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Forging Futures: Changing the nature of iron and steel production

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Contents

Glossary

APAC	Asia-Pacific
BF-BOF	Blast Furnace-Basic Oxygen Furnace (the most common method used by current integrated steel plants)
Bn	Billion
CBAM	Carbon Border Adjustment Mechanism
CO2-e	Carbon dioxide equivalent
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
ETS	Emissions Trading Scheme
EU	European Union
GHG	Greenhouse gas
Green H2	Hydrogen produced using only renewable energy and water
Green iron / steel	Iron and steel produced using solely renewable energy sources and renewable hydrogen, mitigating fossil fuel use[1]
GW	Gigawatt
Ha	Hectare
HBI	Hot Briquetted Iron (export product format of DRI plant reduced iron)
H2-DRI	Direct Reduced Iron produced using hydrogen as a reductant instead of fossil fuels.
ILUA	Indigenous Land Use Agreement
IUCN	International Union for Conservation of Nature
Met coal	Metallurgical coal
Mt	Million tonnes (metric)
Nature Positive	A global goal to stop and reverse biodiversity loss by 2030, and fully recover nature by 2050.
NG-DRI	Natural Gas Direct Reduced Iron
Regenerate Nature	Regenerating nature in mining and industrial processes requires a holistic approach that balances economic development with environmental protection. It refers to implementing practices and strategies aimed at minimising environmental impact, restoring ecosystems and promoting sustainability throughout the lifecycle of mining and industrial activities.
UK	United Kingdom
USA	United States of America

Executive summary

Australia is in the *'messy middle'* of responding to the climate change challenge and clean energy transition. Rules and incentives are beginning to increase the pace of decarbonisation, but it's an everything, everywhere, all at once transition. The stakes are high – by choosing rapid decarbonisation, Australia would be making a bold play for 240,000 more jobs and a bigger, cleaner, more complex economy.[2] **To successfully achieve a net-zero economy in Australia, we must embrace low emissions industries to replace displaced revenue from the exclusion of fossil fuels.** One such emerging industry in Australia is manufacturing green iron for steel production, which represents an opportunity estimated between \$96bn[3] and \$295bn[4] per year.

Steel production is one of the most emissions-intensive industries in the world, representing 7-9% of global greenhouse gas (GHG) emissions.[5] To address climate change globally, steel must decarbonise. These emissions disproportionately come from the Asia-Pacific (APAC) region - which houses 9 out of 10 of the world's largest steel companies - due to the higher percentage of Blast Furnace-Basic Oxygen Furnaces (BF-BOF) used in this region.[6] Currently, there is little incentive for Asian steel-makers to decarbonise themselves, and analysis shows that **without intervention, green steel is unlikely to be commercially viable until the 2040s.**[7] Australia, as a key supplier of inputs to the steel-making process in APAC, namely iron ore and metallurgical (met) coal, has the opportunity to help catalyse the decarbonisation of the industry.

While rapid decarbonisation is essential, if not managed effectively, it has the potential to harm Australia's natural assets. An orderly climate transition depends on both speed and scale. Moving too slowly risks irreversible climate impacts, while moving too quickly without safeguards could have impacts on nature that compound economic risk. Our current approach is neither fast nor regenerative and, without intervention, we are on track to lose economic prosperity while also suffering repercussions from concurrent ecological and climate damage. Therefore, while we must accelerate our action, this is only viable if we regenerate nature and our economies. The redesign of heavy industry for emissions reduction offers the opportunity to redesign our approach to industry development to correct these threats and repair past damage. Creating a modern economy for the 21st century that has nature-positive, circularity, and clean industrial transformation at its heart, while we support our nearest neighbours to do so as well, will be essential to managing the transition.

Developing green iron manufacturing capacity[8] offers the clearest avenue for Australia to competitively move up the green steel value chain. As carbon emissions become explicitly priced and internalised, green H2-DRI/HBI production is most likely to be cost-competitive with NG-DRI and BF-BOF production routes.[9] Furthermore, Australia's abundant iron ore reserves and renewable energy potential are considered strategic advantages for green H2-DRI production. Becoming a green H2-DRI/HBI producer would see Australia both diversify its economy and maximise emission reduction benefits for our region. **Green iron also stands to be the least materially intensive and requires the smallest land allocation** compared to other production routes and therefore is also in the best interest of Australia's natural capital. **This means it is imperative that the Australian Government positions itself for a rapid transition to green steel-making.**

Australia's economic dividend from green iron will be determined by the pace of renewable deployment and the scale-up of Asian carbon pricing. Australia's renewable deployment rates must be substantially lifted to accelerate steel decarbonisation in Asia. Currently, our deployment rates are too slow to drive scaled emissions reductions in the 2040s.[10] To decarbonise 10% of steel-making across Asia would require ~52 DRI/HBI plants[11] requiring upwards of 330GW of renewable capacity in Australia, which at our current deployment rate could take over 100 years.[12, 13] In order to realise its competitive advantage, Australia will need to focus on supplying a high volume of low-cost nature-positive renewables quickly. In parallel, Asian carbon prices must rise to price the carbon externality and provide steel-makers with an economic incentive to go green. Variations in carbon price may shift the breakeven point between regions and see green steel breakeven with incumbent processes earlier as an inevitable policy response to the growing climate crisis emerges at scale.

While in the country's best interest, there are material implications for Australia's natural environment and First Nations communities that will need to be considered. More than half of Australia's fifteen biodiversity hotspots interact with current or announced projects required to deliver green iron exports, including mining, solar, wind, and green hydrogen assets.[14] These activities are also commonly located in areas of high water stress, requiring the adoption of circular water models and innovations.[15] Specific protections, conditionalities, and incentives will need to be established to mitigate these impacts for the long-term prosperity of our natural assets. In addition, most Australian iron ore value chain projects are located on Indigenous land. This includes approximately 65% of iron ore assets on land subject to a Native Title Declaration and over 60% interfacing with registered Indigenous Land Use Agreements.[16] Collaboration efforts in this space remain immature, and a green iron industry should provide Indigenous Australians with the ability to negotiate on land use and help strive for better development. More considered and long-term economic participation outcomes need to be a successful part of a future iron ore value chain.

The material requirements of a domestic green iron value chain offer opportunities for upstream industries. Deloitte's analysis shows that a 2.5Mt per annum green steel plant could require approximately 7.1GW of renewable power.[17] To construct such a plant, approximately 7% of Australia's domestic concrete production,[18] 5.5% of domestic aluminium production,[19] and 0.8% of domestic steel production[20] would be required. This is an excellent opportunity for government demand-pull strategies, including domestic content requirements to improve the community benefits of these capital-intensive deployments. This could align well with the Community Benefits Principles under the Future Made in Australia legislation.

To unlock Australia's green iron opportunity, action must be taken both domestically and with our key trading partners in APAC. The Australian Government must ensure that domestic renewable deployment accelerates and that iron production is incentivised to decarbonise quickly. At the same time, protections and incentives for nature must be included. Pragmatic green statecraft with APAC is also required to ensure regional carbon pricing and alignment of high integrity standards.

This report is supported by two technical appendices, *Mined the Gap: Australia's place in the emerging green iron value chain* and *Ore Else: Preliminary nature impacts of a green iron value chain,* which outline the green steel opportunity and nature imperative in further detail.

Recommendations

Australia can be a *green iron key* that unlocks decarbonisation for our trading partners and delivers an economic dividend at home. However, realising a regenerative green iron and steel industry is a generational project. Hesitancy risks our economic future and our trade partners pursuing opportunities elsewhere. An alliance between Australia and our steel value chain trading partners is the most prudent way forward.

We have identified three priorities for Australia to advance at home, and three opportunities to collaborate with our trading partners to accelerate development of a cross-border green steel value chain.

Australia must change its domestic processes to ensure it captures its economic advantage while protecting nature.

Accelerate renewable energy deployment rates. At the current pace, it would take Australia over 100 years to deploy the renewables required to replace 10% of Asian steel-making with green iron. To grasp this opportunity, Australia must substantially increase the speed of renewable deployment while managing the material, land, and nature impacts of the rollout.

Government incentives for regeneration and decarbonisation. The Australian Government must advocate for a fast transition to hydrogen-based iron-making for Australia to realise its economic and environmental dividends, however this must include conditions on regenerative outcomes to balance the nature imperative.

Clustering development with clear scenarios and regional based assessments. The use of localised piloting and nature-based assessments, as well as regulatory sandboxing, would support regional monitoring of nature and climate impacts from development.

Australia must collaborate and support its APAC trade partners to establish a successful green steel value chain.

Establishing pragmatic green statecraft and APAC carbon pricing. Australia must engage in pragmatic green energy statecraft with new bilateral and multilateral green iron corridors between Australia and trading partners, leveraging contracts for difference for blended green iron contracts, and a buyers' alliance for green iron and steel with Australian and Asian offtakers. It must also support the introduction of a regional carbon price and establish a critical focus on greening the steel supply chains.

Alignment of high integrity standards. Australia will need to work with its partners to achieve a harmony of standards across industry and jurisdictions to establish common emission intensity thresholds for green hydrogen and alignment on emissions boundaries for a global green steel definition.

Positioning Australia as the partner of choice. Australian policymakers and industry players will need to work with international supply chain partners to emphasise cross-value chain partnerships, development projects, and explicit opportunities for mutual economic benefit.

1. Steel has an emissions problem and a nature problem

1.1. The hard-to-abate steel sector is responsible for 7-9% of global GHG emissions

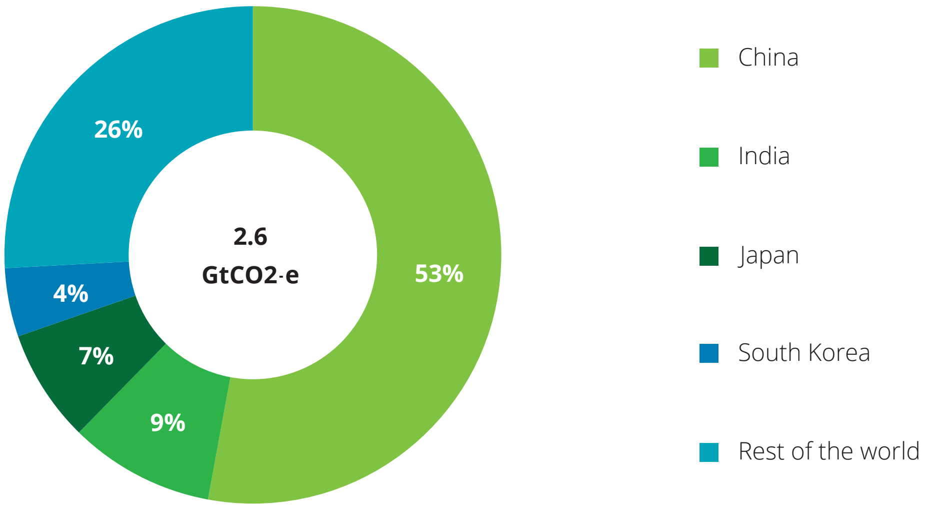
Steel is one of the most emissions-intensive industries in the world. Steel manufacturing accounts for 7-9% of global GHG emissions.[21] The steel value chain has significant energy requirements and process emissions related to its major inputs, metallurgical coal and iron. Net-zero cannot be achieved unless steel emissions reduce. Attempts to reduce emissions in steel-making involve large-scale infrastructure and material supply changes and technological challenges. The transition of this sector is particularly undermined by the absence of a carbon price in international trade.

This problem is projected to grow. A 33% rise in global steel demand, driven largely by growing urbanisation in developing countries such as India, is projected by 2050.[22] In the absence of development and uptake of abatement technologies, the transition challenge of the steel industry will be exacerbated.

The issue disproportionately impacts the APAC region. **China, South Korea, Japan, and India represented 69% of global steel production in 2023 and are responsible for 73% of global steel emissions** (Figure 1).[23, 24] These countries have 9 out of 10 of the world's largest steel companies.[25] Similarly, most of the steel produced is consumed domestically, highlighting the importance of behaviour change in these consumer markets.[26]

It is paramount that APAC steel players step up and accelerate their decarbonisation efforts. For the world to collectively achieve net-zero targets, the global steel value chain needs to decarbonise rapidly. APAC steel producers and consumers are essential to the solution.

