Wuppertal Institut

Agora Industry

15 insights on the global steel transformation

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Who we are

Agora Industry Team

Agora Industry, steelworks field visit in 2022

Who we are

Agora Industry is a sub-brand of Agora Energiewende, a Berlin-based think tank and policy lab. We are ~20 industry transition experts.

Financing

We are independent and non-partisan with a diverse funding structure.

What we do

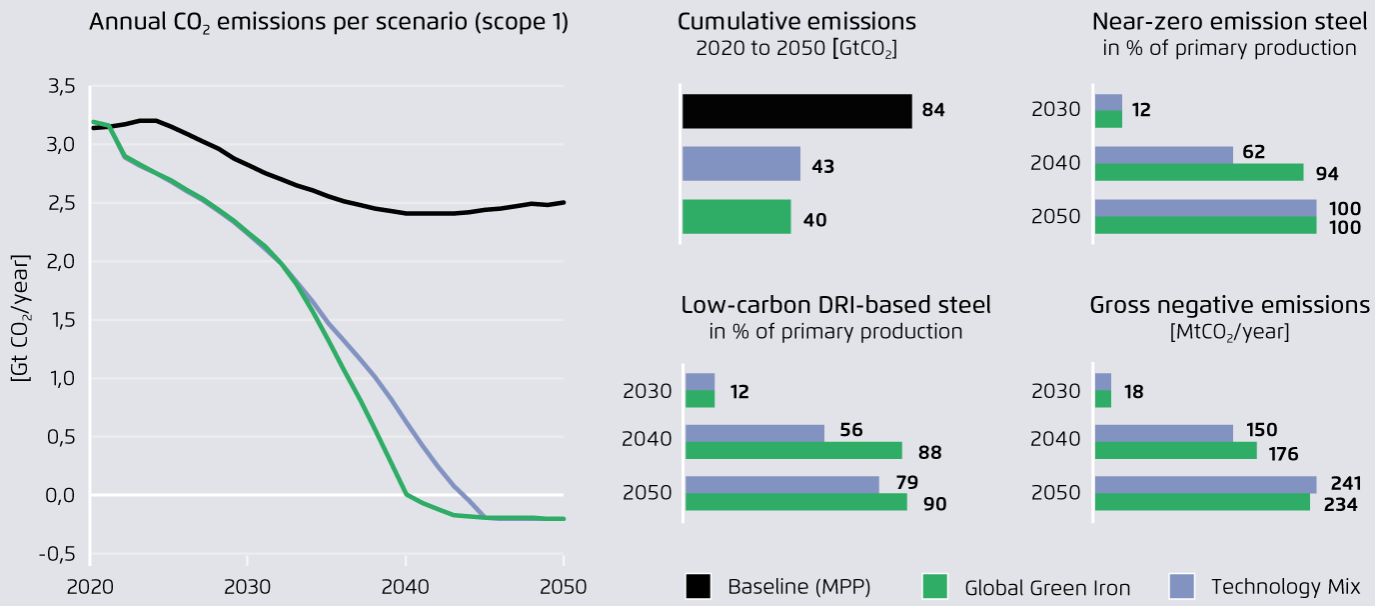
We develop strategies and policy instruments for the transformation of industry to climate neutrality across different value-creation chains.

How we work

Agora Industry collaborates with a range of stakeholders, including companies, NGOs, researchers, policymakers and trade unions.

Insight 1: The steel industry can turn from a hard-to-abate to a fast-to-abate sector. A net-zero steel sector by the early 2040s is technically feasible

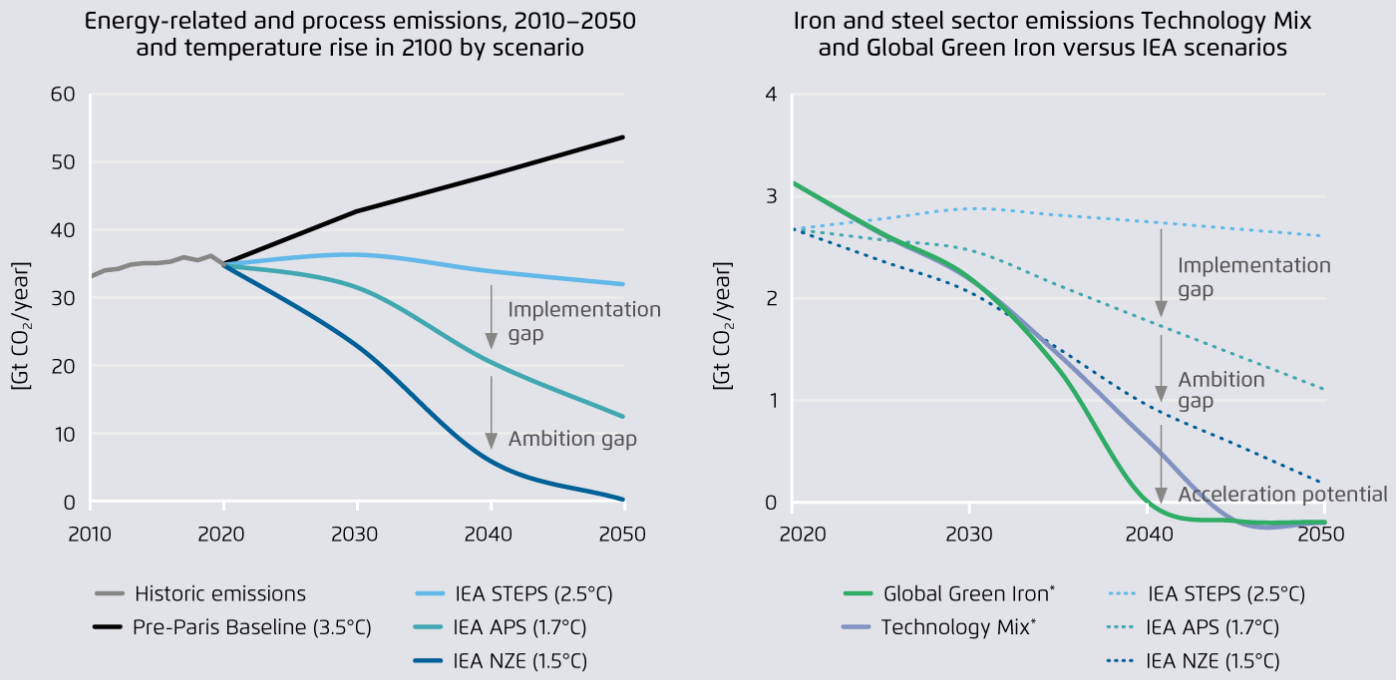
Pathways to net-zero: annual CO_2 emissions in the steel sector (left) and key metrics (right) Figure 1



Agora Industry and Wuppertal Institute (2023). Note: We did not model the Baseline scenario ourselves, but directly retrieved it from Mission Possible Partnership (MPP 2022). MPP's Baseline scenario covers scope 1 and scope 2 emissions. DRI = Direct reduced iron.

