SOUTH AUSTRALIA – NW EUROPE VIA ROTTERDAM
GREEN STEEL SUPPLYCHAIN ANALYSIS

February 2024

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

GREEN STEEL SUPPLY CHAIN SA-POR

CONTENTS

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

SOUTH AUSTRALIA'S GREEN IRON POTENTIAL

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

SOUTH AUSTRALIA

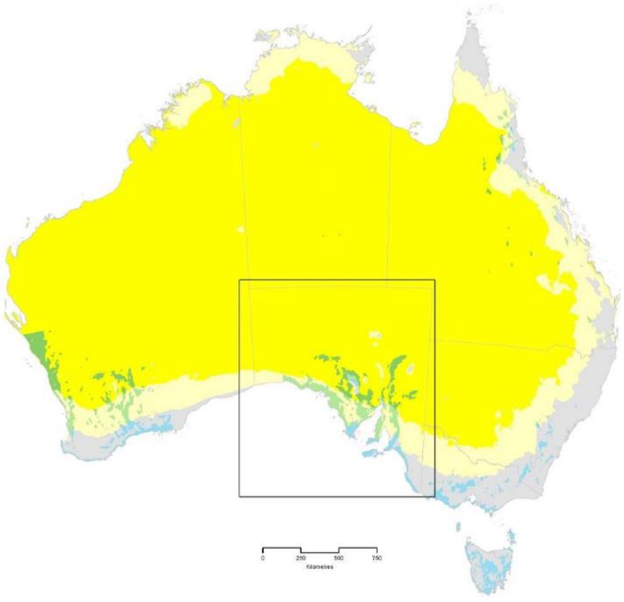
HUGE RENEWABLES AS WELL AS LARGE MAGNETITE POTENTIAL

OFFICIAL

South Australia has a competitive advantage in green hydrogen from coincidental wind and solar

Optimal location for:

- SOLAR FARM
  DNI greater than 23.5 MJ/m2
- SOLAR FARM
  DNI greater than 20.5 MJ/m2
- WIND FARM
  Predicted ave. wind speed above 7.31 m/sec
- WIND FARM AND/OR SOLAR FARM
  Predicted ave. wind speed above 7.31 m/sec
  DNI greater than 23.5 MJ/m2
- WIND FARM AND/OR SOLAR FARM
  Predicted ave. wind speed above 7.31 m/sec
  DNI greater than 20.5 MJ/m2



South Australia's Renewable Energy (RE) characteristics:

- With 75% RE in 2023, the world's highest % share of variable renewables in a GW scale grid.
- Decisive government that has allowed for one of the world's most rapid transformations to RE, and still growing. From 100% fossil fuel based electricity to 75% RE in ~17 years.
- Co-located and complimentary solar and wind resources - A key competitive advantage for green hydrogen production.
- A new Hydrogen and Renewable Energy Act to deliver competitive land release on government owned land for large-scale hydrogen and renewable energy projects.
- The world's first 200MW hydrogen powerplant with potential to supply H2 to Whyalla steel plant being developed. ATCO & BOC-Linde selected.
- Several potential H2 Hubs in the Upper Spencer Gulf - Port Pirie, Cape Hardy, Port Bonython, Whyalla and Port Augusta.

SOUTH AUSTRALIA | Government of South Australia, Department for Energy and Mining | Port of Rotterdam

SOUTH AUSTRALIA

ONE OF THE BEST COMBINATIONS OF SUN AND WIND AS WELL AS LARGE MAGNETITE RESERVES

SA has significant iron ore potential:

- Australia's 2nd largest iron ore reserves after Western Australia (WA).
- SA resource is mostly magnetite and beneficiates to ≥65% iron content, which is needed for direct reduced iron process.
- Currently, SA has an integrated coal-based steel-works in Whyalla (mine to port) that is transforming its operations to produce green steel (EAF and DRI) by 2030.
- New magnetite mines are at various stages of approval and development.

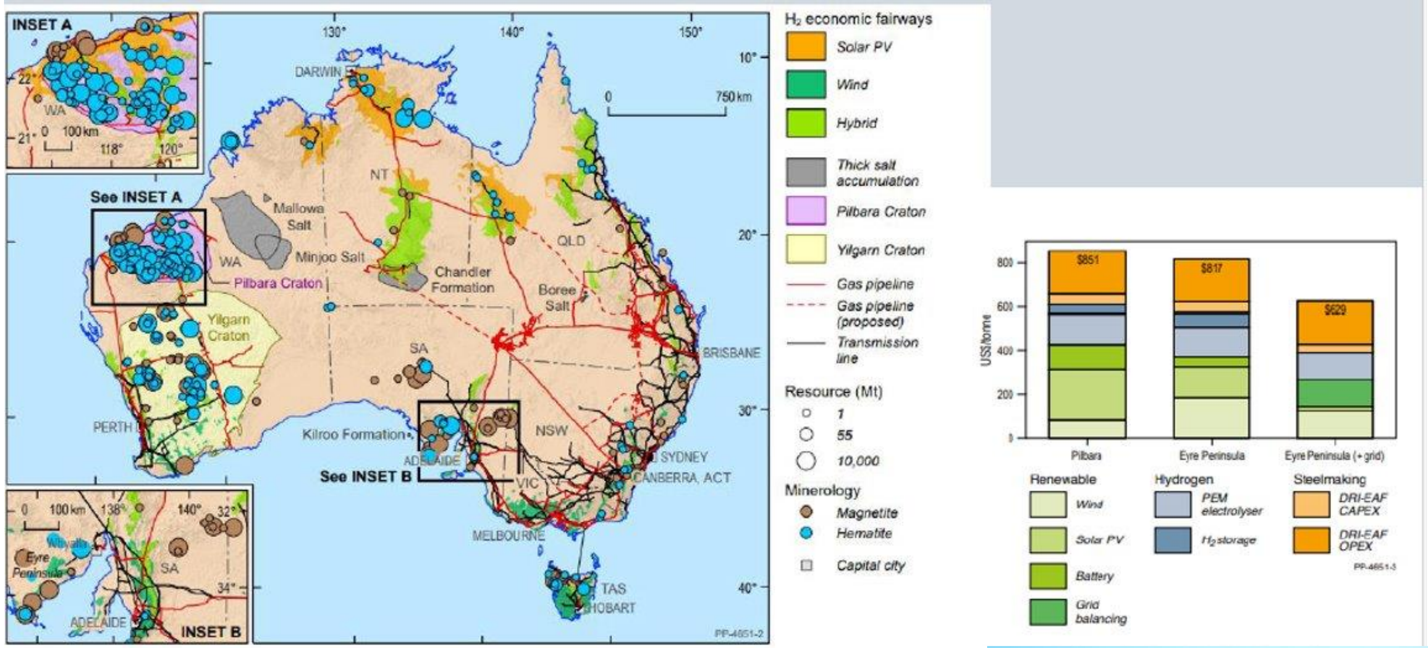


Figure 2 Locations of Australian iron ore resources by mineralogy. Coloured polygons highlight high-potential regions for the production of off-grid hydrogen from solar, wind or hybrid (i.e. equal wind and solar) sources (Walsh et al., 2021).

Diagram Courtesy: Monash University

SA also has significant volumes of graphite, copper and other critical minerals needed for the energy transition

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

SOUTH AUSTRALIA

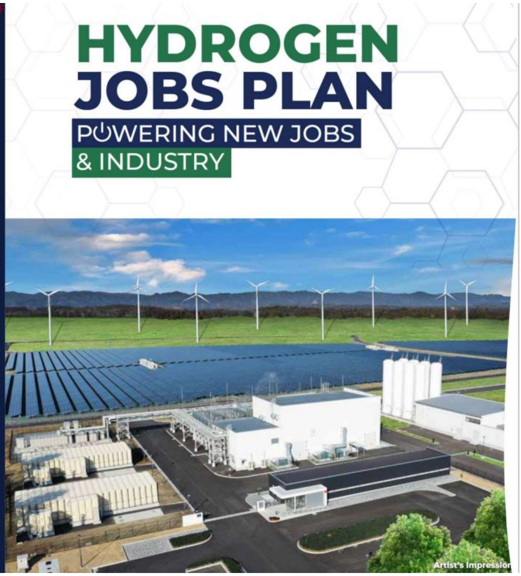
EXTENSIVE HYDROGEN DEVELOPMENTS ALREADY UNDERWAY

What

- $593 million in capital funding:
  - 250 MWe electrolyser
  - 200 MW hydrogen fueled power plant
  - Hydrogen storage facility
  - Land identified in the Whyalla area
  - operational by December 2025

Why

- Accelerate hydrogen industry, capture 1st mover advantage & create new jobs
- Add new large flexible load and 200MW new source of zero carbon firm power generation to lower energy prices for SA customers inc. industry



Northern Water Business Case

Business case will consider:

- Seawater desalination plant up to 260ML/day in the Upper Spencer Gulf (95GL per annum*)
- A 450km water pipeline to the north of South Australia
- Connections to identified customers, particularly miners and hydrogen producers
- Business case scheduled for completion mid 2023

*Total SA consumption >1000GL per annum

Port Bonython

- State owned site: over 2,000 hectares of available land and 2.4km jetty
- EOI for land process
- Currently working with 6 partners - AMP Energy, Fortescue Future Industries, H2U, ENEOS, Origin Energy, Santos
- State awarded $70m Commonwealth Funding, matched by State and industry for common user infrastructure
- Proximate to Whyalla steelworks


Whyalla steelworks (GFG)

Other H2 hubs under development – publicly announced

Port Pirie (Trafigura)	Cape Hardy (Iron Road and Amp Energy)	Port Adelaide (AGL and partners)	Iron Knob / Whyalla (CIP)	Elliston (EntX)
				
• 440MW electrolysis, developed in 2 stages • Green ammonia production • $750m project • $2.5m SA Gov't grant towards FEED • At the FEED stage	• Iron Road is the developer of the Central Eyre Iron Project and the Cape Hardy (greenfield) port • Iron Road completed EOI for hydrogen partner(s) in 2022 and entered into exclusivity arrangement with Amp Energy for a 5GW / 5 million T p/a green ammonia facility	• AGL leading detailed feasibility study into green hydrogen production at its Torrens Island Power Station site • Partners include Adbri, Brickworks, Flinders Ports, INPEX Corporation, Osaka Gas Australia, SK ecoplant, Spark Renewables	• CIP developing vertically integrated green hydrogen project comprising 10GW wind, 4GW solar and 7GW electrolysis • Land access subject to passage of proposed *Hydrogen and Renewable Energy Act* and outcome of subsequent Gov't tender process	• EntX has secured a gas storage exploration licence to explore the Polda Basin salt deposit on the western Eyre Peninsula for its underground hydrogen storage potential.

