Iron Solutions webinar

Decarbonization of steel and impacts in iron ore supply

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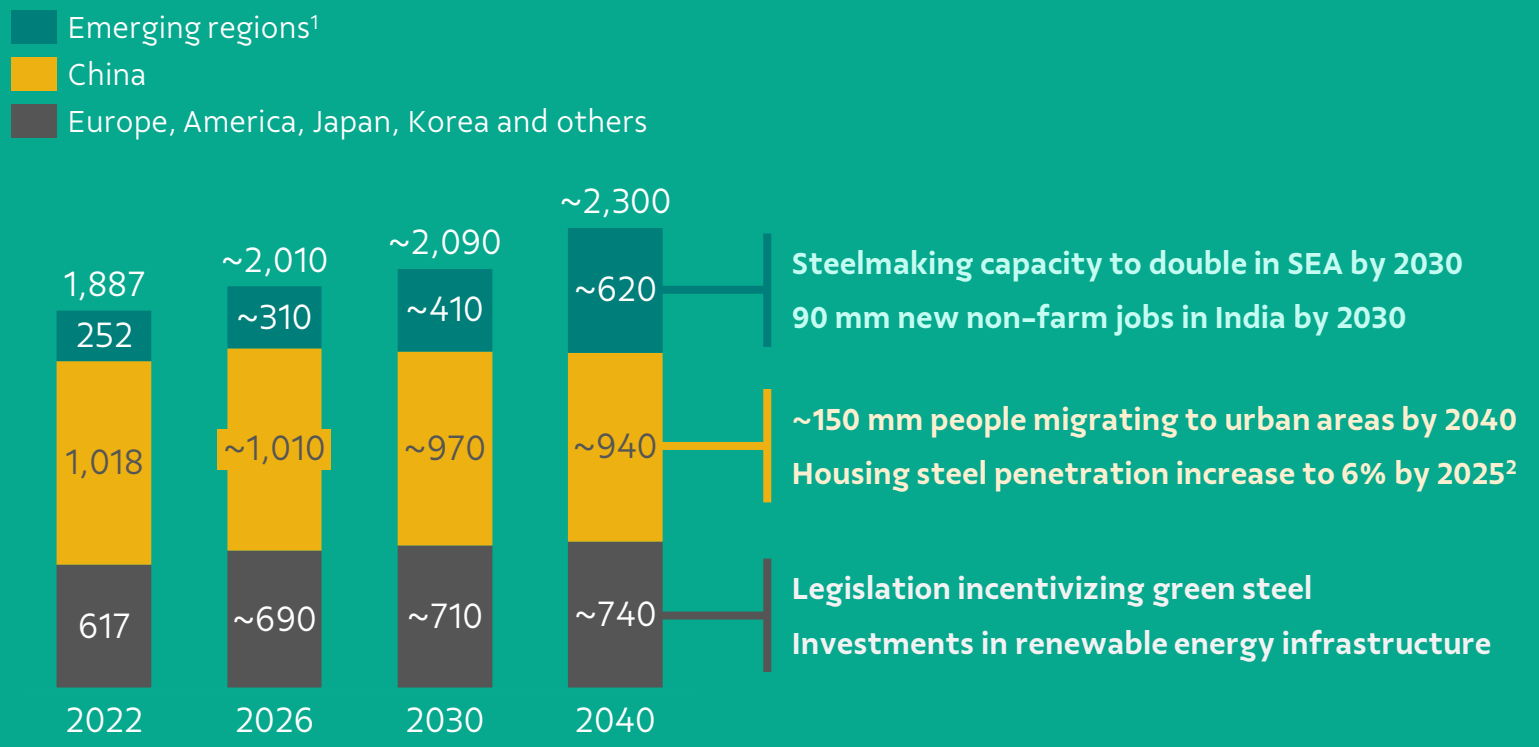
Steel to remain in high demand for a very long time...

Megatrends for steel demand

- **Population and economic growth**
- **Urbanization**
- **Energy transition**
- **Onshoring and reduced steel imports**

Steel production by region (Mt)



[1] Including India, Southeast Asia, Middle East and Africa. [2] According to some estimates, the penetration rate of steel structures for housing is expected to increase from 0.8% in 2018 to 6.0% in 2025.