Insight 2: An accelerated steel transformation can be a key element to increase climate ambition

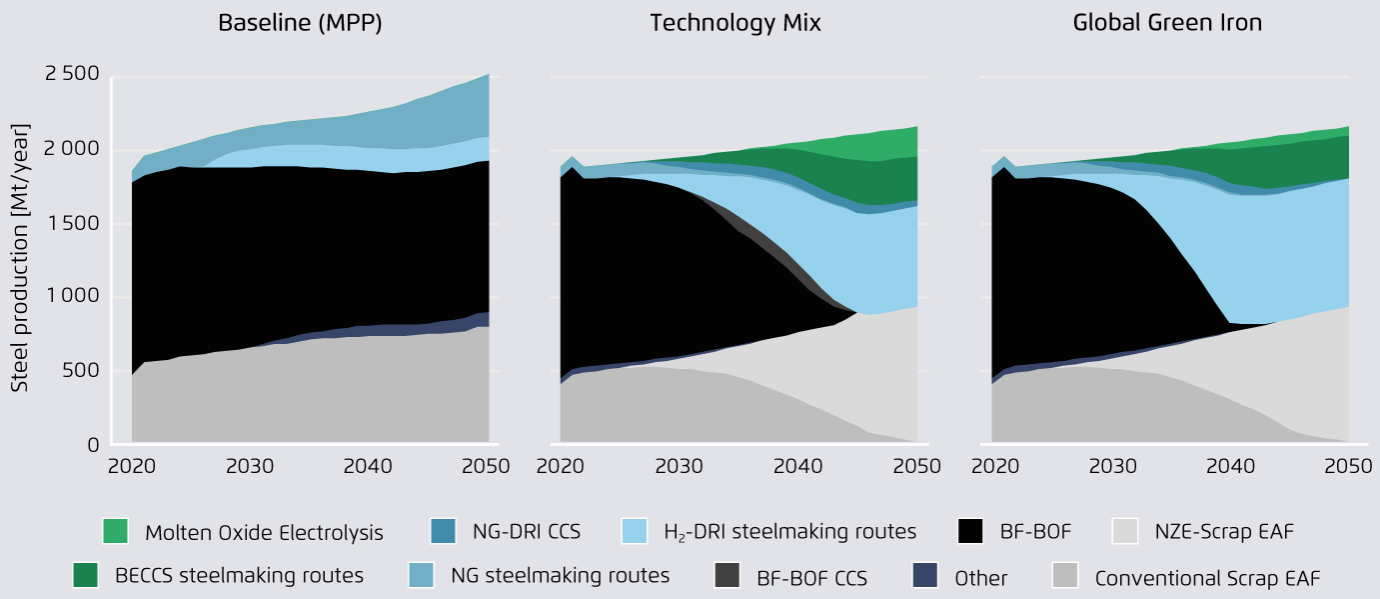
Scenario comparison: Global CO_2 emissions (left) and iron and steel sector emissions (right) Figure 3



Agora Industry and Wuppertal Institute (2023) based on IEA (2022a). Note: STEPS = Stated Policies; APS = Announced Pledges; NZE = Net-Zero Emissions. *CO_2 emissions from industrial power plants on integrated steel sites accounted for in steel CO_2 emissions instead of power sector.

Insight 3: The key levers enabling a 1.5°C compatible steel decarbonisation pathways are material efficiency, scrap- and H2-based steelmaking as well as BECCS

Scenario comparison: steel production per route (2020–2050) Figure 5

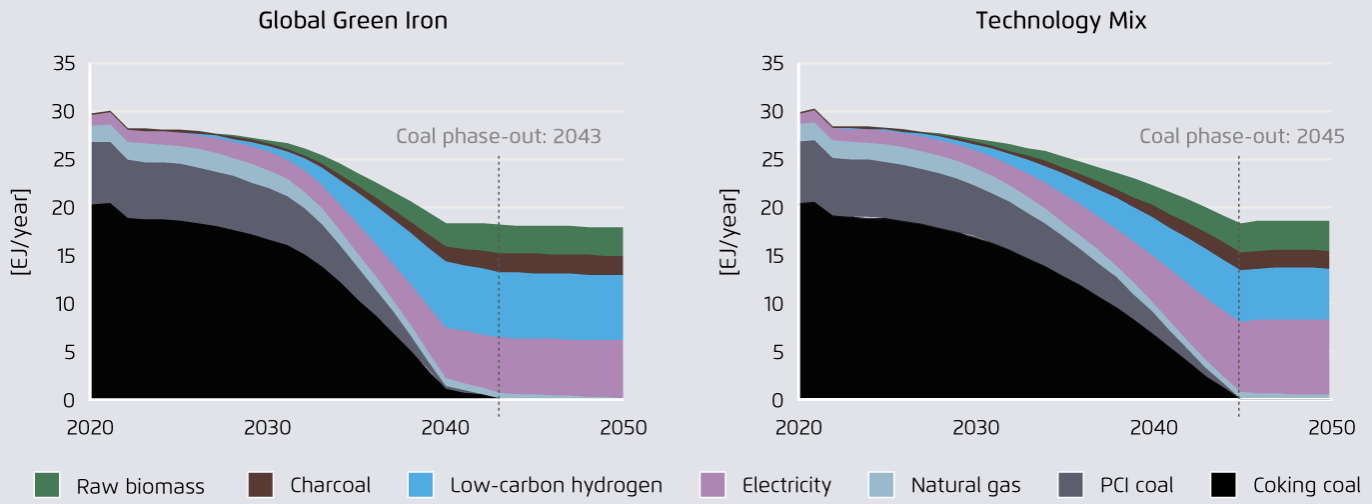


Agora Industry and Wuppertal Institute (2023), MPP (2022). NZE-scrap EAF stands for near-zero emissions scrap electric arc furnace which is defined as a scrap-EAF route with lower emissions than 0.01 tCO_2 per t of crude steel. NG = natural gas; BECCS = Bioenergy and carbon capture and storage.

