volume green iron supply for our region.

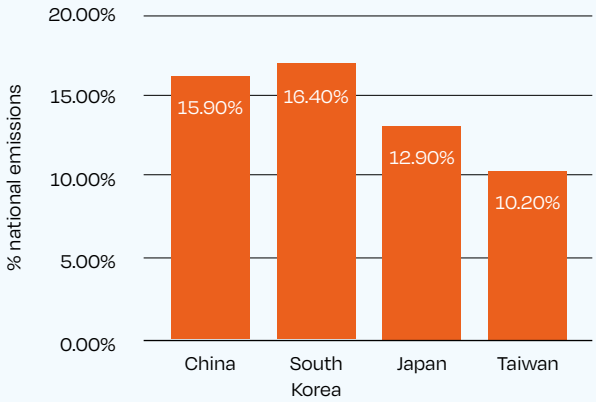
Developing new, strong trade relationships based on joint investment into green iron production in Australia will be crucial to helping reduce the emissions profile of our trading partners and creating a significant new export industry at home.

Emissions from producing Australian iron ore to steel are over 3x larger than Australian whole of economy emissions.



Source: National Inventory Report (DCCEEW); Springmount Advisory calculations

Steel production share of national emissions



Source: Lund University. Sweden: Fraunhofer Institute. Germany.

8 https://worldsteel.org/wp-content/uploads/Fact-sheet-raw-materials-2023.pdf

9 BF-BOF technology generates average emissions of 2.33 t CO2-e/t compared to 1.37 t CO2-e/t for Direct Reduced Iron - Electric Arc Furnace processes and 0.68 t CO2-e/t for scrap to EAF production https://worldsteel.org/steel-topics/sustainability/sustainability-indicators-2023-report/

10 https://www.sciencedirect.com/science/article/pii/S1364032121002306

The risks if we don't seize the moment

Global steelmaking accounts for between seven and nine per cent of global carbon emissions.[11] To get to a net zero world, we must fully decarbonise steel production.

The majority of WA's hematite ore exports are converted into steel via BF-BOF technology which generates average emissions of 2.33 t CO2-e/t. This is compared to 1.37 t CO2-e/t for gas-fired direct reduced iron–electric arc furnace (DRI-EAF) processes, and 0.68 t CO2-e/t for scrap-to-electric arc furnace production. New processes, like Swedish steelmaker H2 Green Steel's Boden plant, will produce steel with emissions of only 0.04t CO2-e/t from magnetite ore.[12]

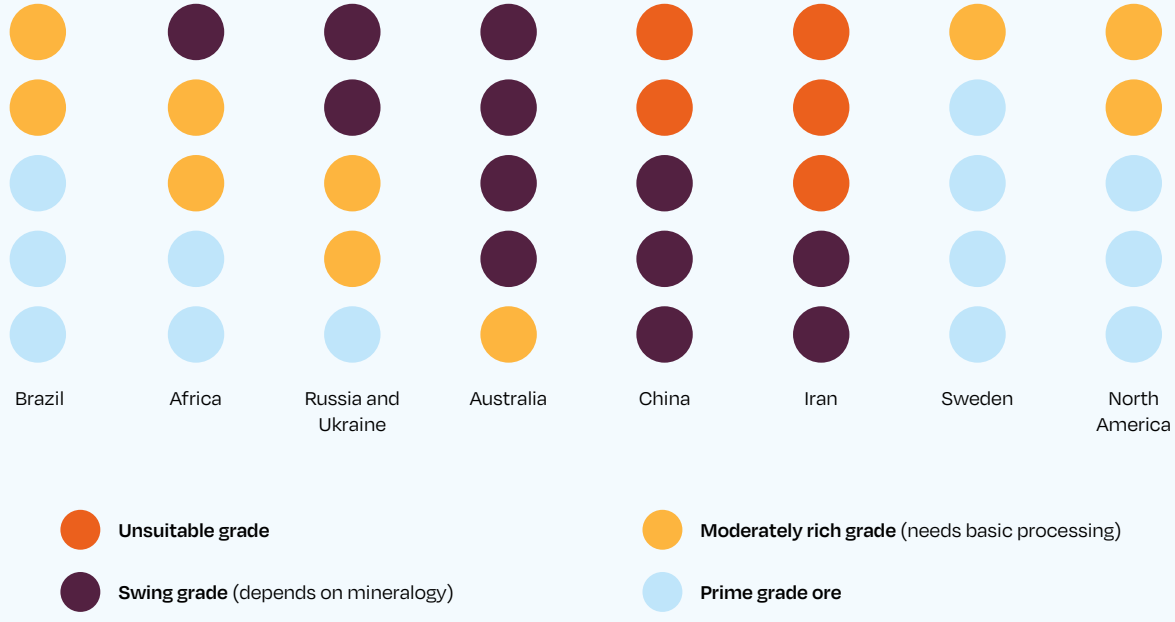
This presents a challenge for the WA iron ore industry. Iron and steelmaking furnaces designed to produce emissions-free steel generally require higher purity ores than those shipped from the Pilbara and increasingly require different ore types altogether.

Despite being the world's largest iron ore producer, the quality of Western Australian ore is low by global standards and deposits have been developed to meet the ore mix needed for BF-BOF processes. Other iron ore mining regions such as Brazil and Guinea have higher grade ores that are more suitable for existing green steelmaking methods.

While these regions have not historically exported the volumes needed to be competitive with WA's giant operations in the Pilbara, the shift to green iron and steel production is shifting the investment equation. In particular, the development of the Simandou high-grade iron project in Guinea[13] will pose a significant threat to future demand for WA iron ore.

New mines entering the seaborne iron ore market over the next five years are big, owned by dominant market players, and of a much higher ore grade than most Pilbara ores. They also have direct ownership links to major Chinese steel mills. These new mines are positioning to outcompete the Pilbara on ore grade and cost, as well as setting up a new supply for green steel processes.

Where will the supply of high-grade ore originate from?



Source: Wood Mackenzie

11 https://worldsteel.org/publications/policy-papers/climate-change-policy-paper/

12 https://www.hydrogeninsight.com/industrial/h2-green-steel-secures-4-5bn-of-additional-funding-for-world-s-first-large-scale-green-hydrogen-based-steel-plant/2-1-1586810

13 https://www.riotinto.com/en/operations/projects/simandou

Global investment is already shifting

More than half of new global investments in steel plants over the next three years will be in electric-arc furnace (EAF) plants, while 42% are in BF-BOF plants. Some region's capacity increases are almost only EAFs.[14]

An industry-wide shift away from BF-BOF technology in favour of green iron and steel production methods will create a structural decline in demand for East Coast metallurgical coal exports. Without investment in green iron production using Western Australian iron ore, the West Coast iron ore export market will also be at risk of structural decline.[15]

Alongside ore grade and changes to steel-making technology, the speed at which the global steelmaking industry is moving rapidly outpaces any policy initiative or project progression in Australia.

Currently, there are at least five green iron projects proposed for Australia including three in WA: the Port Hedland Green Steel Project (POSCO), Christmas Creek Green Iron Plant (Fortescue Future Industries), Mid West DRI Plant (Green Steel WA), the Whyalla Green Steel Transformation project in South Australia (SA Government, GFG), and Queensland's Gladstone Green Iron (Quinbrook). However, as of writing, ground has yet to broken on any of these plants.

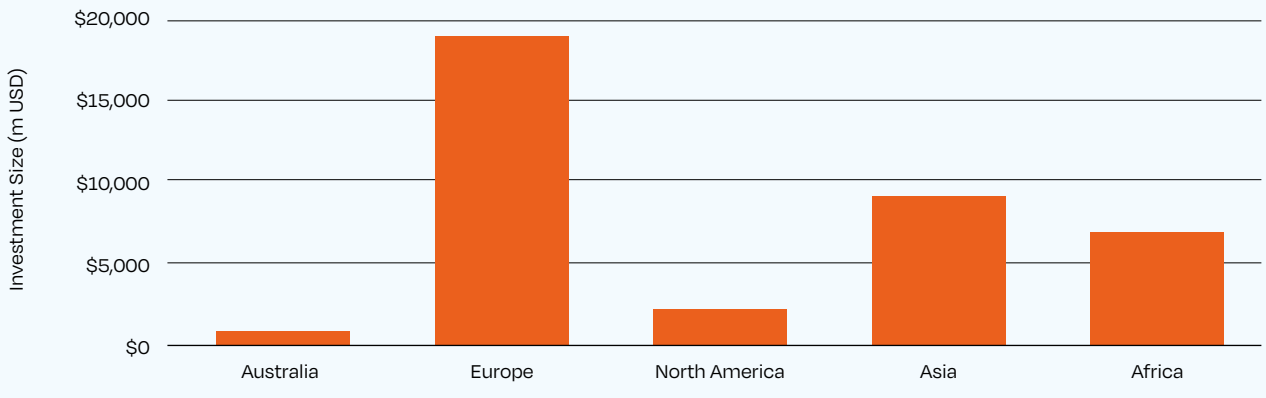
The lack of investment and project commencement to date is likely because there is no clear government policy or substantial industry development programs to establish and support green iron in Australia.

A further consideration is that all Australian projects plan to use magnetite ores for green iron production. A clear government focus on attracting emissions-free iron-making technology that favours the Pilbara's predominantly hematite ores is urgently required.