... but steelmaking needs to change for a world challenged to decarbonize

More than **70 countries committed to net zero targets**

Steelmaking represents **8% of global CO_2 emissions**

> US$ 1 trillion investments required to decarbonize steel industry

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Steelmakers are exploring multiple solutions to decarbonize

The steel industry will most likely decarbonize in steps

Step 1: Operational efficiency
Up to 15% CO_2 reduction

- Burden mix optimization with high-quality ores
- Energy optimization
- Increased scrap usage

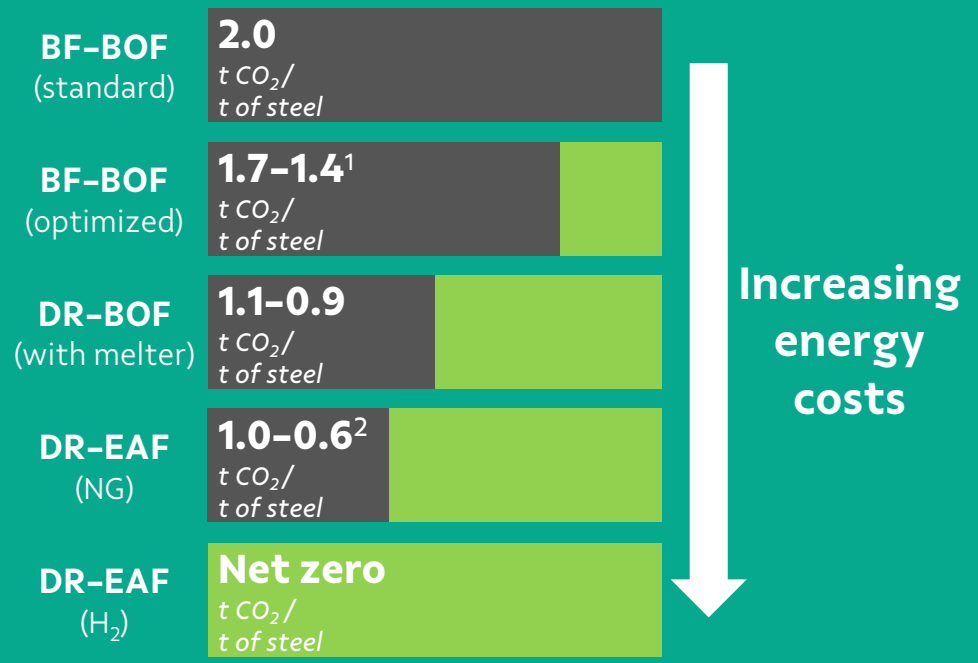
Step 2: New technologies (excluding green H_2)
15–60% CO_2 reduction

- Low carbon fuels & enhanced O_2 in BF
- CCS adoption

Step 3: 100% green H_2
60–100% CO_2 reduction

- H_2 + DR route

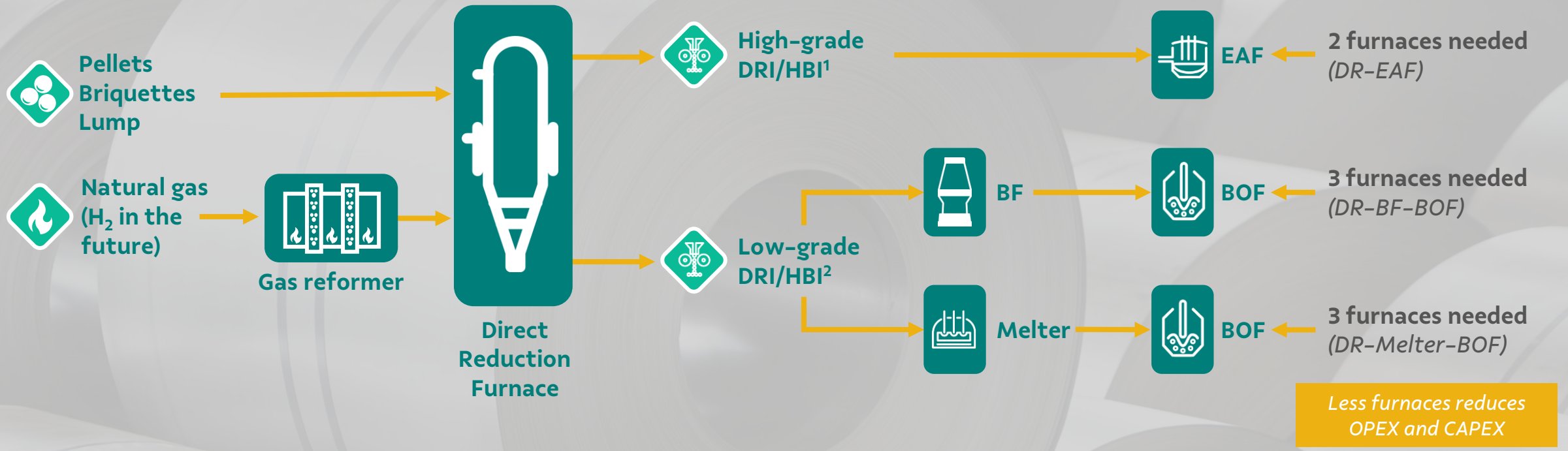
Steelmaking emissions



[1] Considering increased O_2 utilization in blast furnace in the best scenario. [2] Considering Carbon Capture and Storage (CCS) in the best scenario.