Insight 4: A phase-out of coal in steelmaking by the early 2040s is technically feasible

Scenario comparison: Final energy demand

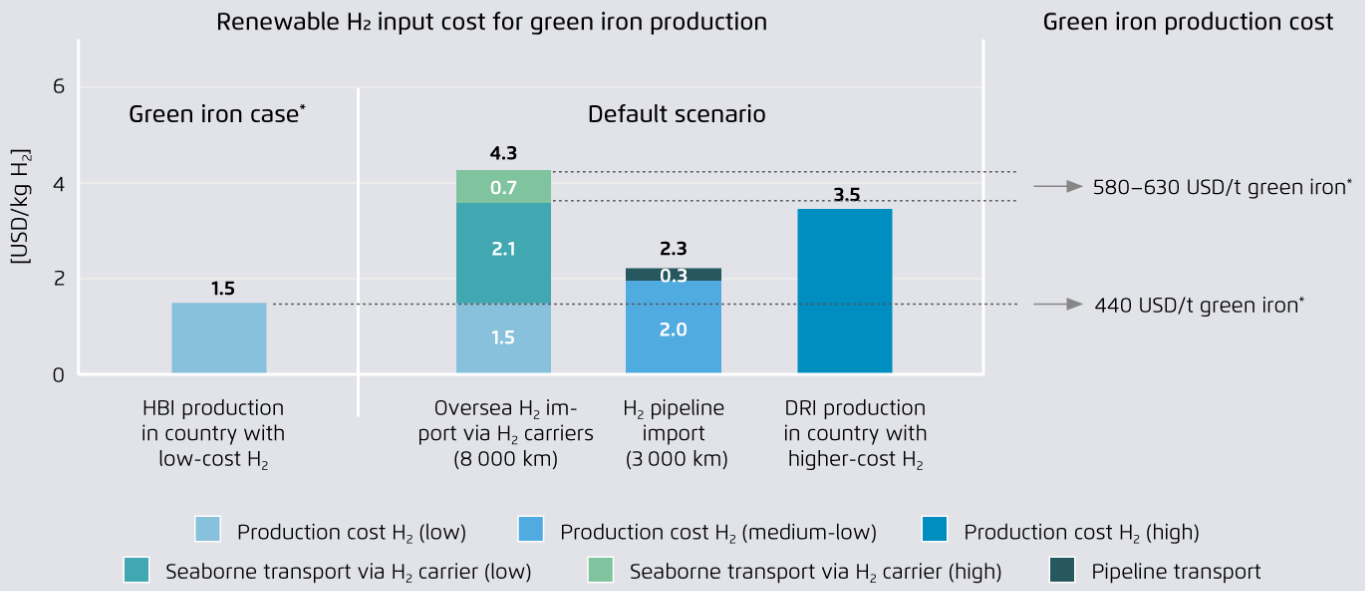
Figure 7



Agora Industry and Wuppertal Institute (2023). Note: Our modelling scope was limited to ironmaking and steelmaking. The energy demand from steel finishing is not included. PCI = pulverised coal injection.

Insight 5: International green iron trade can lower the costs of the global steel transformation

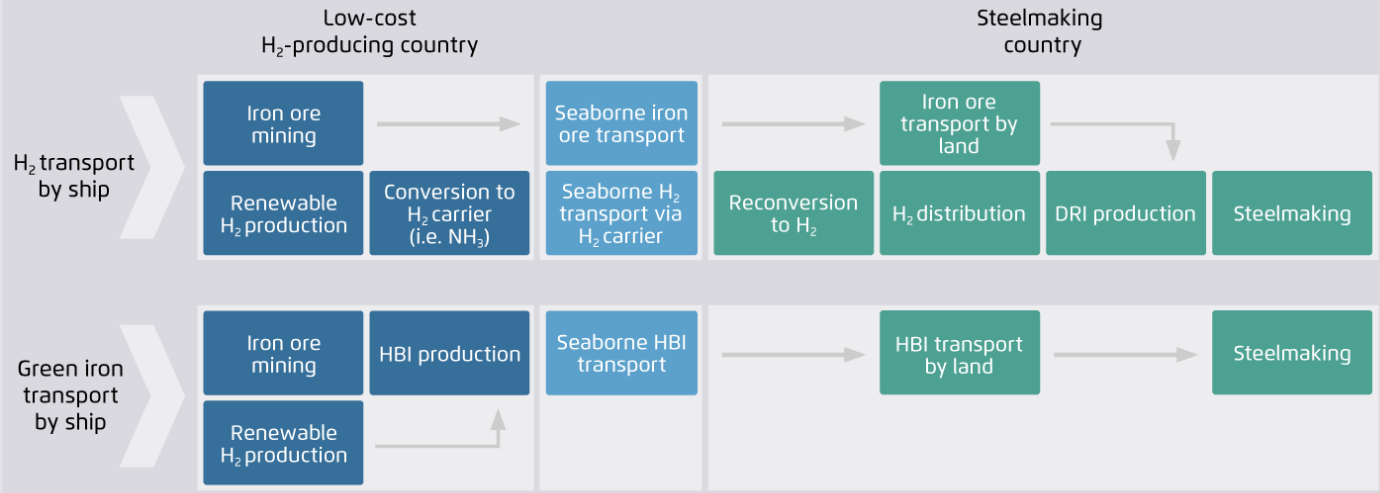
Impact of renewable H_2 input cost on green iron production cost 2030 under various scenarios — Figure 9



Agora Industry and Wuppertal Institute (2023), authors' analysis based on IEA (2022c). Note: Renewable H_2 production costs are derived from BNEF (2022a) and IEA ETP (2023) but are for illustration only. Actual assumptions in our modeling can deviate (see upcoming publication on key technologies for a net-zero steel industry). *According to IRENA (2022a), shipping costs of green iron could range from 15 to 50 USD/t. According to McKinsey (2022), shipping costs for green iron in the form of hot briquetted iron (HBI) are similar to those of iron ore pellets; reheating the HBI for use in steelmaking would require 100 to 150 kWh.

Importing green iron in the form of hot briquetted iron instead of ammonia will be more efficient and require significantly less new infrastructure

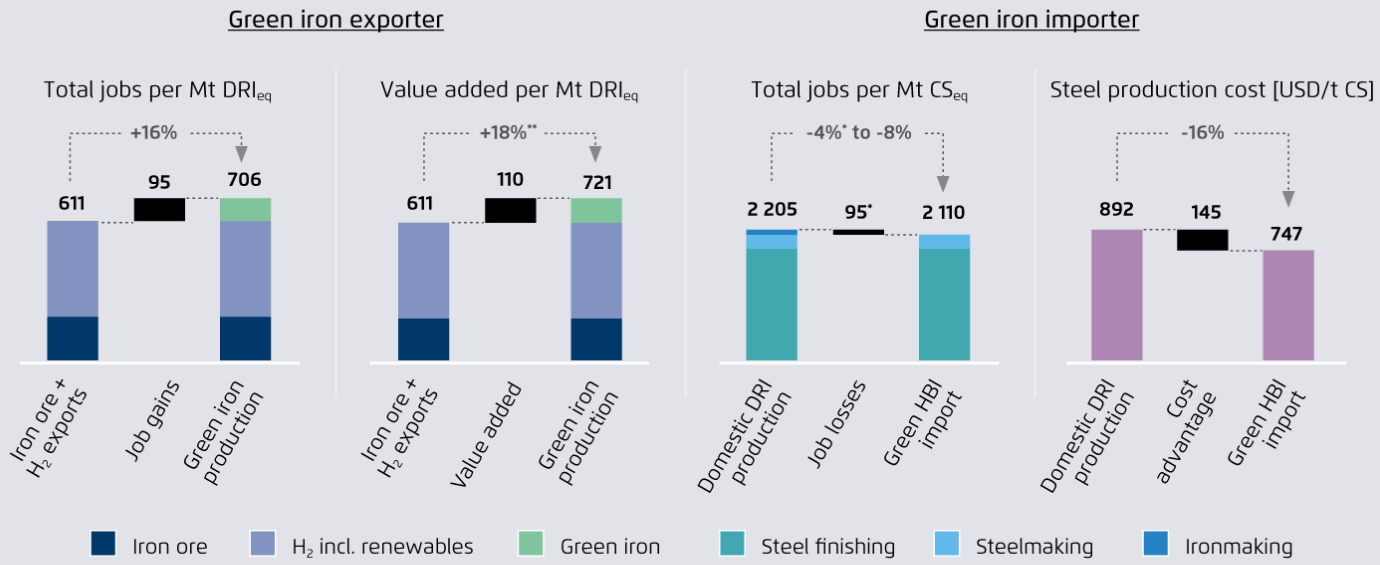
Comparison of two cross-country low-carbon steelmaking process chains — Figure 10