Figure 1: Share of world steel emissions by country in 2023



Source: Climate Trace, 2023

1.2. There is currently little incentive for Asian steel-makers to decarbonise

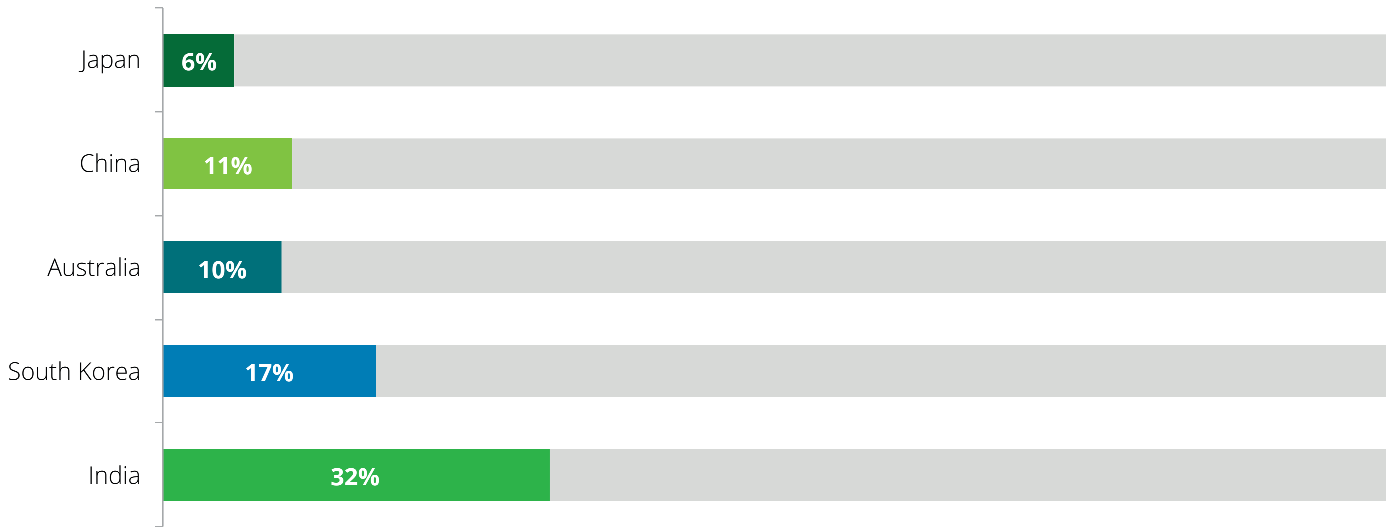
Asian steel-makers' willingness to pay for low emissions iron is currently too limited to catalyse investment in steel abatement. Exceptionally low or absent carbon prices in this highly competitive industry hinders the adoption of lower emissions production pathways like green H2-DRI processing.

Existing policy mechanisms in APAC lack the magnitude or incentives needed to drive industry to implement decarbonisation solutions. Supply-side policy for green iron and steel production is emerging; however is insufficient to stimulate market creation and bridge the commercialisation gap to date. Demand-side policies, such as zero-emissions construction, that enforce the green iron and steel production uplift are lacking. A carbon price for the APAC region would help to create the right incentives for both the demand and supply side of steel and heavy industries to decarbonise and make industries more competitive.

In contrast to Asian markets, the combination of the emissions trading scheme (ETS) and Carbon Border Adjustment Mechanism (CBAM) has somewhat insulated the European Union (EU) from this dynamic while helping to build support for green steel. As carbon prices rise, the cost premium for green H2-DRI/HBI production as an input for green steel falls dramatically. Spillover from Europe's CBAM could drive some change in APAC at the margin. However, only a small portion of APAC steel-makers' exports are exposed to the EU CBAM, meaning that further incentives will be needed in the APAC region (Figure 2).[27]

Coordinated action across APAC is needed to shift the dial. Higher carbon prices and the adoption of a CBAM in target markets in the Asian region will improve the case for green steel. Leaving the adoption of green iron and steel production to the existing market forces could see adoption delayed until beyond 2040, locking in higher cumulative emissions and detrimental outcomes for nature, and locking out slow-moving steel supply chain participants.

Figure 2: European Union Carbon Border Adjustment Mechanism (EU CBAM) exposure: Share of iron and steel exports destines for the European Union by exporting country in 2022



Source: OEC, 2022

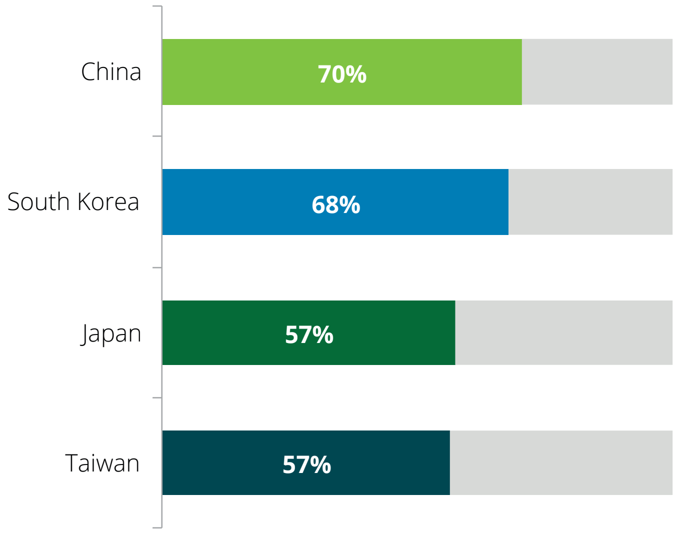
1.3. Australia plays an integral role in steel's emissions challenge and has an imperative to help steel decarbonise

As the primary supplier of the world's iron and metallurgical coal,[28] Australia is a significant enabler of the embodied emissions of steel. Through exports of iron ore and met coal, Australia is indirectly responsible for 23% of global steel emissions.[29]

Australia's economic and social prosperity are reliant upon these two export products. During FY23, Australian met coal represented 13% of total commodity export earnings, with iron ore valued at 27%.[30] In FY23, Australia exported $124bn worth of iron ore and $62bn worth of met coal.[31]

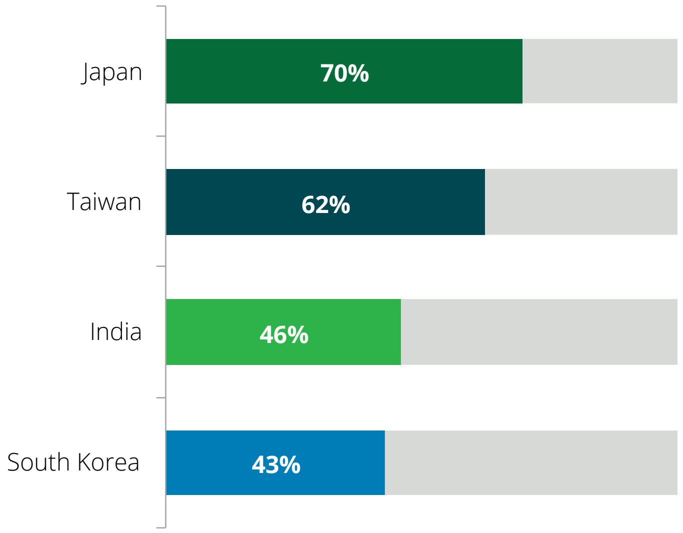
Australia's key trade partners are the emissions-intensive Asian steel-making countries. Australia is the key supplier of iron ore to China, South Korea, Japan, and Taiwan, and of coal to Japan, Taiwan, India, and South Korea (Figure 3 and Figure 4).[32] As a key part of this emission-intensive production process, Australia has an imperative to be a part of the solution. In addition, as these players seek to decarbonise their value chains in the long-term, failure to act could leave Australia worse off as metallurgical coal is replaced in the steel-making process and as steel firms pivot to higher iron content, lower impurity iron ore sources offshore.

Figure 3: Australia's share of iron ore supply by importing country



Source: OEC, 2022

Figure 4: Australia's share of coal briquettes supply by importing country



Source: OEC, 2022

1.4. Steel has a significant nature footprint and the transition to green must balance the speed of decarbonisation with regeneration

The steel value chain is highly impactful on natural resources and this will need to be carefully managed in the transition to green steel. To successfully realise Australia's green iron export opportunity, resource availability and swift action must be balanced.
Decarbonising too slowly risks both irreversible climate impacts and an inability for Australian companies to break into a highly competitive international green metals market. However, a focus on rapid decarbonisation without regeneration risks the collapse of ecosystems and limited availability of resources. For example, growing demand for Indonesian nickel in the development of electric vehicle batteries is causing catastrophic impacts to nature and local communities.[33] Thus, going faster is only viable if we protect and restore nature, so Australia must balance decarbonisation and regeneration to ensure an orderly transition.

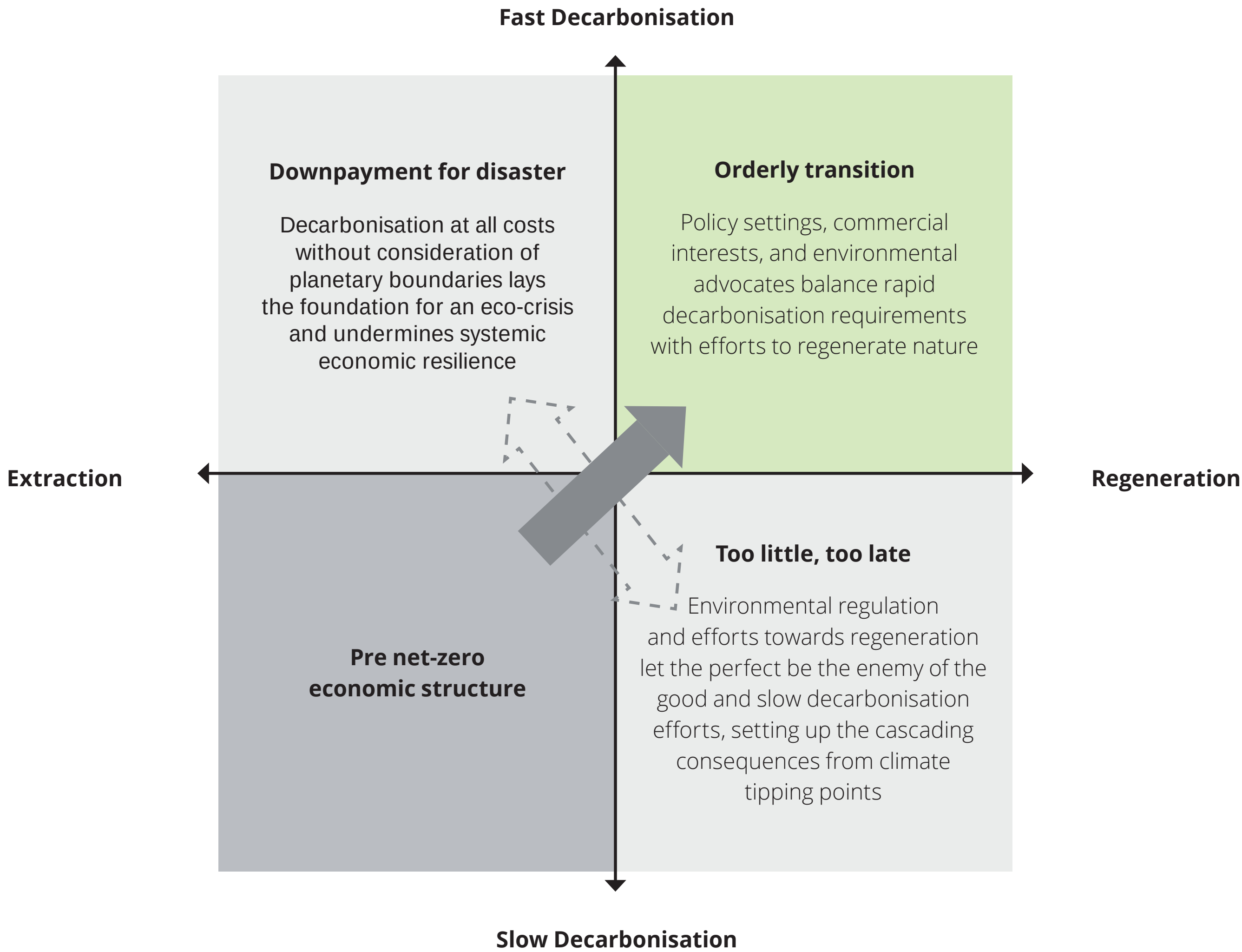
We need to thread the needle through reform and practice by understanding that:

- Going faster will create additional commercial value for developers; and
- Speed must be conditional on an element of this new value being reinvested in regenerating nature and shared prosperity through equitable ownership and benefit-sharing with Traditional Owners and other affected communities.