Initiatives under the Future Made in Australia Act like Hydrogen Headstart and the Hydrogen Tax Incentive scheme, while a good start, are too small to drive the development of a large-scale green iron export industry. The risk is that once green iron facilities are established in other regions, the race will have been run. Those countries will dominate green iron production and Australia will be stuck with an iron ore export industry with a comparative disadvantage in ore quality.

Australia needs to look to the history of major industry development to avoid that scenario and instead apply the lessons of the past to build a high-quality, competitive green iron industry as fast as possible. By doing so, we can set up a lucrative 21st-century Australian export industry that respects workers, shares benefits with First Nations Peoples and local communities, and leads the way in environmental management.

Green steel investment size (m USD) as of March 2024



Source: Green Steel Tracker, Green steel investment as of March 2024

14 https://one.oecd.org/document/DSTI/SC(2024)3/FINAL/en/pdf

15 Resources and Energy Quarterly, June 2024

IV Build industry - what we need to achieve scale quickly

The Australian Federal and State governments have been instrumental in developing the nation's industrial base, from steelmaking to aluminium smelting to LNG production.

The Western Australian government provided Woodside Energy the structural support needed to build Australia's offshore gas industry through the provision of long-term offtake contracts above market price and taxpayer-funded construction of supporting infrastructure. State and Commonwealth governments have been instrumental in establishing Australia's aluminium smelting capabilities at Bell Bay, Portland and Boyne Island, while long-term government contracts and close industrial coordination were critical to the creation of our domestic steel-making sector.

The government has always been the central actor able to convert theoretical advantages into actual advantages that deliver sustained national industrial capacity.

Requirement 1:
Establish the **Australasian Green Iron Corporation** as a joint venture between the Australian and Western Australian governments, a key trading partner, a major iron ore miner, and steel makers.

Establishing a large-scale green iron industry will be a complex task, even with Australia's comparative advantages. It will require significant technical know-how, deployment of major capital investment, construction of large-scale renewable energy projects, innovative policy settings, signing green iron offtake agreements, and a willingness to take risks.

Joint ventures combine the foresight, financial heft and purchasing power of government with the skills, market awareness, production capacity and technological edge of industry and are the optimal development pathway to establish a green iron sector.

Europe is at the forefront of the emerging green iron and steel sector - with industrial development being spearheaded by joint ventures, like Hybrit and H2 Green Steel in Europe.

Hybrit, a joint venture comprised of Vattenfall - Sweden's state-owned power company, SSAB - the largest producer of sheet steel in Scandinavia, and LKAB (Luossavaara-Kiirunavaara Aktiebolag) a state-owned Swedish mining company that produces 80% of the European Union's iron ore[16], is building a 1.2 mtpa green iron green demonstration plant. Financial support for the project has been provided by the European Union and once production commences in 2026, the plant will produce the equivalent of one-quarter of total steel production in Sweden.[17]

H2 Green Steel (H2GS) is the other green steel leader in Europe. The joint venture was established in 2020, inspired by the model established by Hybrit[18]. H2GS has raised more than €4bn euro in debt financing to build a green steel plant in Sweden with production commencing in 2025.

Key lenders include Svensk Exportkredit (the state-owned Swedish Export Credit Corporation) and the European Investment Bank together with commercial banks, led by BNP Paribas, ING, KfW IPEX-Bank, Societe Generale and UniCredit. Lending for the project has been provided cover by Riksgälden (the Swedish National Debt Office), as a green credit guarantee and covers 80% of the loan amount.[19]

> *"The steel industry is a strategic sector, being at the heart of the EU economy. Our commitment to reach net zero by 2050 requires this sector to undergo transformative changes. It is important that the EIB, as the EU climate bank, is supporting H2 Green Steel in its pioneering development"*
>
> - Vice-President of the European Investment Bank, Thomas Östros.

Founding the Australasian Green Iron Corporation as a joint venture between the state and industry is a crucial intervention that is both consistent with how the sector is developing internationally and able to significantly de-risk the establishment of a large-scale green iron industry in Australia.

16 https://lkab.com/en/press/europes-largest-deposit-of-rare-earth-metals-is-located-in-the-kiruna-area/

17 https://www.hybritdevelopment.se/en/hybrit-demonstration/

18 https://www.h2greensteel.com/latestnews/bibendum-sit-malesuada

19 https://www.h2greensteel.com/latestnews/h2-green-steel-raises-more-than-4-billion-in-debt-financing-for-the-worlds-first-large-scale-green-steel-plant

Why establishing a green iron joint venture makes sense for Australia

Joint ventures are commonly used in the development of complex and highly capital-intensive industrial projects because they have several key advantages. Joint ventures enable access to a wider range of expertise, technologies, and market knowledge, allowing partners to leverage each other's strengths. They also allow partners to share the capital burden and investment risk.

A joint venture that includes state enterprises taking a cornerstone stake offers additional strategic advantages. Aside from bringing substantial financial resources and a lower cost of capital to a project, which is useful to attract private sector investment, state enterprises help align the joint venture's objectives with national economic and strategic interests, ensuring long-term support and alignment with government priorities.

A government stake in a joint venture will also ensure that future revenues will deliver a return to the public. This will help ensure that an Australian green iron industry avoids the historic pitfall of socialising the costs and privatising the benefits of industry development programs.

Working with our trading partners to cooperatively establish the Australasian Green Iron Corporation with purposefully selected partners will assist all of our economies to decarbonise and thrive, and realise a shared vision for a decarbonised steel sector.

Enabling the green iron value chain

Iron ore | **Green hydrogen** | **Green iron production** | **Green iron export** | **Green steel production** | **Green steel used to manufacture final products**

Renewable energy supply, green hydrogen and green iron production occurs in Australia

Existing initiatives:

- Hydrogen headstart
- Hydrogen PTC
- Rewiring the Nation
- Strategic Industrial Areas

Required initiatives:

- Renewable Energy Zones in WA
- Guarantee of Origin

Existing initiatives:

- Proposed green iron facilities

Required initiatives:

- Future Made in Australia support
- Green iron procurement contracts and offtake agreements to underpin demand
- A Perth Green Metals Exchange

Steel production and utilisation occurs in trading partners industrial sector

Required initiatives:

- Green iron export agreements with trading partners
- Green iron cooperation with major steel producers
- Green steel offtake agreements from major steel consumers in automotive, appliance, infrastructure and ship building industries

Required initiatives:

- Green steel procurement weighting for infrastructure and vehicle contracts

Joint venture partners should include:

The Commonwealth and Western Australian governments;

A state investment vehicle from a major trading partner;

A major iron ore producer;

A local and an international steel maker.

Case study

Yahata Steel Works and Nippon Steel, Japan

The Yahata Steel Works in Japan was established as a state-owned enterprise that commenced production in 1901 and was designed to meet Japan's increasing steel demand for railway steel, shipbuilding, defence materials and residential construction. The plant was responsible for between 80% and 90% of Japan's iron and steel production during the first decades of operation[20] and continues to provide steel for Japan's car-making industry.

The steelworks are now a core part of Nippon Steel, one of the largest steel makers in the world.

Australasian Green Iron Corporation Joint venture partner attributes

Australian and WA Governments

Australian Government

GOVERNMENT OF WESTERN AUSTRALIA

Attributes:

- Keystone investment and vision setting
- Align energy and industry policy settings
- Construction of renewable, transmission and hydrogen capacity

A trade partner

Attributes:

- Keystone investment and vision setting
- Align green iron trade import settings
- Upgrade steel manufacturing to accommodate green iron inputs
- Offtake agreements

An iron ore major

Fortescue

RioTinto

BHP

Attributes:

- Research and development of optimised ore mix for green iron production
- Scale and reliable supply of ore inputs

Steel producers

BAOWU

posco

NIPPON STEEL

BlueScope

Attributes:

- Development and deployment of green iron plants
- Large scale green iron offtake agreements
- Supply of green steel to industry

As we show below, this structure is well-established and has been used over the past century to set up new industries and develop comparative industrial advantages in Australia and overseas.

Case study

Woodside Energy, Western Australia

Woodside Energy only became a profitable business because of significant and sustained government support. The company started as a small Victorian gas and oil explorer in 1954 but pivoted to Western Australia in the 1970s. The North West Gas Development (Woodside) Agreement Act 1979 in particular was central to the success of Woodside's oil and gas development off the Pilbara and Kimberley coasts.

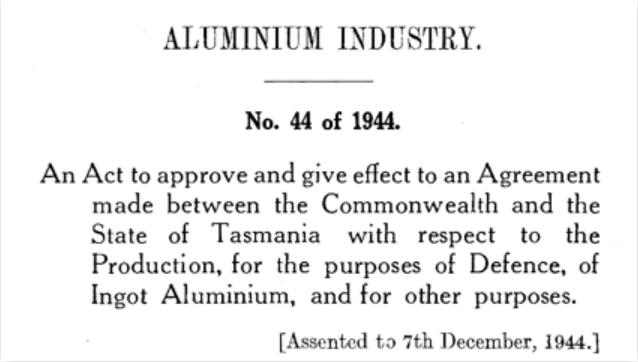
20 Shimizu Norikazu (2010). "The Establishment of the State-Owned Yahata Steel Works

Australia and East Asia's industrial history

The Australian aluminium industry

In 1944, the Federal and Tasmanian Government established a joint venture[21] to construct the first aluminium smelter in the Southern Hemisphere. The governments contributed equally to the Australian Aluminium Production Commission's capital costs.[22]

The smelter helped overcome wartime aluminium shortages and the dependency on imports from Europe and the United States.



ALUMINIUM INDUSTRY.

