Processing Pilbara Iron Ore in Electric Smelting Furnaces

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Hatch Ltd.

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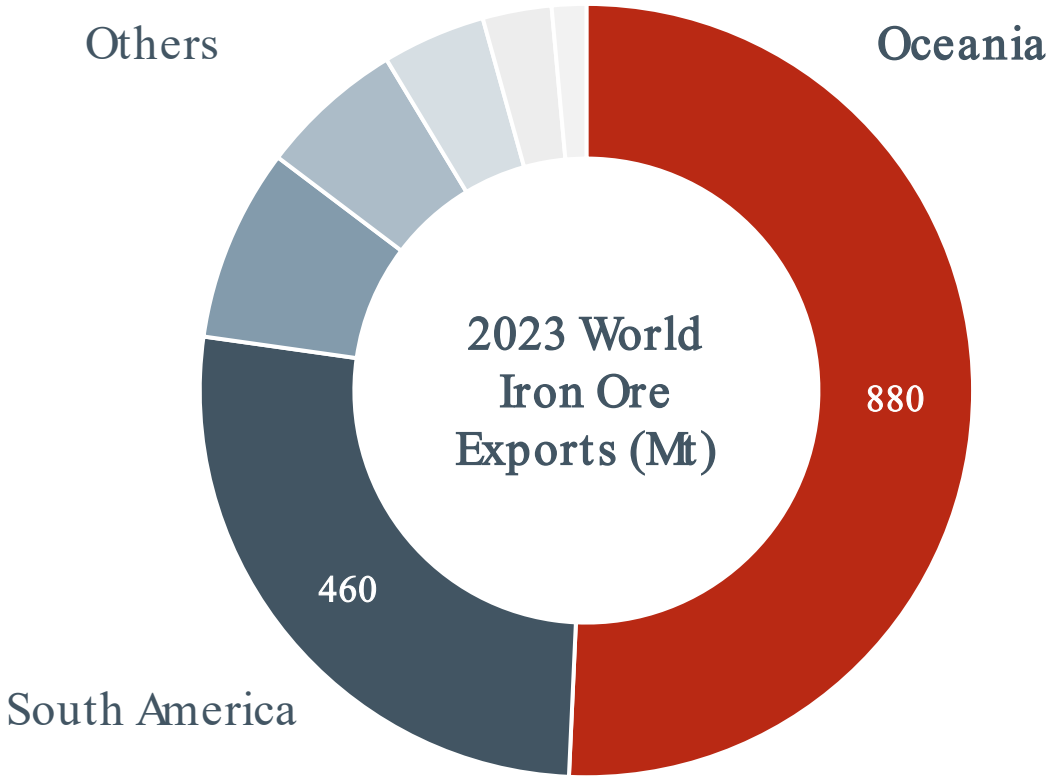
Pilbara iron ore: critical, efficient, challenging?

Australian exports fulfill much of the world's iron ore demand, mostly supplying BF-BOF. Identifying low-emission pathways for Pilbara iron ore is essential to decarbonize the steel industry.