At present, our development trajectory is not tracking towards an orderly transition. Our current approach is both extractive and slow (Figure 5). **Without smarter interventions, we are on track to lose out on economic prosperity while also suffering repercussions from concurrent ecological losses and impending climate catastrophe.**

Achieving an orderly transition will require a shift in thinking, adopting a new mindset of coupling nature regeneration with development to reduce further degradation of these areas. This means significantly increasing the efficiency of resource and land use, and improving regulation to encompass nature protections.

Figure 5: Conceptual framework for understanding the relationship between decarbonisation & regeneration



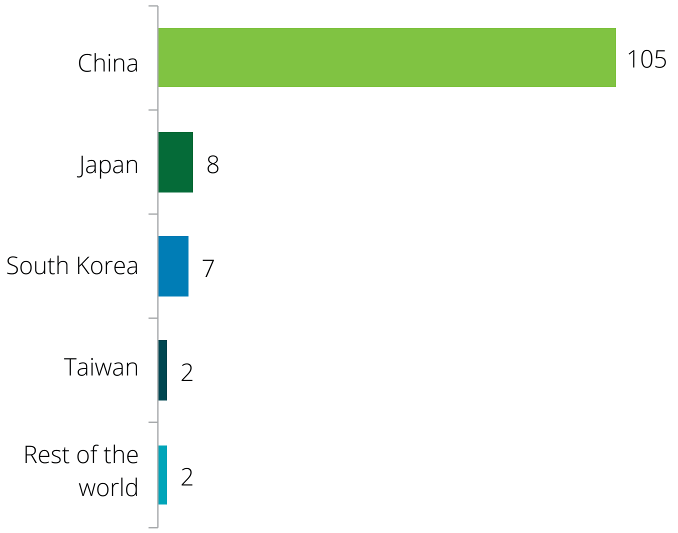
2. Australia has an opportunity to be a top supplier of green iron while regenerating nature

2.1. Australia's exports are exposed to the energy transition and will need to diversify

Australia has an opportunity to expand its industrial base while replacing diminishing revenue from fossil fuel industries in a decarbonising world. Australia is reliant upon revenue from fossil-fuel activities such as metallurgical coal, thermal coal, and natural gas to support our economic position (Figure 6 and Figure 7).[34] Without diversification into new low-carbon industries, where Australia has a comparative advantage, such as iron manufacturing, Australia risks missing out on a substantial economic advantage.

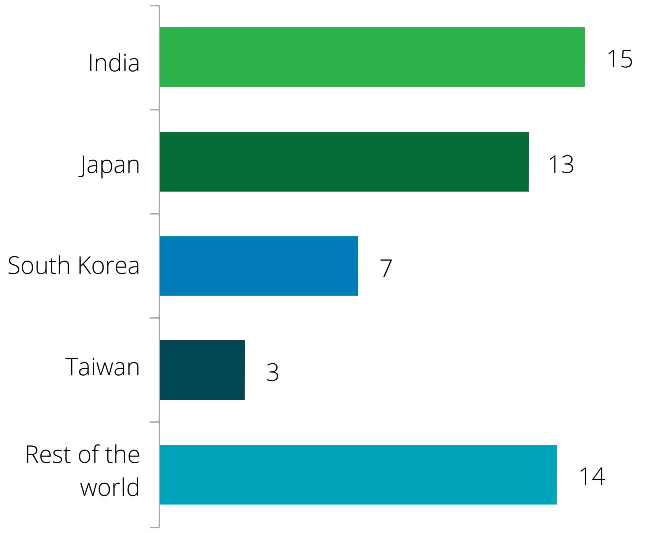
By neglecting first-mover advantages, Australia will miss the opportunity to future-proof its largest industries and economy as decarbonisation policy, carbon pricing, green technological advancements, and emissions regulation place ever-shortening horizons on coal usage.

Figure 6: Australia's iron ore export earnings by destination in 2022-23 ($bn)



Source: Resources and Energy Quarterly, March 2024.

Figure 7: Australia's metallurgical coal export earnings by destination in 2022-23 ($bn)



Source: Resources and Energy Quarterly, March 2024.

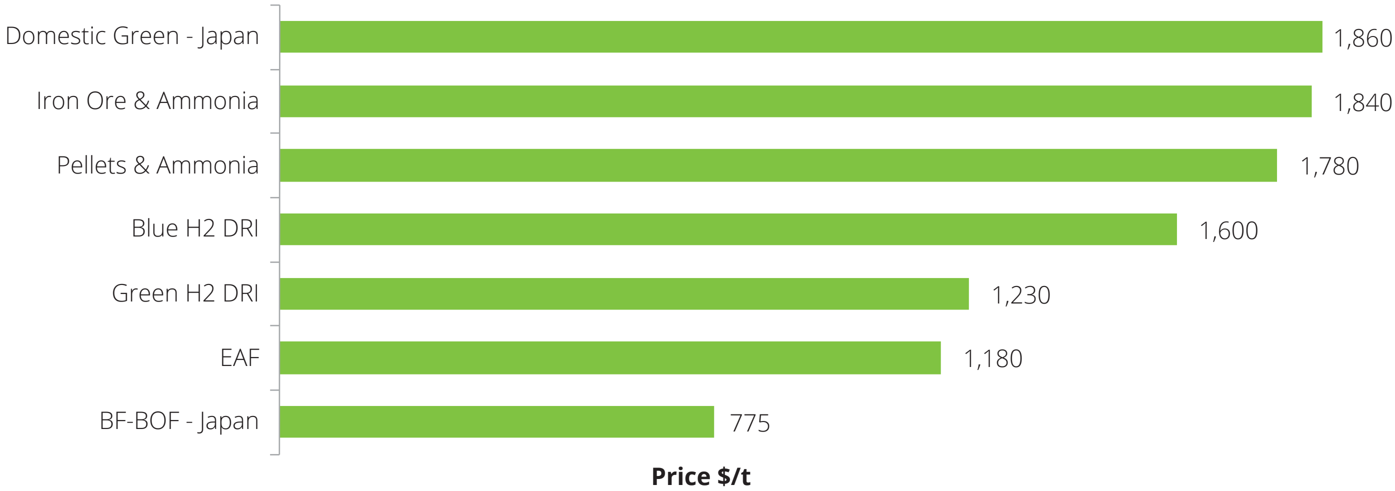
2.2. Green iron is the most viable pathway for Australia to capitalise on the green metals opportunity

There are multiple export pathways available for Australia to support decarbonisation of Asian steel-making. Different green production technologies and value chain configurations exist, with varying investment and abatement implications. However, green iron is likely to strike the balance between cost and viability.

Figure 8 examines the cost of potential green steel value chain options for Australia-Japan trade in 2030 with current market incentives included. Seven different configurations are considered and explained in more detail in the technical appendix. Five insights are apparent:

1. It is very expensive for Japan to completely onshore steel decarbonisation. This could be done by importing iron ore and producing hydrogen in Japan, or by importing iron ore and green ammonia and cracking it back into hydrogen. Regardless, these options are more than double the cost of traditional steel-making pathways.
2. Australia could seek to accelerate decarbonisation of steel-making in Japan with the export of blue hydrogen. However, the link between Australian gas prices and global markets could make it hard to produce cheap blue hydrogen.
3. Green iron (green H2-DRI/HBI) produced in Australia and exported to Japan is considerably more cost-effective than other value chain configurations.
4. Australia could service Asian markets with green steel produced via EAF at a comparable price point to green iron (green H2-DRI/HBI). However, Asian countries have historically prioritised domestic production and offered support mechanisms to retain these capabilities. It could be expected that Asian economies would protect domestic steel-making capability from offshoring.
5. With carbon prices as they are, the traditional steel-making route remains the cheapest alternative. However, it must be noted that this does not price the carbon externality or nature costs.

Figure 8: Comparison of future delivered end steel prices along the Australian export value chain to Japan in 2030[35]



Source: Deloitte Green Value Chain Explorer - Iron and Steel, 2024

Note: Figure 8 shows end steel prices based on 7 different configurations for the value chain from lowest to highest cost (inclusive of raw materials and transport).

1. BF-BOF Japan: Incumbent BF-BOF technology which assumes both blast furnace and basic oxygen furnace occur in Japan, powered by Australian iron ore and coal.
2. EAF: Complete vertical integration in Australia, with green iron turned into steel via an electric arc furnace in Australia.
3. Green H2-DRI: Australia exporting green iron as HBI to be turned into steel via an electric arc furnace in Japan.
4. Blue H2-DRI: Australia exporting blue iron (made with blue hydrogen) as HBI to be turned into steel via an electric arc furnace in Japan.
5. Pellets & Ammonia: Australia exporting pelletised iron ore and ammonia, with both the direct reduced iron and electric arc furnace process occurring in Japan.
6. Iron Ore & Ammonia: Australia exporting iron ore and ammonia to Japan, with the electric arc furnace process occurring in Japan.
7. Domestic Green Japan: Producing green iron and steel in Japan from iron ore and ammonia imports.

For transport, ore type, and support policies applied see footnotes 36 and 39. Model parameters are provided in Appendix A (Mined the Gap report).

2.3. Exporting green HBI is Australia's natural sweet spot

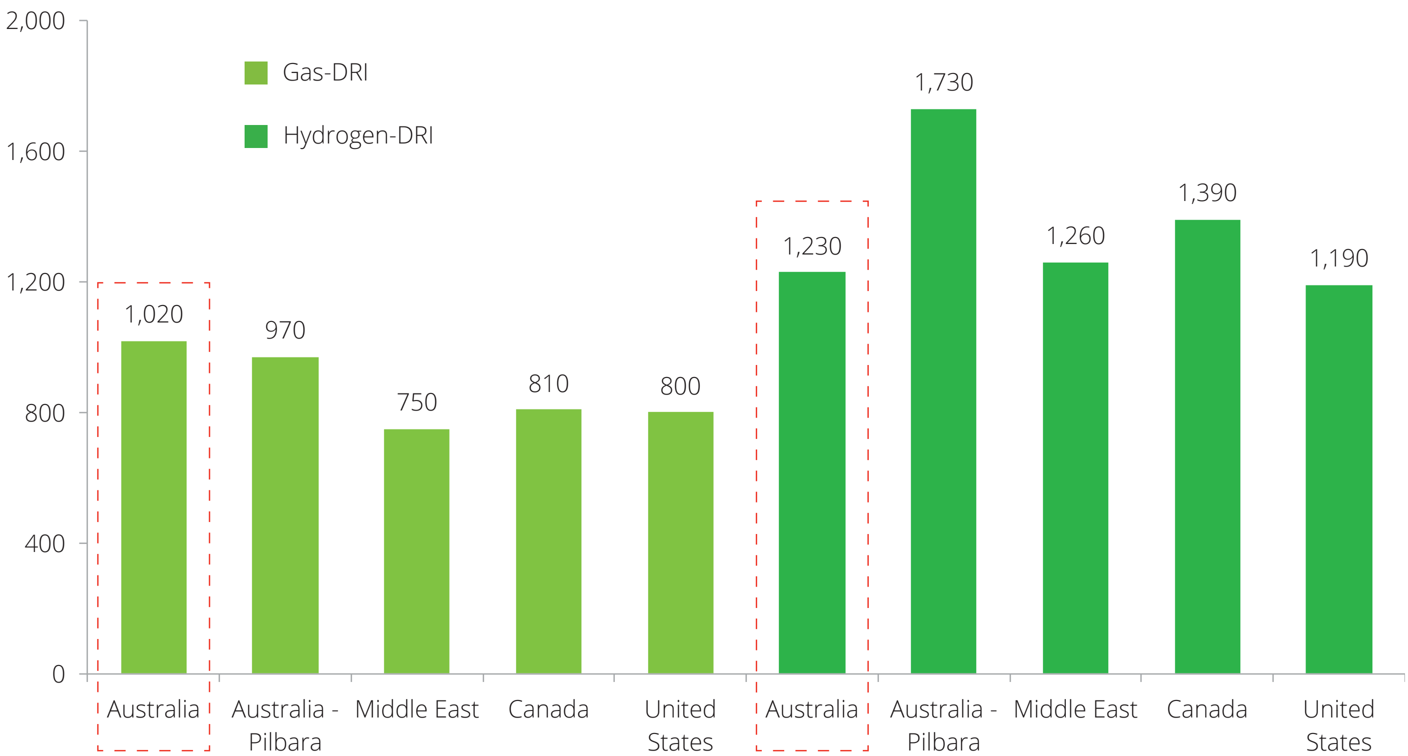
Australia is well-placed to capitalise on production of Hydrogen DRI as it has a competitive advantage in exporting green iron to Asia. Notably, its abundance of iron ore reserves and leading market position in iron ore supply, its renewable energy and green hydrogen potential, political stability, and proximity to Asian markets (transport distances are between 7%-50% shorter than other prospective exporters)[36] are considered strategic advantages. In addition, Australia is viewed as a reliable and trusted partner to do business with.[37] Reducing the cost of domestic renewable energy production in Australia would further increase our advantage.