DECARBONISATION OF EU STEEL MILLS

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

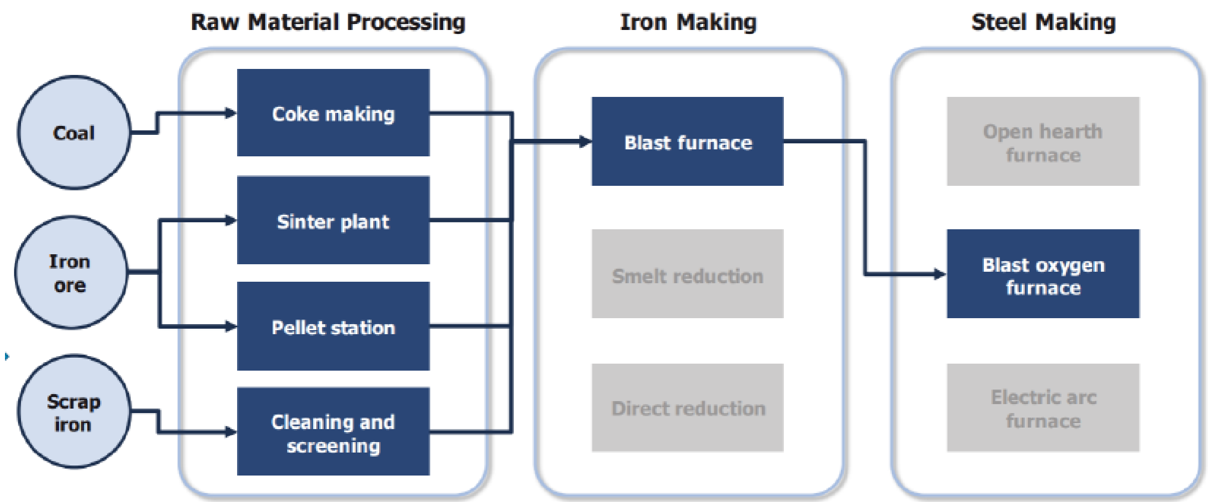
Port of Rotterdam

TRADITIONAL PROCESS

TWO PRODUCTION PATHWAYS

There are two major conventional pathways for producing steel

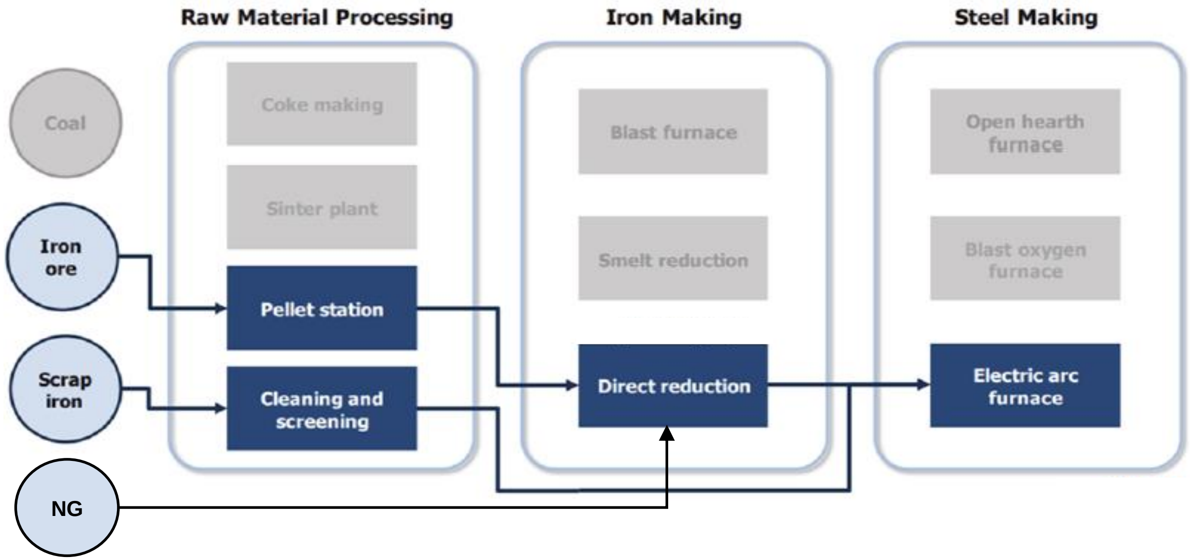
1. Traditional: Blast Furnace (BF) – Basic Oxygen Furnace (BOF)
   - Extracted iron ore is crushed, refined and sintered
   - Sintered iron ore, coke and limestone are melted inside BF to produce molten iron whereas impurities as removed in the form of slag
   - The molten iron is then combined with additives and oxygen to be processed further in the BOF to remove impurities and produce steel
   - The heat and energy requirements for this route are very high and are met through coal which produce a lot of emissions
   - 90% of world's iron is currently produced through the BF pathway



TRADITIONAL PROCESS
TWO PRODUCTION PATHWAYS

2. The future: Direct Reduced Iron (DRI)/Scrap Steel – Electric Arc Furnace (EAF)

- Two main types of DRI processes: Gas-based DRI and Coal-based DRI
- Iron ore pellets, typically containing a mixture of iron oxide and other elements are prepared
- Iron ore pellets undergo chemical reactions with reducing agent (natural gas or carbon from coal), resulting in the removal of oxygen to produce direct reduced iron in the lower part of the shaft
- The DRI along with scrap steel, is then charged into the Electric Arc Furnace
- Electricity is used to generate an electric arc that melts the DRI and scrap steel in the furnace
- Alloys or other additives are added to achieve the desired steel composition
- This process also produces significant emissions due to the use of fossil energy source as a reducing agent and non–renewable electricity
- 10% of world's iron is currently produced through the DRI pathway



GREEN STEEL PROCESS

HYDROGEN TO REPLACE NATURAL GAS AND COAL AND DECREASE CARBON EMISSIONS

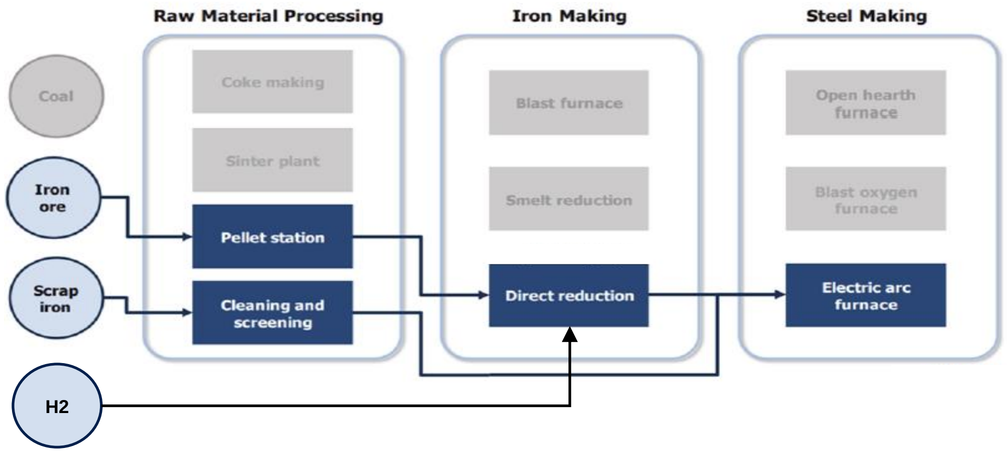
Green steel is a steel production process that aims to reduce the environmental impact of traditional steelmaking. The key process used for production of green steel is the use of green hydrogen in the direct reduction process:

- Iron ore (magnetite) is mined and processed into DR suitable pellets
- Green hydrogen is produced using renewable energy sources through electrolysis
- Hydrogen is introduced as a reducing agent instead of natural gas or coal in the shaft furnace
- Hydrogen removes the oxygen from the iron ore pellets in a shaft furnace, creating DRI
- DRI is melted in an EAF alongside scrap steel and alloying elements to produce molten steel before it is refined further to achieve desired properties
- H2DRI-EAF provides a cleaner and more energy-efficient alternative to traditional blast furnaces due to use of green hydrogen and electricity produced from renewable energy
- H2-DRI is a fairly new technology which requires further research and commercial demonstration

