Agora Industry

Green iron trade

Unlocking opportunities for Europe

Version 1.0, September 2025

Introduction

- The steel industry produces around 5–6% of Europe's total emissions.[1] Transforming the industry is thus essential for the EU to be climate neutral by mid-century. Instead of CO_2-intensive coal-based blast furnaces, primary green steel can be made using hydrogen to produce Direct Reduced Iron (DRI), which is fed into downstream steelmaking processes (EAFs or BOFs)[2] to produce steel.
- Europe produces around 70 Mt[3] a year of pig iron through the blast furnace route. In the coming decades, recycled scrap-based steel production in EAFs is projected to play an increasingly important role, potentially accounting for over 50% of total steel production (compared to 45% today). However, a significant share of steel will still need to be made from virgin iron ore, requiring an estimated 50-60 Mt of iron (depending on future steel demand).
- European steel companies have announced plans to build up to 34 Mt capacity of H_2-DRI by 2030. However, projects have struggled to reach FID in recent years, with only 12 Mt capacity at FID or under construction, while several large projects have recently been postponed or cancelled. Fully realising this pipeline would cover roughly half of the EU's projected low-carbon iron demand, but doing so will require the EU and its Member States to ensure that industry has access to cheap and abundant renewable energy.
- Complementing domestic production with imports of green iron from renewable energy rich regions can be an additional important piece of the puzzle, providing EU steelmakers with a cost-competitive low-carbon intermediary material. Unlocking these value chains through strategic industrial partnerships – initiated by European Commission and backed by Member States – with regions capable of producing green iron at scale will be essential for safeguarding the competitiveness of the EU's green steel sector.

[1] JRC Raw Materials Information System, Report, 2025.
[2] EAF - Electric Arc Furnace; BOF - Basic Oxygen Furnace. If DRI-grade iron ore is not available for DRI, the EAF step can be replaced by a smelt-BOF process, which can accommodate lower-grade iron ore.
[3] Worldsteel, World Steel in Figures, 2025

A three-phase strategy strengthening domestic EU production and green iron imports can support a resilient and cost-effective transformation towards climate neutrality

Phase 1 — A **first wave of DRI plants** replacing blast furnaces is critical to ensure resilience of local production, accelerate technology deployment and kickstart a market for green steel. Policy measures along the value chain are needed to **unlock investments** and **scale the hydrogen ramp-up** for these projects.