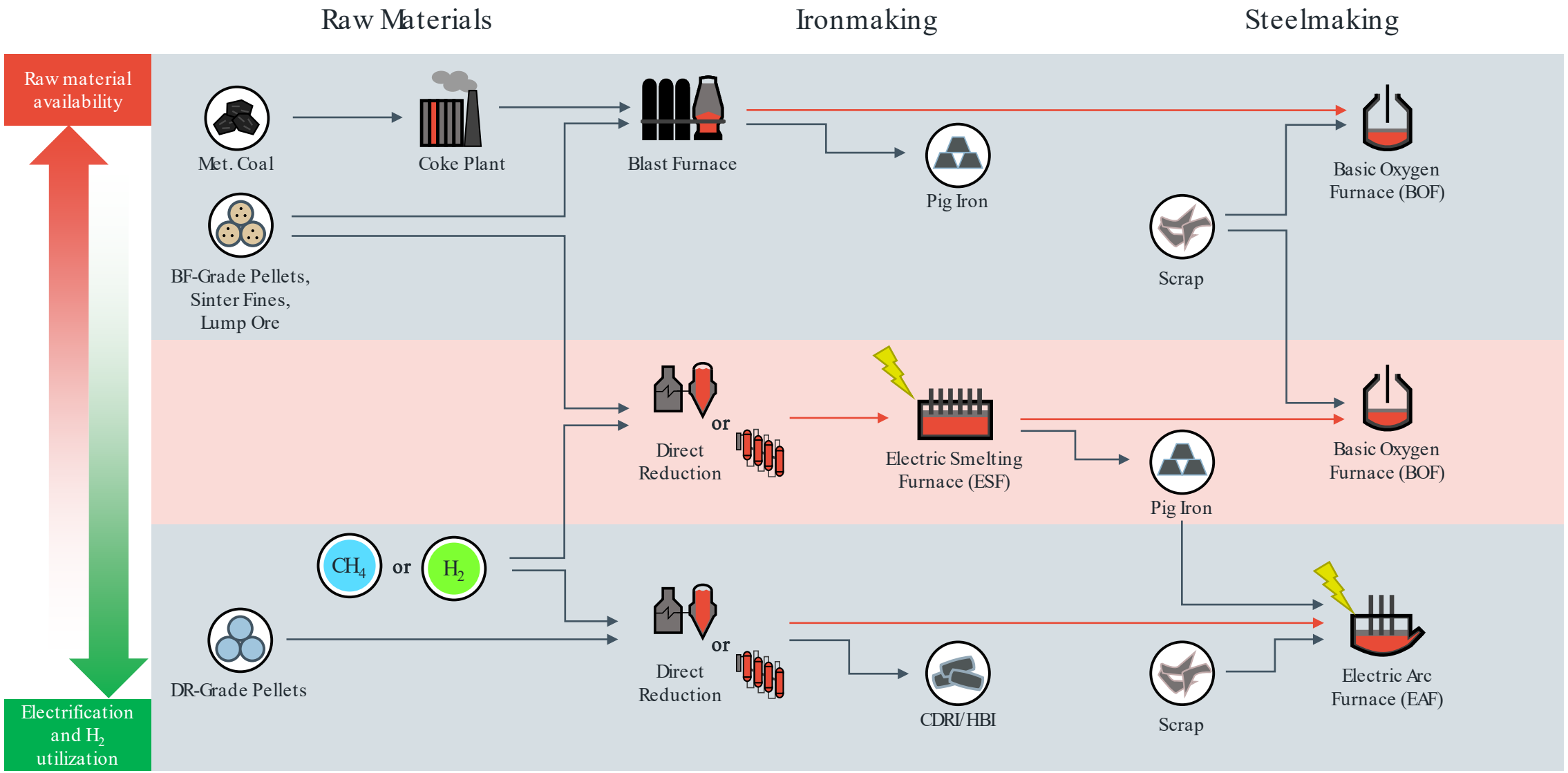


Source: World Steel Association

Characteristics of Pilbara iron ore

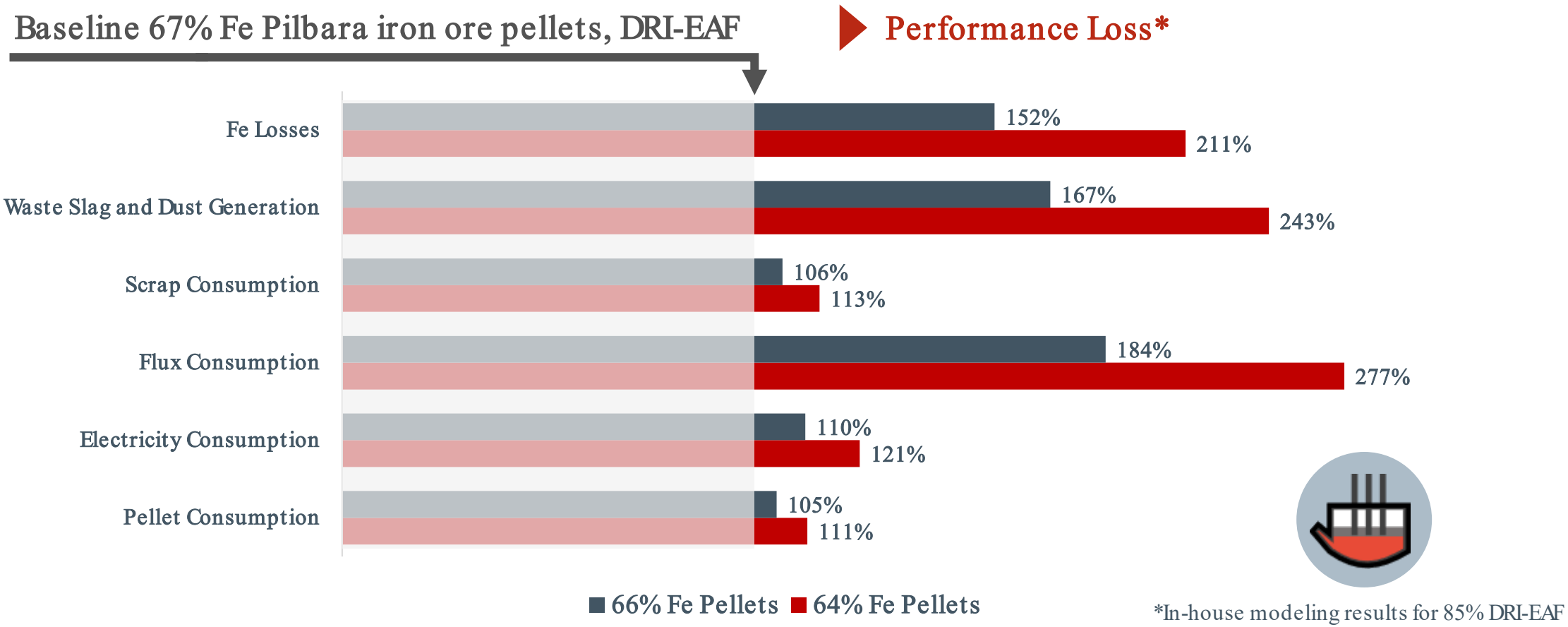
- Many high-Fe Pilbara iron ores require no beneficiation for BF use (Direct Shipping Ore, DSO)
- Typical Concerns:
  - Phosphorus
  - Gangue (esp. Al_2O_3)
  - More LOI as crystalline H_2O
- Challenging to upgrade and pelletize in high blend proportions at DRI quality due to gangue / LOI
- Limited current use in commercial DRI production
- **Irreplaceable** source of iron for the world