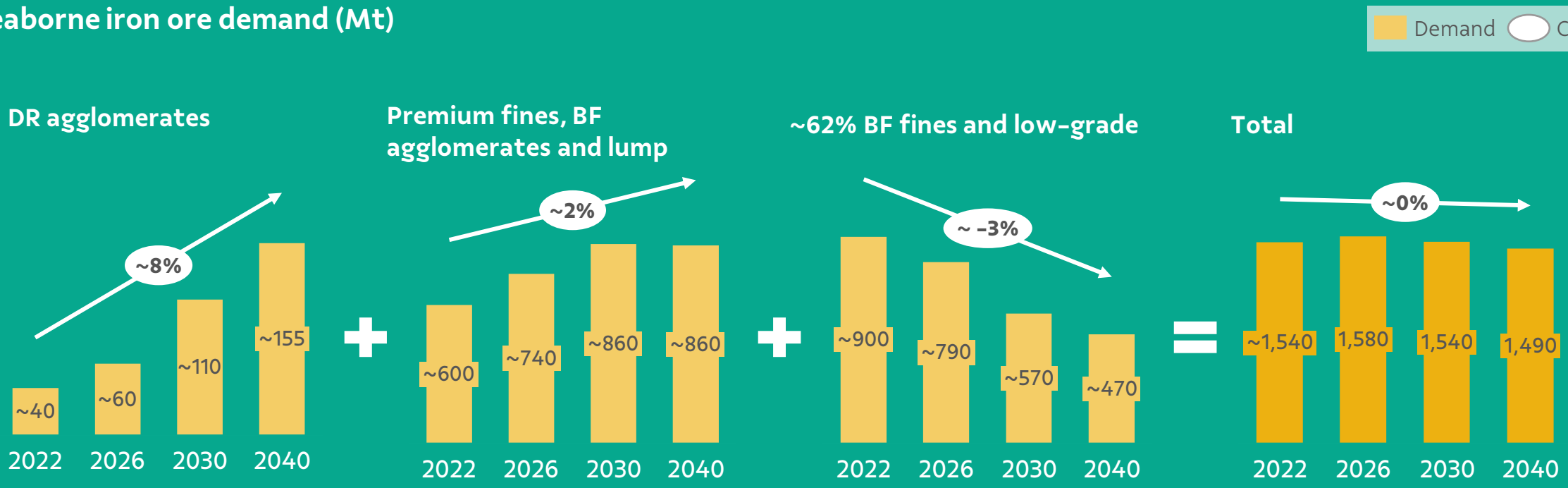
HBI has varied application routes with different economics

Simplified direct reduction flowsheet and applications



[1] Considering a high-grade DRI/HBI of %Fe total greater than or equal to 90% and % metallization greater than or equal to 93%.
[2] Considering a low-grade DRI/HBI of %Fe total less than or equal to 90% and % metallization less than or equal to 93%.

The iron ore market to segment in three main categories with higher demand for premium products

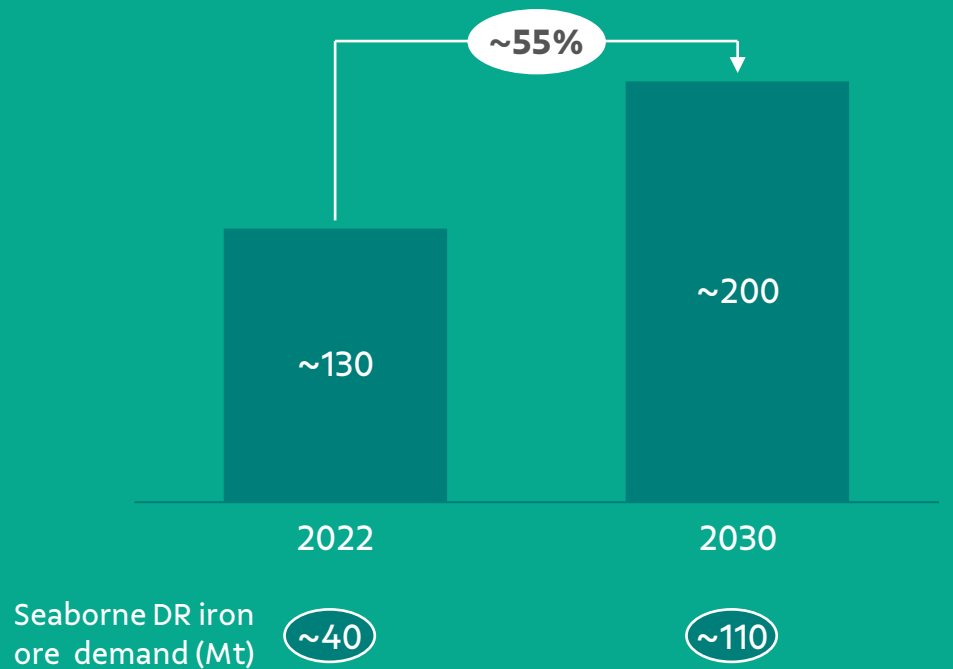


Increasing demand may create a DR agglomerates' S-D gap of ~70 Mt in 2030

Source: Vale's estimates.