No. 44 of 1944.

An Act to approve and give effect to an Agreement made between the Commonwealth and the State of Tasmania with respect to the Production, for the purposes of Defence, of Ingot Aluminium, and for other purposes.

[Assented to 7th December, 1944.]

Image: Australian Aluminium Act 1944[23]

Bell Bay was chosen due to its natural comparative advantages, in particular its deep water facilities and access to Tasmania's hydroelectric power system.

The plant was sold to Rio Tinto Aluminium in 1960 and operation continues at the site today.

The Portland Aluminium Smelter in Victoria also received extensive support from the Victorian government. This included the construction of the Loy Yang power station and a 550km transmission line to power the smelter.[24] However, no public ownership stake was secured which meant that, despite footing the bill and derisking the venture, there has been no substantive financial return to the public. The public bore the costs, while the profits were privatised.

Similarly in Queensland, the Boyne Aluminium Smelter near Gladstone was established as a joint venture in 1982. The Queensland and Federal governments paid for the construction of the Gladstone Power Station to provide subsidised electricity to the plant[25], but didn't take a public ownership stake.

Case study

Baowu Steel Group, China

Baowu Steel is the world's largest steel producer, with an output of 132 million tonnes of steel in 2022[26]. Originally established as Baoshan Iron and Steel in 1978 as part of Deng Xiaoping's program of economic reform, the company's first plant was built in Shanghai and was largely designed in line with Nippon Steel's facilities.[27]

Baowu Group remains a state-owned corporation and has expressed interest in establishing a clean steel joint venture in Australia.[28]

21 https://www.riotinto.com/en/operations/australia/bell-bay

22 https://www.utas.edu.au/library/companion_to_tasmanian_history/C/Comalco.htm

23 Image source: https://classic.austlii.edu.au/au/legis/cth/num_act/aia194444o1944293/

24 Craig Horne, The History of the Alcoa Aluminium Smelter in Portland, available at: https://search.informit.org/doi/epdf/10.3316/ielapa.888948460124699

25 Dunn, Col (1985). The History of Electricity in Queensland. Bundaberg: Col Dunn. pp. 157–161

26 https://mepsinternational.com/gb/en/news/global-steel-production-and-capacity-round-up-dec-2023

27 https://www.wsj.com/articles/how-china-built-a-steel-behemoth-and-convulsed-world-trade-11545668295

28 https://www.afr.com/policy/foreign-affairs/world-s-biggest-steelmaker-looks-to-wa-for-massive-green-investment-20230512-p5d7xa

The Federal Government should: lead the establishment of the Australian Green Iron Corporation by opening discussions with key trading partners about a joint investment to unlock the green iron sector.

The Western Australian government should: support this process by opening Expressions of Interest, similar to the process the South Australian government commenced in June 2023[29], for relevant iron ore miners and steel producers to collaborate on a detailed industry plan for Western Australia's green iron industry.

Requirement 2:
Construct enabling infrastructure for green iron projects by activating **Renewable Energy Zones linked to WA's Strategic Industrial Areas** - in particular, the Boodarie and Oakajee Strategic Industrial Areas.

Establishing a single common-user grid infrastructure in the greater Pilbara with very high volumes of renewable energy capacity will be the critical enabler of a large-scale green iron export industry in Western Australia.[30]

The three scenarios detailed in this report **(see VII How big, how fast?)** find that **129 GW of renewable energy will need to be installed in the Pilbara and Mid-West by 2040 to convert around 20% of current iron ore exports into green iron.**

The build-out of transmission infrastructure and renewable energy must be closely integrated with the Strategic Industrial Areas (SIAs) most likely to host large-scale green iron plants, in particular the Boodarie and Oakajee SIAs. The Federal and Western Australian governments should deliver a coordinated, ambitious plan that **maximises the co-location of green iron industrial hubs with renewable energy resources.**

The Federal and Western Australian Governments must accelerate renewable energy and transmission assessment processes by adding additional capacity to relevant approvals agencies, building on the momentum of WA's Green Energy Approvals Initiative. A priority should be the urgent deployment of the $3bn Clean Energy Finance Corporation concessional financing committed to WA in August 2023 under the Rewiring the Nation program for the build-out of new transmission infrastructure coupled with the declaration of Renewable Energy Zones linked to the SIAs.[31]

The Federal Government should prioritise the Pilbara for strategic national-interest public investment to expedite investment into the common-user infrastructure and renewable energy construction required to power a green iron industry.

All developments should be required to meet high environmental standards to ensure a strong social licence remains, assisting projects to enter operations with minimal delays. The Commonwealth government should update environmental laws so they set strong standards for environmental protection with a focus on waste management, air pollutants and minimising land clearing from new industrial projects.

The WA government should fast-track strategic industrial land activation plans for Boodarie and Oakajee SIAs. Land activation should include building out the large-scale renewables needed to ensure emissions-free electricity powers SIA industrial developments from day one.

See also VI Ensure Justice: What we need to make sure benefits are shared fairly >

Case study

China Steel Corporation, Taiwan

Taiwan's largest steel producer, China Steel Corporation, was established in 1971 by the Taiwanese government to provide the steel for nation's rapid industrialisation.[32] The firm was privatised in 1995, however, the Government of Taiwan has retained a 20% stake in the company.[33]

29 https://www.premier.sa.gov.au/media-releases/news-items/south-australia-backs-in-its-green-iron-credentials-on-the-world-stage

30 https://climateenergyfinance.org/wp-content/uploads/2024/08/CEF_FINAL_Pilbara-Electrification-Report_13Aug2024.pdf

31 https://www.wa.gov.au/government/media-statements/Cook-Labor-Government/Joint-media-statement---$3-billion-Rewiring-the-Nation-deal-to-power-WA-jobs-and-growth--20230829

32 https://www.steelonthenet.com/kb/history-csc.html

33 https://www.marketscreener.com/quote/stock/CHINA-STEEL-CORPORATION-6492310/company-shareholders/

The Act obliged the WA government to build an airport and to create a port authority, provide electricity and all housing for Woodside workers, construct water infrastructure and provide water for the enterprise, build and maintain roads for the project, and provide schools, hospitals and police facilities to support Woodside's development of the North West Shelf region.

The Act also required WA to apply for special borrowings from the Loan Council to support the project, exempted the project from stamp duty, and provided Woodside with tenure, licences and leases to support the development including resuming land from existing title holders.

In 1980 the WA government sought $1 billion from the Commonwealth government, which was used to fund enabling infrastructure including constructing the Dampier to Bunbury gas pipeline to transport gas produced by Woodside into the South West market.

The size of the initial capital investment by the WA and Commonwealth governments in enabling Woodside's early viability was 80 per cent greater than the combined investments of the four major iron ore joint ventures in the Pilbara during the 1960s and 70s. Woodside was created by government policy.

Today, we need the same level of government support that established Woodside to be directed to establish new green industries. Doing so would signal to major iron ore and steel producers that zero-emissions export industries are the future of industry in Western Australia.

Today, we need the same level of government support that established Woodside to be directed to establish new green industries.

Requirement 3:
Build domestic demand for green iron and steel through **government green steel procurement** for civil and energy infrastructure, shipbuilding, rail expansion and other projects.

The Federal and Western Australian governments should embed a green metal procurement weighting into all major infrastructure, vehicle, and government contracts, as well as include mandates or incentives bonuses for green metals use in other government-supported programs, like the Capacity Investment Scheme and Rewiring the Nation.

Recent research by the think tank Transitions Asia has found that producing green steel via a green H2-DRI-EAF process with an Australian green hydrogen price of USD$5/kg would add a premium of USD$227 per tonne of steel compared to traditional BF-BOF steel production.

The impact of this on final consumer prices is minimal. For example, a car made with 100 per cent green steel at this price would only cost an additional USD$204 compared to the cost of a non-green steel vehicle.[34]

Overall, the automotive industry accounts for 12% of global steel demand and is a major steel consumer in China, Japan and South Korea. Procurement policy settings in those countries preferencing local steel for local car manufacturing demonstrates that procurement policies can be a demand lever for green steel production, with relatively minimal impact on the final price of a product or service.

Government procurement has historically been a major driver of industry development, including its role in establishing Australia's steel industry. Aligning government demand with a green iron procurement policy will send a strong signal to the steel industry that there is demand for green iron and steel which will help unlock the significant investment required in new facilities.

Case study

Lithgow Steel Works, New South Wales

The Lithgow steel works were the first integrated iron and steel works built in Australia. While the steelworks were a private venture, the New South Wales government created certainty for investment by providing long-term base demand for the plant's product. This included the provision of a 7-year contract in 1905 to supply all of the NSW government's needs for iron and steel - especially heavy steel for the construction of NSW's railway system.[35]

34 https://transitionasia.org/green-steel-economics/

35 https://trove.nla.gov.au/newspaper/article/14752395

The contracts also ensured local supply chain development, including that local iron ore, coal and limestone be used to produce iron. These local content requirements underpinned the construction of a large modern blast furnace that commenced production in 1907.

Further support was provided by the Commonwealth through a major industrial package intended to support the local iron and steel industry, the 1909 Manufacturers' Encouragement Act. Bounty recipients under the act were required to pay fair and reasonable wages to their employees.[36]

See V Work For Workers: What we need to ensure secure jobs and a say for workers >

Steelworking operations were relocated to Port Kembla in 1928, which to this day remains the heart of Australia's steel industry.