17%

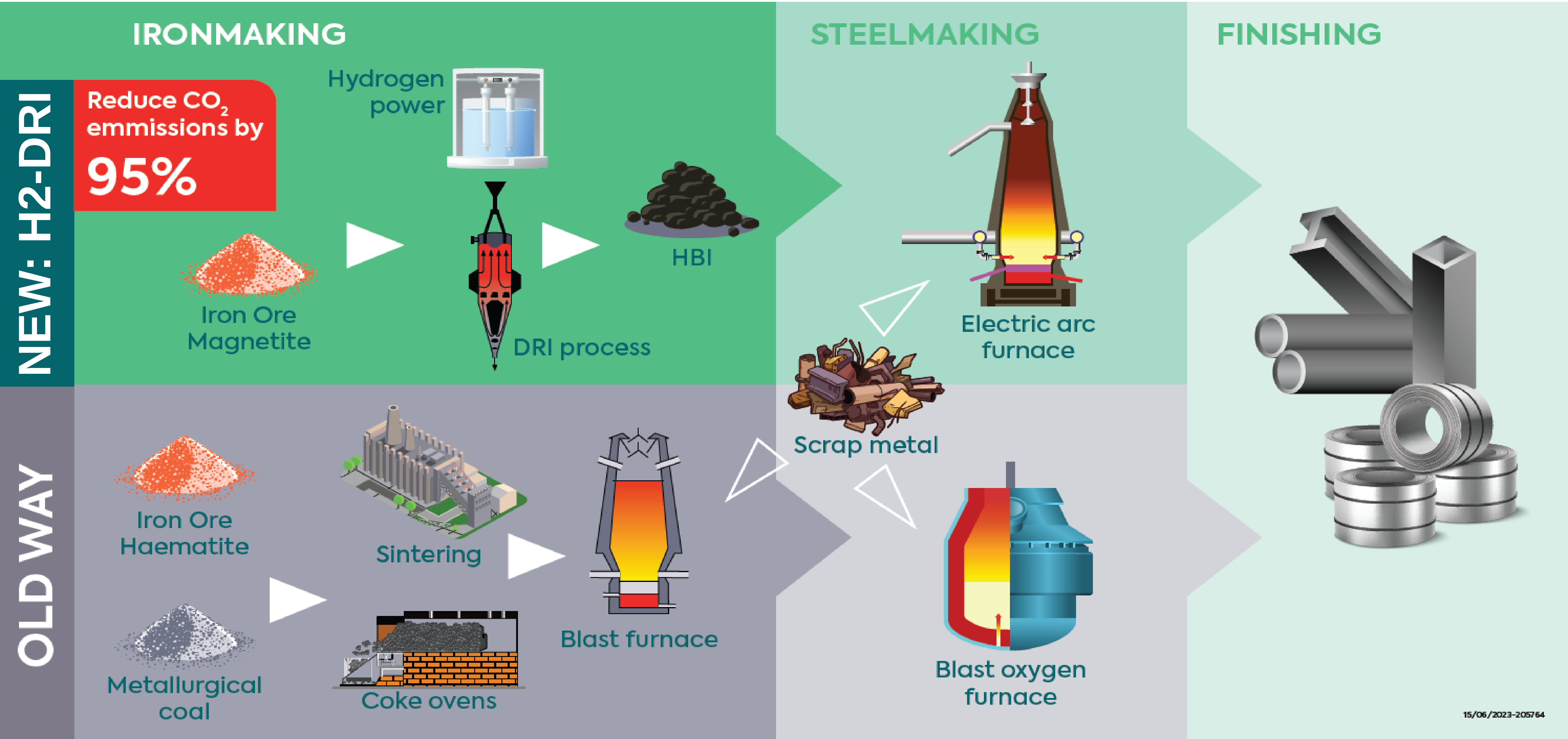
Direct Reduced Iron (DRI) market is poised to leap from 10% in 2022 to a commanding 17% by 2030.

This sharp rise reflects the industry's strategic shift towards low emission steel production to cut emissions from steelmaking.



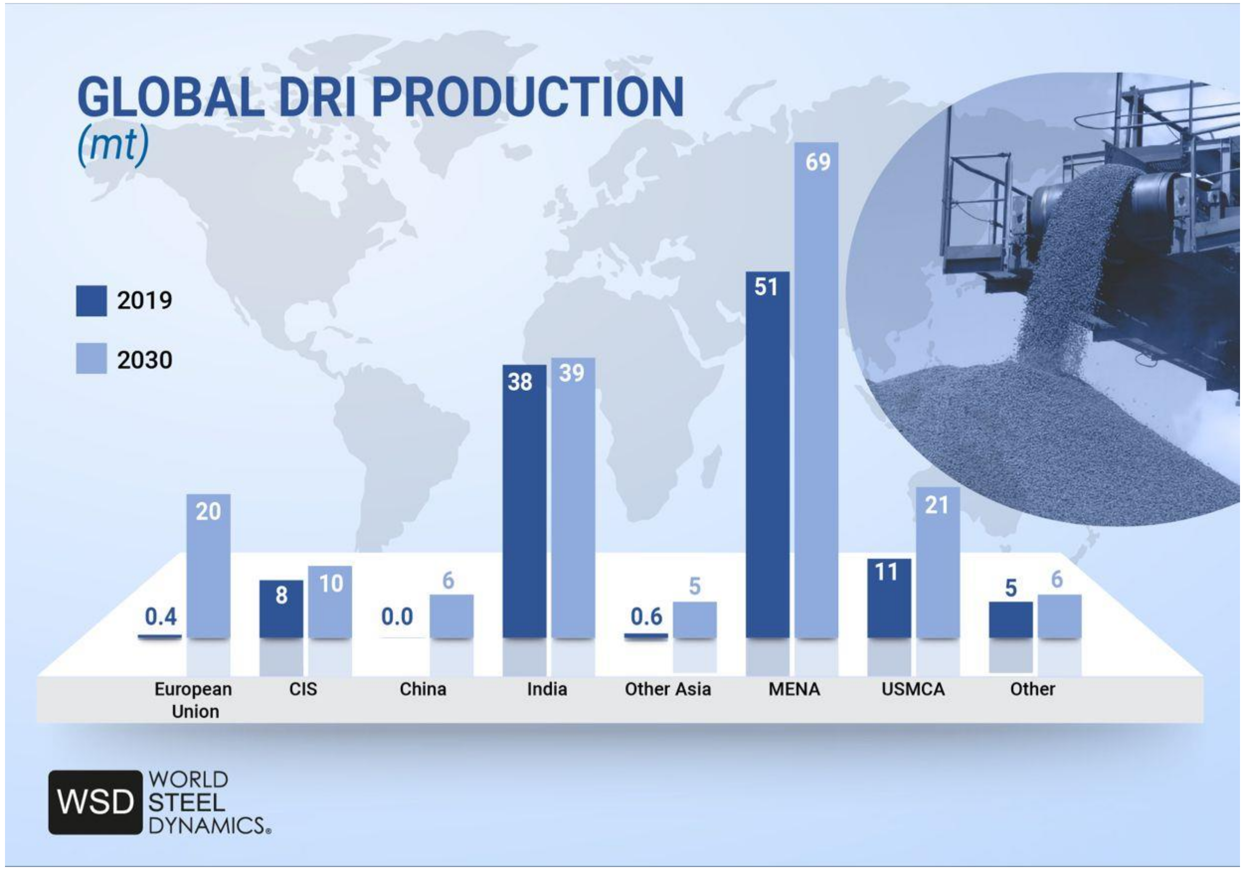
COMPARISON OF FOSSIL BASED AND GREEN STEEL

THE CHANGING STEEL MARKET



EXISTING DRI PRODUCTION & EXPECTED GROWTH

THE CHANGING STEEL MARKET



Global DRI production forecast (World Steel Dynamics)

The outlook for DRI production is positive. Both World Steel Dynamics (WSD) and the International Energy Agency (IEA) foresee strong growth.

1. WSD expects global DRI production to increase from 112mt in 2019 (125mt in 2022) to ~**175mt** in 2030. With the largest increases expected in the EU (20mt) and MENA (18mt). WSD expects natural gas to continue to be the primary global DRI reductant in 2030, though clean hydrogen will hold significant shares in the Nordics and potentially other regions.

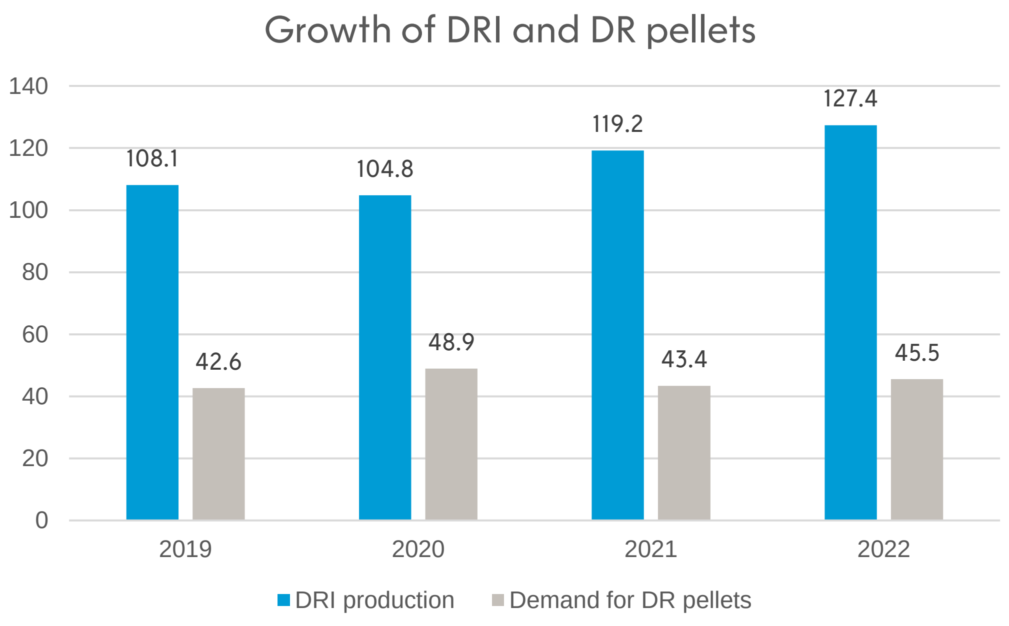
2. According to estimates in its "sustainable development scenario," the International Energy Agency (IEA) projects the market for commercial DRI to continue its growth from 115 Mt per year in 2019 to **157.3 Mt** by 2030. At the same time, the IEA expects that gas-based DRI will account for 8% of steel production by 2030

Sources:

- International Energy Agency
- Steel Decarbonization Dynamics Service (World Steel Dynamics)
- The New Age of Hot Briquetted Iron (HBI): How will the Steel Industry Transform? - Midrex Technologies, Inc.

