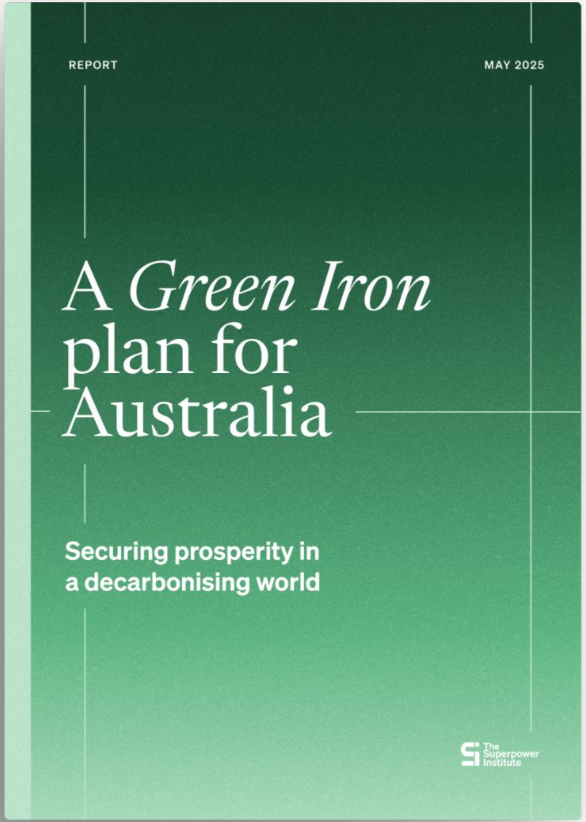


Webinar series: Session 2

The technological path to Australian green iron

Wednesday 11 June, 2025

Chris McMahen
Technical Lead for Green Iron

The Superpower Institute

A Green Iron Plan webinar series

Session 1

Australia’s $400 billion green iron opportunity

Dr Ingrid Burfurd
Carbon Pricing and Policy Lead, TSI

Watch recording

Session 2 - Today

The technological path to Australian green iron

Chris McMahen
Technical Lead for Green Iron, TSI

Session 3 - Thursday 19 June

Modelling green iron production in five Australian regions

Chris McMahen
Australian Director, Bivios

Ben Scott
Economist, TSI

Mission

The Superpower Institute is a not-for-profit organisation dedicated to helping Australia seize the extraordinary economic opportunities of the post-carbon world.

The global shift to net zero is Australia's opportunity.

TSI specialises in practical research and policy development to support the policy settings and market incentives necessary for making Australia a green export superpower to support global development in a post–carbon world.

Our role is to embed climate ambition in a broader economic context and to change the public narrative, so that decision-makers are comfortable adopting the required policies and incentive structures that will unlock the Australian superpower.

Chris McMahen

Technical Lead for Green Iron, TSI

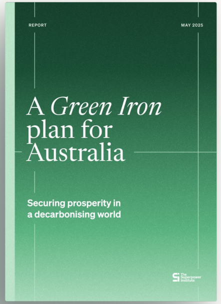
Chris has a background in analytical chemistry, QA/QC, QMS, R&D and process control, and more than 35 years of experience in mining, process metallurgy, refining and marketing.

Chris also represents the Minerals Council of Australia within the International Standards Organisation, and has previously held executive roles with Fortescue Metals Group, Anglo American, Rio Tinto and Alcoa.

The Technical Marketing function which Chris has lead is responsible for the evaluation of alternative green iron and steel making technologies, positioning the iron ore Industry to continue supplying the raw materials required by a future decarbonised iron and steel making industry.