Figure 9 examines which HBI manufacturing option (choice of reducing agent) would give Australia a competitive advantage over HBI producers in other regions. This Figure compares a 2.5Mt DRI facility using natural gas or using green hydrogen in different countries all exporting to Japan. In all cases, the figure shows the end cost of EAF-based steel. It is clear that Australia's competitiveness is higher in green iron than alternatives, relative to global competition.[38]

It is in Australia's economic interest to make a swift transition to green iron, where our comparative advantage is clear.

While Australia would not be competitive in a global market dominated by NG-DRI, it would be a competitive supplier of green H2-DRI/HBI production to Asia over other jurisdictions, such as the Middle East and Canada, due to potential for low-cost renewable energy and iron ore access if we leverage our scale potential. China is also strategically over-dependent on Australian iron ore and coking coal supply, so Australia needs to encourage collaboration to avoid China reducing its own supply chain risk by investing elsewhere to develop competing suppliers, e.g. Guinea and the Middle East.

Figure 9: Comparison of cost of steel production for NG-DRI and H2-DRI for producing countries in 2030[39]



Source: Deloitte Green Value Chain Explorer - Iron and Steel, 2024

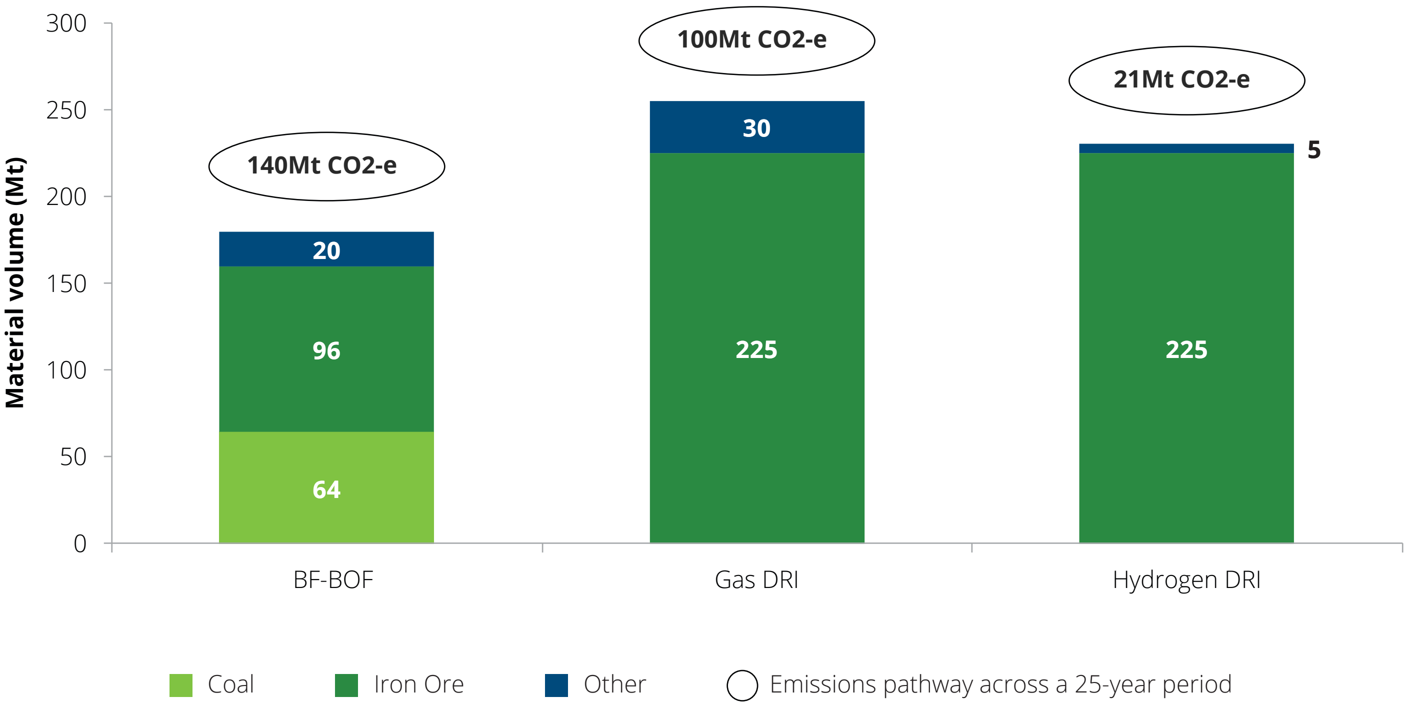
Note: Cost of steel production comparing gas-DRI and green hydrogen-DRI in Australia (Pilbara), Australia (outside Pilbara, for example South Australia), Canada, the USA, and Middle East. Includes raw material and energy inputs, transport, and EAF-based steel production. For transport assumptions applied see footnote 35. Model parameters (including support policies) are provided in Appendix A (Mined the Gap report).

2.4. Green H2-DRI/HBI production is the best pathway for Australia's resources and natural capital

Hydrogen DRI is Australia's best economic opportunity and stands to be the lower carbon and material intensive pathway compared to other production methods. While it requires more material inputs than BF-BOF plants, including two to three times more iron ore and critical minerals for renewables,[40] it is materially less carbon intensive than both BF-BOF and NG-DRI plants and is less land intensive as well.

Current commercial green H2-DRI/HBI production requires nearly 230Mt of material inputs, and produces 21Mt CO2-e over a 25-year operational lifespan (Figure 10). Comparatively, NG-DRI requires approximately 255Mt of material inputs and produces approximately five times the total emissions (100Mt CO2-e). BF-BOF plants require the least material inputs (180Mt) but are significantly more carbon emission-intensive (140Mt CO2-e).[41] Figure 10 shows the input requirements across these three production pathways and associated emissions over a 25-year period. The BF-BOF route is modelled using hematite ores, while the DRI pathways use a low-grade magnetite, which needs significant beneficiation.

Figure 10: Material input requirements across three Australian iron production pathways[42]



Source: Deloitte analysis based on material requirement per production pathway data from MRIWA, 2024.

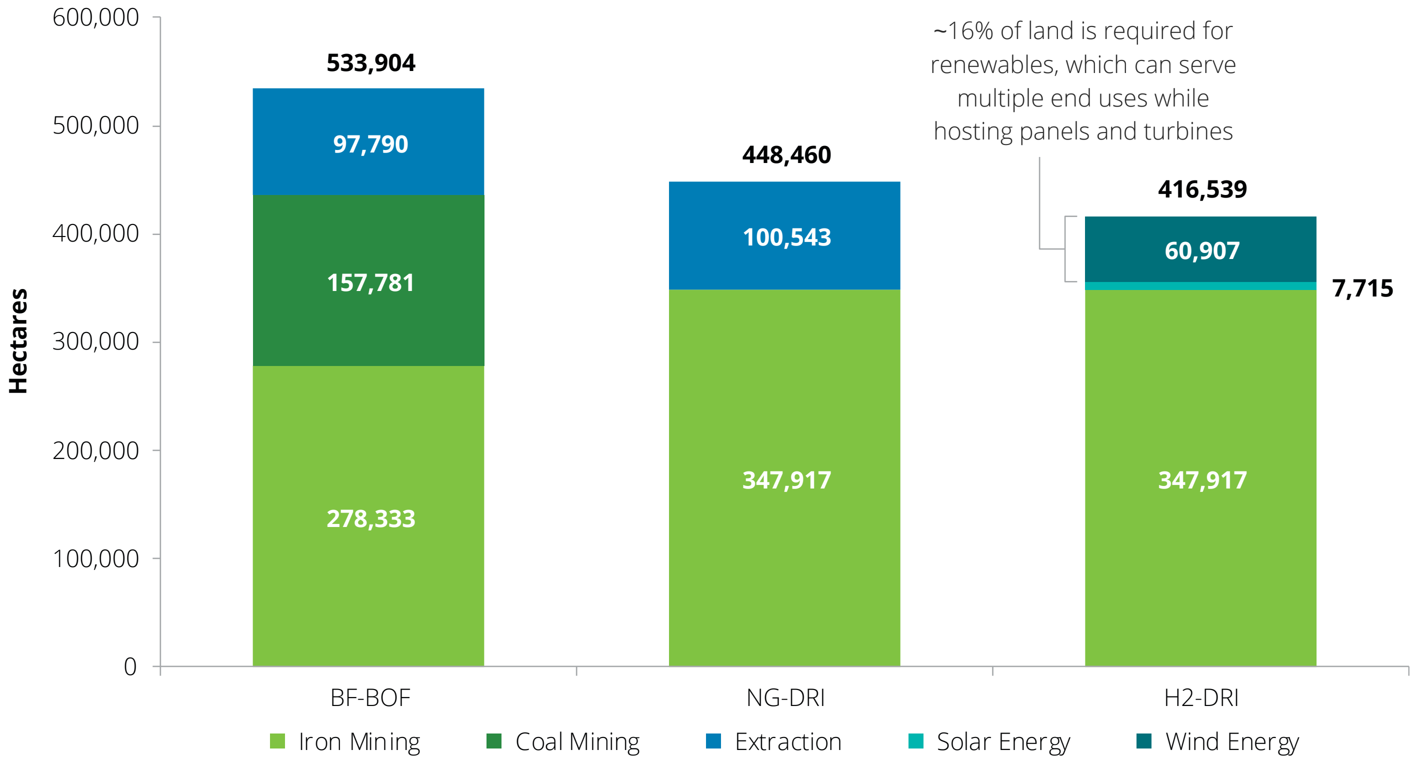
Note:

1. Material requirements are mapped across value chain configurations using a 2.5MtPA steel value chain capacity assumption.
2. Material inputs and emissions intensity of the beneficiation and pelletisation processes are embedded within the two DRI pathways.
3. A 25-year horizon was used based upon the average lifespan of renewable energy assets.
4. Natural gas conversion factor (GJ to metric tonnes): 1GJ = 0.019 t from: British Columbia Ministry of Finance.
5. It is assumed the NG-DRI pathway uses conventional grid electricity (no renewable energy).
6. The 'Other' category includes natural gas, hydrogen, and solid fuels. Concrete and steel were included for the H2-DRI pathway, as it was assumed hydrogen projects would be greenfield developments, with existing NG-DRI and BF-BOF assumed to be retrofitted (brownfield developments); hence less construction is required.
7. Mine waste was not explicitly captured in this assessment. Iron ore volumes differ between BF-BOF and DRI due to the beneficiation required for magnetite ore to be suitable for the DRI process compared to hematite for BF-BOF processing.

Over a 25-year time horizon, green iron uses 21% less land than BF-BOF (Figure 11), and in the long term, it could become the least land-intensive production process due to its potential for dual land use and rehabilitation.[43] Renewables make up 16% of the land required for green H2-DRI/HBI production – this covers electricity requirements in beneficiation, hydrogen production, and to operate the DRI facility. However, unlike land used for mining purposes, which requires significant rehabilitation, land for renewables remains useable for secondary purposes, including improving biodiversity and environmental value.[44]

Additionally, land allocation for renewables, while substantial in size, is a one-off occurrence. In comparison, resource extraction requires ongoing allocation of new land. Figure 11 shows that innovation in land use efficiency could also drive further reductions in land intensity of green iron production, noting the ore grade of magnetite used during the NG-DRI and green H2-DRI process is lower than hematite, resulting in a higher land requirement for NG-DRI and H2 DRI to extract additional material than BF-BOF.