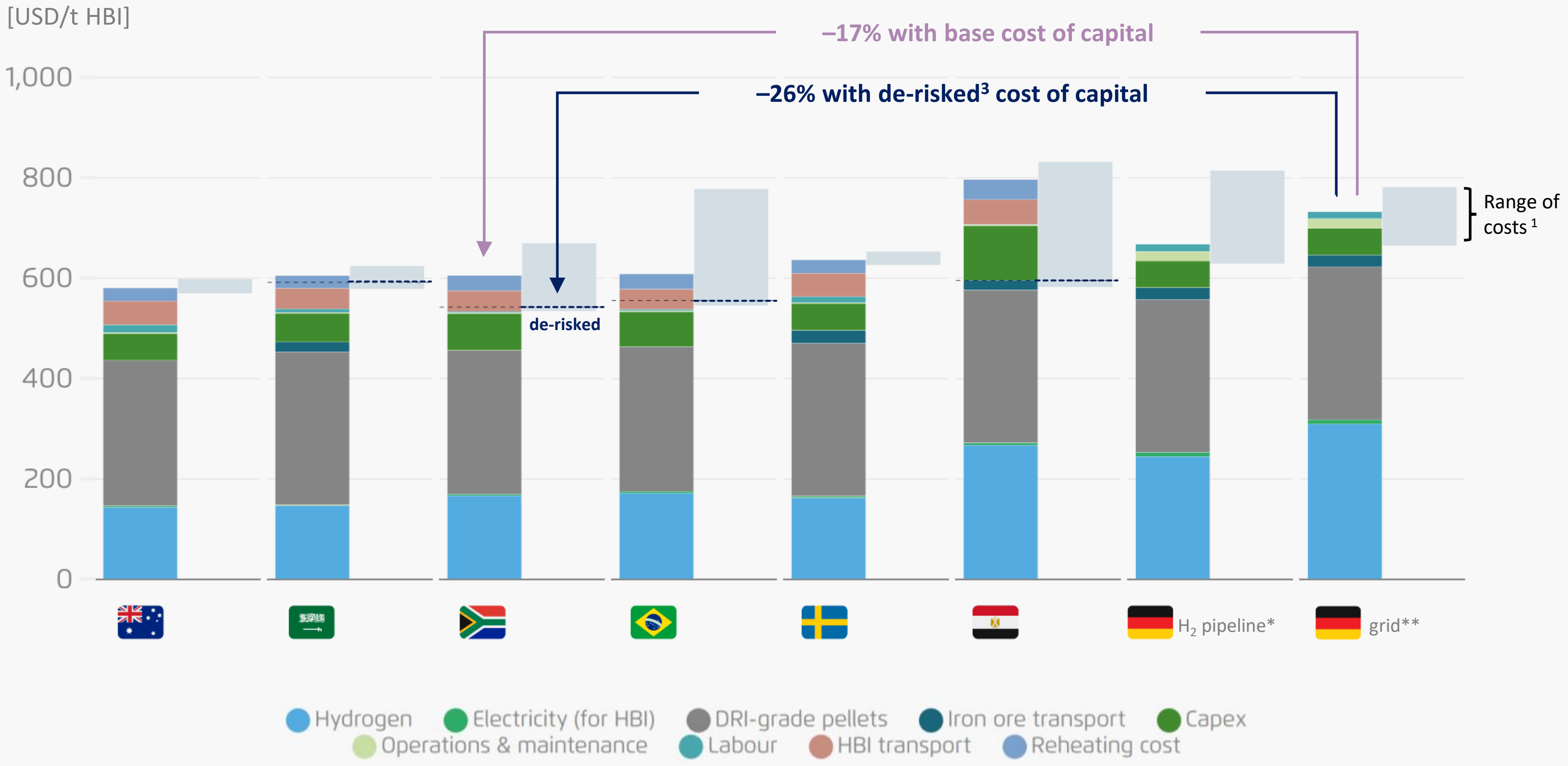
Phase 2 — A common European industrial vision should **strengthen the EU Single Market** and develop value chains that leverage regional strengths and competitive advantages, firmly establishing European steel production as a **cornerstone of resilience and security**.

Phase 3 — **Strategic industrial partnerships** can enhance the cost-competitiveness of European steelmaking by diversifying supply chains and importing green iron as an intermediary material from renewable energy-rich regions.

→ A future-orientated industrial strategy that strikes the right balance between robust domestic support and future green iron imports can lower the cost of producing green steel while safeguarding higher-value steel production sites and downstream value chains.

Unlocking production in regions with high renewables potential could create significant cost-reduction opportunities

Germany case study: HBI production and import[2] costs in 2040 based on medium cost scenario