Session 2

The technological path to Australian green iron



Overview

01. The big picture of Australian iron ore

02. Ore types and production challenges

03. Iron and steel-making processes

04. Which green iron technologies we modelled and why

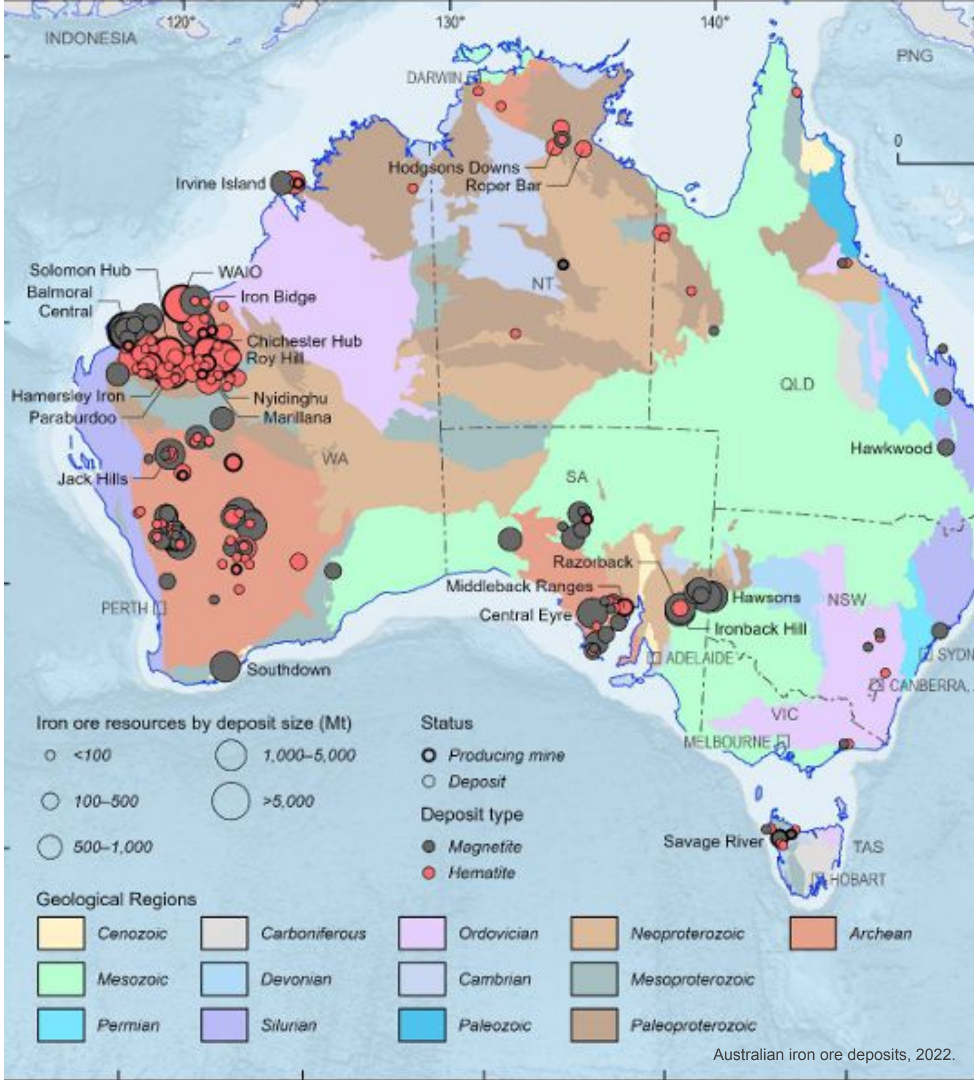
05. Conclusion

01.

Australian iron ore: where is it found and what are its qualities?