Agora Industry and Wuppertal Institute (2023). HBI = hot briquetted iron, DRI = direct reduced iron.

Insight 6: International green iron trade can be a win–win for importers and exporters

Green iron trade can be a win-win for importers and exporters — Figure 11



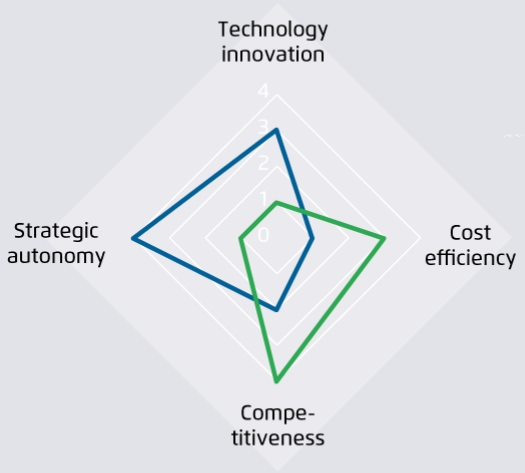
Agora Industry and Wuppertal Institute (2023). Note: The job intensity of steelmaking varies significantly across different countries. For our calculations we used a weighted average for iron ore mining jobs in the largest five iron ore exporting countries and assumed a job intensity of 8 full time equivalents for the production of 1000 t renewable H_2 per year and 53 kg H_2/per t of DRI. The numbers for green iron importers are derived from employment numbers in steelmaking from Germany. *The 4% share includes direct jobs in DRI ironmaking but does not include potentially associated jobs in administration and logistics. **Wages of jobs per Mt DRI_{eq} used as proxy + 2% depreciation rate of CAPEX. DRI = direct reduced iron; CS = crude steel

Unlocking the full speed and scale of the green steel transformation requires an international level playing field and strategic partnerships

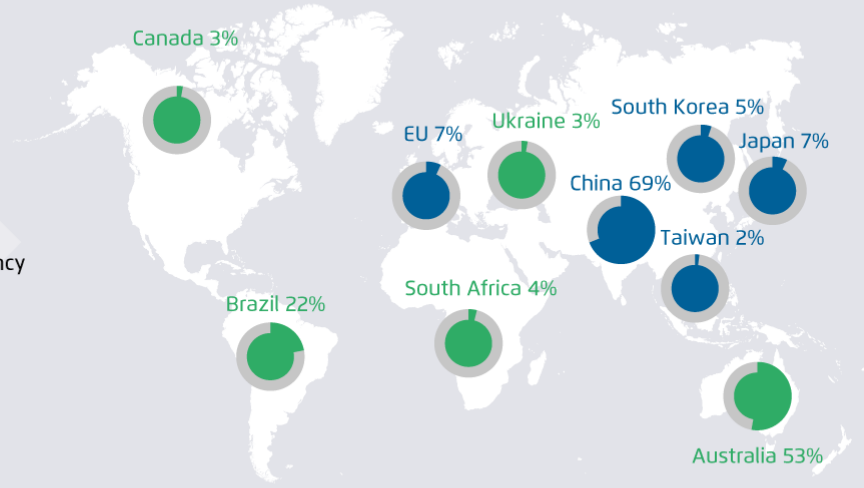
Green iron importers and exporters: due to potential market power risks diversified strategies will be key

Figure 12

Green iron importers: finding the right import share



Top 5 global iron ore exporters and importers, 2021

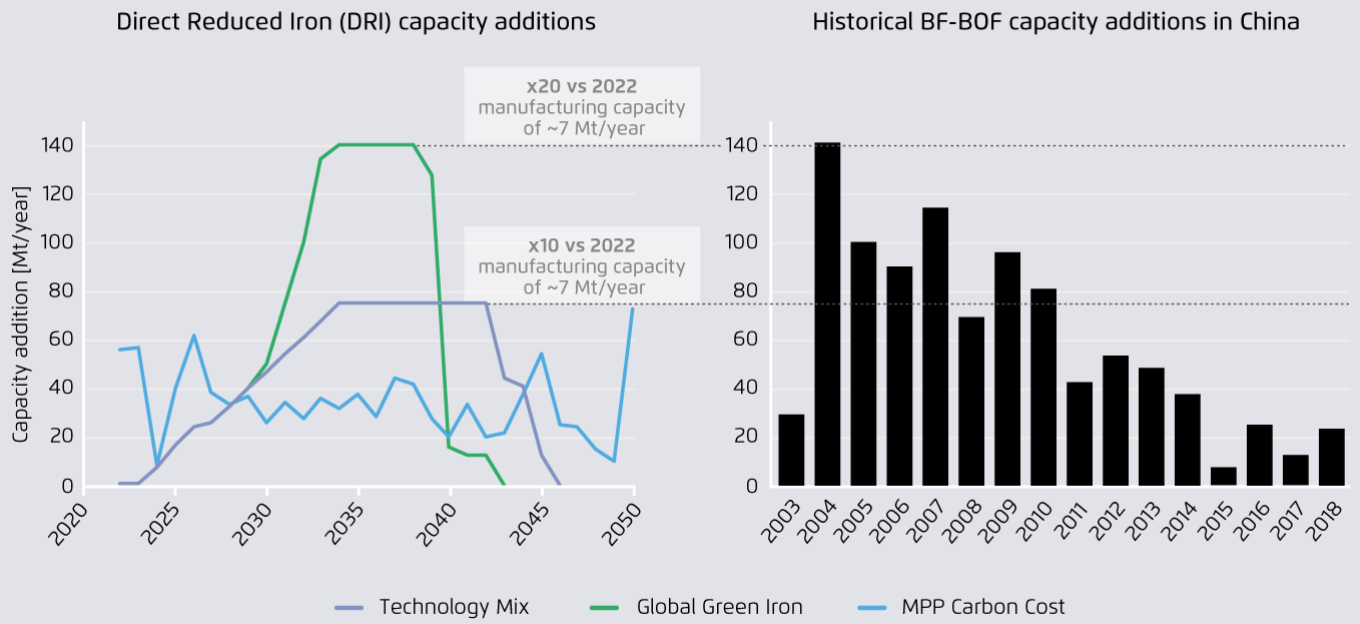


Focus: domestic production — Focus: imports — Top five exporters* — Top five importers*