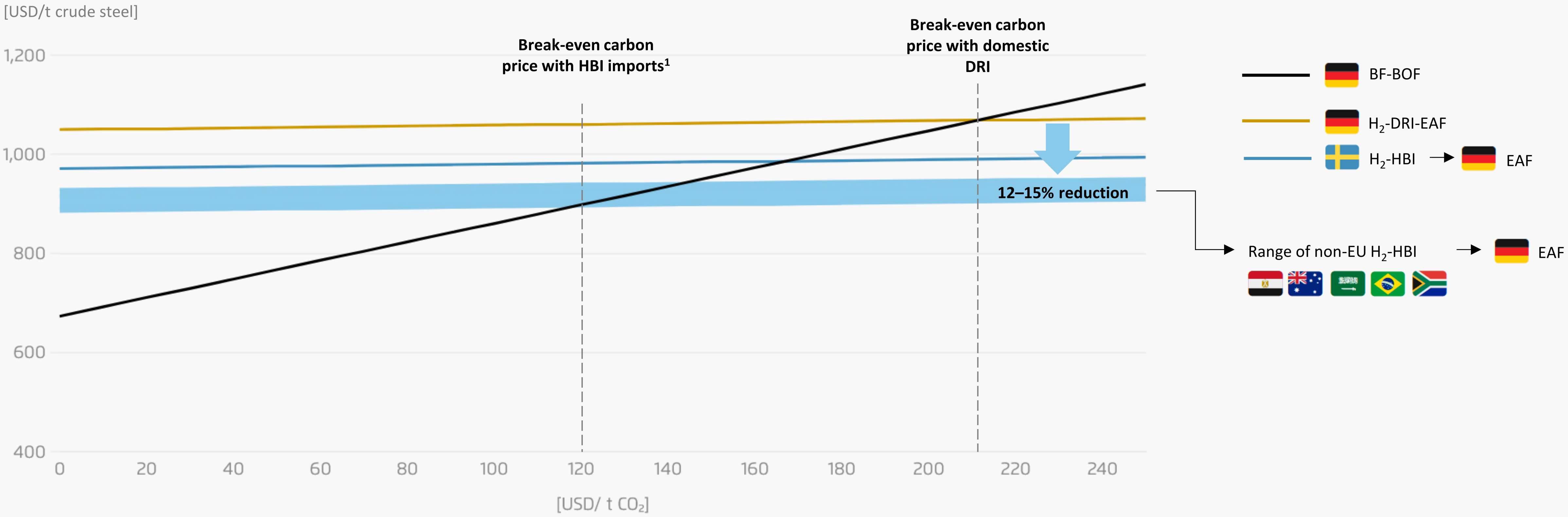


- Projects in many exporting countries will need supporting derisking[4] measures to be developed.
- As a global green iron market develops, access to cost-competitive HBI imports would enable more cost-effective steel production.
- Using imported green HBI with up to 26% lower production costs can lead to a cost reduction of 15% of overall steelmaking in Germany.

Agora Industry (2025). * H_2 pipeline in Europe considering imports from Spain (medium cost scenario); **HBI production costs based on grid-based electricity procurement.
[1] The light grey columns indicate the range of HBI production costs across low, medium, and high cost scenarios. [2] import costs include re-heating cold HBI; [3] de-risked cost of capital assumed to be 4.3%.
[4] De-risking includes measures such as concessional finance and offtake contracts that result in lowering the cost of capital for investments in HBI production. For detailed information on the scenarios assessed, see slides in the Appendix.

Importing green HBI imports from regions rich in iron ore and renewables could nearly halve the break-even CO_2 price needed for green steel to compete with BF-BOF in Germany

Germany case study: crude steel production costs in 2040 using imported (de-risked*) and domestic HBI/DRI.
Importing HBI could cut 12–15% of steel production costs.



Agora Industry (2025). *de-risked cost of capital: 4.3%; production costs of green steel include: shipping costs of iron pellets and HBI, losses during transportation, cost of re-heating cold HBI as well as costs associated with higher tap to tap time by using cold HBI. For detailed information on the scenarios assessed, see slides in the Appendix.

Transformation: turning risk into opportunity for Germany's steel sector

- Germany's steel sector is navigating a sluggish economy, persistent global overcapacities and geopolitical uncertainties. However, this challenging environment also presents a pivotal **opportunity for Germany to regain competitiveness and future-proof its industry** through innovation and leadership in green steel production. By supporting the transformation of its steel sector – the largest in the EU – Germany can reinforce its position as a global green industry and technological innovator.
- To achieve climate neutrality, it is crucial for Germany to decarbonise its steel industry, which is currently responsible for around 7% of national greenhouse gas emissions, and one third of industrial emissions. **Coordinated climate and industrial policy are needed to achieve competitiveness, resilience and sustainability**.
- A **clear strategy along its industrial value chains** is needed to preserve this strategically important sector. This means combining policy measures that unlock investments in domestic green iron and steel production with a deliberate approach to diversifying supply chains.
- **Green HBI imports can hedge against high H_2 import costs**, enhancing the cost-efficiency of high-value German steelmaking. This could lower green steel production costs by 12–15% – a meaningful reduction in a highly competitive, margin-sensitive industry.