The Sustainable Steel Trilemma: Emissions, Raw Material, and Capital Costs



Traditional Approach: Beneficiate to DR-grade to Optimize EAF Steelmaking

While lower-grade pellets may be used in the EAF, they impact energy use, Fe yield, and productivity. Blending Pilbara iron ore with other pellet feeds lessens these impacts.



*In-house modeling results for 85% DRI-EAF

Efficiently Rejecting Gangue

Intensive (Wet) Beneficiation

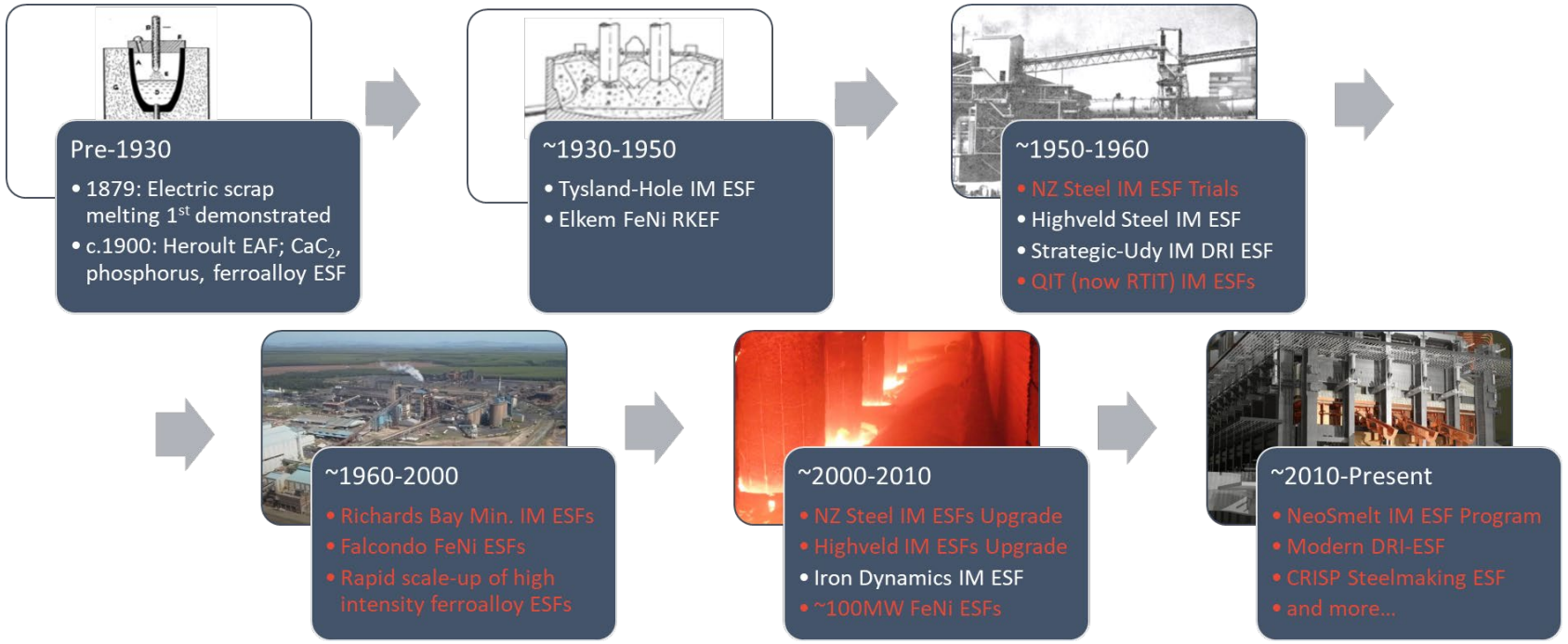
Gangue is physically removed with tailings after comminution, producing a concentrate which often requires agglomeration