Agora Industry and Wuppertal Institute (2023) illustration (left) and Australian government Resources and Energy Quarterly, 2022 (right). The examples in the spiderweb diagram are for illustration only. They assume that the production cost of green iron in countries with cheap and abundant renewables and the purchasing cost for green iron importers does not deviate too much, so that the cost advantage is to some extent passed on to allow for greater cost efficiency. This does not always have to be the case in reality. *% of world imports/exports in 2021 world trade data

Insight 7: DRI plant engineering and construction capacities are currently a major bottleneck and need to be massively scaled up as they will set the pace of the global steel transformation

A massive scale-up of DRI is necessary to accelerate the global steel transformation — Figure 13

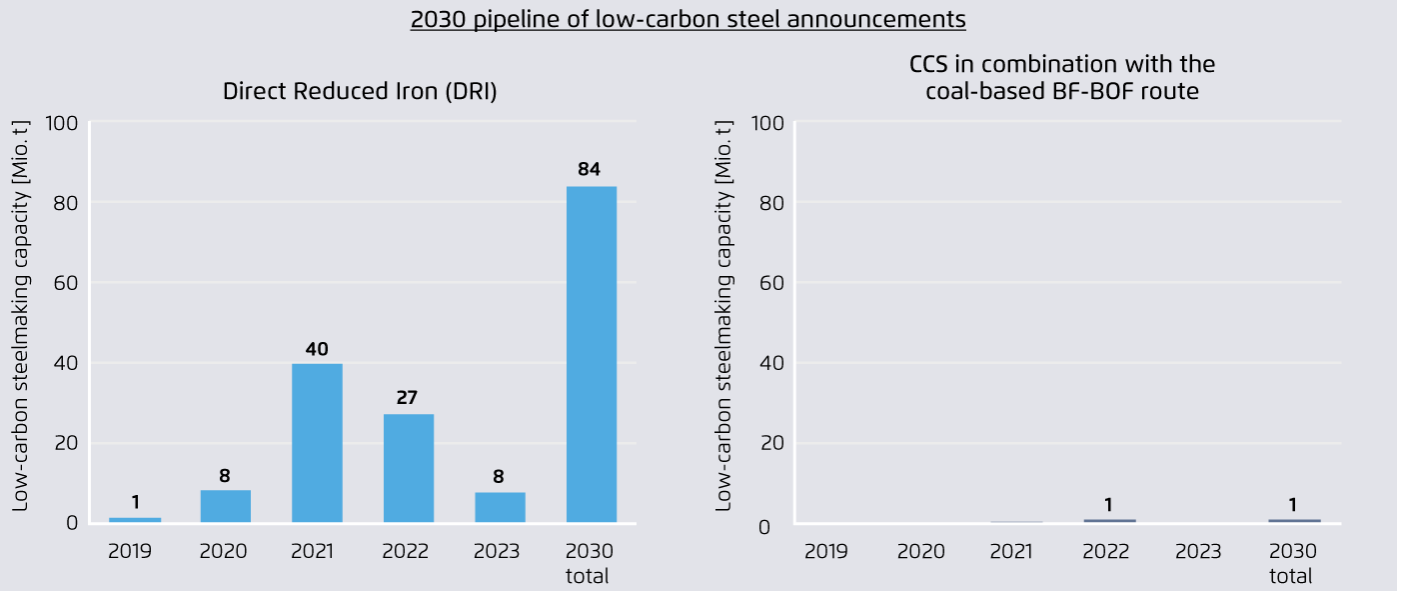


Agora Industry and Wuppertal Institute (2023) left; Vogl et al (2021) right. Note: MPP = Mission Possible Partnership's 1.5°C compatible Carbon Cost Scenario from September 2022; Technology Mix and Global Green Iron Scenario by Agora Industry and Wuppertal Institute (2023).

Insight 9: CCS on the BF-BOF route will not play an important role in the global steel transformation

Where the global steel industry is heading: 2030 pipeline of low-carbon steelmaking announcements

Figure 17



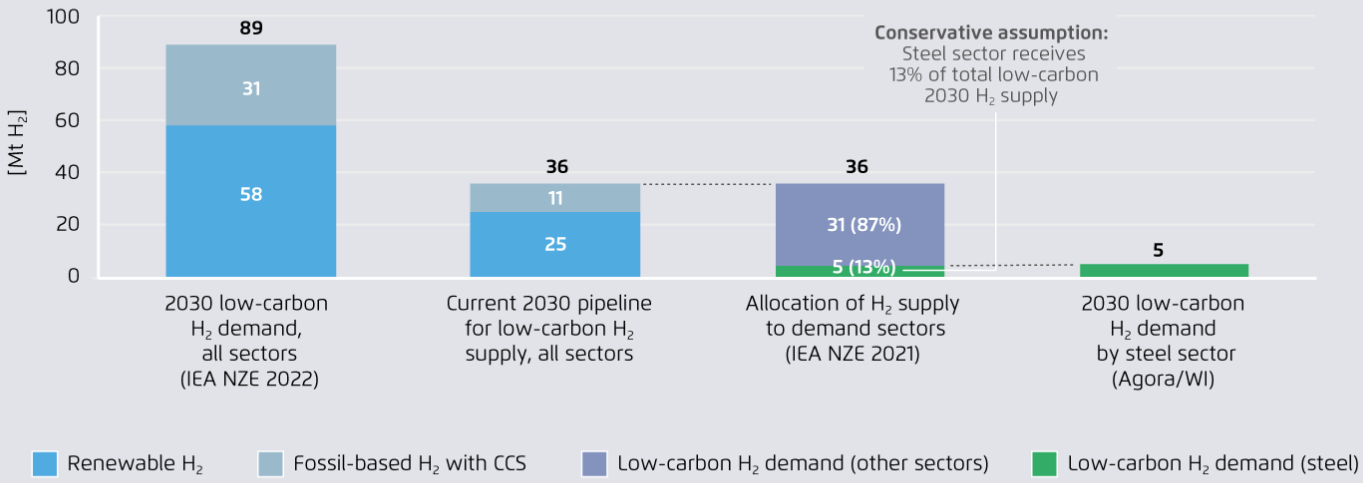
Agora Industry, Global Steel Transformation Tracker (2023). Note: The 2030 project pipeline of DRI plants includes H_2-ready DRI plants that may operate with natural gas initially. To date, the 3D project in Dunkirk is the only demonstration-scale CCS project on the BF-BOF route announced and aims to capture 1 $MtCO_2$ per year.