Requirement 4:
Create the **Perth Green Metals Exchange** to provide a distinct market for low-carbon and ethically produced metals, underpinned by Guarantee of Origin certification.

The lack of a common definition for green steel is a key barrier to establishing a clear price signal for green iron and overcoming the green premium barrier. The Guarantee of Origin scheme[37] being established by the Federal Government is a key mechanism that will help address this issue by providing trusted third-party verification.

However, the other significant barrier is the lack of a dedicated green metals exchange to help set a price premium for sustainable and ethically produced metals. The lack of a dedicated marketplace for metals produced with strong ESG credentials has been most apparent in the nickel sector. Since 2023, Indonesian nickel producers have flooded the London Metal Exchange (LME) largely at the expense of Australian producers, despite having emissions up to 300% higher per unit than Australian producers.[38]

Case study

Whyalla, South Australia

The Whyalla Steelworks commenced operations in 1941, providing steel for the Whyalla Shipyards.[39] The shipyards were established to provide military vessels for the Australian Royal Navy and the British Admiralty - in particular the Bathurst-class corvettes.[40] Each vessel cost £250,000[41] – equivalent to $24 million per vessel today. Contracts to provide steel for the vessels underpinned the development of the steelworks.

The future of steelmaking in Whyalla is directed by a new government initiative, the Whyalla Hydrogen Facility.[42] The project is being delivered by Hydrogen Power SA, a state government entity, and will see half a billion dollars invested to build 250MWe of electrolysers and a 100t hydrogen storage facility with operations commencing in 2026. The facility will supply the Whyalla Steelworks and enable green steel production to begin in South Australia.

Utilising local content requirements can leverage the large volumes of steel used in many government projects and help create the pull-through demand required to establish an Australian green iron industry.

36 https://www.legislation.gov.au/C1908A00026/asmade/text
37 https://cer.gov.au/schemes/guarantee-origin
38 https://www.gtlaw.com.au/knowledge/could-green-metal-exchange-provide-liquidity-commodity-markets-while-protecting
39 https://www.hydrogen.sa.gov.au/projects/hydrogen-jobs-plan/whyalla-hydrogen-power-facility
40 https://www.whyalla.com/museums-and-history
41 https://en.wikipedia.org/wiki/HMAS_Whyalla_(J153)
42 Stevens et al., The Royal Australian Navy, opp. p. 112

The LME's price discovery mechanism is agnostic about how a metal is produced and creates markets for buyers and sellers from across the world without recognising different production scenarios. This is despite major differences in the environmental and social impacts of production. LME's failure to differentiate products means there is no pathway for the market to recognise and reward producers with higher-quality processes.

Given Western Australia's outsized global role in metal ore production and high ambition to become a leading producer of value-added transition metals like lithium and rare earth metals alongside a large-scale green iron industry - there is a strong case for establishing a Perth Green Metals Exchange.

A Perth Green Metals Exchange would provide the market with a dedicated platform to procure high quality, low emissions metals which consumers increasingly demand, as well as ensure producers are able to secure a premium price for low carbon products. Clear price signals will help crowd in investment and help drive a broader market shift to a sustainable and ethically produced metals industry.

The Commonwealth and Western Australian governments should undertake a detailed scoping study

Requirement 5:
Establish **mutually complementary trade policies and incentives** to encourage the trade of green iron, and finished products constructed with green iron inputs. Prioritise establishing a common definition for green steel and the introduction of carbon border adjustment mechanisms with our trading partners in East and Southeast Asia.

Our key trading partners have strong steel manufacturing sectors supporting a vibrant broader industrial base. This is a result of clear government vision and aligned policy support and trade practices.

It is instructive to note that comparative advantage in steelmaking in steelmaking countries was secured after the industries were established. Many of our trading partners had a distinct natural *disadvantage* for steel production, like Japan and Korea which are energy-constrained, lack substantial domestic iron or coal resources and in the case of Korea, had no prior modern steelmaking experience before the establishment of Posco in the 1980s.

Today their steel industries are global leaders, underscoring the instrumental role of the state in establishing the steel sector.

Case study

POSCO, South Korea

The Pohang Iron and Steel Company, today known as POSCO, was established by the South Korean government in 1968 with financial assistance from Japan to help drive the nation's rapid industrial development. Japan's Export-Import Bank provided the funding, and detailed planning support for the plant was provided by Mitsubishi Heavy Industries. Japanese steelmakers, Nippon Kokan and Nippon Steel Corporation provided the underlying technology required for the plant.[43]

The shared investment and close cooperation with Japan and its industrial sector meant that despite South Korea having no previous experience in modern steel making, production commenced four years[44] later and transformed the small fishing city of Pohang into a major industrial centre.

Posco's second facility, the Gwangyang Steel Works constructed in the 1980s, remains the largest facility in the world with an annual production capacity of 23 mtpa.[45] In contrast, Australia's largest steel plant, Port Kembla at 3 mtpa, is a little more than a tenth of the capacity. POSCO was privatised in 2000, but the state of Korea still maintains a significant stake in the company along with original partners such as Nippon Steel.[46]

POSCO is planning to invest up to $40b (USD) in Australia in green iron and hydrogen projects.[47]

43 https://www.company-histories.com/POSCO-Company-History.html

44 South Korea: A country study. Available at: https://books.google.com.au/books?id=_adMWevoEq0C&pg=PA150&redir_esc=y#v=onepage&q&f=false

45 https://www.gem.wiki/POSCO_Gwangyang_steel_plant

46 https://www.marketscreener.com/quote/stock/POSCO-439944/company-shareholders/

47 https://newsroom.posco.com/en/posco-group-ceo-jeong-woo-choi-meets-the-prime-minister-of-australia-anthony-albanese-to-discuss-future-eco-friendly-projects/

Australia can do the same by driving the establishment of a vibrant green iron industry. By working with our trading partners from the start to apply the lessons of the past, we can jointly build a strong green iron future that will benefit our whole region and decarbonise the steel sector.

A priority should be on securing international trade agreements for the export of green iron from Australia to feed the steel-making industry of our trading partners and associated industries like automotive manufacturing, shipbuilding and infrastructure.

The process will be facilitated by establishing the Australian Green Iron Corporation as a joint venture with our trade partners so that trade settings and policy support can be harmonised across the supply chain.

The Commonwealth government is at the time of writing engaged in a diplomatic bid to host COP31 in Australia. If successful, an Australian COP31 focused on green metals and global decarbonisation of furnace and smelting operations would provide an opportunity for Australia to lead on an important new industry for the country and play an outsized role in reducing global emissions. A green metals Australian COP31 could have established green metals definitions and a global green metals premium price standard as its aims.

Japan, South Korea, and Taiwan have each pledged to achieve zero emissions by 2050 and China has pledged to achieve zero emissions before 2060 - the pathway to achieving their emissions reduction targets runs through the establishment of a large-scale green iron industry in Western Australia.

Requirement 6:
Improve **Commonwealth and WA environmental laws** to set strong standards for environmental protection with a focus on waste management, air pollutants and minimising land clearing, with a focus on existing industries as well as future growth sectors like green iron and hydrogen production.

Ensuring Commonwealth and Western Australian environment laws are updated and enacted as soon as possible is essential to provide industry clarity and minimise impacts ahead of the green iron construction boom. As a major feedstock into some potential green iron technology pathways, environmental issues related to hydrogen production should be made a priority. Leakage, NOx emissions, and other toxics emissions are potentially significant pollutants from hydrogen production processes and require careful consideration and management. Some of these issues can be addressed through stronger federal environment laws which will provide a suitable framework for assessing environmental impacts and management options. Strong environmental legislation will be critical to enabling new technology so that it does not compromise high environmental protection measures.

Where possible, these laws should reflect the intent of the Federal Nature Positive reforms.

Particular attention should be paid to ensuring the large-scale roll out of renewable energy and transmission infrastructure occurs in appropriate areas with minimal environmental disruption, and where possible deliver nature-positive outcomes.

Bioregional planning and the establishment of renewable energy zones have the potential to minimise land clearing and impacts on nature and enable consideration of cumulative impacts at a regional scale. Alongside this level of strategic planning, we need strong nature laws and processes that limit land clearing, end the clearing of critical remnant native vegetation for biodiversity protection and enforce strong restoration conditions to ensure a net positive biodiversity outcome.

Similarly, new green iron plants should be required to provide world-class environmental reporting, in a transparent and accountable way, to ensure environmental objectives are being met. Overall, there must be improvements in public reporting on activities and impacts, data accessibility, and mechanisms to hold responsible parties who fail to meet these high standards to account.

Commonwealth and Western Australian environmental agencies need to be better resourced to both efficiently and effectively make decisions, and also to fulfil compliance, monitoring and regulation functions. The independence of these agencies is critical to their function. Public input which often draws on important knowledge and evidence from the community has an important role in informing government about environmental values and threats.

V Work for workers: what we need to ensure secure jobs and a say for workers.

The first major industrial package introduced in Australia to support the iron and steel industry, the 1909 Manufacturers' Encouragement Act, required industry recipients of 'bounties' to pay fair and reasonable wages to their employees. A 21st-century WA green iron industry should continue this tradition of ensuring industrial programs deliver better outcomes for workers and local communities.

Requirement 7:
Work with the **Net Zero Economic Agency, WA worker transition programs and the Clean Energy Centre of Excellence** to create secure transition pathways for workers into the green iron industry.