The big picture of Australian iron ore

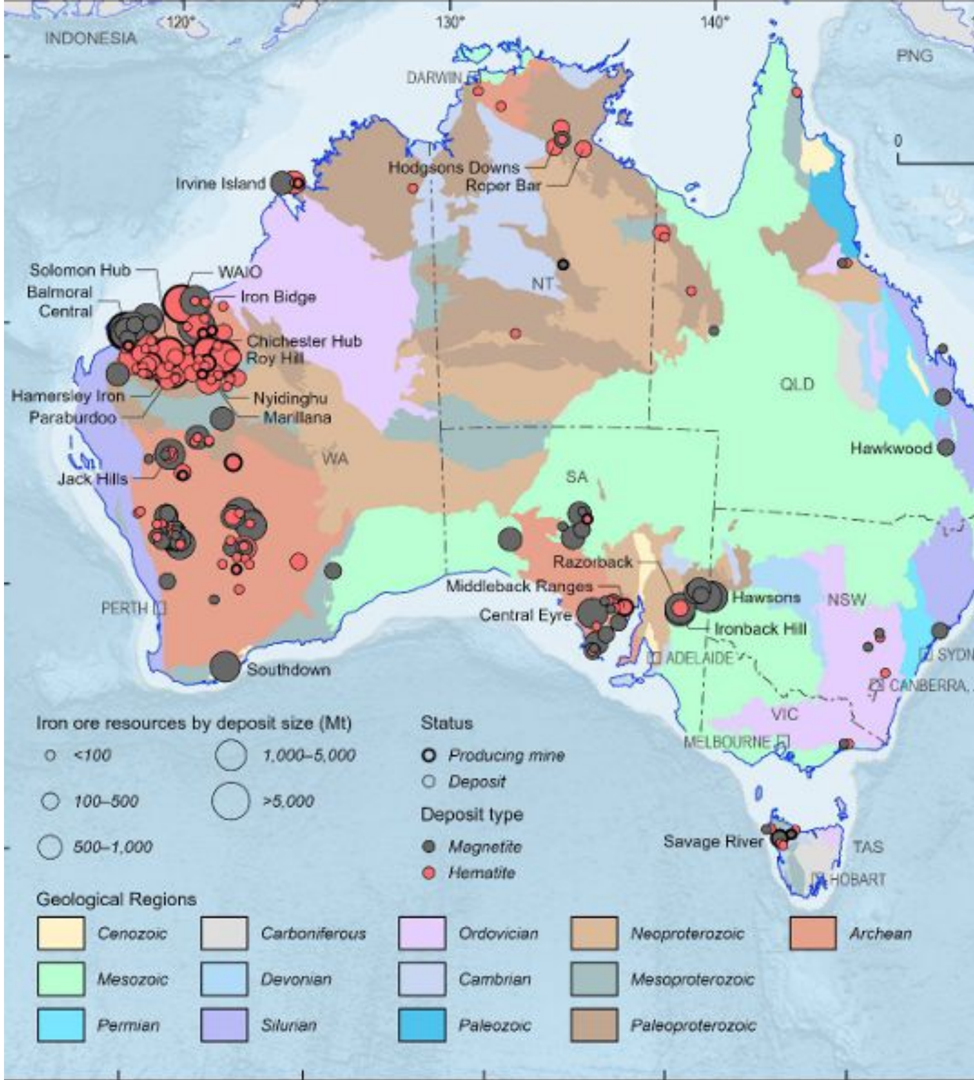
- Australia has large iron ore resources, of both **hematite** and **magnetite**
- Resources are heavily concentrated in Western Australia, particularly the Pilbara region
- South Australia has significant magnetite resources
- Operating mines are dominated by hematite resources
- Hematite typically has a lower cost of development and lower operating cost
- Magnetite typically requires more intensive and costly processing



Australian iron ore deposits, 2022.

The big picture of Australian iron ore

- Iron ore producers operate cost-focussed, price-taking, business models
- Economies of scale are important
- High cost of infrastructure is a barrier to new entrants
- Iron ore producers do not typically invest in iron and steel making



02.

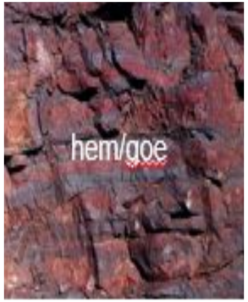
Not all ores are created equal.

Source: USTC - Beijing

Mineralogy largely determines the maximum potential upgrade, unless some form of reduction method is utilised

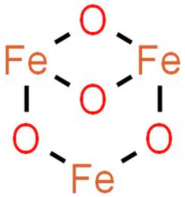
Pilbara iron ore processing facilities typically use physical gravity/density separation (limited WHIMS)

Applying ‘novel’ technologies (e.g. roasting) potentially improves Fe liberation towards theoretical maximum Fe grades

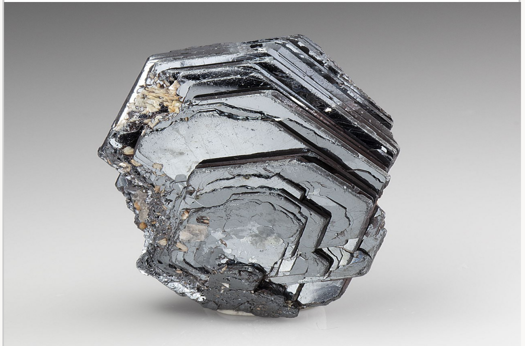


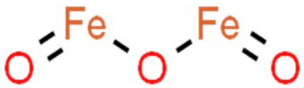
Mineral	**Formula**	**Fe content (theoretical pure)**
Magnetite (taconite)	Fe_3O_4	72.36% Fe
Hematite (itabirite)	Fe_2O_3	69.96% Fe
Goethite	FeO.OH	62.85% Fe
Ocherous Goethite	$FeO.OH.nH_2O$	60.4% Fe (assuming $0.1H_2O$)