DEMAND FOR DR PELLETS WILL GROW WITH INCREASE IN DRI PRODUCTION

THE CHANGING STEEL MARKET



Between 2019 and 2022, demand for DR pellets increased 7%, while DRI production increased 18%

DRI production will grow to 200mt by 2030

Some of the largest DR pellet suppliers:

Vale, LKAB, Ferrexpo, Rio Tinto (IOC), Arcelor Mittal Canada, Bahrain Steel, CMP, Samarco, Metalloinvest, Severstahl, FMO, Cleveland Cliffs

20 largest DRI plants in the world		
Mobarakeh Steel A - E	Iran	4,00
Mobarakeh Steel (Kharazi A & B)	Iran	2,76
Tosyali Algérie 1	Algeria	2,50
Algerian Qatari Steel (AQS)	Algeria	2,50
Tosyali Algerie 2	Algeria	2,50
Nucor Steel Louisiana	USA	2,50
Myingyan Steel	Myanmar	2,50
BriqOri	Venezuela	2,20
H2 Green Steel	Sweden	2,10
Khouzestan Steel Co. I - II	Iran	2,05
ArcelorMittal Texas HBI	USA	2,00
Emirates Steel I (GHC)	UAE	2,00
Emirates Steel II (GHC)	UAE	2,00
ArcelorMittal Dofasco	Canada	2,00
Suez Steel	Egypt	1,95
Ezz Rolling Mills	Egypt	1,90
South Kaveh Steel A & B	Iran	1,86
Torbat	Iran	1,85
Jindal Steel & Power	India	1,80
LGOK HBI-3	Russia	1,80

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

CONVERSION PLANS OF STEEL MILLS IN EUROPE

ALREADY UNDERWAY

Many Blast Furnaces in Europe are at or near the end of economic life and need replacement. Paris Agreement/Green Deal/Fit for 55 set targets too reduce the CO2 emissions. Steel produced from H2-DRI is therefore required.

Subsidy packages granted by National governments and approved by EU:

- 460M euro to ArcelorMittal plant in Gijon, Spain
- 280M euro to ArcelorMittal in Gent, Belgium
- 1B euro to Salzgitter, Germany
- 850M to Arcelor in Dunkerque, France
- 550M to Thyssenkrupp in Germany with up to 1,5B for support to buy hydrogen. Total 2B euro.

Tata Steel Ijmuiden Netherlands has no subsidy package granded (yet), TBC. Plans for DRI on natural gas

Total:4,5 Billion euro

These subsidies have been granted to save jobs.

The Jobs-multiplier factor
Each job in a steel plant has 7 other jobs of secondary and tertiary suppliers linked to it.

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

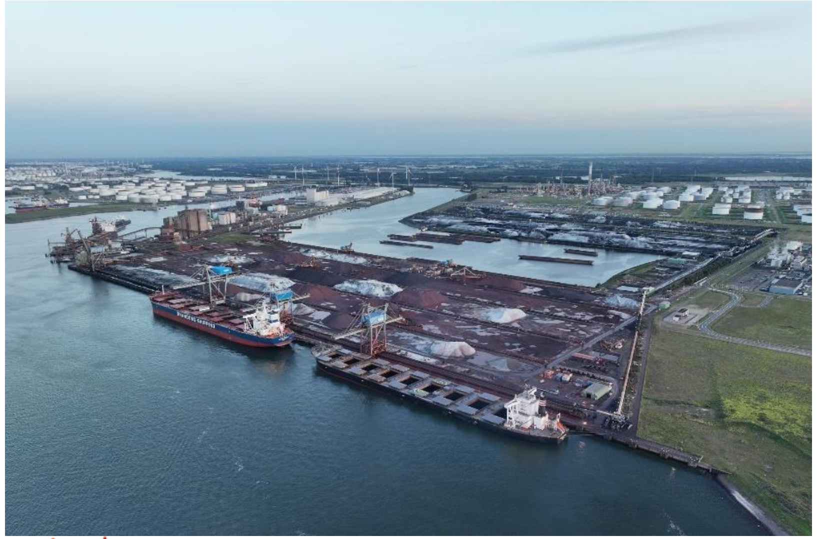
PORT OF ROTTERDAM
GATEWAY TO STEEL INDUSTRY IN NORTH-WEST EUROPE

The Port of Rotterdam:

- Rotterdam iron ore throughput: 30 mtpa
- Economies of scale (24m draught)
- 2 State of the art dry bulk terminals: EMO & EECV
- H2 infrastructure under construction including importterminals for green ammonia & cracking
- Excellent Hinterland connections in all modalities

Steel mills supplied via PoR:

- ArcelorMittal (Germany, Belgium)
- Thyssenkrupp Steel, HKM
- Saarstahl/Dillingen
- Voestalpine (Austria)

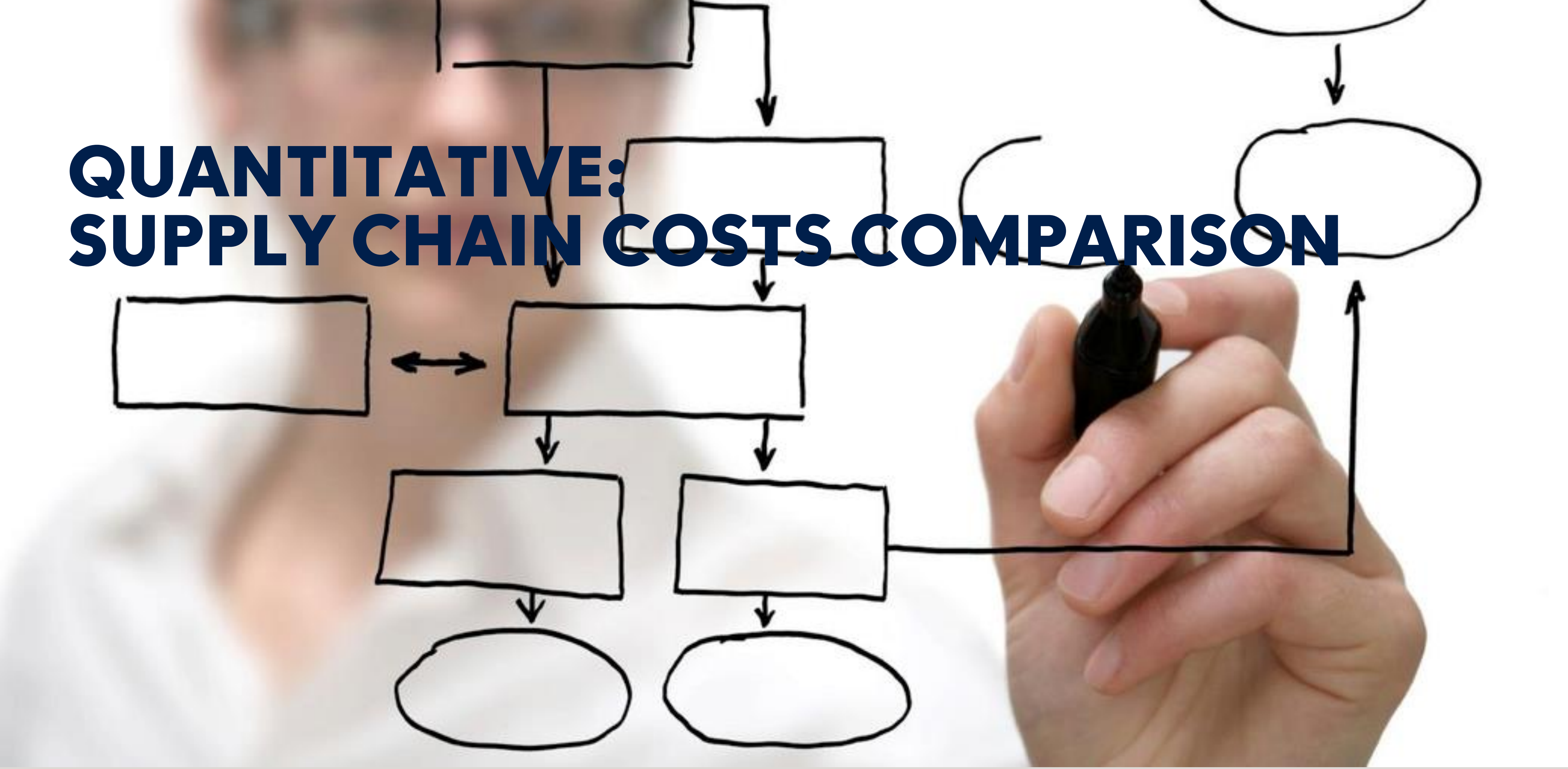


SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

QUANTITATIVE: SUPPLY CHAIN COSTS COMPARISON



SUPPLY CHAIN CONFIGURATIONS

THIS STUDY COMPARED THE COSTS OF TWO SUPPLYCHAIN CONFIGURATIONS

MODEL INPUT: FEEDSTOCK COSTS ANALYSIS

FEEDSTOCK COSTS EXERT THE MOST SUBSTANTIAL INFLUENCE

Feedstock analysis with Monash University (AUS)

Monash University used Mixed Integer Programming (MIP) to pinpoint the most cost-effective setup and calculate the feedstock costs of Renewable-Powered Steelmaking in South-Australia. Two systems are evaluated (1) Vertically Integrated System and (2)Disaggregated System (one operating at 100% capacity for continuous use, and another optimizing capacity and plant size to meet daily hydrogen requirements for DRI plant optimization).