Figure 11: Land use by production method, 25th year of operation[45]



Source: Deloitte analysis based on data from Santos et al., Global Energy Monitor, and Correas, et al. for iron ore mining land use intensity, Lovering et al. for gas extraction land use intensity, and CSIRO for solar and wind land use intensity.

Note:

1. Material requirements are mapped across value chain configurations using a 2.5MtPA steel value chain capacity assumption.
2. Material inputs and total emissions were taken from the Deloitte Green Value Chain Explorer - Iron and Steel, 2024.
3. A 25-year time horizon was used based upon the average lifespan of renewable energy assets.
4. Iron ore mining land intensity of 0.0028ha/tonne.
5. Coal mining land use intensity of 0.00383ha/tonne.
6. Renewable land intensity of 2.5ha/MW (solar) and 1.8.1ha/MW (wind).
7. Gas extraction land use intensity of 0.0011ha/GJ.
8. It is assumed BF-BOF uses hematite while NG-DRI and green H2-DRI uses magnetite.
9. The land estimate for renewables includes electricity for the benefication plant, the hydrogen production plant, and operation of the DRI facility.
10. Renewable energy requirements included for hydrogen generation, beneficiation, and DRI plant operation.

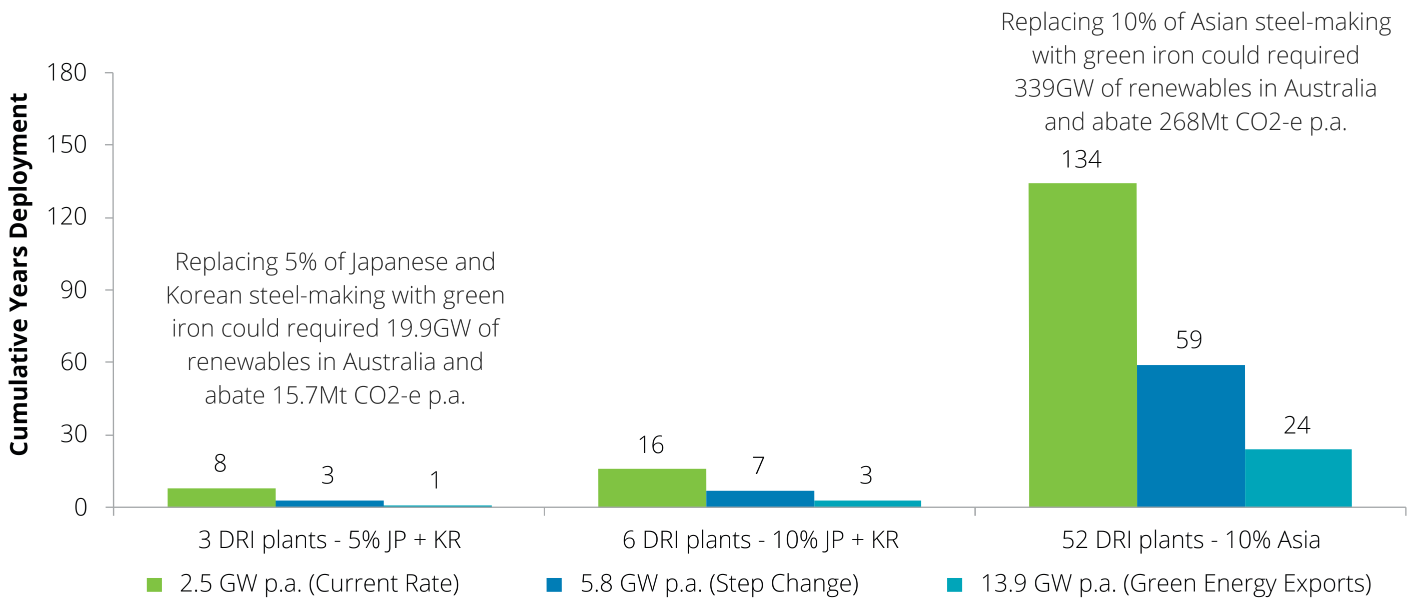
2.5. The timing of Australia's realisation of economic dividends from green iron will be determined by Asian carbon pricing and domestic renewable deployment

The competitiveness of green iron production hinges on energy costs, as renewables and hydrogen are key inputs in the process. Therefore, the timing of Australian green iron competitiveness will be driven by how rapidly green hydrogen and renewable energy costs decline. Achieving meaningful emissions reductions from Asian steel-makers will require significant renewable deployment.

Figure 12 shows that replacing 5% of Japanese and Korean steel-making (7.7Mt) with green iron could require ~3 Australian DRI/ HBI plants.[46] Replacing 10% of steel-making across Asia (131Mt) would be closer to 52 DRI/HBI plants, requiring upwards of 330GW of renewable capacity in Australia.[47]

If Australia wants to dictate terms in the future green iron marketplace, we need to rapidly speed up renewable deployments. At the current pace, it could take over 100 years to deploy the renewables required to replace 10% of Asian steel-making with green iron (Figure 12).[48]

Figure 12: Years to deploy sufficient renewables based in different Asian steel decarbonisation scenarios under various deployment assumptions[49]

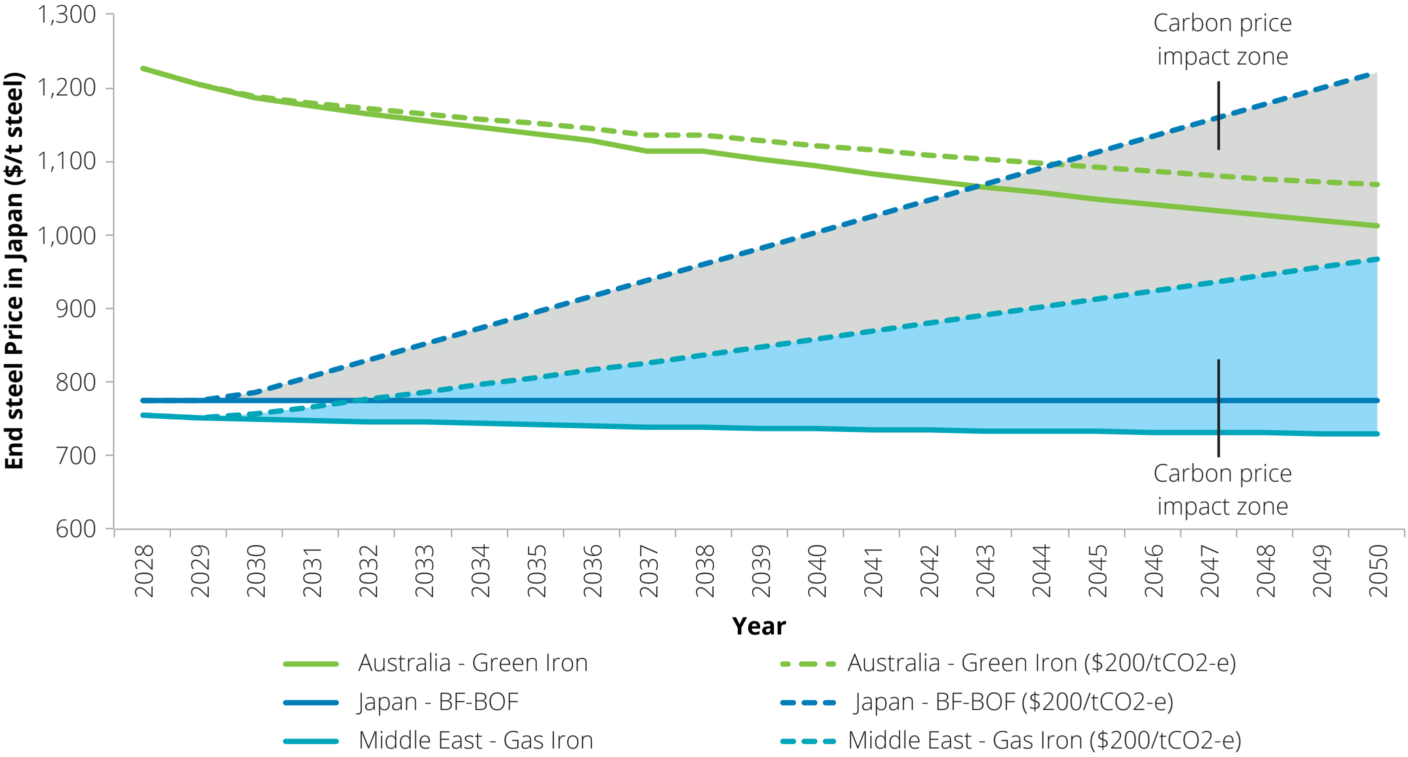


Source: Steel-making capacity numbers are taken from Worldsteel, 2023. Abatement potential and renewable requirements are taken from Deloitte's Green Value Chain Explorer – Iron and Steel, 2024. Deployment rates are taken as a 5-year rolling average in 2030 from 2024 ISP scenarios. The SunShot report - Accenture 2023 assumes 100% of Australia's met coal exports are replaced by an equivalent volume of green iron. It is important to note the years of deployment estimates assume all renewables are dedicated to green iron which is unlikely to ever be the case. It is also important to note that there are supply limits for DR-grade iron ore which could also limit green iron via a H2-DRI-EAF process for Australia.

In parallel, Asian carbon prices must rise to price the carbon externality and provide steel-makers with an economic incentive to go green (Figure 13). Dynamics within iron ore, coal, gas, green hydrogen, renewables, and the degree of carbon pricing between markets will govern when breakeven occurs, but waiting for this cost gap to be resolved could mean that Australia misses out, given major overseas competitors are positioning now to build expertise and gain global share.

Variations in carbon price may shift the breakeven point between regions and see green steel breakeven with incumbent processes earlier as and when an inevitable policy response to the growing climate crisis emerges at scale. The development of global green iron and steel value chains is contingent upon the establishment of uniform carbon pricing between regions given the globally integrated nature of value chains. As such, the continued variability in carbon pricing across the APAC region and globally could contribute to delaying the adoption of green steel.

Figure 13: End steel price for green hydrogen-based and gas-based DRI delivered to Japan from Australia with an escalating regional carbon price from $5/tCO2-e in 2030 to $200/tCO2-e in 2050 (dotted line) and no carbon price (full line)[50]



Source: Deloitte Green Value Chain Explorer - Iron and Steel, 2024.

Note: Linear growth in the carbon price is assumed between 2030 and 2050. Australian green iron is assumed to utilise hydrogen supported by Hydrogen Headstart and a Hydrogen Production Tax Credit. Domestic support for green steel on the demand-side in Japan may accelerate the dynamic illustrated.