Magnetite
Octahedral

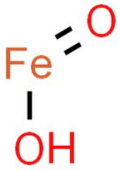


Hematite
Micro platy





Goethite
Orthohombic

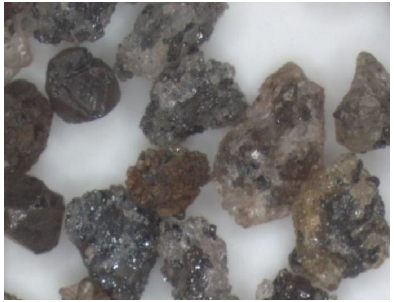


Separating the iron minerals from the non-iron minerals is *dependent on the nature of the resource.*

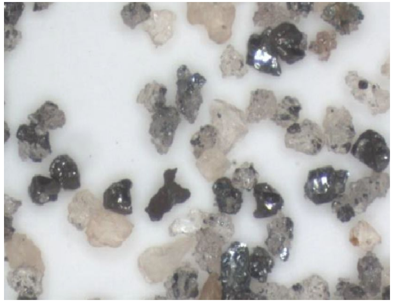
Moving to higher grade ores

- Example of Magnetite Resource Beneficiation: Run Of Mine (ROM): ~38% Fe & ~40% silica
- Upgraded by closed loop AG mill grinding (liberation), with screening at 1.4 mm

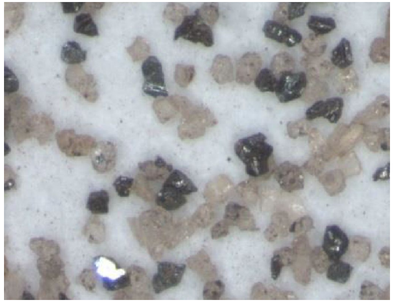
Pilbara hematite/goethite ores do not typically present with such distinct separations of iron and gangue particles. In many cases, there is gangue-mineral substitution in the molecular iron crystal.



Unliberated
1.180mm – 0.850mm



Mostly liberated
0.425mm – 0.300mm



Well Liberated
0.150mm – 0.106µm

Pilbara ores are difficult to upgrade because gangue particles are often substituted within the iron crystal structure.

This limits the effectiveness of physical beneficiation.
Step change for these ores requires the use of *heat*.

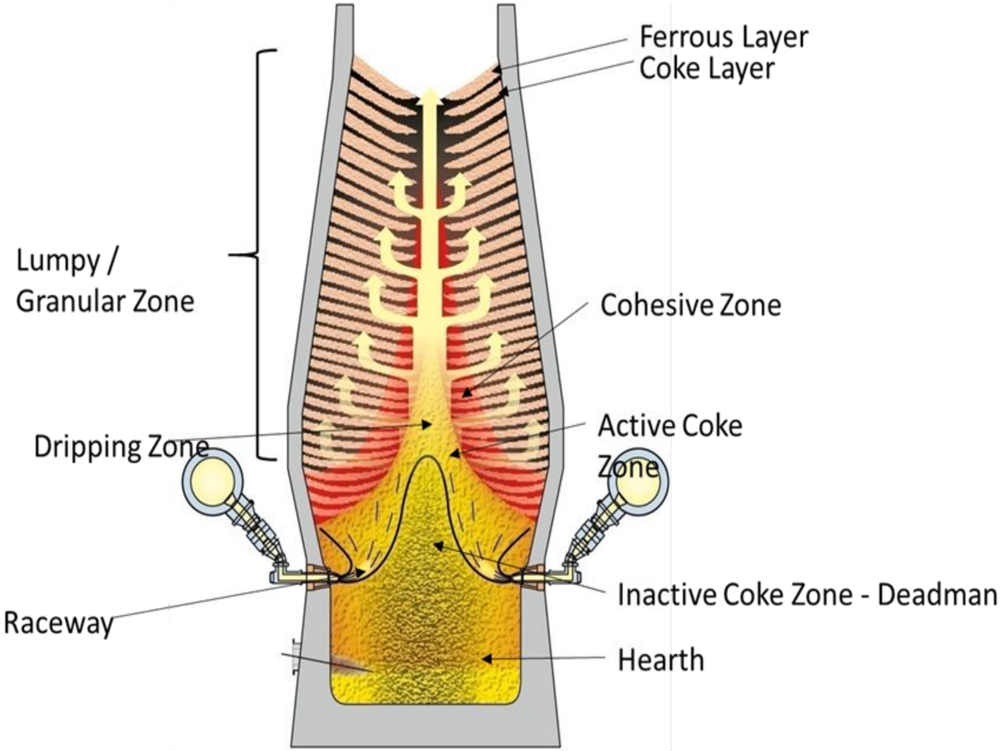
03.