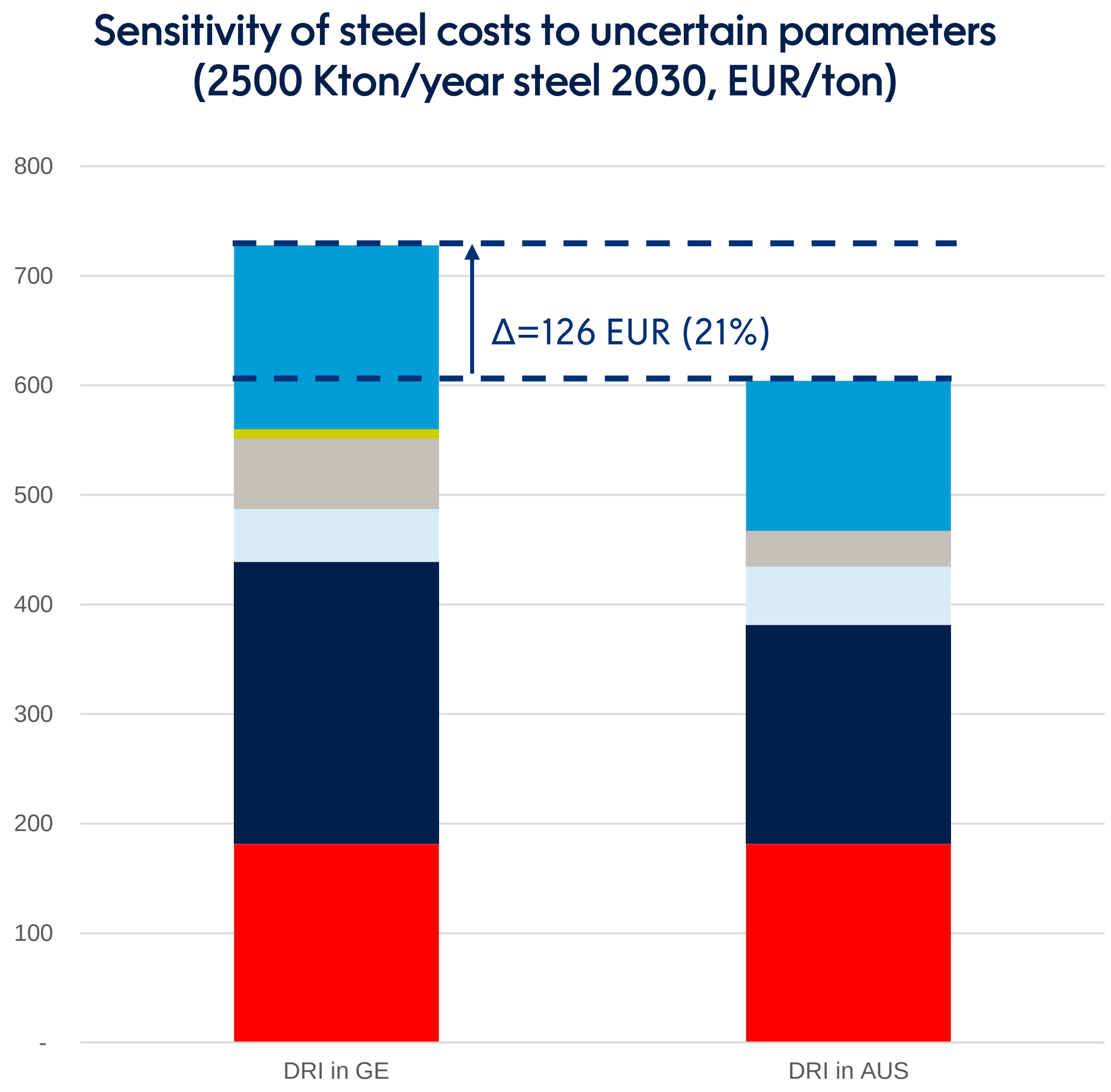
Feedstock costs:
Integrated production systems yield significant advantages. Therefore, the feedstock costs of this system are included in this study. The input is used:

Unit Prices (expected 2030 levels) used in model	
Configuration supply chain	2.5 mtpa (Optimized, Integrated)
Iron ore (€/ton)	120
Hydrogen (€/kg)	3.0
HBI (€/ton)	407

These findings are validated with the Australian industry. These values are used to calculate the cost price with the Green Steel Supply Chain Cost Model of the PoR. Results are presented on the next slide.

SOUTH AUSTRALIA Government of South Australia Department for Energy and Mining Port of Rotterdam

RESULTS



Analysis

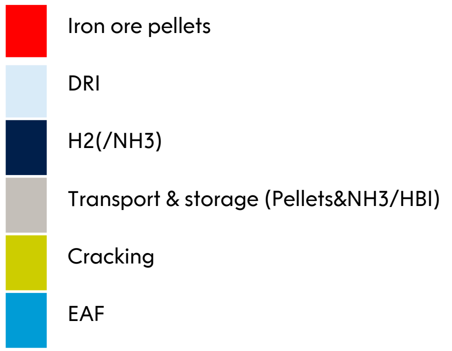
The green steel price with the DRI in South Australia is competitive with the grey steel price.

In case where steel is produced from locally produced DRI in Germany, the cost **increases** by **21%** compared to importing HBI from South Australia.

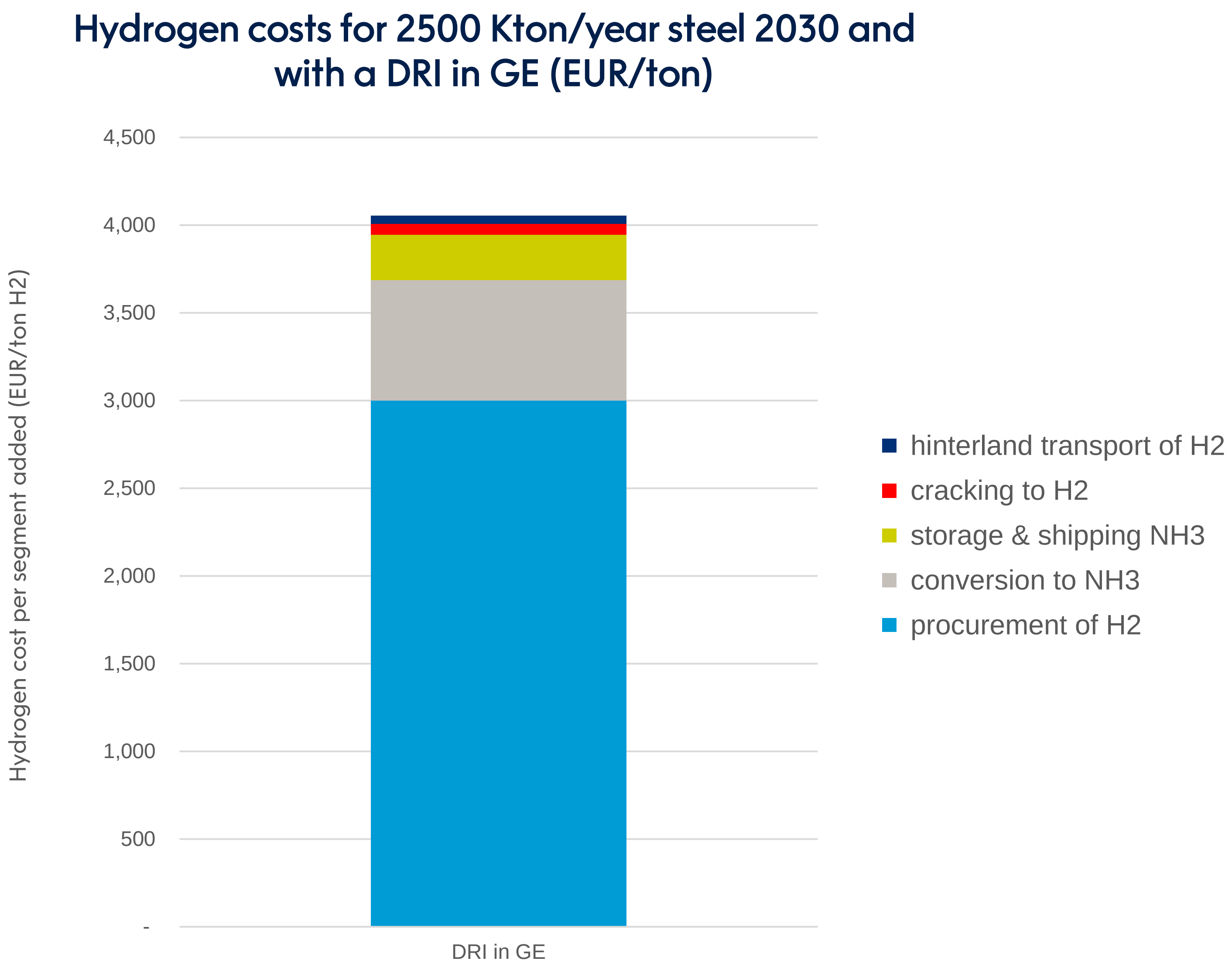
Despite some heat efficiency, co-located DRI and EAF in Germany are at a cost disadvtange as compared to importing HBI from South Australia due to:

- Higher transport & storage costs
- Extra costs due to ammonia supply chain
- Increased DRI Costs (higher electricity cost)

Feedstock costs (hydrogen & iron ore pellets price) exert the most substantial influence on overall pricing of green steel.



HYDROGEN COST ANALYSIS



Analysis

In the graph is shown how much each step contributes to the hydrogen cost. As explained in the slides above the cracking cost seem to contribute not a lot. However, the efficiency of the cracker is taken into account in the cost of conversion to NH3.

QUALITATIVE: INTERVIEW INSIGHTS - OTHER CONSIDERATIONS

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

INTERVIEW INSIGHTS – QUALITITATIVE FEEDBACK FROM EU STEEL MAKERS

HBI IMPORTS NEXT STAGE

Importing HBI vs producing DRI themselves is not just a question of costs for European steel makers.