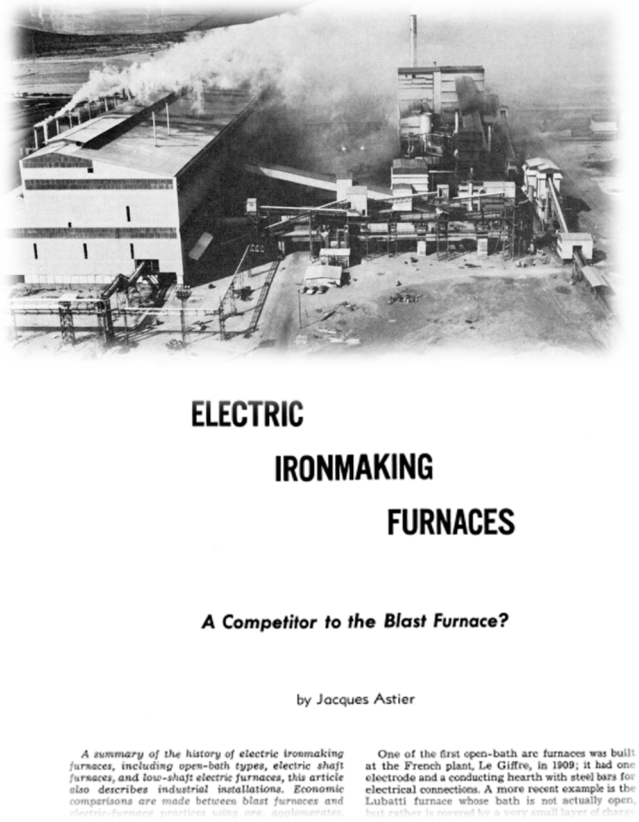
Pyrometallurgical Processing

Gangue is removed as a slag through energy-intensive melting, producing a higher purity, gangue-rejected, molten metallic product

Electric Ironmaking – It's Not New!

Ironmaking electric furnaces goes back almost a century
Hatch supplied majority of the world's largest ironmaking / ferronickel ESFs over our history





ELECTRIC
IRONMAKING
FURNACES

A Competitor to the Blast Furnace?

by Jacques Astier

A summary of the history of electric ironmaking furnaces, including open-bath types, electric shaft furnaces, and low-shaft electric furnaces, this article also describes industrial installations. Economic comparisons are made between blast furnaces and

One of the first open-bath arc furnaces was built at the French plant, Le Giffre, in 1909; it had one electrode and a conducting hearth with steel bars for electrical connections. A more recent example is the Lubatti furnace whose bath is not actually open,

Journal of Metals, 1963

ESF Technology for DRI Melting – CRISP+

Integration with DRI Process

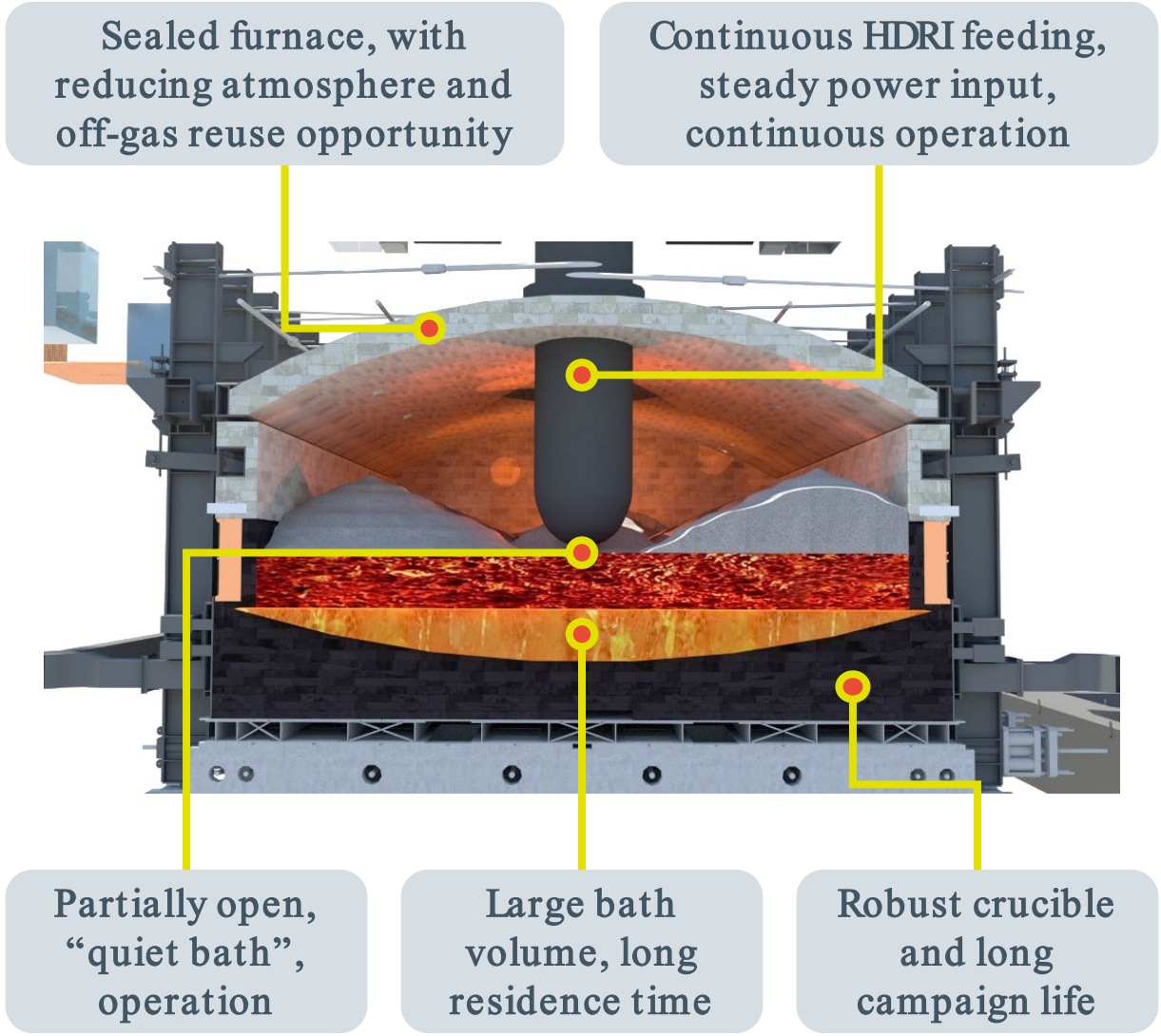
Thermal integration raises energy efficiency, and revert feeding to boost Fe yield