Iron and steel-making processes

“Inside blast furnaces there are 458 chemical reactions, each one is more-or-less out of control.”

– Wei-kao Lu, Professor Emeritus, McMaster University

Coal-based blast furnace



Source: Modern BF Ironmaking, Geerdes et al

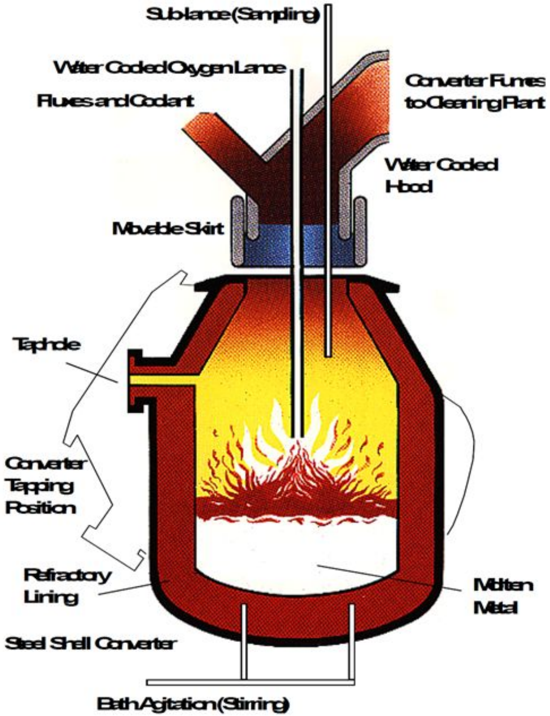
Steel-making after the BF

Basic — The vessel in which the process takes place

Oxygen — The reagent to remove the impurities is oxygen

Furnace — To make liquid steel

	Hot Metal	Primary Steel
Carbon	4 – 5%	0.03 – 0.05%
Silicon	< 1%	0%
Manganese	< 0.5%	< 0.15%
Phosphorous	0.05 – 0.13%	0.005 – 0.015%
Sulphur	< 0.1%	0.001 – 0.01%
Temperature	1,250 – 1,450º C	1,550 – 1,750º C

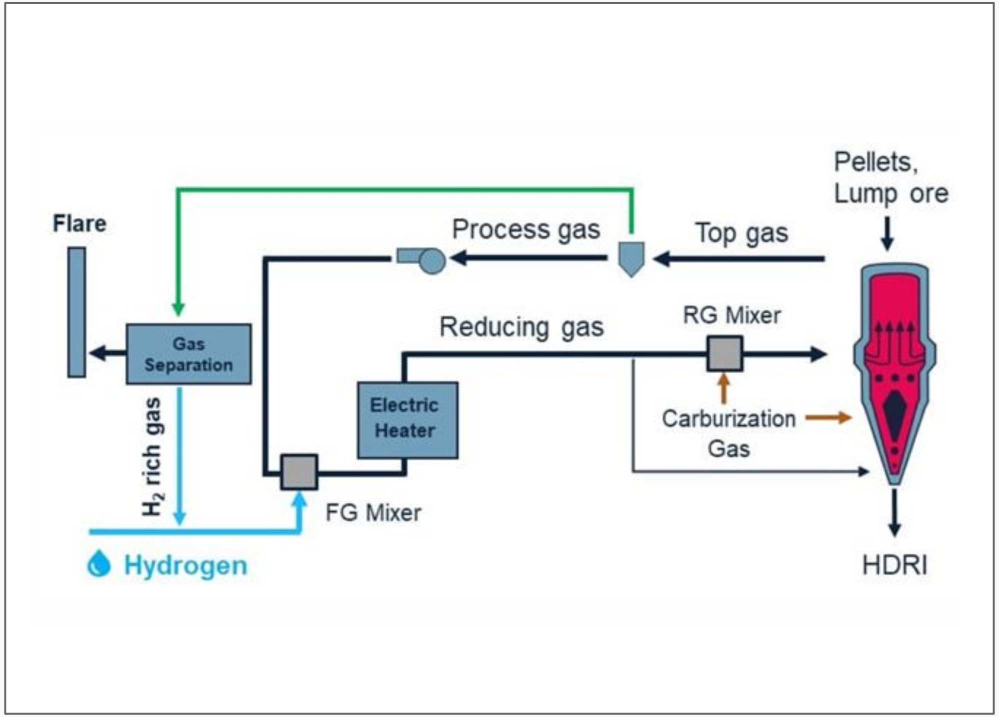


Source: XX

04.