Steelmakers want to:

- Keep control of the steel making process & the supplychain
- Retain jobs – Jobs multiplication factor
- Secure government support/financing – not available for outsourcing
- Retain procurement flexibility – HBI market not mature yet
- Maintain long decisionmaking & development timelines, with the decision for first stage already made and set in motion

From interviews, we conclude most steelmakers see the transition in stages:

Stage 1: now to 2030: Convert BF's to EAF's with local DRI plants

Stage 2+: - after 2030: Possibly import HBI from countries with competitively priced green energy

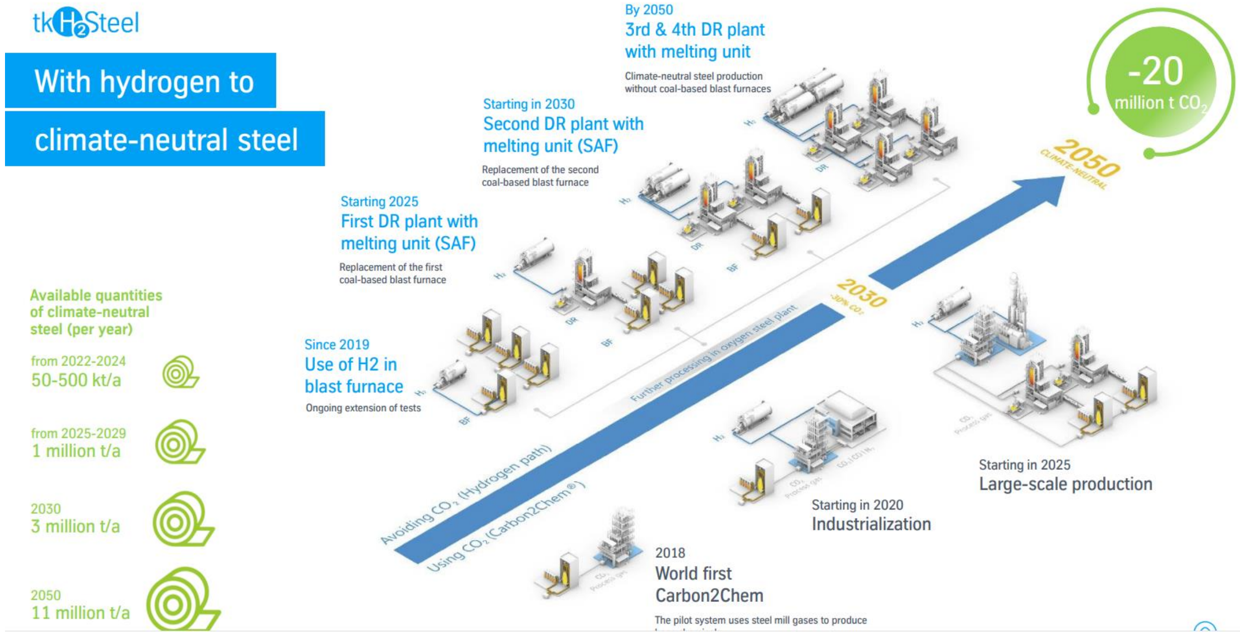


Fig. example conversion plan bby TK in 2021. First stage is already set in motion. For 2nd and 3rd stage final decision not made yet

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

OTHER CONSIDERATIONS

Shipping DRI presents a significant risk when carried in bulk and requires special precautions, unlike HBI. HBI is DRI that has been briquetted under very high pressure and at elevated temperature to form dense briquettes that are much less porous than DRI.

<u>Hazards</u>

DRI: Risk of overheating, fire and explosion. DRI reacts with air and with (sea)water to produce heat and hydrogen. Cargo heating may generate very high temperatures that are sufficient to ignite the cargo.

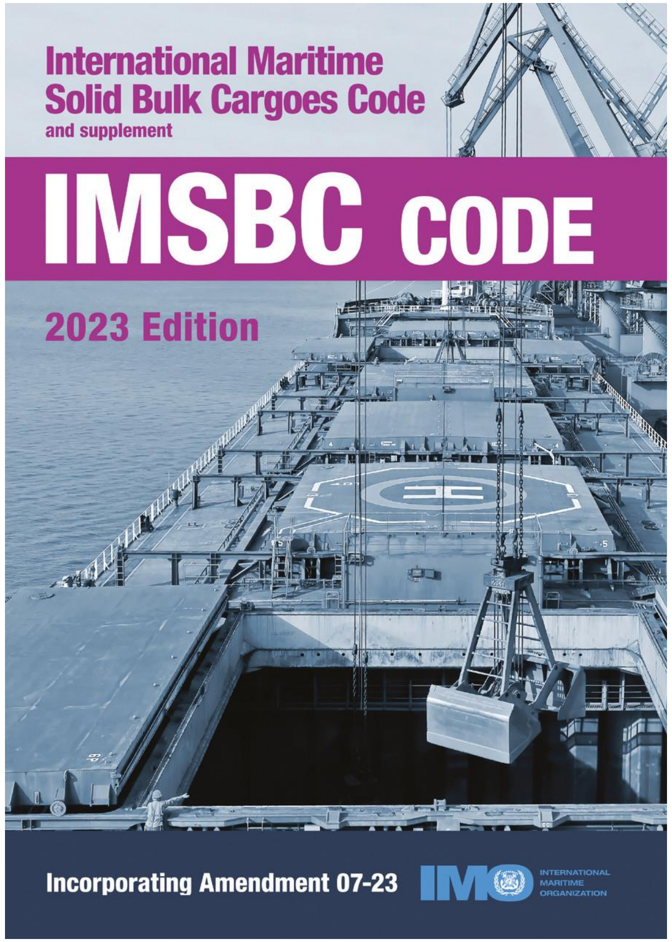
HBI: This cargo is non-combustible or has a low fire risk.

<u>Precautions</u>

DRI: **Loading:** introduce hydrogen at tank top level so that the inert gas purges the air from the cargo; all vents, accesses and other openings, shall be closed and sealed.
Ventilation: cargo shall remain tightly sealed, and the inert condition maintained during the voyage.

HBI: Surface ventilation only during the voyage

(IMO)



The insurance cost for HBI cargoes is also considerably less than those for DRI shipments. HBI can be stored at almost any location, much like scrap steel. Contrary to this, DRI must be kept not only out of the rain but also off the ground in order to prevent contact with moisture, which could lead to oxidation and combustion. (voestalpine, MIDREX)

OTHER CONSIDERATIONS

Besides the safety risks, the transport and handling may damage the product and result in fines.

“Basically, each handling step degrades briquettes (or DRI). Thus, each drop should be as low as possible”

“The use of Hot Briquetted Iron (HBI) offers advantages over DRI. Due to its compact form and density, it is easier to transport and incurs less damage and oxidation”

“DRI creates fine dust being rubbed off the surface. HBI will rather give pieces”

“Less production of **fines** during handling. And the fines may be recycled into briquettes, increasing productivity and value added”

“But when collected and shipped HBI fines should be treated the same as DRI!”

“Handling (of briquettes) is similar to scrap; an additional advantage is the relatively small and uniform product size (charging of furnaces)”.

(Quotes: Köppern, MIDREX)

HBI is 100 times more resistant to reoxidation than conventional DRI and will pick up 75% less water. HBI also generates fewer fines, which provides greater value to users and reduces safety concerns during handling and shipping (source MIDREX)

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

CONCLUSIONS

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

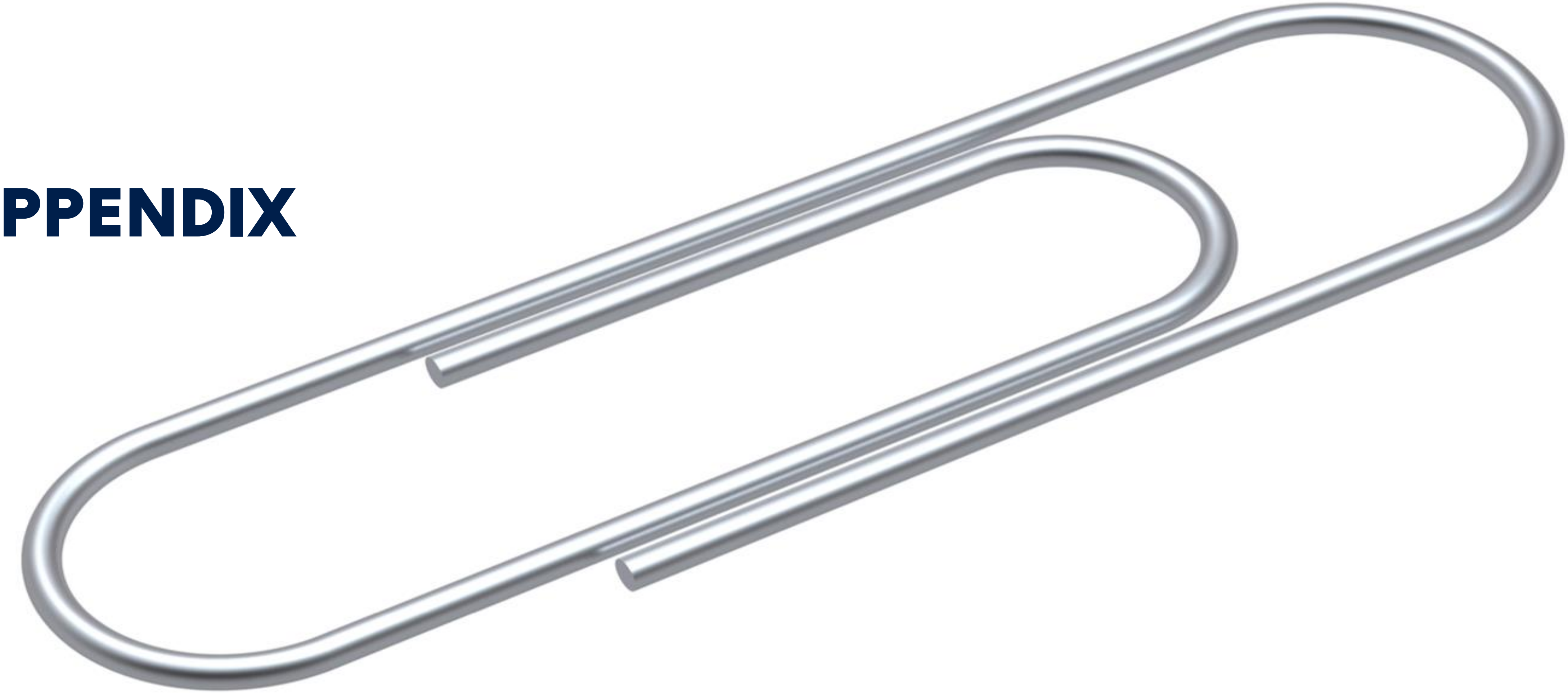
CONCLUSIONS

First exports of liquid hydrogen derivatives and critical minerals, later to include green iron