- → CCS leaves high residual emissions
- → It will be prone to disruptive technology developments by competing technologies
- → It cannot address upstream emissions which can become an additional business risk
- → It faces an offtake risk in green lead markets

Insight 12: Low-carbon H2 supply will likely not be a major bottleneck for the global steel transformation…

2030 low-carbon H_2 supply pipeline versus low-carbon H_2 demand from steel sector by 2030 in our scenarios

Figure 23

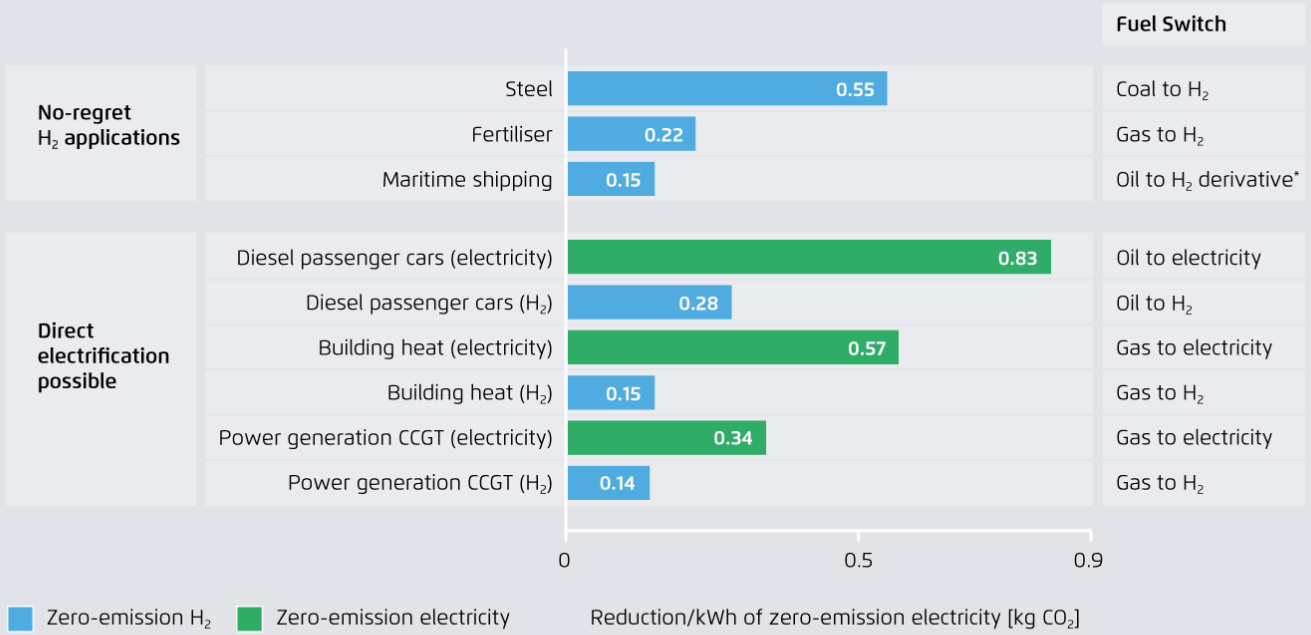


Agora Industry (2023) based on IEA (2021), IEA (2022a), IEA (2023) and BNEF (2022b). Note: H_2 allocation to steel compared to other sectors based on IEA NZE (2021). 2030 low-carbon H_2 demand from steel sector based on Technology Mix scenario.

… if the limited supply of low-carbon H_2 is channeled into no-regret applications

No-regret H_2 use: steel has the highest CO_2 mitigation potential compared to various other H_2 applications

Figure 24



Agora Industry and Wuppertal Institute (2023) based on concept developed by RMI (2022) and authors' calculations in Agora Energiewende (2023). Note: We assume 2.1 t CO_2/t of crude steel for a world average conventional BF-BOF plant and an electricity requirement of 3.84 MWh/t of crude steel for the DRI-EAF route that runs on 100% renewable H_2. *For maritime shipping based on RMI 2022, we assumed that ammonia replaces heavy fuel oil in a 39% efficient internal combustion engine. All other assumptions are retrieved from Agora Energiewende (2023).

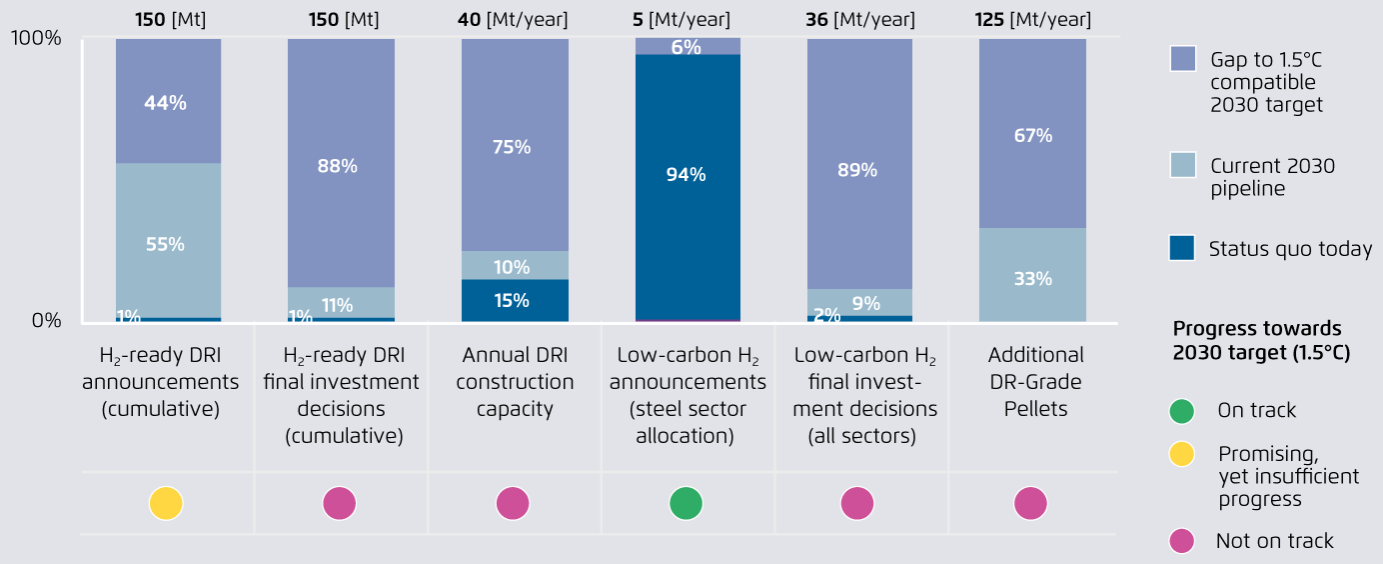
Insight 13: Availability of DR-grade ore is a potential bottleneck. Solutions exist, but they need to be actively pursued

How the bottleneck of DR-grade pellets can be addressed — Figure 25

Agora Industry and Wuppertal Institute (2023), based on MPP (2021). Note: DRI-SMELT-BOF = direct reduced iron – electric smelter – basic oxygen furnace; DRI-EAF = direct reduced iron – electric arc furnace. DR-grade pellets refers to direct reduction grade pellets, which are required for the DRI-EAF route, but not the DRI-SMELT-BOF route.