3. Australian green iron production must ensure protections are in place for nature and communities

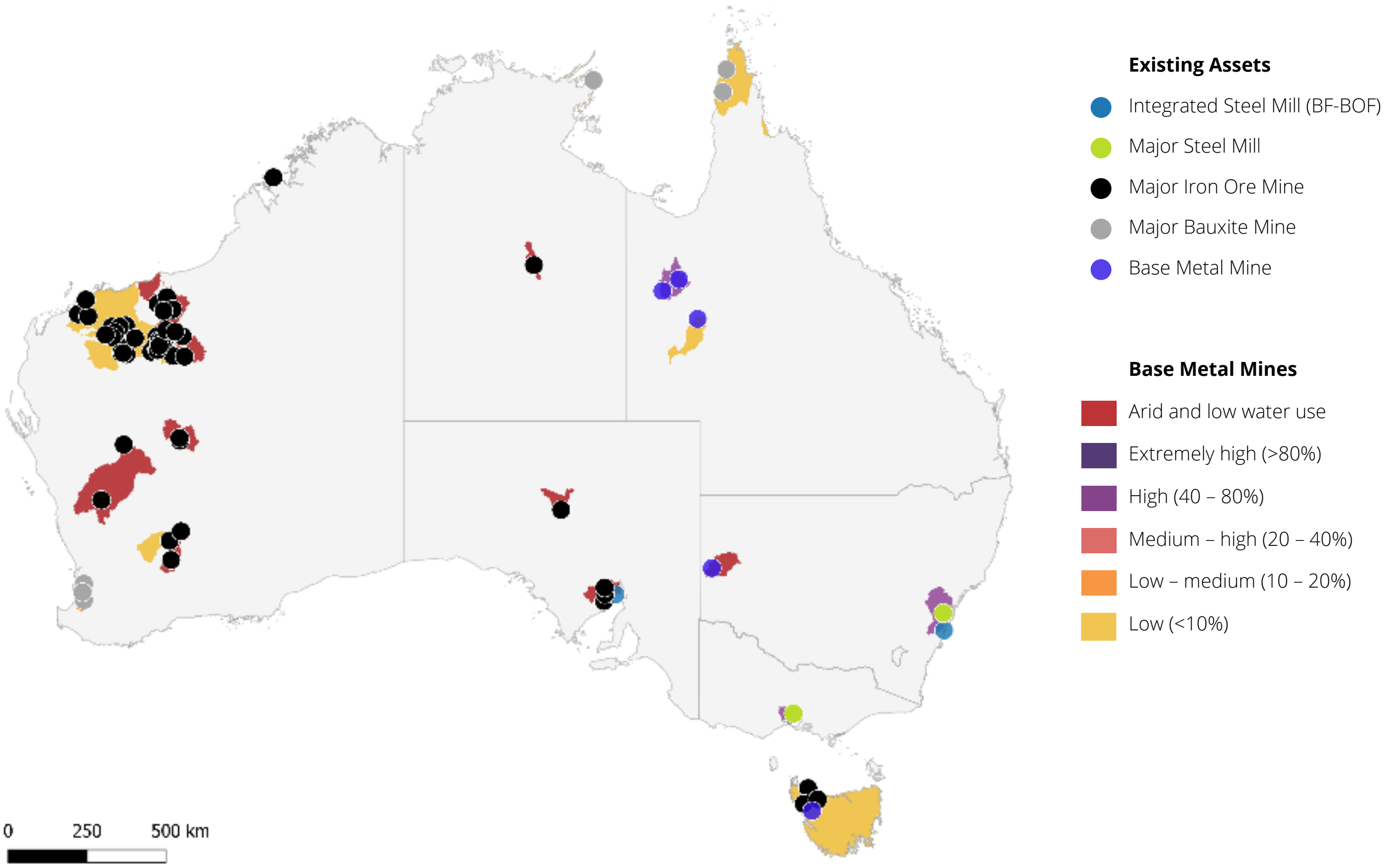
There is significant overlap between Australia's natural environment and assets within the green iron value chain. More than half of Australia's fifteen biodiversity hotspots[51] interact with current or announced projects required to deliver green iron exports.[52] Additionally, most Australian iron ore value chain projects are located on Indigenous land. Consideration of the impacts of renewable energy, green hydrogen, and extractive activities is required to mitigate any harmful effects of the green iron value chain on nature.

3.1. Green iron's extractive activities encroachment on nature must be managed

Existing mining activity interacts with at least 2 of the 15 recognised biodiversity hotpots, including highly biodiverse areas in the Pilbara and Northern Kimberley regions of Western Australia.[53] However, they do not however heavily interact with International Union for Conservation of Nature (IUCN) protected areas.[54] Mining operations are already subject to several environmental obligations as part of project applications. These require restoration of the biodiversity of disturbed sites and managing interactions with natural resources throughout the project life. However, increased extractive activities for green iron resources may demand investment towards increasing biodiversity value above the baseline to offset the impact. Australia also has a national '30 by 30' target to protect and conserve 30% of land and marine areas by 2030, which may mean that as coverage increases, so does the interaction between IUCN areas and the green iron value chain.[55]

Green iron mines and facilities are also located in areas of high water stress,[56] despite magnetite iron ore processing being water-intensive (Figure 14).[57] Adoption of circular water models, including dry beneficiation processes and other innovations, shared desalination plants and reinjection into the water table, and ensuring the industry is minimising water impact may be considered to reduce overall impacts to water security in vital regions for exploration.

Figure 14: Interactions between mining assets and areas of water stress



Source: Deloitte analysis (based on data from World Resource Institute), 2024

The green iron value chain is also primarily located on Indigenous land, including approximately 65% of iron ore assets on land subject to a Native Title Declaration and over 60% interfacing with registered Indigenous Land Use Agreements (ILUAs).[58] This theoretically provides Indigenous Australians with the ability to negotiate land use and help inform better development, which aligns well with the Community Benefits Principles under the Future Made in Australia legislation passed in December.

However, Indigenous Peoples, while compensated under ILUAs, have not had the benefit of economic participation in the iron ore value chain. It may be necessary to negotiate amendments to ILUAs and Native Title Determinations to incorporate nature conservation practices and facilitate Traditional Owner involvement in environmental management. Learnings from benefit sharing associated with the renewable energy transition will also help inform how this translates to the iron ore value chain.

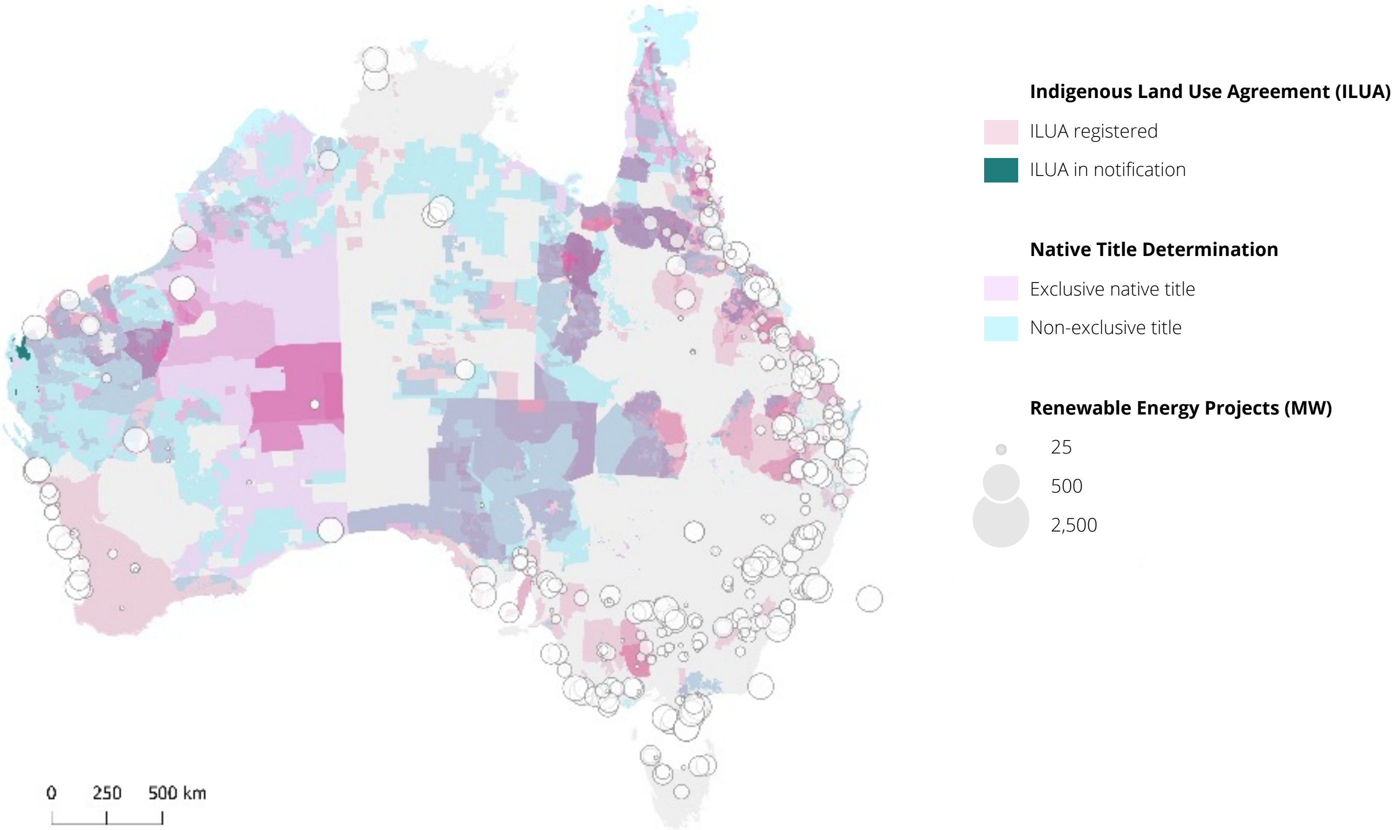
3.2. The renewable energy requirements for green iron-making will need to consider the nature imperative

While only 4.5% of announced projects are expected to be located within IUCN-protected areas, they would interact with at least 10 of Australia's 15 biodiversity hotspots.[59] While renewable energy developers are subject to environmental assessments to meet a net regenerative outcome, there needs to be a greater focus on an approach that considers both environmental and economic transition objectives. Global guidelines and directives are showcasing best practice methods and opportunities to create environmental benefits across renewable energy development.[60, 61, 62] Various state-based and community guidelines are also being considered in Australia, such as the Victorian Government's commitment to develop a handbook with mandatory guidelines for renewable projects to better consider environmental management.[63]

More than 45% of announced renewable energy projects will be situated on Indigenous land (Figure 15).[64] However, only 1% of Australia's existing renewable energy projects provide equity benefits to Indigenous Peoples, compared to Canada's 20%.[65] The federal government finalised its First Nations Clean Energy Strategy in December 2024. This strategy aims to support First Nations participation in and benefit from the clean energy transformation.[66]

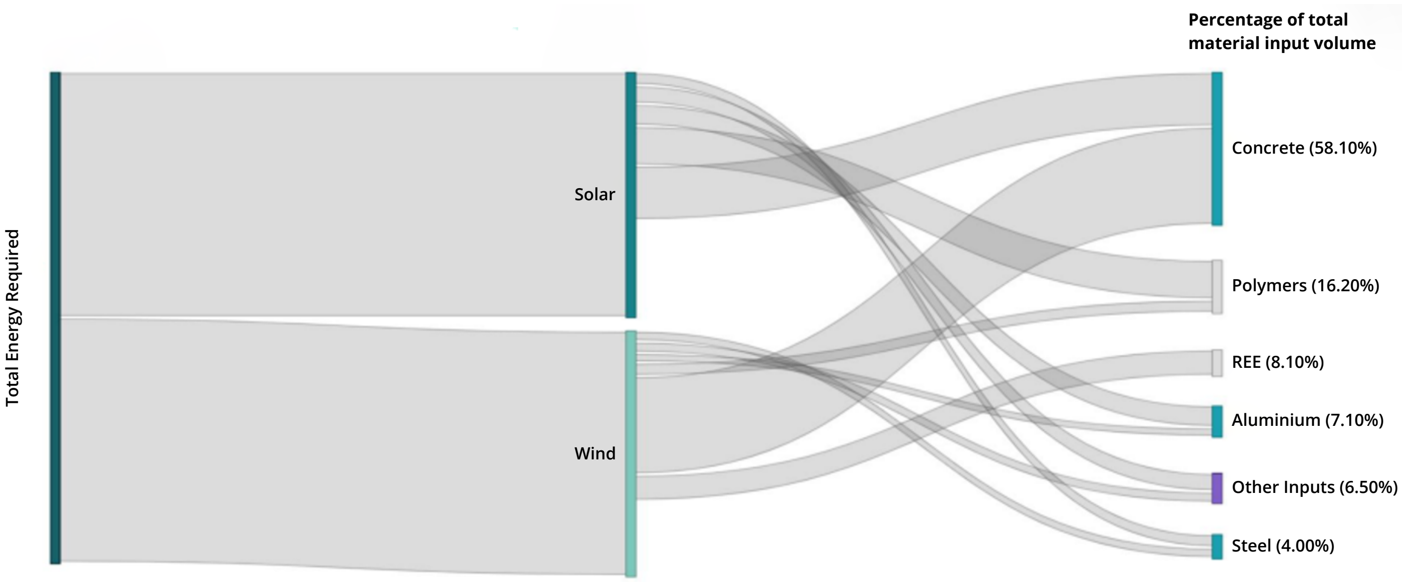
Renewable energy requirements will also require large material inputs and have implications for Australian biodiversity and First Nations communities. Deloitte's analysis shows that a 2.5Mt per annum green iron plant could require approximately 7.1GW of renewable power and 1.4Mt of materials.[67] To achieve this, approximately 7% of Australia's domestic concrete production,[68] 5.5% of domestic aluminium production,[69] and 0.80% of domestic steel production[70] would be required. This will require enhanced efficiency in development to ensure the careful use of finite resources for competing need (Figure 16).[71]