New direct reduction plants are being announced

Global DRI/HBI production (Mt)



Growth is lead by key regions:

MENA gas availability and competitiveness **attracting investments**

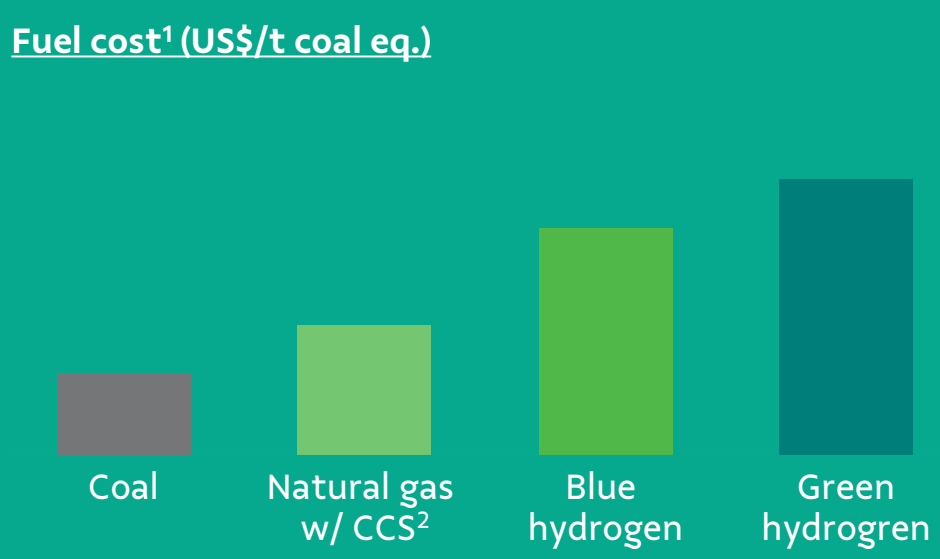
~US$ 8 billion incentives announced in **Europe**

Inflation Reduction Act and government support attracting **new investments into North America**

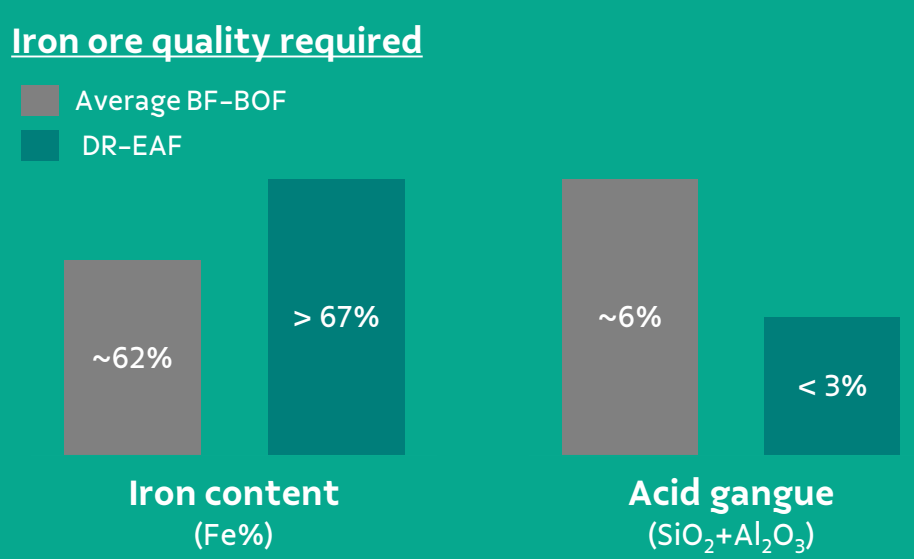
Source: Vale's estimates.