Insight 14: The bottlenecks for a 1.5°C compatible steel transformation pathway are manageable…

Key bottlenecks up to 2030: The state of play — Figure 27



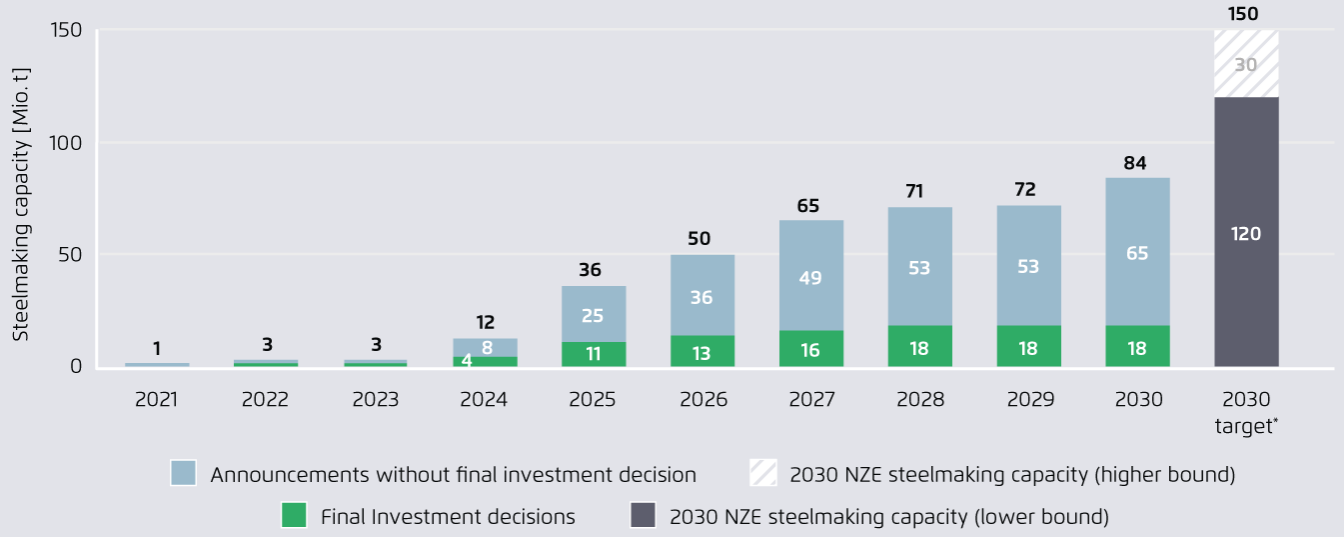
Agora Industry (2023), based on Agora Industry Global Steel Transformation Tracker (2023), IEA (2022a), IEA (2023), BNEF (2022b); IEEFA (2022a). Note: The target of 120 to 150 Mt H_2-ready DRI capacity is based on our modelling and the latest Breakthrough Agenda Report 2022 which called for "more than 100 Mt of near-zero emissions primary steel by 2030". The figure displays the upper range of the 2030 target numbers for H_2-ready DRI announcements (120 to 150 Mt) and additional DR-grade pellets (100 to 125 Mt). With regards to final investment decisions, status quo today refers to plants that have begun operations since 2021 and current 2030 pipeline refers to final investment decisions. Based on BNEF 2022b and IEA ETP 2023, we estimate the current low-carbon H_2 project pipeline to be 36 Mt by 2030. In our modelling scenarios the steel sector requires around 5 Mt low-carbon H_2 by 2030, which constitutes 13% of total low-carbon H_2 supply, if the entire current low-carbon H_2 project pipeline is realised.

…but joint action from governments *and* industry is needed

Insight 14: Currently, the share of final investment decisions for near-zero emission capable steelmaking capacity is still low

2030 pipeline: near-zero emissions primary steelmaking capacity announcements and final investment decisions

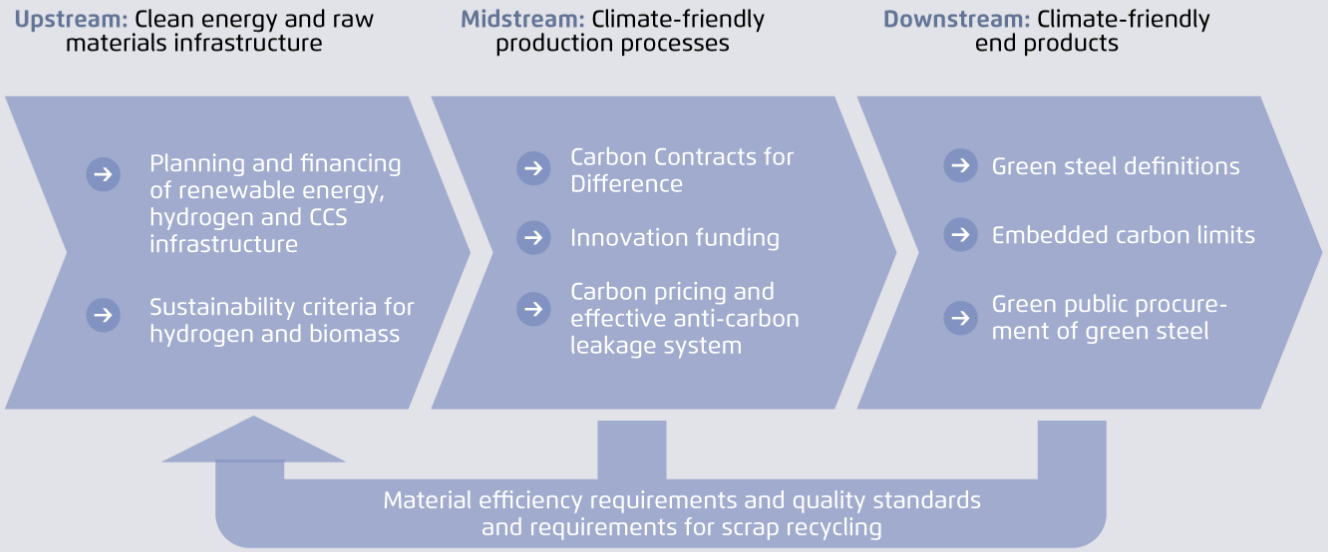
Figure 28



Agora Industry (2023), Global Steel Transformation Tracker (2023). Note: All announced projects can be H_2-ready DRI plants, in principle. However, to date only around 25% of the project pipeline is designed at outset to accommodate switch to renewable H_2. All other DRI plants will run on natural gas or a mix of natural gas and H_2 with the stated intention of most companies to switch to 100% low-carbon H_2 eventually, once it becomes available (see Agora Industry, Global Steel Transformation Tracker). *The 2030 targets refer to the near-zero emissions primary steelmaking capacity that would be needed to be on a 1.5°C compatible pathway based on IEA, IRENA, UN 2022 and authors' scenarios.