The value of engineering construction work yet to be done in Western Australia and Northern Territory fell 2.7% to $39.9 billion in the March quarter of 2024, and has significantly contracted since the construction boom of the late 2000s and early 2010s.[48]

Establishing a green iron sector will help revitalise construction investment and provide a valuable workforce transition pathway for workers as gas construction and operations ramps down.

The combined green iron and renewable energy construction modelled in this report will create a steady and long-term increase in construction job work in Western Australia.

A green iron industry is an ideal pathway as it leverages existing skills in heavy industry, engineering, and project management as well as creating new employment opportunities in renewable energy and transmission infrastructure, hydrogen production, and green iron plant construction and operations.

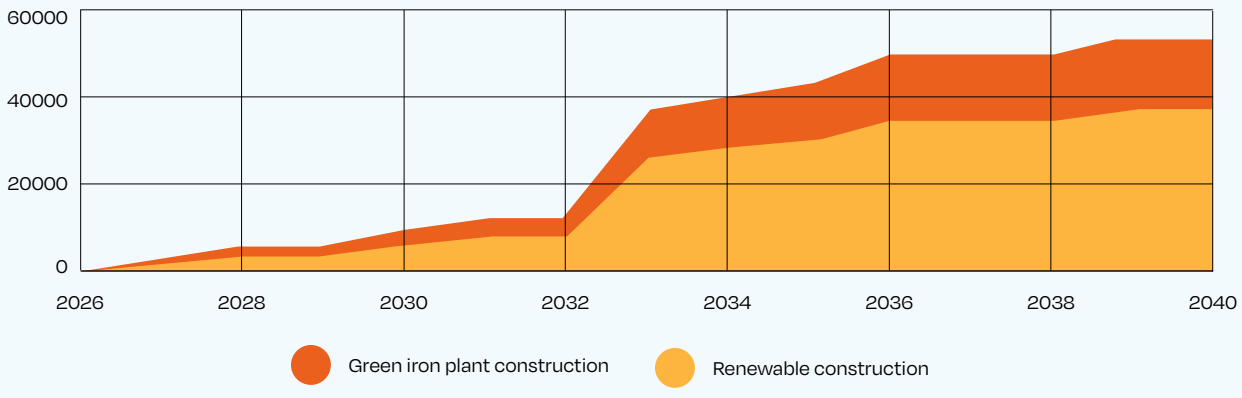
By 2040, this would see 15,000 construction jobs in green iron plant construction and a further 37,000 jobs involved in the mass build-out of renewable energy and transmission infrastructure.

By transitioning these workers into the green iron industry, we can maintain employment levels, utilise their expertise in large-scale industrial projects, and contribute to a more sustainable economy, ensuring a just and equitable shift away from fossil fuel-dependent sectors.

Establishing a green iron industry will also moderate the boom-and-bust impacts of major infrastructure construction work by creating a base of ongoing green iron smelter and energy workforce positions.

A large-scale green iron sector could create more than 30,000 ongoing jobs in ironmaking and renewable energy by 2040.

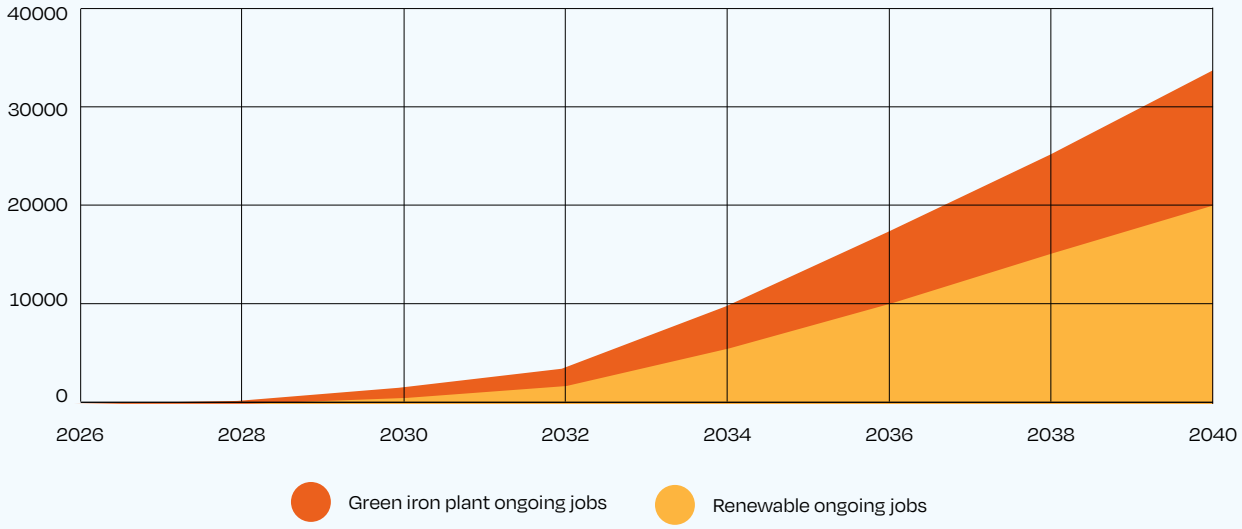
Renewable energy and green iron plant construction jobs



Source: Springmount Advisory, Forging our Future jobs model

48 Western Australia Economic Profile – July 2024, Department of Jobs, Tourism, Science and Innovation. Available at:https://www.wa.gov.au/government/publications/western-australias-economy-and-international-trade

Ongoing energy and green iron plant jobs



Source: Springmount Advisory, Forging our Future jobs model

The Western Australian government can start preparing the workforce and supporting the transition by developing a North West Transition Plan informed by the successful Collie Just Transition Plan.

The newly formed TAFE Clean Energy Centre of Excellence in Karratha could provide a base for the initial rollout of worker transition training, individual transition plan mapping, and other transition support.

Investing in the next generation of skilled energy workers will be essential to modernising and building a large-scale interconnected renewable electricity system in the North West and Mid-West regions and addressing critical

Requirement 8:
Ensure **strong collective bargaining structures and union agreements** on all new green iron projects.

Making sure green iron jobs are secure, union jobs will mean that benefits from the industry are better shared with more Western Australians. Mandating that enterprise agreements (EAs) or project heads of agreement must exist for a proponent to access Commonwealth or WA government industry attraction funding, or entry into the Australasian Green Iron Corporation, is the most straightforward to achieve this.

Union agreements provide a structured framework for negotiating standards and conditions in new industries and will ensure that workers are consulted in a meaningful way over the transition from iron ore or other resources mining to green iron production. This will not only enhance productivity but will also help to retain skilled workers committed to the industry's long-term success.

EAs can also assist implementation of training and workforce development programs essential to building out a green iron industry at scale. Through collective bargaining, workers and unions can bargain for training opportunities and upskilling initiatives, ensuring that jobs in green iron production are long-term and stable. This approach will build a resilient workforce able to meet evolving operational demands while creating institutional buy-in to the success of the industry.

Mandating EAs will also enhance the overall social license to operate for green iron producers. By creating positive, democratically agreed terms between companies and workers, green iron EAs will promote stability and trust. This will be essential for attracting investment and maintaining community support.

As global demand for sustainable iron products grows, having a workforce that is well-treated and engaged is a competitive advantage. This alignment of interests will lead to increased productivity, reduced turnover, and a more positive public perception of the industry, ultimately supporting the long-term viability of a large-scale green iron industry.

VI Ensure justice: what we need to make sure benefits are shared fairly

Establishing a green iron industry is an opportunity to ensure First Nations people and communities hosting green iron facilities directly benefit from the development of new industries.

Requirement 9:
Prioritise **First Nations consent, participation and co-ownership** through all green iron industrial policy initiatives by adhering to the First Nations Clean Energy Network's Best Practice Principles for Clean Energy Projects.

Requirement 10:
Deliver outcomes for host communities by aligning all green iron project approvals and conditionality with the **Community Benefit Principles** detailed in the Future Made in Australia Act. [50]

All green iron projects will use resources and operate on the lands of First Nations Peoples. Investment in the capacity of Traditional Owners to engage in the conception, design, planning, implementation, and ownership of green iron projects is crucial for achieving good results and building an inclusive economic future.

Federal and Western Australian programs should ensure First Nation capacity building and benefit sharing is embedded as a condition for green iron and related renewable energy infrastructure approvals. At a minimum, First Nations' rights of self-determination and Free, Prior and Informed Consent for Traditional Owners should be a precondition for any green iron project.

The First Nations Clean Energy Network has developed Principles and Guidelines[49] for the development of renewable energy, to ensure that the country is protected and to make sure First Nations communities share the benefits of Australia's clean energy boom. The principles and guidelines should also be followed by renewable energy industries and the governments that regulate projects.

Integrating First Nations consent, participation, and joint ownership of new energy infrastructure as standard practice will improve project outcomes and build the social licence required for the industry to develop at speed and scale.

Green iron plants and supporting green hydrogen and renewable energy infrastructure are long-term projects and it is important to ensure that local communities are considered core stakeholders in the industry's development. Project proponents will need to build trust-based relationships with local communities and operate on a basic principle of fairness. The establishment of Community Benefit Funds[51] that continually reinvest back into host communities over the lifetime of the projects will deliver long-term beneficial outcomes for Western Australia.

Investment into long-term education and training facilities in host towns will be particularly beneficial to project operators and communities alike. Education and training co-investment provides a pathway for community members to learn the skills required to work in and benefit directly from green iron and renewable energy industries while also addressing critical skills shortages.