DR route success demands competitive energy costs, investments and typical iron ore quality

Shift to greener routes increases reductant costs



DR route set up is more sensitive to iron ore quality



Government support both in mitigating risks, financing and providing long term regulatory certainty regarding carbon pricing will be decisive

[1] Assumptions: Electricity@$30/MWh; CCS@$60/ton.CO_2 [2] Carbon capture and storage

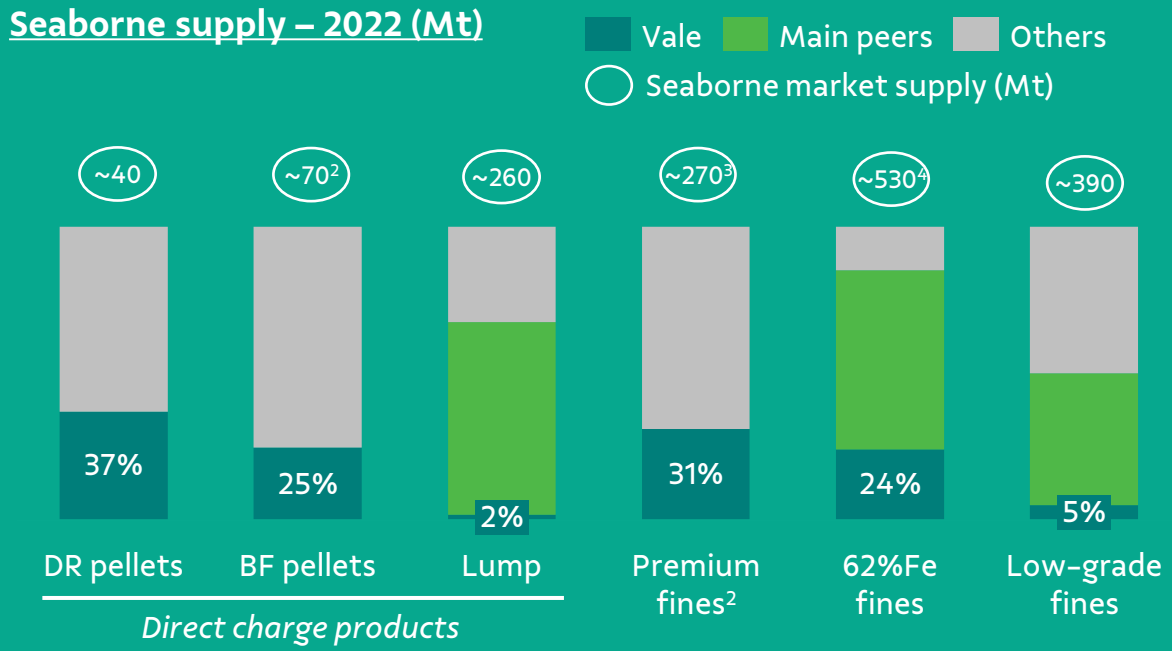
Current seaborne iron ore quality is not suitable for a “carbon-neutral” steelmaking world

Ore concentration is a trade-off between additional costs and premiums

LOI[1] and density differentials in some orebodies decrease mass recovery in concentration

Quality requirements tend to increase beneficiation costs and decrease mass recovery

Vale is leader in premium products (DRP, BFP and premium fines)



[1] Loss on ignition. [2] Including Vale’s sales of BF pellets in Brazil. [3] Including pellet feed sales. [4] Including BRBF low alumina products.

Vale is innovating to fill the supply-demand gap of agglomerates

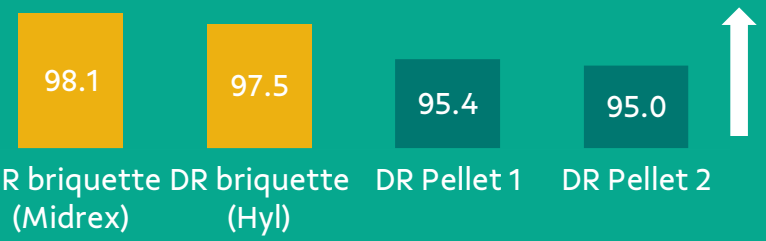
Tests in clients' furnaces are confirming the benefits of iron ore briquettes

- **70 kt** of briquettes tested
- **8 industrial tests** in 6 blast furnaces
- Basket **tests in Midrex and Hyl** DR furnaces
- **9 tests** scheduled **for 2023**

Direct Reduction basket tests results

Metallization[1] (%)

The higher, the better



Disintegration (% <6.3mm)[2]

The lower, the better

[1] Metallization of DRI is a measure of the conversion of iron oxides into metallic iron. Higher metallization means high productivity, less gas consumption and lower costs.
[2] Disintegration (% <6.3mm) is a measure of the fines generation during the reduction process from oxide to metallic iron. Lower disintegration means higher yield, higher productivity and smoothly operation.

Higher demand for premium products will promote a market segmentation

Spread over 62%Fe index (US$/dmt)

DR agglomerates (68%Fe)		BF agglomerates (65%Fe)		Premium fines (65%Fe)		Low-grade fines (58%Fe)	
2018–2022	2030+	2018–2022	2030+	2018–2022	2030+	2018–2022	2030+
74	~95	66	~75	18	~22	–27	~ –30
Premiums increase with higher demand for direct reduction agglomerates		Remaining blast furnaces demand more agglomerates		Premium fines maximize productivity in new low-CO_2 processes		Low-grade fines become feedstock for high-CO_2 emitting blast furnaces (typically in regions without emission restrictions)	

Vale's market

Assumptions: 62%Fe iron ore price (US$/dmt) = 75 (2030+); Steel margins (US$/t) = 75 (2030+); CO_2 price (US$/t) = 30 (2030+); Coke price (US$/t) = 335 (2030+); and Natural gas price (US$/MMBtu) = 6 (2030+).