- The European steel market **will need to switch** to DRI and EAF to meet climate targets
- **First Transition processes** have already been set in motion to build local DRI plants, in order to keep control of integrated steel processes and jobs
- **Some disadvantages of outsourcing** the ironmaking process are quality loss during shipping and safety. These issues need to be improved on in the future.
- **Price advantage for imported HBI** processes is inevitable – market for HBI already building up
- However, large scale imports of green HBI from countries like Australia will be **second stage transition** and to start > 2030-2035
- South Australia is **well positioned** because of large magnetite and low-cost hydrogen potential
- Infrastructure for green iron and hydrogen production at industrial scale **is still missing**
- SA should **use the coming decade to develop and build infrastructure**, ideally concentrated around one and not multiple Integrated Hydrogen Hub port complex. That hub will include common-user infrastructure that will allow for lower utility and logistics costs rendering hydrogen derivatives even more competitive. This is Port of Rotterdam's expertise.

SOUTH AUSTRALIA
Government of South Australia
Department for Energy and Mining
Port of Rotterdam

APPENDIX



SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

Port of Rotterdam

SA JOBS PLAN & WHYALLA GREEN STEEL: SPECIAL CASE

250 MW Electrolyser, 200 MW powerplant - operations set to commence early 2026. $593 million South Australian Government Investment to:

- Enhance grid security through new dispatchable generation
- Prove large-scale hydrogen production and generation technology
- Activate other hydrogen projects in development, including export-focused projects
- Support South Australia's continued clean energy transition and decarbonisation
- Potentially provide green hydrogen offtake for local green iron and steel making

FEEDSTOCK COSTS ANALYSIS – MORE INFORMATION

FEEDSTOCK COSTS EXERT THE MOST SUBSTANTIAL INFLUENCE

Feedstock analysis with Monash University (AUS)

Goal: Analyse Renewable-Powered Steelmaking Scenarios

How: We utilize Mixed Integer Programming (MIP) to pinpoint the most cost-effective setup. Two systems are evaluated:

1. Vertically Integrated System
2. Disaggregated System (one operating at 100% capacity for continuous use, and another optimizing capacity and plant size to meet daily hydrogen requirements for DRI plant optimization)

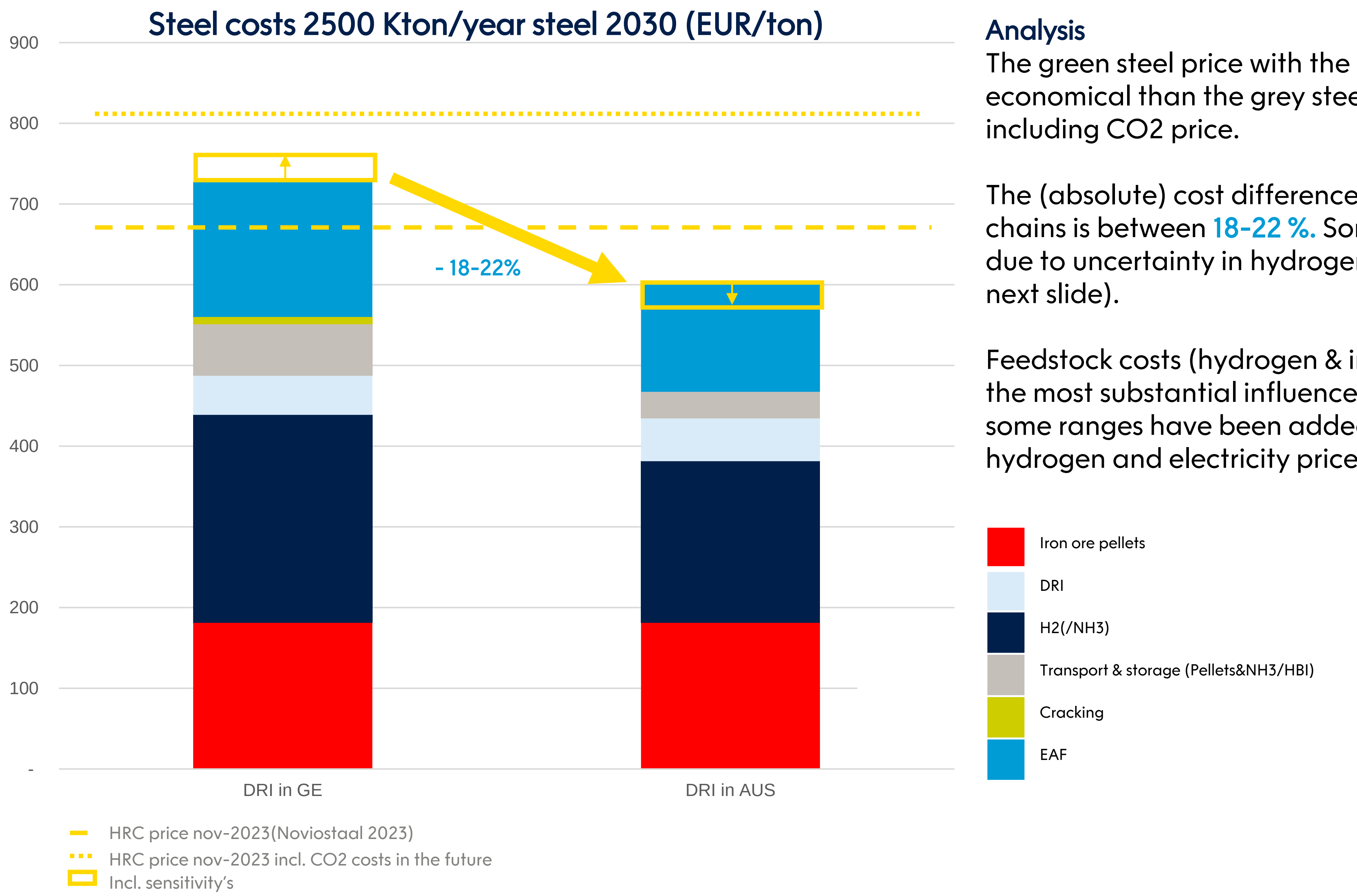
Results:

Integrated production systems yield significant advantages. Combining wind and solar energy for green hydrogen production, iron ore heating, and manufacturing leads to cost and efficiency enhancements.

Unit Prices (expected 2030 levels) used in model				
Configuration supply chain	Integrated		Disaggregated	
	0.5 mtpa Optimized	2.5 mtpa Optimized	Optimized 2.5 mtpa	Full load 2.5 mtpa
Iron ore (€/ton)	120	120	120	120
Hydrogen (€/kg)	3	3	3.4	5.3
HBI (€/ton)	432	407	415	517

These findings are validated with the Australian industry. The values of the 2.5 mtpa integrated scenario are used to calculate the cost price with the Green Steel Supply Chain Cost Model of the PoR. Results are presented on the next slide.

SUPPLY CHAIN COSTS COMPARISON



Analysis

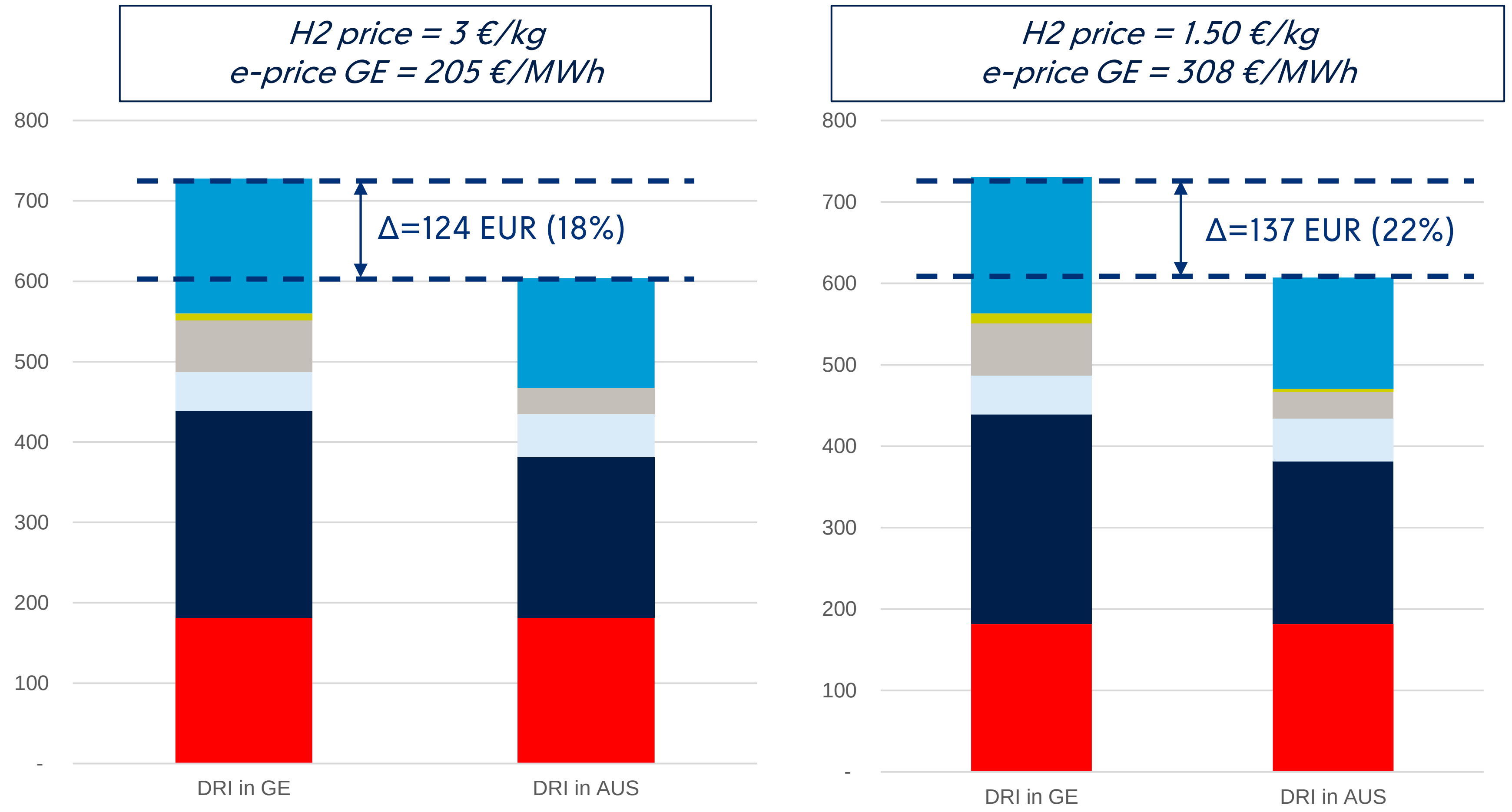
The green steel price with the DRI in AUS is already more economical than the grey steel price. Especially when including CO2 price.