Appendix

List of abbreviations

AEL: Alkaline iron electrolysis

BF: Blast furnace

BOF: Basic oxygen furnace

Capex: Capital expenditures

CCS: Carbon capture and storage

DRI: Direct reduced iron

EAF: Electric arc furnace

EU ETS: EU emissions trading system

Fe: Iron

FID: Final investment decision

GHG: Greenhouse gas

H_2: Hydrogen

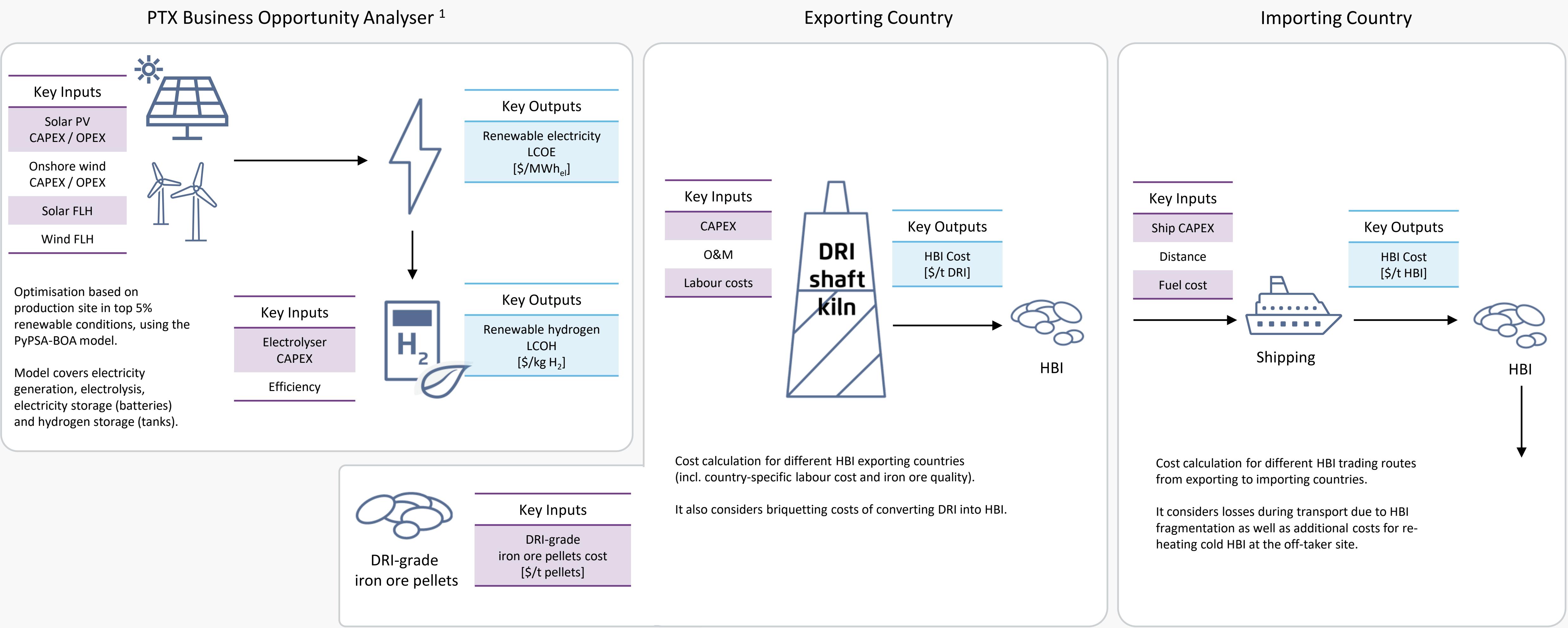
HBI: Hot briquetted iron

MOE: Molten oxide electrolysis

NZE-scrap-EAF: Near-zero emissions scrap electric arc furnace

Opex: Operating expenditures

Appendix – calculation methodology



[1] Oeko-Institut, Agora Energiewende & Agora Industry (2024): PTX Business Opportunity Analyser, Version 2.0