How is Vale supporting the steelmaking scope 1 reduction?

Fostering
Mega Hubs creation

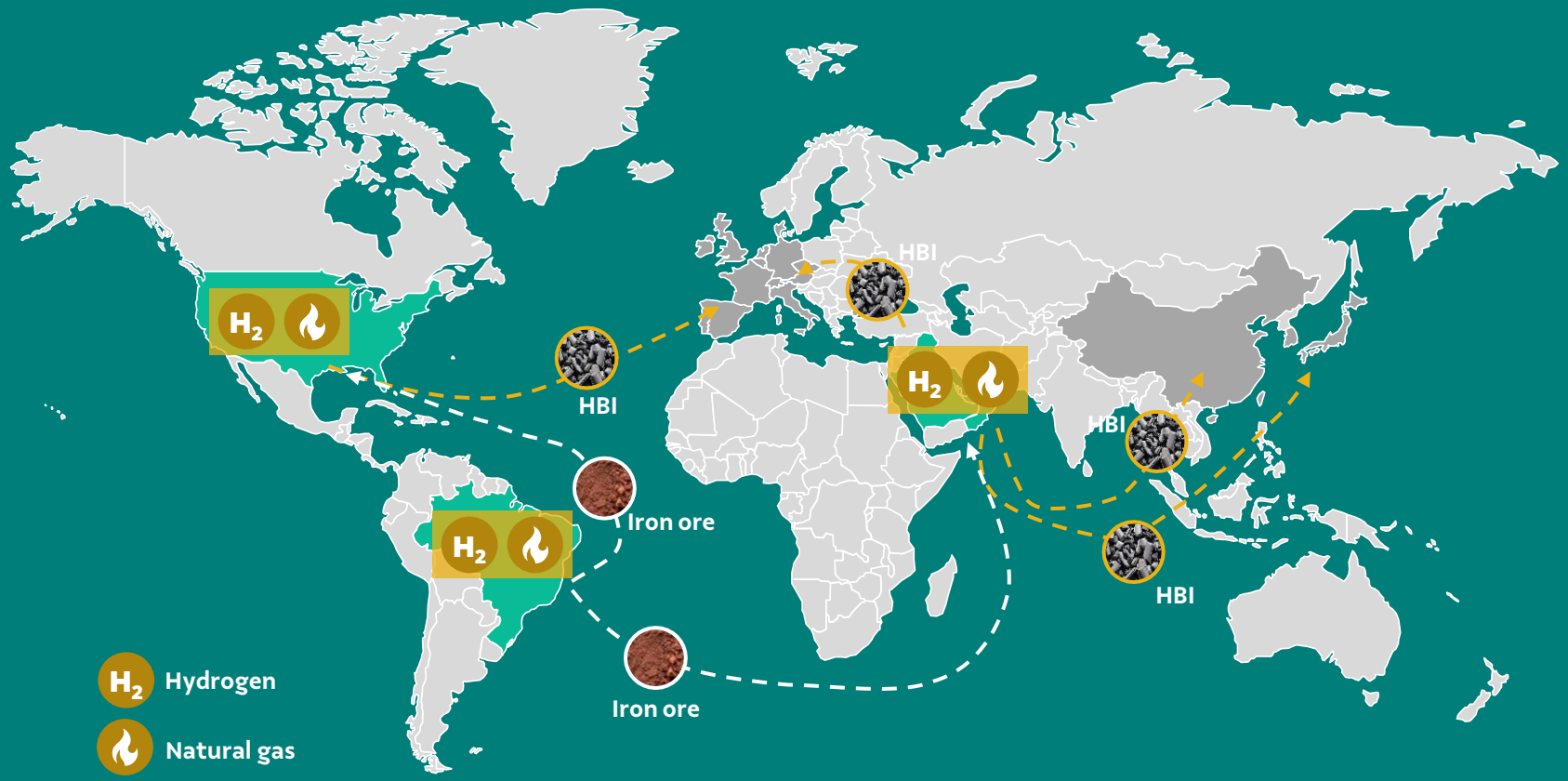
Developing
Concentration capacity

Increasing
Agglomerates production

Note: Steelmaking scope 1 is Vale's scope 3.