Can be coupled with different DR processes and a variety of potentially low-emissions reductants

Electric Smelting

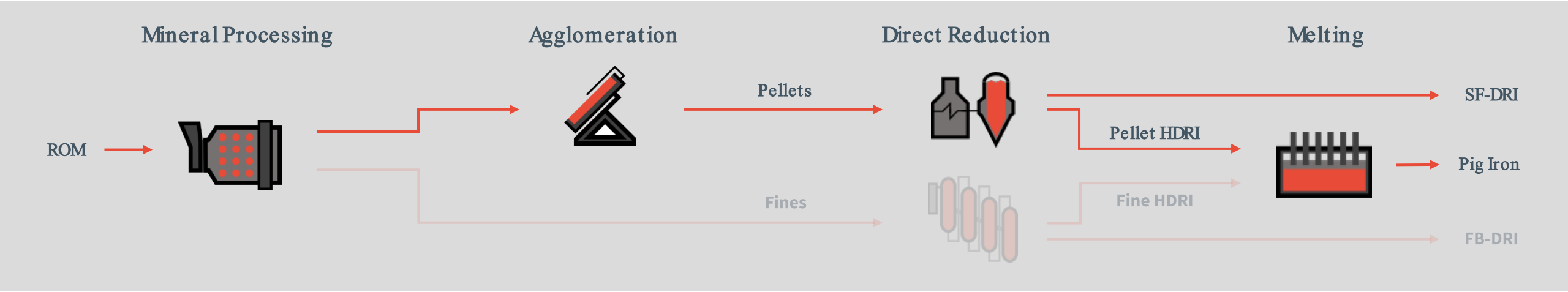
Final reduction, melting, and refining of DRI into pig iron for EAF/BOF steelmaking

Efficiently rejects gangue. Slag design enhances hot metal quality, melting efficiency, campaign life, and is suitable for cement industry usage.



Scenario Modeling and Analysis

Combining first principles process models of all major process steps, and incorporating real-world pricing, operating, design, and market data.



Pellet Feed: *Degree of Beneficiation*

- 61% (DSO) – No Beneficiation
- 63% – Moderate Beneficiation
- 66% – Intensive Beneficiation

Reduction Technology

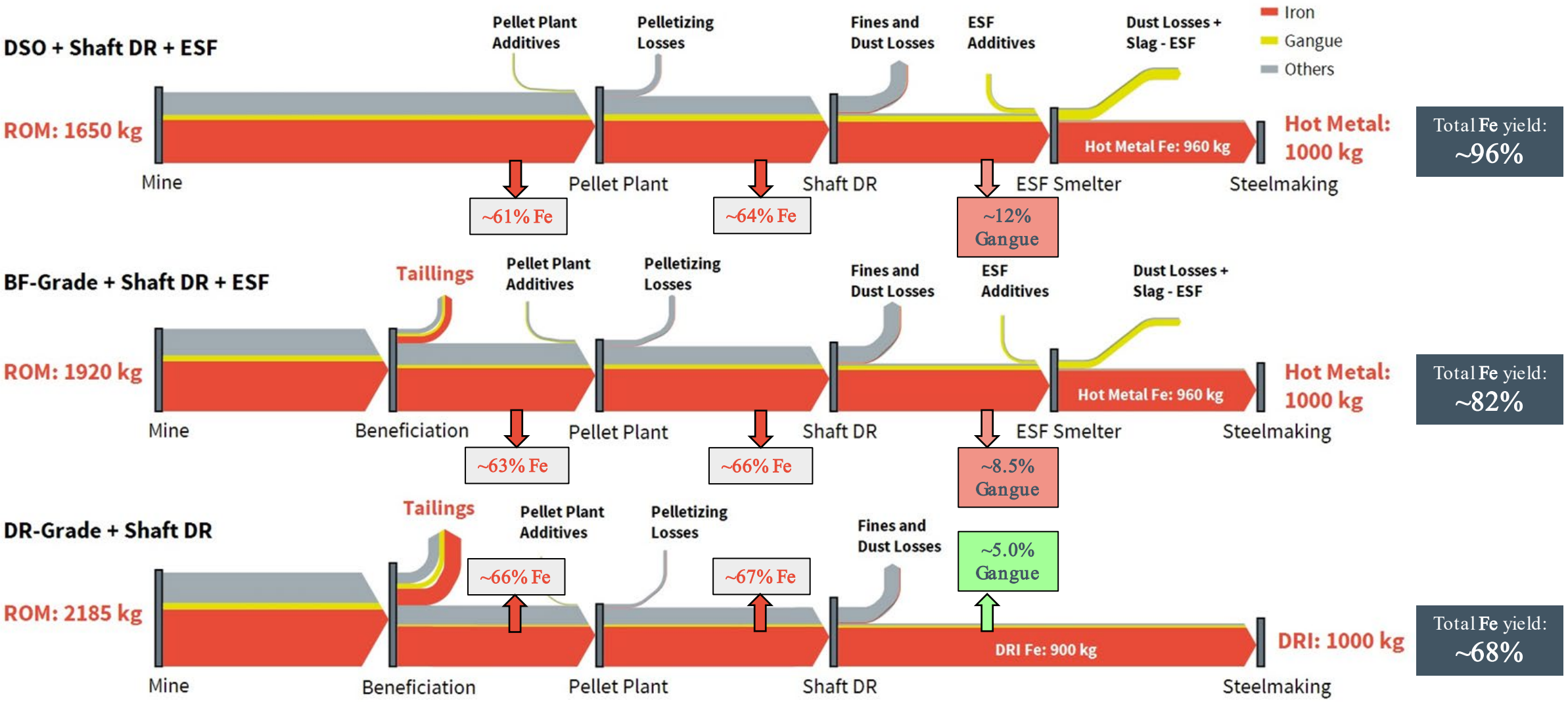
- Fluid bed reduction is potential future alternative
- Not discussed in this presentation