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Appendix – key assumptions

Overall values

Parameters		Value	Reference	Comment
Amortisation time (years)		20	Own assumption	-
Capacity utilisation (%)		90	Own assumption	72% for EAF charged with cold HBI[1]
DR grade iron pellets (USD_{2024} / tonne)		207	1, 2	Price for countries without DR grade iron ore. Countries with DR grade iron ore can produce pellets with lower costs.
DRI plant	CAPEX (USD_{2024} / tonne DRI per year)	633	2	-
	Fixed OPEX (% of CAPEX per year)	3	2, 4	-
	Electricity consumption (kWh / tonne DRI)	93	2, 3	Including DRI briquetting
	Hydrogen consumption (kg H_2 / tonne DRI)	69	2, 4	Including H_2 pre-heating
EAF plant	CAPEX (USD_{2024} / tonne CS per year)	468	2,	-
	Fixed OPEX (% of CAPEX per year)	3	2, 4	-
	Electricity consumption (kWh / tonne HBI)	651	2, 4, 5	Including re-heating of cold HBI (150 kWh / tonne HBI)

Note: [1] The capacity factor of the EAF was adjusted to account for lower productivity when charged with cold HBI compared with hot HBI due to a higher tap-to-tap time.

Appendix – key assumptions

Overall values

Parameters		Value	Reference	Comment
BF-BOF plant	CAPEX (USD_{2024} / tonne CS per year)	326	10	-
	Fixed OPEX (% of CAPEX per year)	3	10	-
	Coking coal (USD_{2024} / tonne)	257	2	-
Alkaline electrolyser	CAPEX (USD_{2024} / kW_{el})	657	8	-
	Fixed OPEX (USD_{2024} / kW_{el}-year)	13	8	-
	Efficiency	71.5%	8	-

Appendix – key assumptions

Country-specific values

Parameters	Case	Australia	Brazil	Egypt	South Africa	Saudi Arabia	Germany*	Germany**	Japan	South Korea	References
Discount rate*** (%)	High	4.3	14.6	14.3	10.8	5.1	4.3	4.3	5.3	4.9	6,7
	Medium (default)	4.3	7.7	14.3	8.3	5.1	4.3	4.3	5.3	4.9	6
	Low	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	6
CAPEX of wind onshore (USD_{2024} / kW)	High	1,176	910	1269	868	1,482	1,456	-	-	-	8
	Medium (default)	1,037	802	1,119	765	1,307	1,624	-	-	-	8
	Low	977	756	792	721	1,232	1,531	-	-	-	8
CAPEX of solar PV (USD_{2024} / kW)	High	698	564	628	515	977	1,042	-	-	-	8
	Medium (default)	528	426	475	389	357	434	-	-	-	8
	Low	411	332	370	303	278	505	-	-	-	8

* H_2 pipeline for Germany is based on H_2 production in Tunisia (high case), Spain (medium case) and Denmark (low case). ** grid-based electricity for Germany; *** country-specific equity risk premiums (ERP) and government bond yields are used as simplified approach in levelised cost calculations, since a more detailed weighted average cost of capital (WACC) is intrinsic to each individual project; All costs refer to 2040 technological scenario.

Appendix – key assumptions

Country-specific values

Parameters	Case	Australia	Brazil	Egypt	South Africa	Saudi Arabia	Germany*	Germany**	Japan	South Korea	References
Cost of renewable energy (USD_{2024} / MWh)	High	37	64	77	70	26	55	105	105	105	8,9
	Medium (default)	32	38	55	29	21	39	90	90	90	8,9
	Low	29	27	22	21	16	45	70	70	70	8,9
Cost of renewable hydrogen (USD_{2024} / kg)	High	2.3	4.0	4.3	4.5	2.4	4.6	5.2	5.2	5.2	8,9
	Medium (default)	2.1	2.5	3.9	2.5	2.1	2.9	4.5	4.5	4.5	8,9
	Low	1.9	1.9	2.0	2.0	1.8	2.8	3.5	3.5	3.5	8,9

 * H_2 pipeline for Germany is based on H_2 production in Tunisia (high case), Spain (medium case) and Denmark (low case); ** grid-based electricity for Germany; All costs refer to 2040 technological scenario.

Imprint

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