Figure 15: Interactions between announced renewable projects and Indigenous Agreements or Declarations



Source: Deloitte analysis, 2024 (based on data from NTT and GEM)

Figure 16: Material flows for Australian renewable energy inputs needed for 2.5Mt green iron



Source: Deloitte Green Value Chain Explorer - Iron and Steel, 2024

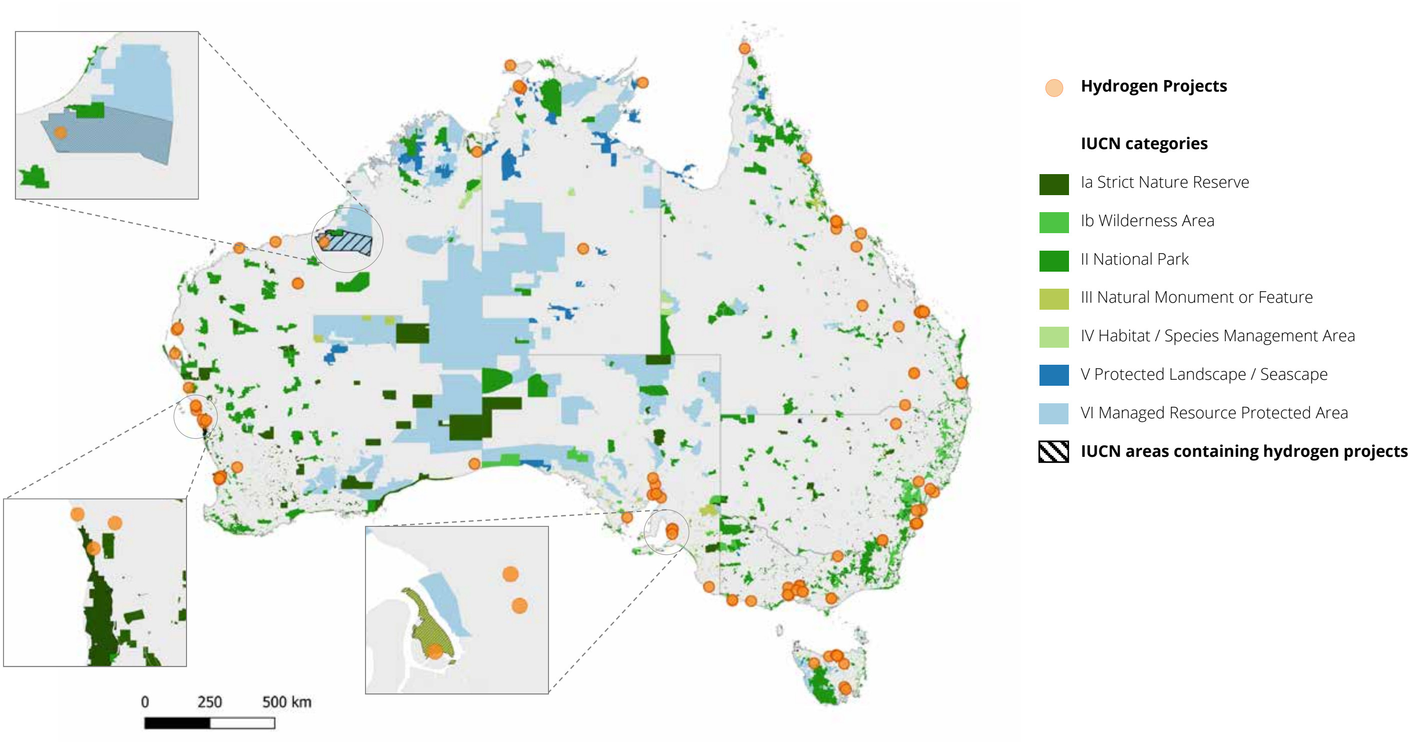
3.3. Further consideration will be required to manage the impact of hydrogen on nature

Announced hydrogen project sites interact with at least half of Australia's biodiversity hotspot areas and three IUCN-designated areas (Figure 17).[72] The renewable energy inputs used to produce green hydrogen require sizeable land allocations, which will mean greater disturbances and changes to bioregions. Interactions with biodiversity hotspots and IUCN areas will need to be factored into development processes.

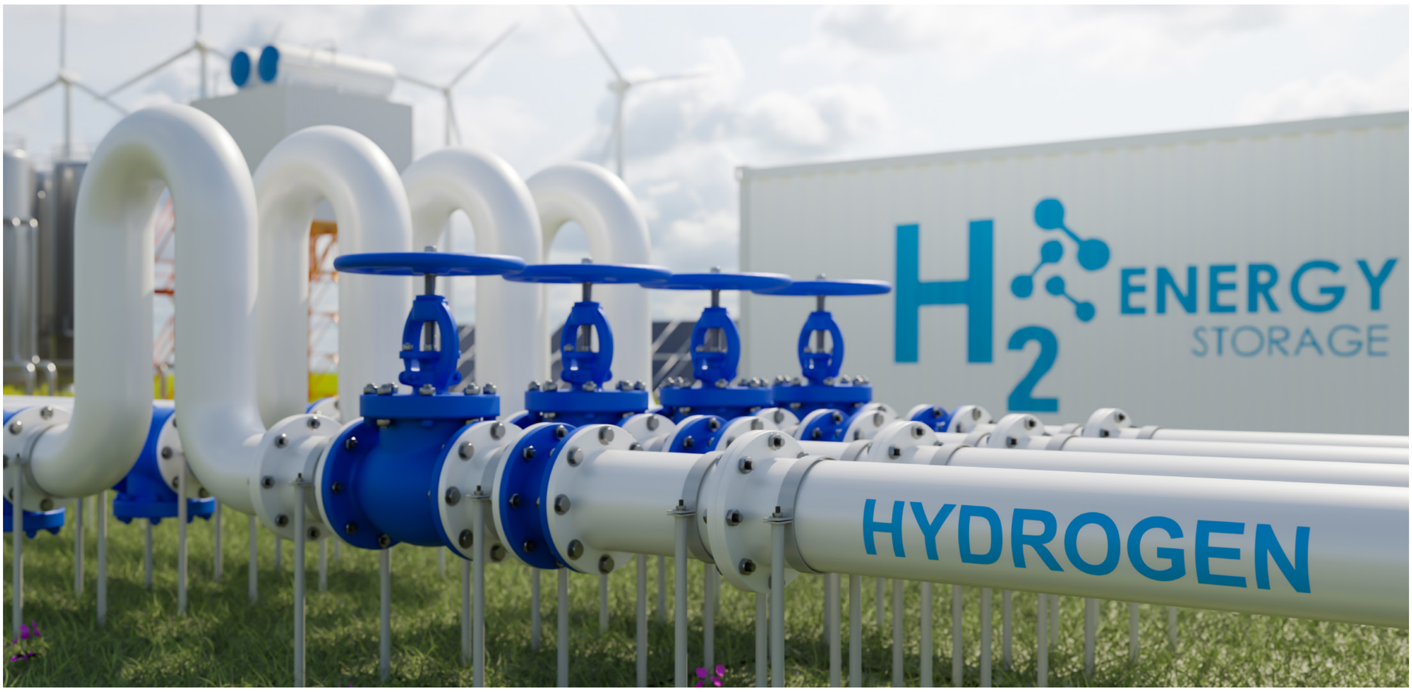
Approximately 45% of announced hydrogen projects are in areas of high water stress.[73] This is challenging as hydrogen is water-intensive, meaning that a 2.5Mt steel facility powered by hydrogen would require 1.78GL of water annually.[74] This is equivalent to just over 13% of the annual water consumption by BHP's South Australia copper mine[75] and 0.01% of Australia's annual water consumption.[76] However, water consumed through electrolysis can also be reused in downstream activities, including processing and cooling, allowing for increased circularity and lower demand from water shelves. Nonetheless, as per all potential impacts, local assessment will be required to understand incremental demand within the local context.

Moreover, green hydrogen will require considerable land during facility construction and thus will likely be subject to First Nations rights and interests. Currently, only 8% of hydrogen projects are on land designated to a Native Title Declaration, while just over 35% are situated on land registered for an ILUA.[77] However, this is expected to grow as the industry does. There is precedent for First Nations collaboration on major hydrogen projects, and the Hydrogen Headstart program's $4 million allocation to support First Nations communities' engagement with hydrogen projects could also see a race to the top.[78, 79]

Figure 17: Interactions between hydrogen projects and Australian IUCN categories



Source: Deloitte analysis (based on data from DCCEEW), 2024



4. Australia will need to consider both domestic action and collaboration with APAC to unlock the green iron opportunity

4.1. How can Australia foster a regenerative green iron industry?

Acceleration of renewable energy deployment rates

Achieving meaningful emissions reductions from Asian steel-makers will require significant renewable deployment, and Australia's current renewable deployment rates are too slow to drive scaled emissions reductions in the 2040s.[80] Therefore, Australia must change its processes to ensure the rapid deployment of renewables without impeding on nature.

Digitisation of permitting and approvals processes can accelerate the processing of applications and allow enhanced deployment of renewable projects. Green planning/permitting sandbox with conditions on incentives and approvals, as well as introducing pilot tools like EasyPermits[81], which streamlines the approvals process for wind farms in Europe, could help with improving the speed of project authorisations. Regional nature-based assessments could also streamline project applications for more efficient scenario planning and regional monitoring.

Projects must be assessed on land and resource efficiency as well as economic efficiency. In addition to analysing the economic efficiency of renewable development, assessing projects based on land and resource efficiency will also ensure consideration of nature interactions within the approvals process. Using geospatial data mapping to measure the impacts on natural capital such as biodiversity, carbon, water, and soil, and requiring project applications to consider how land can be used for dual purposes, will become increasingly important towards balancing rapid deployment with efforts to regenerate nature.

New renewable energy investment will also create significant demand for construction materials. This demand could be leveraged to drive the uptake of construction materials with low embodied carbon. This is an excellent opportunity for government to introduce demand-pull strategies, including domestic content requirements, to improve the community benefits of these capital-intensive deployments.

Government incentives directed towards both regenerative and real decarbonisation outcomes

Australia risks losing out competitively if it moves too slowly across the green steel value chain. However, the race to transition from coal-powered iron processing could have unintended consequences for both nature and climate. Therefore, it is imperative that the government advocates for a rapid transition that is regenerative through clear, directive policy support.

Policy recommendations must support the pathway to transition to green hydrogen. Rapidly shifting the focus to green hydrogen is essential to guarantee real abatement outcomes and Australia's competitiveness, and incentives must be pursued to make this cost-effective. This will provide a strong incentive to shift towards hydrogen blending. Encouraging the deployment of innovation in green iron-making, including innovation in renewables, green hydrogen technologies, and DRI-grade ores, alongside project approvals and common user infrastructure, will further help ensure Australia's competitive advantage.

Nature-linked development conditions can incentivise consideration of regenerative opportunities at the project development stage. Conditions on development linked to nature or biodiversity are already being embedded through the US Inflation Reduction Act and the UK's recently established biodiversity credit scheme, which requires all new building projects to achieve a 10% net gain in nature or biodiversity.[82] These types of schemes are expected to be adopted by other European jurisdictions in the future. Introducing conditionalities on renewable development can support the mutually dependent issues of decarbonisation of the green iron process through renewable deployment while maximising regeneration.

Clustering development with clear scenarios and regional-based assessments and piloting

Green iron development sits alongside renewables development for green hydrogen exports as well as low-carbon liquid fuels development.

As all these industries are likely to be regionally based, localised piloting and nature-based assessments will support regional monitoring of nature and climate impacts from development. Like the concept of a Renewable Energy Zone, the introduction of regional nature zones would allow for centrally managed biodiversity and cultural heritage assessments. This could streamline project application processes and enable more efficient scenario planning and regional monitoring.

Using a regulatory sandbox-style pilot to test what works, understand impacts, and build an evidence base for wider scale up and adoption can draw lessons from financial regulations to support iterative improvements in local planning and monitoring of nature interactions. Geospatial and mapping tools can also be used to support developers with place-based siting to understand and minimise impact on wildlife habitat.