Key Metrics:

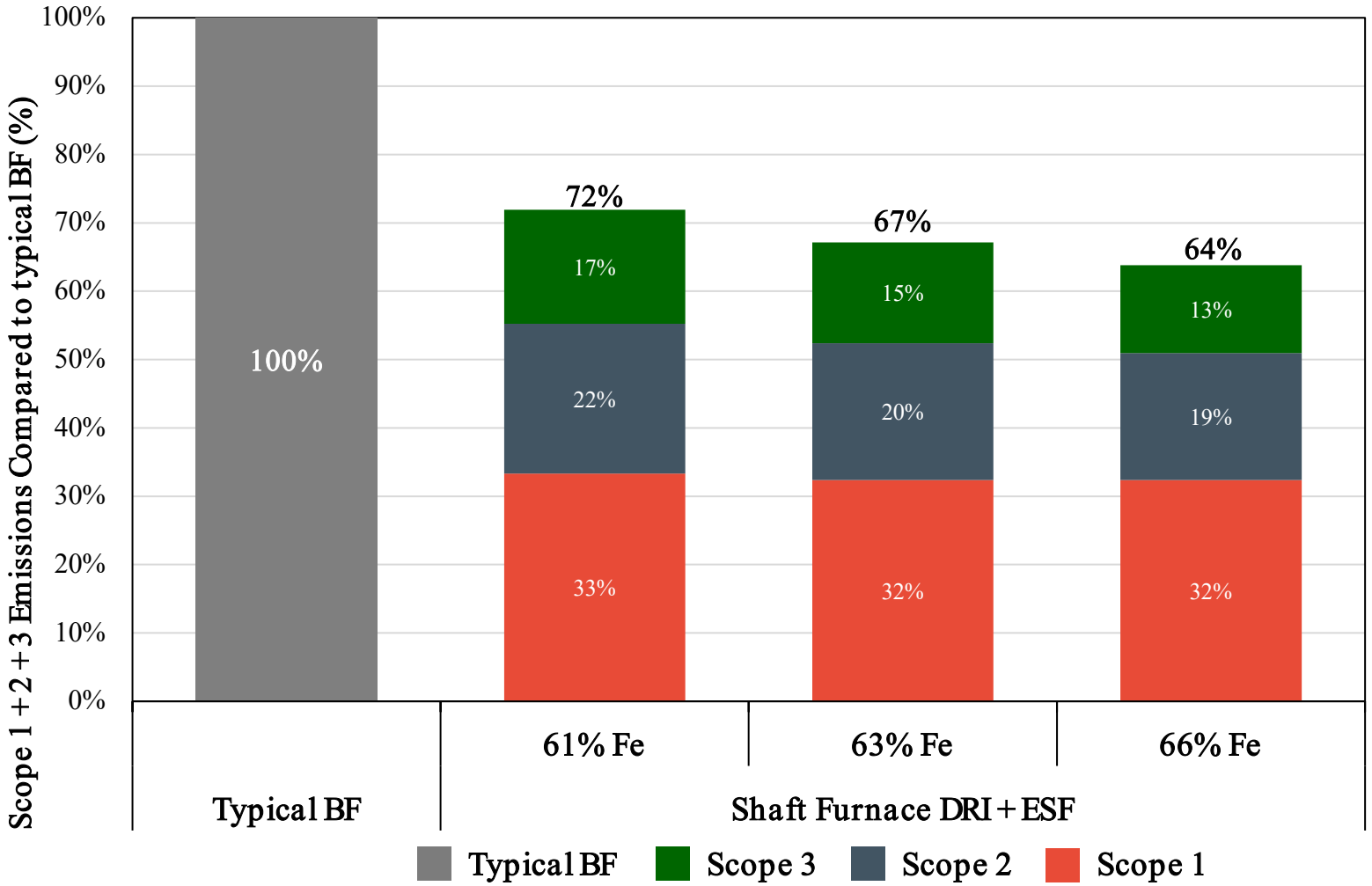
- Iron Yield
- Production Cost
- GHG Emissions