Vale is fostering the creation of Mega Hubs across the globe

Potential regions for Mega Hubs development

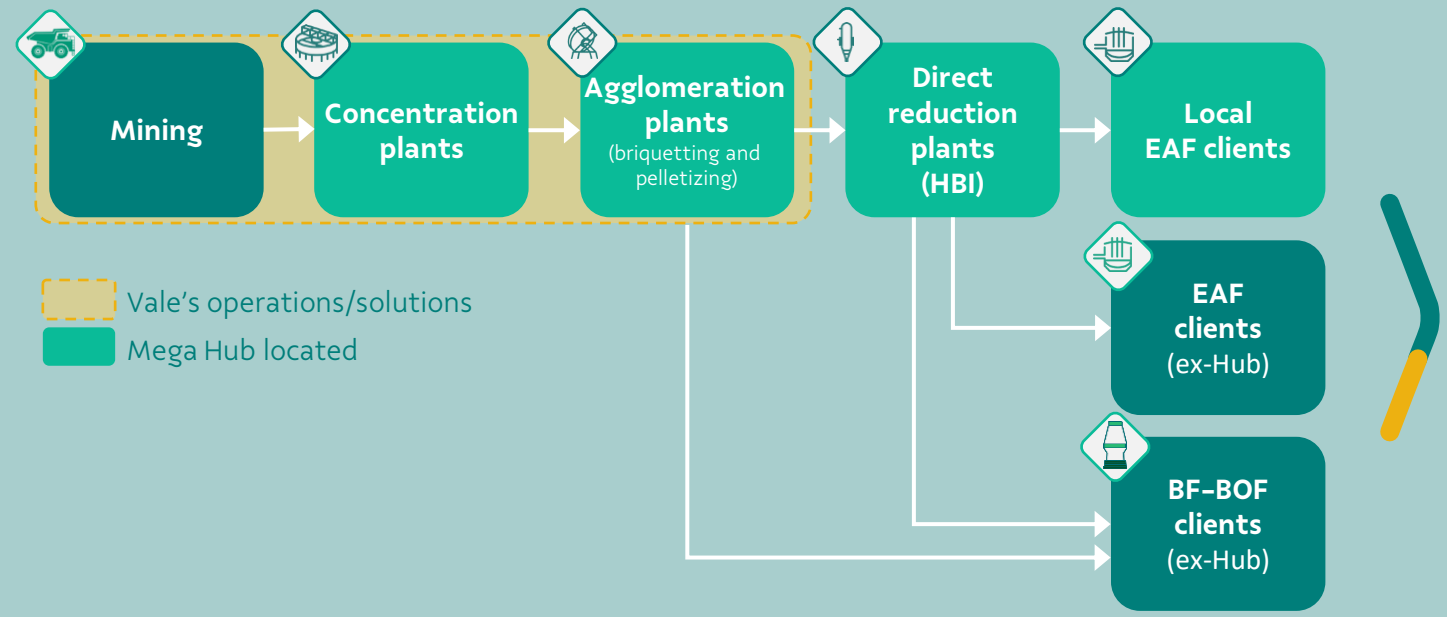


Agreements signed for Mega Hubs studies in Saudi Arabia, UAE, Oman and Brazil

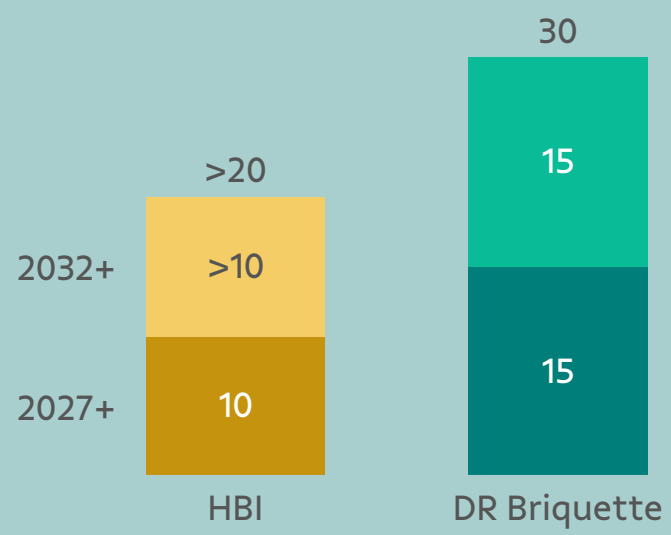
30+ MoU signed with clients for decarbonization