4.2. How can Australia influence APAC to support a regional green steel industry?

Establishing pragmatic green statecraft and regional carbon pricing

To ensure success of a new green steel value chain, Australia must collaborate with its Asia-Pacific partners (current and prospective) on investment, policy support, and offtake of product. It must anticipate what action trading partners are going to take, while also being clear on what it needs partners to do to achieve greater mutual benefits. Creating green iron corridors in the APAC region allows for reductions in operational costs, such as transport and logistical costs, and could minimise the environmental footprint of the value chain, as well as disruption and degradation of local ecosystems. Leveraging existing programs and developing buyers' coalitions with APAC offtakers could utilise trilateral or bilateral government financial support to encourage the development of a green iron industry in the absence of carbon pricing. If Australia hosts COP31 with the Pacific, we have a significant opportunity to make this green iron corridor to Asia one of our key and lasting legacies as we support our trading partners to decarbonise their industries.

A higher carbon price and adoption of a carbon price mechanism in Asia-Pacific markets is needed. This would bridge the cost gap and improve the commercialisation case for Australian-Asia-Pacific green iron. An Asia CBAM would help ensure local efforts to reduce emissions through carbon pricing are effective and not undone by imports of more carbon intensive products. However, it isn't clear how such a mechanism could be designed and placed into force across the range of high- and middle-income economies across Asia. Advocacy groups could investigate added costs across different industries and research efforts on the appropriate sizing and transition of carbon prices in Asia to improve the reputability of the green iron corridor in the Asia-Pacific region.

Alignment of high integrity standards

Developing a green steel value chain is limited by contradictory standards and definitions of what constitutes 'green' or 'low emissions'. This could inhibit investment signals and undermine green premiums, ultimately impacting the emergence of a net-zero aligned green steel market. **This requires harmonisation of standards and collaboration across industry and jurisdictions to establish common emission intensity thresholds for green hydrogen and alignment on emissions boundaries for a global green steel definition.**

Positioning Australia as the partner of choice

To remain 'in the race', Australian policymakers and industry players need to emphasise cross-value chain partnerships, development projects, and explicit opportunities for mutual economic benefit. This will require Australia to incentivise Asian steel-makers to invest in renewable PPAs and partnerships for EAFs with prospective Australian producers. Rapid deployment of innovation in low-cost iron-making consumables, including renewables and DRI-grade ores, alongside project approvals and common user infrastructure will be important for Australia to emerge as Asia's primary steel decarbonisation partner.

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Endnotes

1 World Economic Forum, 2022

2 Deloitte Access Economics, 2023

3 Accenture, 2023

4 Superpower Institute, 2024

5 World Steel Association, 2021

6 Green Steel Tracker, 2024

7 Deloitte Green Value Chain Explorer - Iron and Steel

8 This would involve Australian green hydrogen-based Direct Reduced Iron (green H2-DRI) facilities, and exporting iron as Hot-Briquetted Iron (HBI) for steel-making in Asia

9 Deloitte Green Value Chain Explorer - Iron and Steel

10 Deloitte Green Value Chain Explorer - Iron and Steel

11 Assuming 2.5Mt nameplate capacity per facility

12 Deloitte Green Value Chain Explorer - Iron and Steel based on data taken from 2024 ISP scenarios

13 Deloitte Green Value Chain Explorer - Iron and Steel

14 Deloitte analysis based on data from the Western Australian Biodiversity Science Institute, GeoScience Australia, DISER, the Global Energy Monitor, DCCEEW, and WABSI

15 Deloitte analysis based on data from World Resource Institute

16 Deloitte analysis based on data from NTT, GeoScience Australia, GEM and DISER

17 Deloitte Green Value Chain Explorer - Iron and Steel

18 Climate TRACE, 2024

19 Australian Aluminium Council, 2022

20 Cement Industry Federation, 2022

21 World Steel Association, 2021

22 Mission Possible Partnership – Steel, 2022

23 World Steel Association, 2024

24 Climate Trace, 2023

25 Green Steel Tracker, 2024

26 Deloitte analysis based on data from the Western Australian Biodiversity Science Institute, GeoScience Australia, DISER, the Global Energy Monitor, DCCEEW, and WABSI

27 OEC, 2022

28 Resources and Energy Quarterly, March 2024

29 Assuming Australia's global share of metallurgical coal emissions (430Mt CO2-e in 2023, from Climate Analytics, August 2024) are responsible for steel emissions only, 2022 steel demand of 1840.2Mt (from World Steel Association, no date) and 2022 average global steel emissions intensity of 1.41 tCO2-e/t steel (from IEA, 2023). Refer to Figure 23 in the Mined the Gap report for specific emissions intensity numbers used in the report modelling and analysis results.

30 Resources and Energy Quarterly, March 2024

31 Resources and Energy Quarterly, March 2024

32 OEC, 2022

33 Climate Rights International, 2024

34 Resources and Energy Quarterly, March 2024

35 Figure 8 shows end steel prices based on 7 different configurations for the value chain (inclusive of raw materials and transport).

1. BF-BOF Japan: Incumbent BF-BOF technology which assumes both blast furnace and basic oxygen furnace occur in Japan, powered by Australian iron ore and coal.
2. EAF: Complete vertical integration in Australia, with green iron turned into steel via an electric arc furnace in Australia.
3. Green H2-DRI: Australia exporting green iron as HBI to be turned into steel via an electric arc furnace in Japan.
4. Blue H2-DRI: Australia exporting blue iron (made with blue hydrogen) as HBI to be turned into steel via an electric arc furnace in Japan.
5. Pellets & Ammonia: Australia exporting pelletised iron ore and ammonia, with both the direct reduced iron and electric arc furnace process occurring in Japan.
6. Iron Ore & Ammonia: Australia exporting iron ore and ammonia to Japan, with the electric arc furnace process occurring in Japan.
7. Domestic Green Japan: Producing green iron and steel in Japan from iron ore imports.

For transport assumptions applied see footnote 36. Model parameters (including support policies and ore type) are provided in Appendix A (Mined the Gap report).

36 Deloitte Green Value Chain Explorer - Iron and Steel. Port distance was calculated using a nautical mile calculator (based on data from Sea Distances.org). The difference in nautical mile distance travelled was based upon routes from export partners (Australia, Canada, Middle East, and United States of America (USA)) to ports within the APAC steel-making region (China, Japan and Korea).

37 Deloitte analysis based on data from World Bank.

38 It is acknowledged that successful iron production is also contingent upon improvements in technology to commercially support Australian ore use.

39 Cost of steel production comparing gas-DRI and green hydrogen-DRI in Australia (Pilbara), Australia (outside Pilbara, for example South Australia), Canada, the USA, and Middle East. Includes raw material and energy inputs, transport, and EAF-based steel production. For transport assumptions applied see footnote 36. Model parameters (including support policies and ore type) are provided in Appendix A (Mined the Gap report).

40 Deloitte analysis based on data from MRIWA, 2024. The base high grade 67% hematite fine ore type was chosen as a reference point (1 tonne of iron ore / 1 tonne of product). For magnetite ores, it was assumed that magnetite ore grades are half (33.5%) of the 67% hematite value. Thus, the relative magnetite iron ore requirement was deemed to be twice that of hematite. Note, the iron ore grade can vary and resultingly impact the quantum of iron ore required.

41 Material inputs and total emissions were taken from the Deloitte Green Value Chain Explorer: Iron and Steel

42
1. Material requirements are mapped across value chain configurations using a 2.5MtPA steel value chain capacity assumption.
2. Material inputs and emissions intensity of the beneficiation and pelletisation processes are embedded within the two DRI pathways.
3. A 25-year horizon was used based upon the average lifespan of renewable energy assets.
4. Natural gas conversion factor (GJ to metric tonnes: 1GJ = 0.019 t) from British Columbia Ministry of Finance.
5. It is assumed the NG-DRI pathway used conventional grid electricity (no renewable energy).
6. The 'Other' category includes natural gas, hydrogen, and solid fuels. Concrete and steel were included for the green H2-DRI pathway, as it was assumed hydrogen projects would be greenfield developments, with existing NG-DRI and BF-BOF assumed to be retrofitted (brownfield developments); hence less construction is required.
7. Mine waste was not explicitly captured in this assessment. Iron ore volumes differ between BF-BOF and DRI due to the beneficiation required for magnetite ore to be suitable for the DRI process compared to hematite for BF-BOF processing.

43 Deloitte analysis based on data from Santos et al. and Global Energy Monitor for iron ore mining land use intensity, Lovering et al. for gas extraction land use intensity of 0.0011ha/GJ, and CSIRO for solar and wind land use intensity of 2.5ha/MW for solar and 18.1ha/MW for wind.

44 Deloitte Green Value Chain Explorer - Iron and Steel

45
1. Material requirements are mapped across value chain configurations using a 2.5MtPA steel value chain capacity assumption.
2. Material inputs and total emissions were taken from the Deloitte Green Value Chain Explorer: Iron and Steel, 2024.
3. A 25-year time horizon was used based upon the average lifespan of renewable energy assets.
4. Iron ore mining land intensity of 0.0028ha/tonne.
5. Coal mining land use intensity of 0.00383ha/tonne.
6. Renewable land intensity of 2.5ha/MW (solar) and 18.1ha/MW (wind).
7. Gas extraction land use intensity of 0.0011ha/GJ.
8. It is assumed BF-BOF uses hematite while NG-DRI and green H2-DRI uses magnetite.
9. The land estimate for renewables includes electricity for the benefication plant, the hydrogen prodution plant, and operation of the DRI facility
10. Renewable energy requirements included for hydrogen generation, beneficiation, and DRI plant operation.

46 Deloitte Green Value Chain Explorer - Iron and Steel based on data taken from 2024 ISP scenarios

47 Deloitte Green Value Chain Explorer - Iron and Steel based on data taken from 2024 ISP scenarios

48 Deloitte Green Value Chain Explorer - Iron and Steel

49 Steel-making capacity numbers are taken from Worldsteel, 2023. Abatement potential and renewable requirements are taken from Deloitte's Green Value Chain Explorer – Iron and Steel, 2024. Deployment rates are taken as a 5-year rolling average in 2030 from 2024 ISP scenarios. The SunShot report - Accenture 2023 assumes 100% of Australia's met coal exports are replaced by an equivalent volume of green iron. It is important to note the years of deployment estimates assume all renewables are dedicated to green iron which is unlikely to ever be the case. It is also important to note that there are supply limits to DR-grade iron ore which could also limit green iron via a green H2-DRI-EAF process for Australia.

50 Linear growth in the carbon price is assumed between 2030 and 2050. Australian green iron is assumed to utilise hydrogen supported by Hydrogen Headstart and a Hydrogen Production Tax Credit. Domestic support for green steel on the demand-side in Japan may accelerate the dynamic illustrated.

51 Biodiversity hotspots are areas under threat from human activity, often with high concentrations of endemic species.

52 Deloitte Green Value Chain Explorer - Iron and Steel based on data from Western Australian Biodiversity Science Institute, 2024

53 Western Australian Biodiversity Science Institute, 2024

54 Deloitte analysis based on data from DCCEEW, 2024

55 DCCEEW, 2024

56 Deloitte analysis based on data from World Resource Institute, 2024

57 Mork Water, 2024

58 Deloitte analysis based on data from NTT and GEM, 2024

59 Deloitte analysis based on data from DCCEEW, 2024

60 Orsted, 2023

61 Playa Lakes, 2024

62 Government of UK, 2024

63 DEECA, 2024

64 Deloitte analysis based on data from NTT and GEM

65 The Guardian, 2024

66 DCCEEW, 2024

67 Deloitte Green Value Chain Explorer - Iron and Steel

68 Climate TRACE, 2024.

69 Australian Aluminium Council, 2022

70 Cement Industry Federation, 2022

71 Deloitte Green Value Chain Explorer - Iron and Steel

72 Deloitte analysis based on data from DCCEEW

73 Deloitte analysis based on data from World Resource Institute

74 Deloitte analysis based on data from International Energy Agency

75 BHP, 2009

76 ABS, 2023

77 Deloitte analysis based on data from NTT and CSIRO

78 The Guardian, 2023

79 DCCEEW, 2023

80 Deloitte Green Value Chain Explorer - Iron and Steel

81 Developed between Amazon, Accenture, WindEurope, and the World Economic Forum

82 Government of UK, 2024

Deloitte.

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