Green iron policy initiatives should require both a future Australasian Green Iron Corporation or other green iron proponents receiving state or Commonwealth industry attraction funding to adhere to the Community Benefit Principles of the Future Made in Australia Act.[52]

49 Available at:https://assets.nationbuilder.com/fncen/pages/183/attachments/original/1680570396/FNCEN_-_Best_Practice_Principles_for_Clean_Energy_Projects.pdf?1680570396

50 https://treasury.gov.au/sites/default/files/2024-05/p2024-526942-fmia-nif.pdf

51 https://assets.nationbuilder.com/vicwind/pages/3164/attachments/original/1705557869/Building_Stronger_Communities_%E2%80%93_Community_benefit_funds.pdf?1705557869

52 https://www.pm.gov.au/media/future-made-australia-bill-will-build-stronger-cleaner-economy

VII How big, how fast?

Using our shared industrial heritage and experience in building industry from scratch, Australia and our trading partners can build out a large-scale green iron industry – and do it quickly. We can usher in a new era of industrial prosperity while making a substantial contribution to decreasing global carbon emissions.

The scale of the challenge to decarbonise iron production is large. Forging Our Future sets out a 3-stage plan for scaling the industry at an appropriate rate to meet Australia's and our trading partners' demand for green iron, as well as our ambition to seize the industrial moment.

The following three scenarios have been designed to showcase a feasible pathway for scaling green iron production and export as well as the workforce and renewable energy requirements to power each stage of development.

Green iron industry development scenarios

1.

Domestic green iron consumption

The first scenario sees green iron production commence in 2026 with a goal to provide 100% green iron for Australia's steel production within 10 years. This will create an immediate green iron market and demonstrate Australia's capacity to produce green iron to investors and trading partners.

2.

Green iron exports for South Korea, Japan and Taiwan

Starting with initial green iron exports in 2028 to South Korea, Japan and Taiwan. This scenario builds to meet 70% of the green iron demand of our renewable energy-constrained trading partners by 2040.

3.

Top and tail China's green steel transition

Starting exports to China in 2033 will enable Australia to help provide top and tail green iron exports that will improve China's capacity to decarbonise the domestic steel industry, the largest in the world.

1. Domestic green iron consumption

Green iron for Australia

Scenario 1: Domestic consumption

Green iron production starts in 2026, ramping up to meet 100% of Australian demand in 2036.

1,321 green iron jobs

1,000 renewable jobs

$3.2 billion of production

6.6mt green iron production

7GW renewable energy

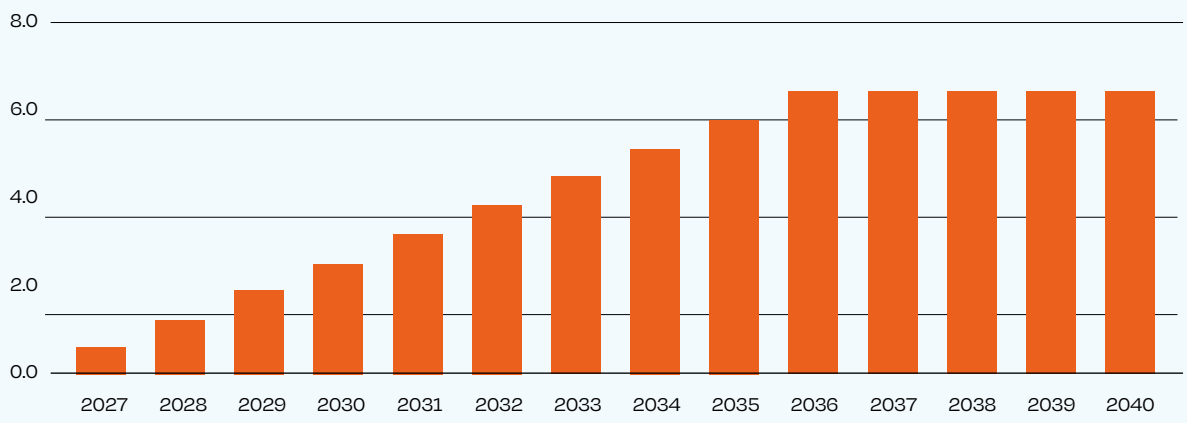
15mt emissions reduction

Australia produces around 5.6 million tonnes of steel each year[53], which requires roughly 9.2 million tonnes of iron ore to produce.

In Scenario 1, green iron production commences in 2026, with an initial pilot plant capable of producing 700,000 tonnes per annum for domestic consumption. Capacity is expanded by 700 thousand each year until 100% of local steel-making demand is met with green iron in 2036.

This will require 7 GW of renewable energy capacity to be installed across the Pilbara and Mid West where green iron production is likely to occur. This is equivalent to over double the full build-out plan of Yindjibarndi Energy Corporation.[54,55]

Scenario 1: Supply Australian steel demand (mtpa)



53 https://australiansteel.com/#:~:text=STEEL%20IN%20AUSTRALIA&text=Approximately%205.7%20million%20metric%20tonnes,COMTRADE%20database%20on%20international%20trade.

54 https://www.wa.gov.au/government/announcements/first-project-approved-through-green-energy-approvals-initiative

55 https://static1.squarespace.com/static/6296f2c0b8414f486cd1625d/t/64b49f663ecdbd7404edd261/1689558888102/03072023+Partnership+Agreement+Media+Release_CLEAN_ACEN+YAC+and+CEC+Approved.pdf

For context, the current installed renewable energy capacity in Western Australia is approximately 1 GW and almost entirely within the South West Interconnected System (SWIS). While there are plans for installed capacity in the SWIS to grow to 55 GW by 2040[56] - a separate and even larger renewable energy growth plan is required for the Mid and North West.

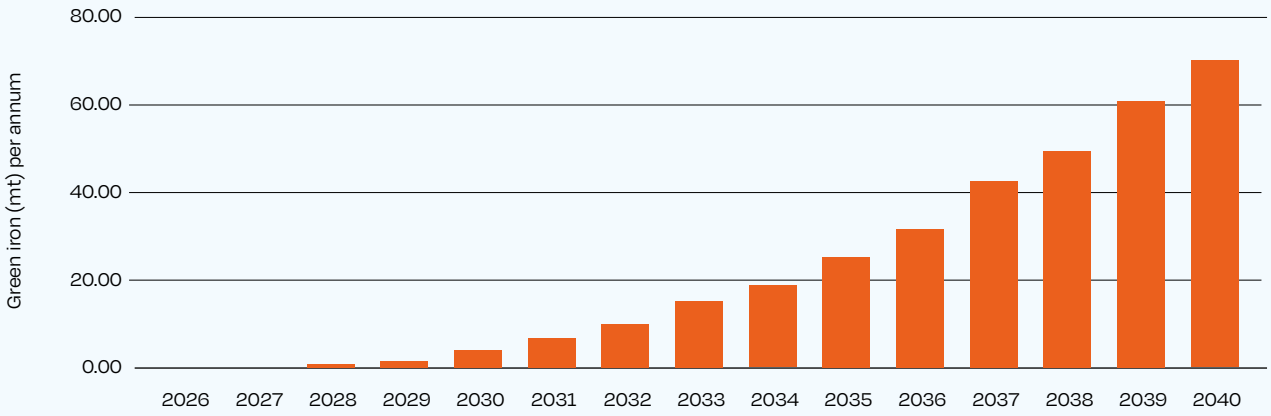
Scenario 1 requires 7 GW - well within current plans to install 55 GW by 2040. This would create 1321 ongoing full-time positions in green iron production in Western Australia alongside 826 construction jobs during the build phase. A further 15,000 construction jobs and 1000 ongoing full-time roles will be created in the renewable energy sector.

Australia's emissions would be structurally reduced by 15 million tonnes per annum in 2036, equivalent to 3% of total national emissions in 2024 or 5% based on government projected emissions in 2035.[57]

The renewable energy expansion will be used to electrolyse the 370,000 tonnes of green hydrogen required to reduce the iron ore into green iron. For context, Australia produced 495,00 tonnes of grey hydrogen in 2022, all produced using fossil fuels[58] this equates to 6.4 Mtc2O-e[59] or 1.5% of annual emissions. The IEA projects that Australia will produce 6 Mt of green hydrogen per year by 2030.[60]

Establishing a domestic green iron procurement policy for all government infrastructure projects would provide the demand needed to unlock this scenario.

Scenario 2: Green iron exports to ROK, JPN, TW



Australia's emissions would be structurally reduced by 15 million tonnes per annum in 2036...

56 https://www.wa.gov.au/system/files/2023-05/swisda_report.pdf

57 https://www.dcceew.gov.au/climate-change/publications/australias-emissions-projections-2023

58 DCCEEW (2023) State of hydrogen 2022

59 https://www.iea.org/reports/towards-hydrogen-definitions-based-on-their-emissions-intensity/executive-summary

60 https://iea.blob.core.windows.net/assets/ecdfc3bb-d212-4a4c-9ff7-6ce5b1e19cef/GlobalHydrogenReview2023.pdf

2. Green iron exports to East Asia

Green iron to Japan, South Korea and Taiwan

Scenario 2: East Asia

Green iron exports commence in 2028, with growth accelerating until it meets 80% of demand in 2040.