Mega Hubs will supply green solutions to the steel industry

Mega Hubs concept

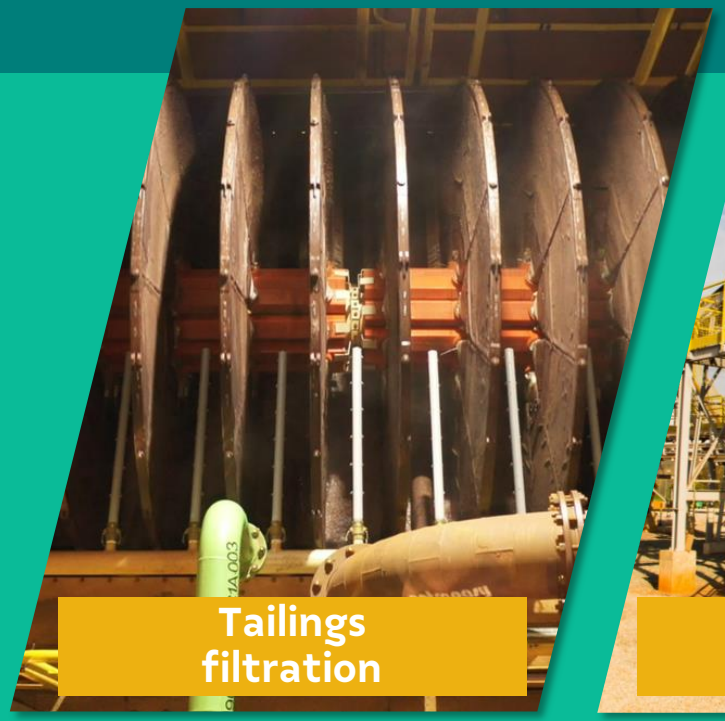


Volumes (Mt, preliminary estimates)



Delivering concentration solutions to supply high-quality feedstock

Innovative business model to optimize capital allocation and value chain



Tubarão briquette plants are 86% complete

Start-up Plant 1: 2Q23

Start-up Plant 2: 2H23

Capacity: 6 Mtpy of briquettes

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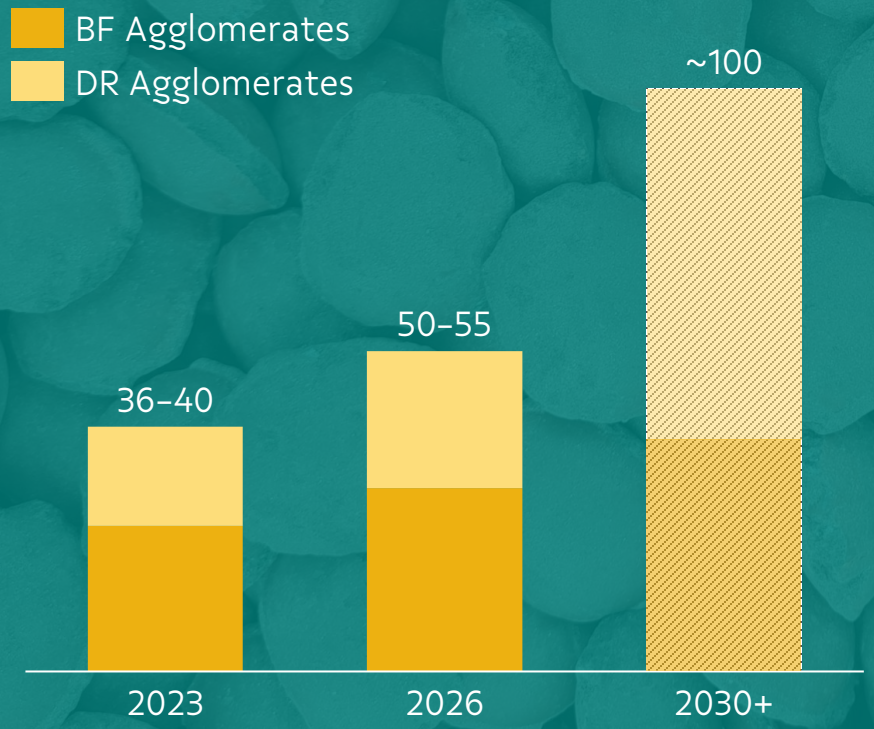
Vale will achieve ~100 Mt of agglomerates production by 2030+

Pellets & briquettes production (Mt)



Briquette plants expected timeline

2021 Approval of Tubarão plants

2023 Start-up of Tubarão plants (6 Mtpy capacity)
Approval of +2 plants

2024 Approval of +3 plants

Adding high-quality capacity to capture higher premiums

	2022	2026	2030+
Volumes	308 Mt	340–360 Mt	>360 Mt
High-grade agglomerates	32 Mt	50–55 Mt	~100 Mt
Grade	62.2% Fe	~63.5% Fe	~64% Fe
Average Premium	7 US$ per metric ton	8–12 US$ per metric ton	18–25 US$ per metric ton

Potential contribution to EBITDA vs. 2022

+ US$ 4–10 bn
by 2026 and 2030+

+ US$ 20–50 bn
value addition[1]

[1] Assuming a 5x EV/EBITDA multiple – diversified miners' average.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