Which green iron technologies did we model – and why?

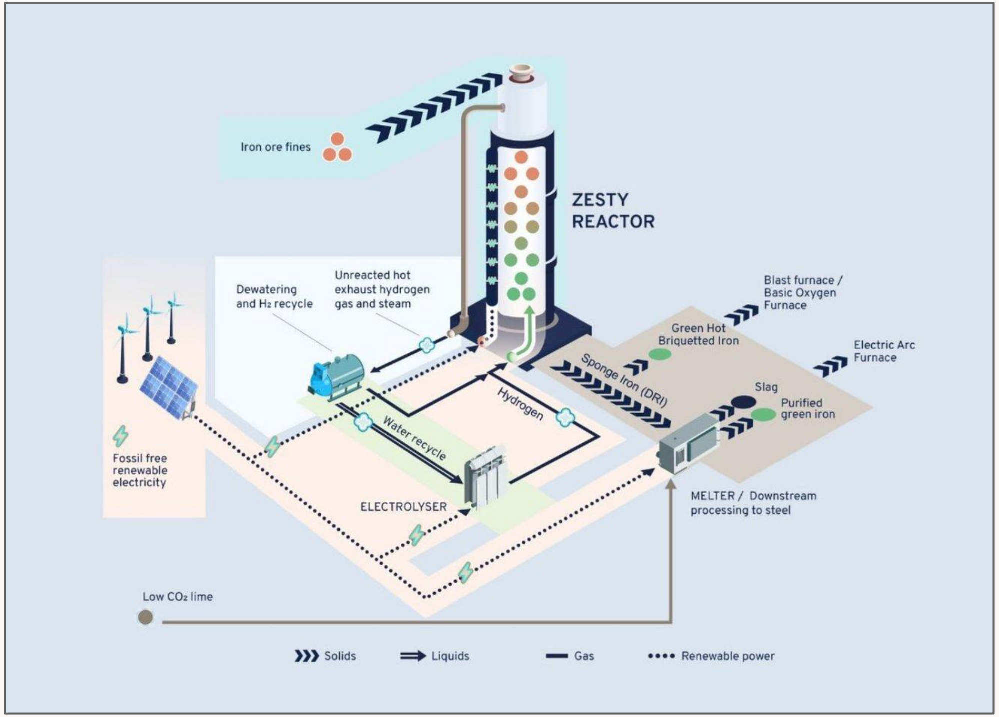
Inflexible technology:
Hydrogen-based Midrex H_2™



- Uses 100% hydrogen for reduction and electricity for heating
- Model assumes 54kg of hydrogen per tonne of Fe
- Pelletised ore required
- Mid-grade ore needed melting to remove gaunge
- High-grade ore briquetted for export as HBI

Source: Primetals presentation Vienna 2024

Flexible technology:
Hydrogen-based Calix (Zesty)