14.1k green iron jobs

11,000 renewable jobs

$46 billion of production

70mt green iron production

72GW renewable energy

158mt emissions reduction

South Korea (48mt), Japan (56mt) and Taiwan (13mt) collectively imported 117 million tonnes of iron ore from Australia in 2022-23, with demand forecast to grow to 123 million tonnes by 2027.[61]

In Scenario 2, Australia commences exporting green iron in 2028, with a relatively small shipment of 1.2 million tonnes (1% of iron ore demand) of green iron equivalent to half the capacity of Green Steel WA's proposed Mid West DRI scheduled to be operational by that year.[62] Exports grow gradually at first, with a much faster growth forecast during the late 2030s when technology advances and deployment experience will increase green iron plant construction and production rates. By 2040, 70 million tonnes of green iron would be exported each year to East Asia, equivalent to 80% of iron export demand from Japan, South Korea and Taiwan.

Seventy-two GW of renewable energy will be required to electrolyse the 4.95 million tonnes of hydrogen required for production. This would represent a significant increase in renewables and hydrogen production for Western Australia - equivalent to three times the size of the proposed Australian Renewable Energy Hub[63].

A green iron workforce of 14,100 would be required by 2040, alongside an ongoing renewable energy workforce of 11,120 workers. Due to the gradual ramp-up, the initial demand for new workers is moderated. For example, in 2030, 705 iron workers and 590 renewable workers alongside 2,200 iron plant construction workers and 4,480 renewable energy construction workers would be needed. The current Pilbara workforce is around 60,000.[64]

By 2040, Australia's green iron exports to East Asia would generate $34.5 billion in annual exports and have reduced global emissions by 158 million tonnes, equivalent to a third of Australia's total emissions in 2024.

Aside from Japan, South Korea and Taiwan's dependence on fossil fuel imports and relatively limited renewable energy potential, prioritising the export of green iron from these three trading partners also makes sense due to the age of steel plants in each nation. Japan in particular has some of the oldest plants in the world and will need to start progressively investing in plant upgrades and replacements.

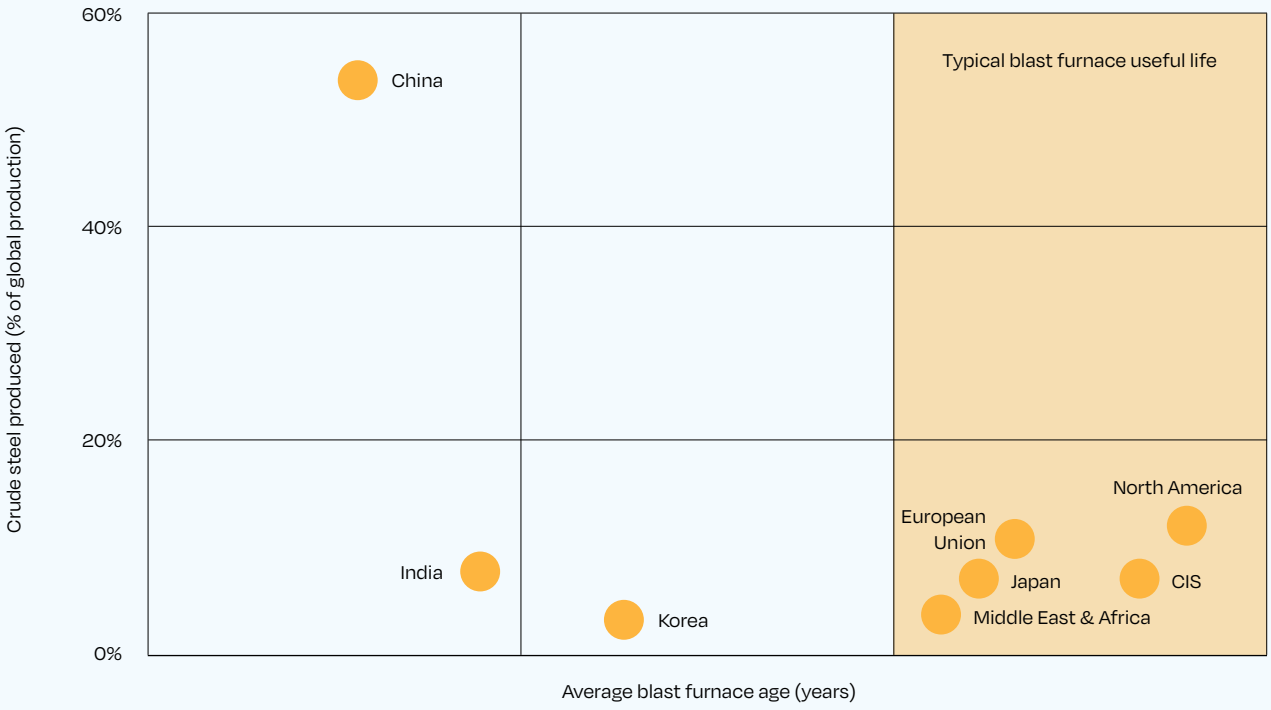
61 Resources and Energy Quarterly, June 2024

62 https://www.greensteelwa.com.au/collie-green-steel-mill-copy/

63 https://research.csiro.au/hyresource/australian-renewable-energy-hub/

64 https://www.pdc.wa.gov.au/our-region/work-in-the-pilbara.aspx

Average BF age and share of global crude steel production



65

An immediate focus on encouraging Japan to replace its ageing blast furnaces with modern Electric Arc Furnaces designed to work with Australian green iron inputs will drive mutually beneficial investment across both nations. A joint venture, led by Australian governments and those of our trading partners would allow a full trade cycle to be established and see Australians given the opportunity to purchase cars from Japan, China, or Korea made with Australian green iron.[66]

The success and learning from those partnerships could be expanded to include joint ventures with the South Korean government, where blast furnaces are still on average a decade away from requiring relining or replacement.

A green iron workforce of 14,100 would be required by 2040, alongside an ongoing renewable energy workforce of 11,120 workers.

65 https://acilallen.com.au/uploads/projects/736/ACILAllen_WAGreenSteel_2023.pdf

66 https://mriwa.sharepoint.com/sites/FinalReports/Shared%20Documents/Forms/AllItems.aspx?id=%2Fsites%2FFinalReports%2FShared%20Documents%2FFinal%2DReport%5F10471%5FMRIWA%5FM10471%20%2D%20Full%20Report%2Epdf&parent=%2Fsites%2FFinalReports%2FShared%20Documents&p=true&ga=1

3. Top and tail China's green steel transition

Green iron exports to China

Scenario 2: China

Green iron exports to China commence in 2033 and grow until 8% of demand is met in 2040.

9,100 green iron jobs

7,600 renewable jobs

$30 billion of production

45.6mt green iron production

50GW renewable energy

102mt emissions reduction

China consumes most of Australia's iron ore exports, importing 760 million tonnes in 2022-23, 85% of Australia's total exports.[67] While China is the largest producer of steel in the world, unlike our other key iron ore trading partners, China also has exceptional renewable energy resources and is constructing almost twice as many renewables per year as the rest of the world combined.[68]

Additionally, China has the youngest steel plant fleet in the world so decisions regarding relining or replacing plants so that they are optimised for green steel production are likely to occur later than our trading partners in East Asia.

These factors inform Scenario 3. In this scenario, Australia will start exporting 8 mt of green iron to China in 2033, meeting approximately 1% of China's current demand. For context, the Port Hedland Green Steel project plans to produce 12 mtpa when fully operational.[69] Green iron exports increase by 8 mtpa per annum until 2040 when total production would hit 46 million tonnes per annum – equivalent to 8% of China's total iron ore demand from Australia being met with green iron exports.

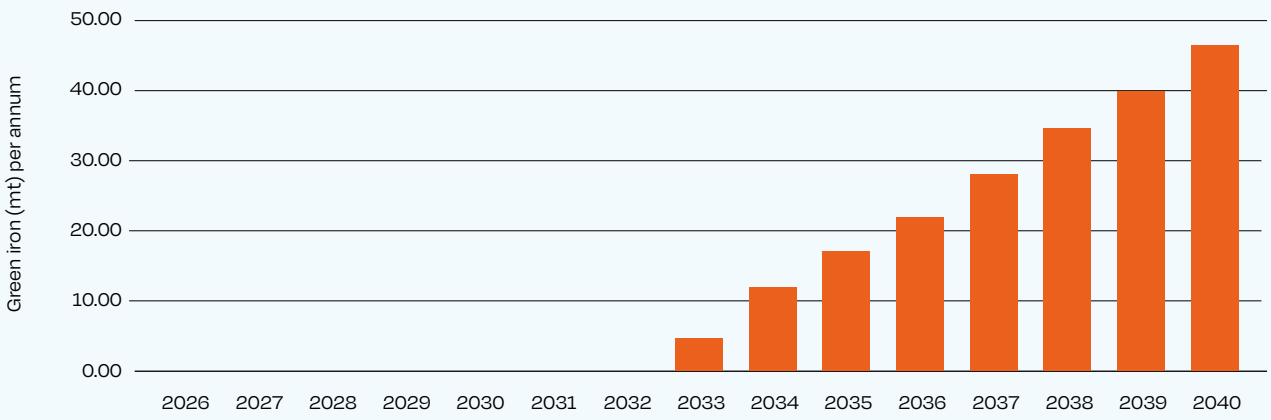
...total production would hit 46 million tonnes per annum – equivalent to 8% of China's total iron ore demand from Australia being met with green iron exports.

67 Resources and Energy Quarterly, June 2024

68 https://globalenergymonitor.org/report/china-continues-to-lead-the-world-in-wind-and-solar-with-twice-as-much-capacity-under-construction-as-the-rest-of-the-world-combined/

69 https://www.abc.net.au/news/2023-12-16/south-korean-green-steel-iron-ore-plans-port-hedland/103201750

Scenario 3: Green iron exports to China



Fifty GW of renewable energy will be required by 2040 to produce the 2.5 million tonnes of hydrogen needed for green iron production. The Australian Government's Sunshot funding initiative has a goal of increasing renewable energy installation from 5GW per year to 50GW per year,[70] so this level of renewable demand is equivalent to one year of construction if that objective is met.