Relevant cases were selected for this presentation from over 30 scenarios modeled and analyzed

Key Results: Fe Yield in Shaft Furnace-DRI Flowsheets



Key Results: Comparing GHG Emissions, from Ironmaker's perspective



Modest decrease in Scope 3 due to benefits in pelletizing/reducing higher grade material

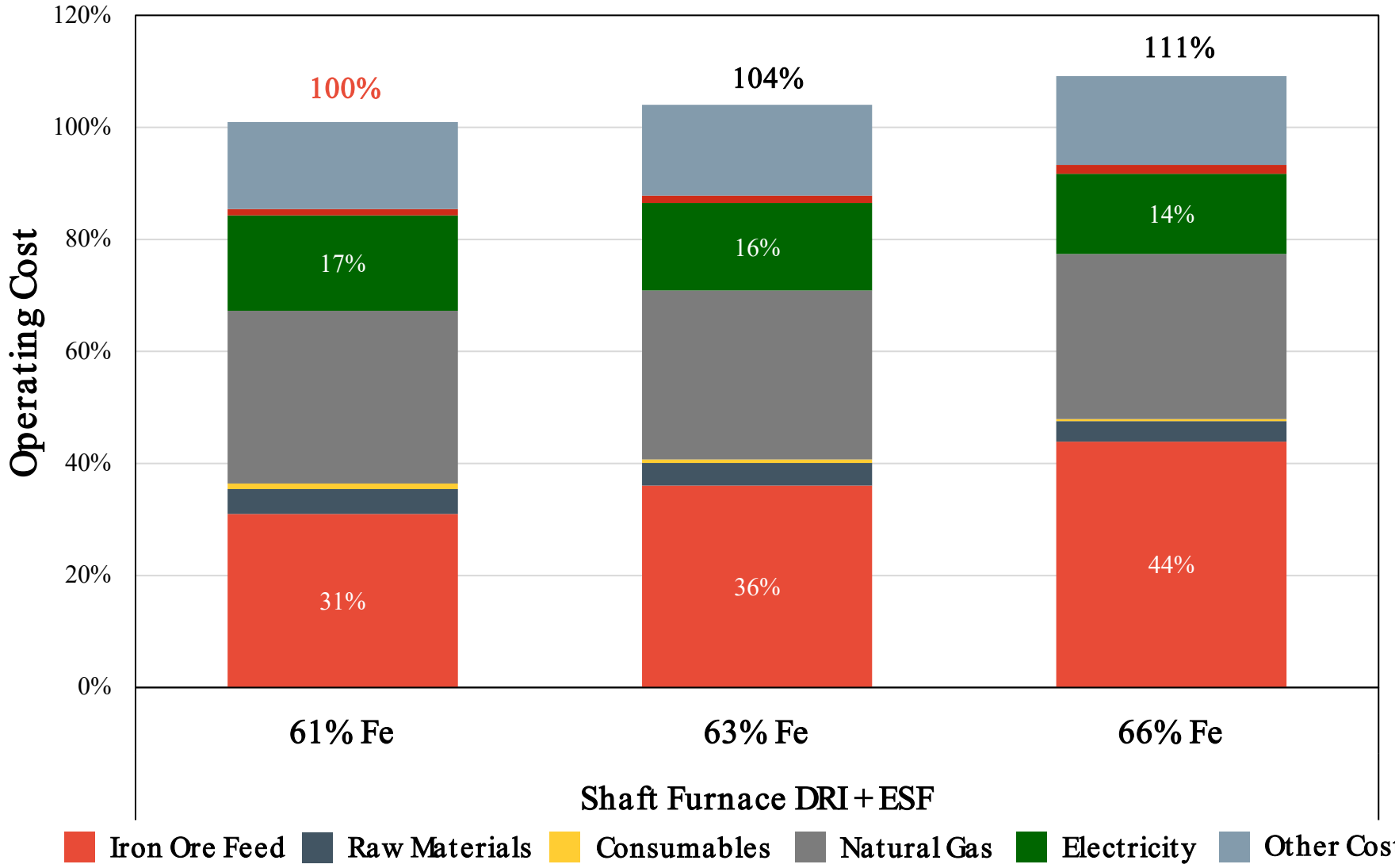
Modest decrease in Scope 2 driven by energy demand to melt gangue

Comparable Scope 1 driven by DR process emissions

Based on in-house modeling results for natural gas-based direct reduction.