The (absolute) cost difference between the two supply chains is between 18-22 %. Some ranges have been added due to uncertainty in hydrogen and electricity prices (see next slide).

Feedstock costs (hydrogen & iron ore pellets price) exert the most substantial influence on overall pricing. Therefore, some ranges have been added due to uncertainty in hydrogen and electricity prices (see next slide).

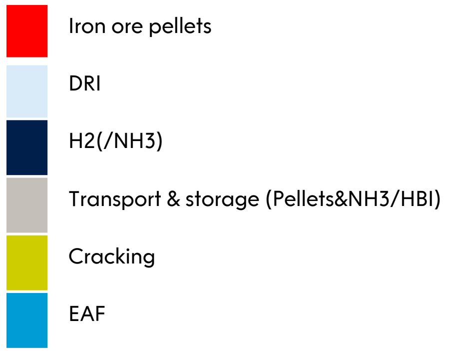
SENSITIVY ANALYSIS OF SUPPLY CHAIN COST COMPARISON

Sensitivity of steel costs to uncertain parameters (2500 Kton/year steel 2030, EUR/ton)



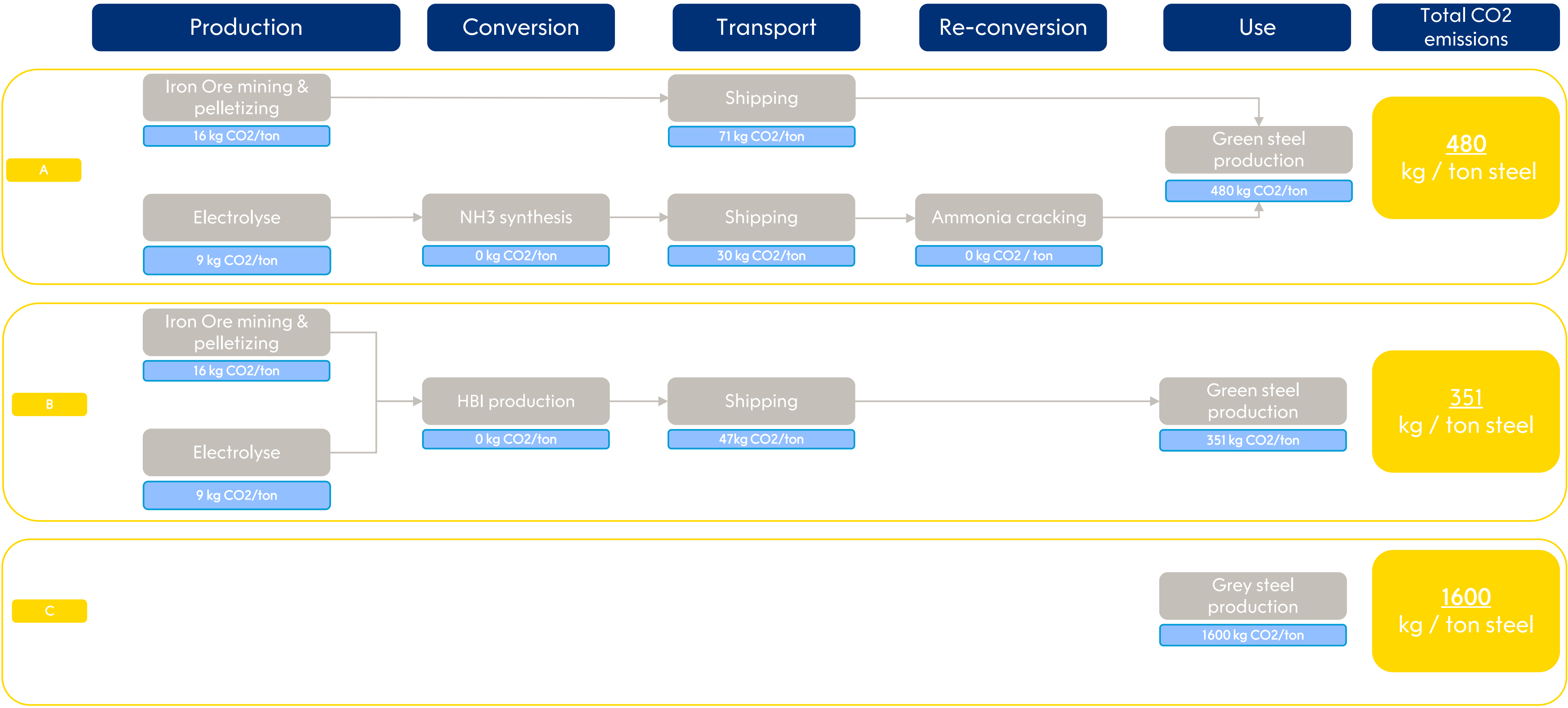
Analysis

The difference depends on the assumptions of its most uncertain parameters, **the hydrogen price** and **the German electricity price.** When decreasing the H2 price with 50% and increasing the German E-price with 50%, we see a costs difference between the supply chains of 22%. This shows the influence of the hydrogen and electricity price on the cost difference.



GREEN STEEL SUPPLY CHAIN ANALYSIS – CO2 EMISSION ASSUMPTIONS

CO2 EMISSIONS



See assumptions slide 8

GREEN IRON COST SUPPLY CHAIN – MODEL ASSUMPTIONS

Key assumptions
Model input is the procurement of iron ore pellets in €/ton iron ore pellets (procurement of HBI is also an option in the model in €/ton HBI). Hence investment costs (CAPEX and OPEX) surrounding mining and pelletising is not taken into account. This is done due to the fact that we received this input from Monash University.
Transport in Australia is not included. It is assumed that the iron ore is procured in the vicinity of the export port. It is also assumed that the DRI and the electrolyser are also placed in the vicinity of the port.
For the second supply chain it is assumed that the ammonia cracker is situated at the import port (Rotterdam). After cracking, the gaseous hydrogen is put into a pipeline that leads directly to the steelplant.
Storage and transport cost are not based on investment (CAPEX and OPEX) but on specific rates. This is because we retrieved certain rates from clients in the port leading to a higher accuracy.
Each segment in the supply chain has a rest value of 0%, hence it is not taken into account in this analysis.
The costs for each segment are depreciated over their specific lifetime. If a specific segment is not at the end of its lifetime when the model lifetime ends a rest value is taken into account.
Losses are accounted for over the full supply chain.
Economy of scale is taken into account for the CAPEX of the DRI and the EAF.
The WACC is not taken for each segment in the supply chain, but it is made country specific. If a segment is between two countries (e.g. overseas shipping), the lowest WACC is chosen.
Cost for compression to HBI is taken into account in the CAPEX cost of the DRI in the first supply chain.
For the EAF the electricity input when situated next to the DRI is less than with HBI input, this is taken into account in the model.

GREEN IRON COST SUPPLY CHAIN – ASSUMPTIONS/DATA

CO2 emissions steel supply chain assumptions	Value	unit	Source
CO2 emissions production of green H2	0,012	kg CO2/kg H2	CO2emissiefactoren.nl
The CO2 emissions of electricity in EU (AUS=zero emissions)	0,37	kg CO2/kWh	CO2emissiefactoren.nl
Electricity use DRI production	0,177	MWh / ton DRI	Wang et all. (2023)
CO2 emissions shipping bulk	47	Kg CO2 / ton	CO2emissiefactoren.nl
CO2 emissions cracking with NG (NH3=0 emissions)	1,53	kg CO2/kg H2	Topsoes ammonia cracking
Green steel production	0,753	MWh/ton crude steel	Wang et all. (2023)
CO2 emissions grey steel production	1.600	kg CO2 / ton crude steel	Rocky Mountain Institute (2020)

Country specific data		Value	unit	Source
Export Country (Australia)	DRI grade iron ore pellets	120	€/ton iron ore pellets	Monash
	Electricity	104	€/MWh	Monash
	Hydrogen	3000	€/ton hydrogen	Monash
	Ammonia	480	€/ton ammonia	Specific calculation in relation to the hydrogen price
	WACC	7,5%	%	Monash
Import country (The Netherlands)	Electricity	175	€/MWh	CBS 2022
	WACC	7,5%	%	Assumption
End-use country (Germany)	Electricity	205	€/MWh	Statista 2022
	WACC	7,5%	%	Assumption

SOUTH AUSTRALIA
Government of South Australia
Department for Energy and Mining
Port of Rotterdam