A green iron workforce of 9,100 would be required by 2040, alongside an ongoing renewable energy workforce of 7,600 workers.

By 2040, Australia's green iron exports to China would generate $128 billion in GDP and reduce global emissions by 102 million tonnes a year, equivalent to a nearly a third of Australia's total emissions in 2024.

Total renewable energy and hydrogen demand

Meeting the full export potential of the three combined scenarios will require a substantial and sustained increase in renewable energy construction and green hydrogen production in the North West region.

Producing 123 million tonnes of green iron in 2040 will require approximately 6.9 million tonnes of green hydrogen production per annum, more than 10 times as much as consumed in Australia today.[71]

A significant ramp-up in renewable energy production will be required to power this large-scale hydrogen production.

Assuming that IRENA's forecast that hydrogen electrolyser efficiency will increase to 45 kWh per kg of hydrogen produced[72], this will require at least 129 GW of renewable energy to be installed in Western Australia.

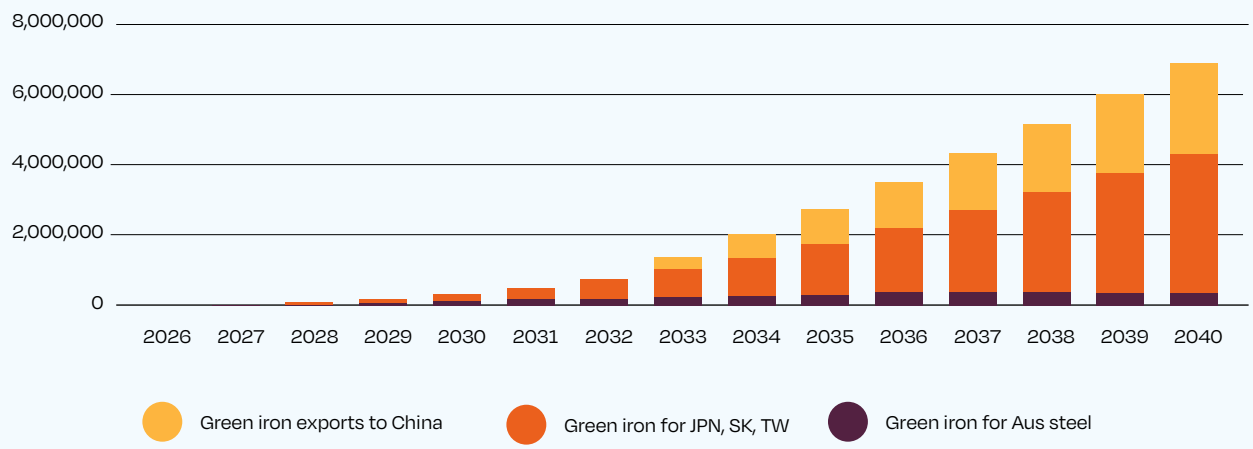
By 2040, Australia's green iron exports to China would generate $128 billion in GDP and reduce global emissions by 102 million tonnes a year.

70 https://arena.gov.au/assets/2024/04/Sunshot-Consultation-Paper.pdf

71 DCCEEW (2023) State of hydrogen 2022

72 https://www.aemc.gov.au/hydrogen-new-australian-manufacturing-export-industry-and-implications-national-electricity-market

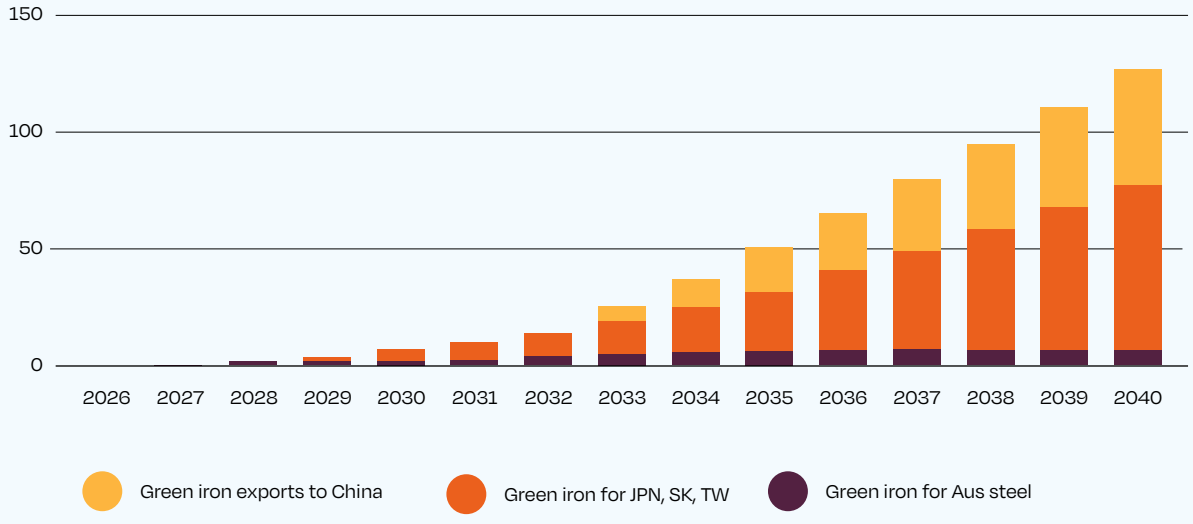
Growth in green hydrogen demand



Western Australia is ideally positioned to host this globally important industry. The state has a highly skilled industrial workforce, a track record of building large, nationally important industries at speed and scale.

A green iron future is how Western Australia can create jobs and export revenue, drive down global emissions, and capitalise on its exceptional renewable energy resources and iron ore deposits to manufacture the green metals our trading partners need. Green iron is how WA can forge our future as an important player in a decarbonised global economy.

Renewable energy required for green iron industry (GW)



Western Australia is ideally positioned to host this globally important industry. The state has a highly skilled industrial workforce, [and] a track record of building large, nationally important industries at speed and scale.

Appendix

Methodology

1. Demand scenario models key assumptions

	Production start year	Model structure
Scenario 1: Green iron to supply Australia's steel-making industry	2026	Assumed steel-making capacity of 5.8 Mt. Scenario models 10% capacity growth YOY from 2026.
Scenario 2: Green iron to meet 100% of South Korea, Japan and Taiwan iron demand.	2028	Green iron exports commence in 2028. Total exports of 123 Mt pa, a gradual increase of ore conversion to green iron, 100% substitution by 2037.
Green iron to partially meet 8% of China iron ore imports	2033	Green iron exports to China commence in 2033 and increase to 8% of China iron ore imports (798 Mt pa).

The model assumes demand for iron ore remains flat from 2027 figures forecast by Resources and Energy Quarterly June 2024 and the iron export shares to trade partners remain constant.

2. Percentages of exports to current main trading countries

	2022–23 (Mt)	%
Iron ore Australian Exports total	895	100%
China	760	85%
Amount going to Japan, South Korea and Taiwan	117	13%

3. Ratios used for various calculations

a. Iron Content used (Iron ore present as hematite Fe2O3)

Fe2O3	Fe	O	Gangue*#	Adjusted	Total (kg)
60%	60.00	25.84	14.163	9.44206	1000

b. DRI Conversion

Fe	O	Other	Gangue	Without O2	Total	Required t
600	258.4	47.2	94.42	694.42	1000	1.440049444

We would like to acknowledge the work of The Superpower Institute in developing the DRI conversion model - https://www.superpowerinstitute.com.au/

c. Iron ore to DRI[73]

Hydrogen (kg)	DRI iron (t)
56	1

d. Hydrogen reduces iron

Iron ore (t)	DRI iron (t)
1.44	1

e. Electricity req. to produce hydrogen[74]

Hydrogen (kg)	Electricity (kWh)
1	45

f. Electricity required to process[75]

Gwh	DRI (t)
860	1

4. Revenue calculation

Indian DRI prices were used, as not many countries trade DRI. (source) the average price of a 10 year period was $350 USD per tonne converted to AUd is $488, then a standard 2% increase rate was applied YOY to 2040

5. Job calculations

Employment factors[76]

Technology	Construction/ installation	Manufacturing – 100%	Manufacturing – onshore	O&M
	Job years/MW			Jobs/Mw
Wind onshore	2.7	1.6	0.38	0.22
utility-scale PV	2.1	3.9	0.09	0.11

Totals calculated

Technology	Construction/ installation	Manufacturing – 100%	Manufacturing – onshore	O&M
	Job years/MW			Jobs/Mw
Wind onshore	138,870	82,293	19,545	11,315
Utility-scale PV	162,014	300,884	6,943	8,486
Total	**300,884**	**383,177**	**26,488**	**19,802**

73 https://calix.global/news/calix-awarded-arena-funding-for-zero-emissions-steel-technology/

74 https://www.aemc.gov.au/hydrogen-new-australian-manufacturing-export-industry-and-implications-national-electricity-market#:~:text=The%20three%20green%20hydrogen%20projects,kWh%20per%20kg%20of%20Hydrogen.

75 https://www.superpowerinstitute.com.au/

76 https://www.uts.edu.au/sites/default/files/2022-11/ISP2022_Workforce_v1.pdf

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