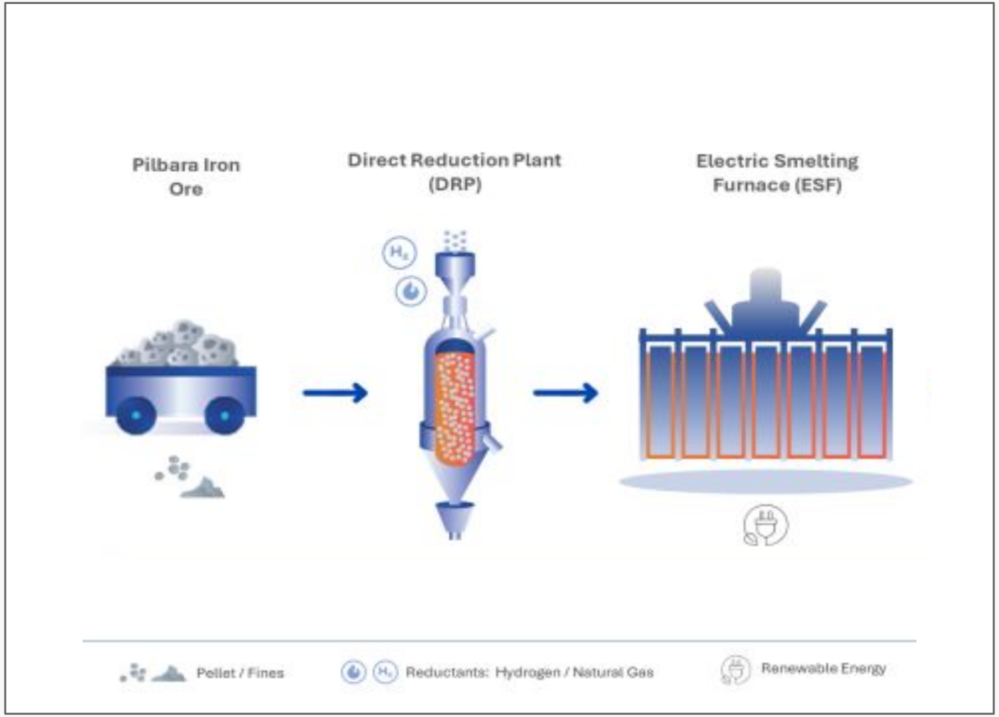


- Uses electricity for process heating
- Hydrogen is used for ore reduction only and is 100% efficient
- Model assumes 54kg of hydrogen per tonne of Fe in DRI
- Operates on fine ores – no pelletising step
- Mid-grade ore require melting; high-grade only briquetting

Source: Calix Investor Presentation August 2024

For high-grade ores, EAF substitutes for the melting process of the blast furnace, *for low and mid-grade ores, the Electric Smelting Furnace is emerging.*

Electric Smelting Furnace: NeoSmelt



- NeoSmelt is the most proximate ESF project to reference, designed to process Pilbara DRI and HBI
- Other examples: Hy4Smelt (Austria), HyREX (Korea), Fortescue (Christmas Creek)

Source: NeoSmelt Information Sheet May 2025

05.

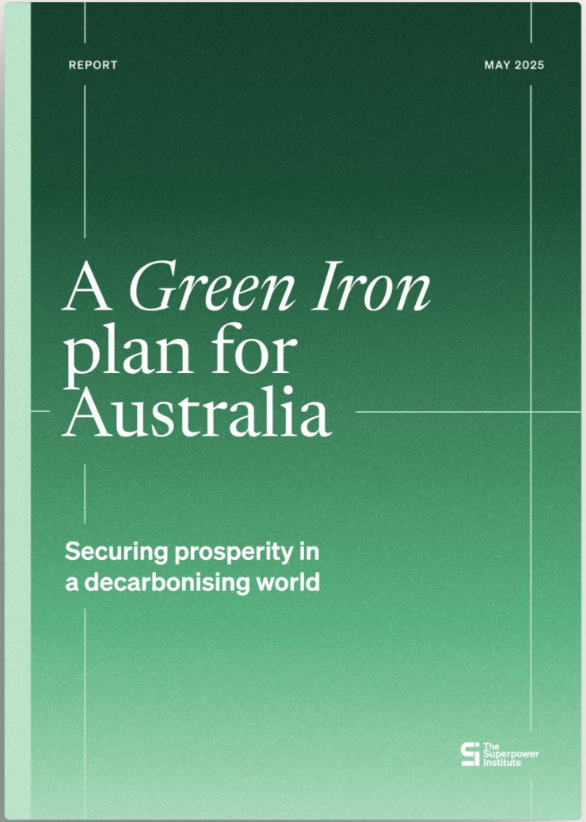
Conclusions

Conclusions

- Green iron is a major export opportunity – especially for energy-constrained Asian partners
- Concerns about Australian ore quality are overstated
- Concerns about hydrogen-based DRI technologies are incorrect – there are several developing technologies that are suited to Australian iron ores
- The key enabler to the use of low and mid-grade ores is in the melting step – and this is being solved
- Higher costs for green iron is largely a function of the market failure to adequately price the externalities of current processes

Technology is not a barrier to capturing the green iron superpower opportunity in Australia

Thank you



Q&A

The Superpower Institute