Agrid emissions factor (GEF) of 0.51 kg-CO_2e/kWh was assumed in this work.

Key Results: Comparing Operating Costs, from Ironmaker's perspective

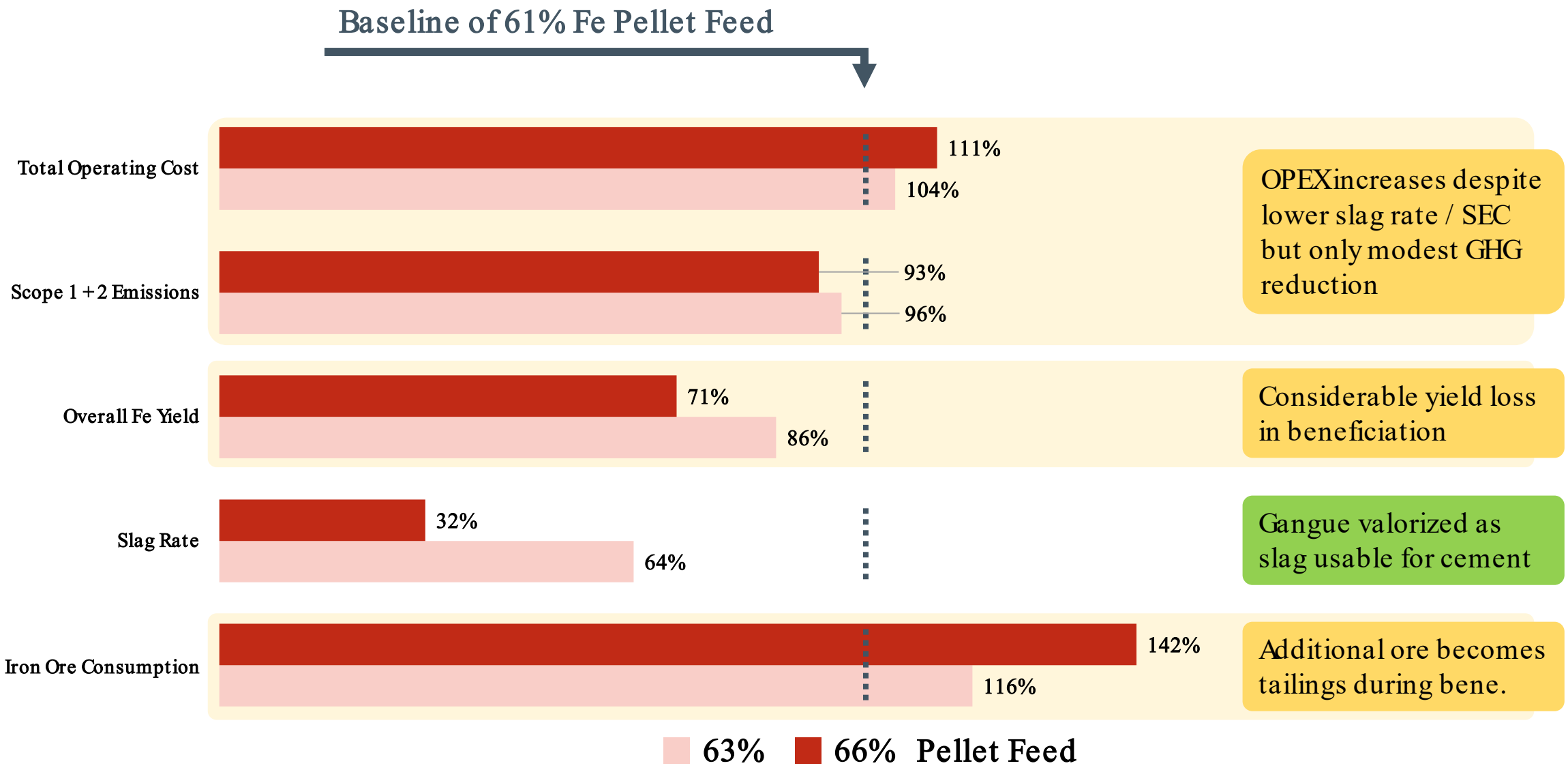


Minor energy savings driven by lower gangue in feed.

Considerable increase in raw material costs driven by yield loss in beneficiation and increased ROM demand.

OPEXestimation is based on process input and commodity pricing collected in 2023-2024.

Key Results: Impact of Beneficiation of DRI-ESF Flowsheets



Key Findings

- ESF ironmaking's feed flexibility is uniquely suited for efficiently processing Pilbara iron ore for low-emissions steelmaking
- DRI-ESF ironmaking allows efficient use of Pilbara iron ore in low-emission DR flowsheets, minimizing yield loss and achieving emissions reduction across all ore grades
- ESF allows effective removal of gangue and impurities without substantial impacts on operating cost or emission performance
- ESF turns challenges of Pilbara iron ore (high gangue and high Al_2O_3) into opportunities via slag valorization for the cement industry

Thank you.

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