Insight 15: Achieving a net-zero steel sector will require governments to adopt a comprehensive policy framework that addresses the entire value chain. International coordination and cooperation will be key in this regard

A net-zero steel sector requires a comprehensive policy framework across the entire value chain Figure 29



Agora Industry (2023)

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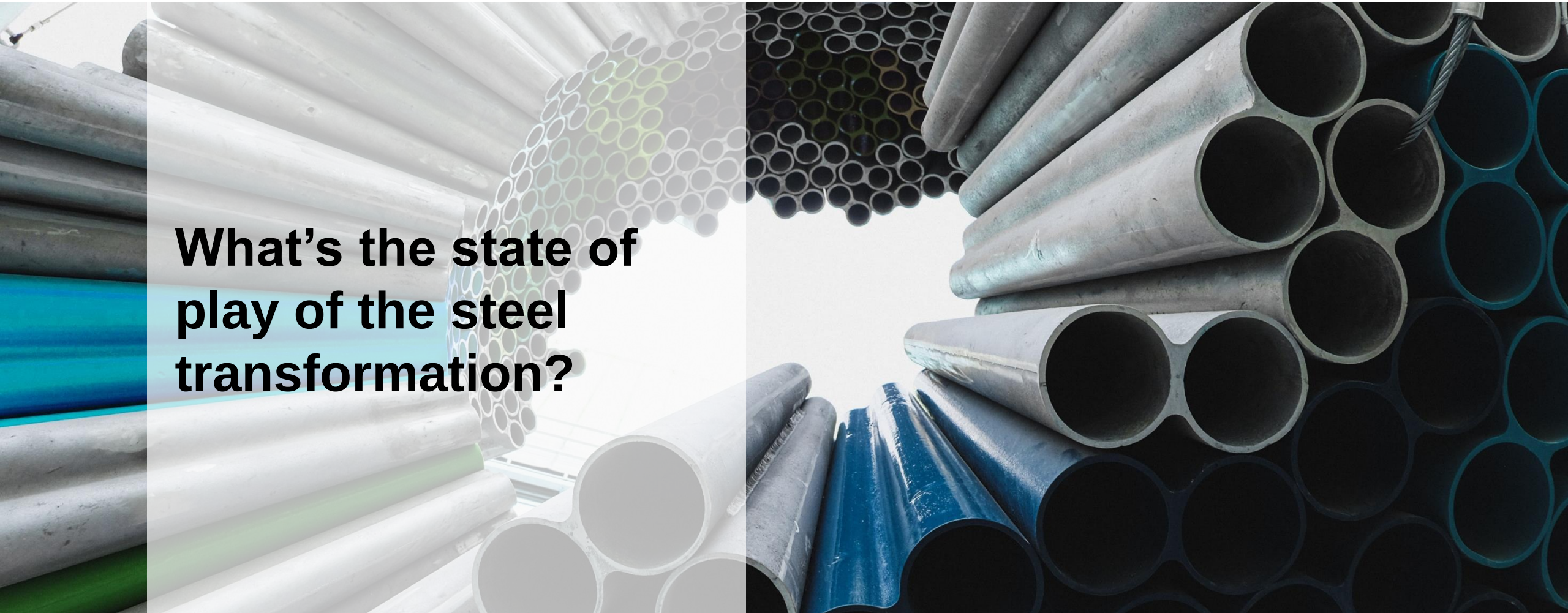

What's the state of play of the steel transformation?

EU: With the agreed EU ETS reform and CBAM, EU steelmakers are under pressure to decarbonise quickly. By 2034, they have to pay the full CO2 price

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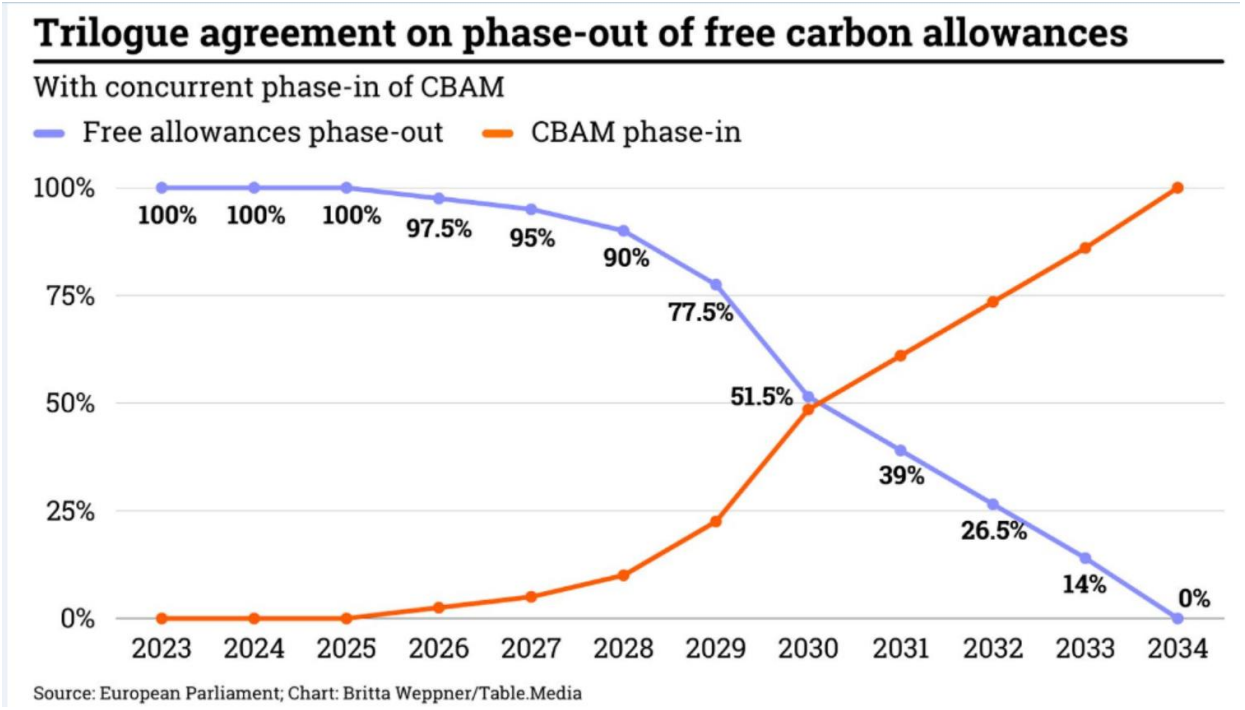
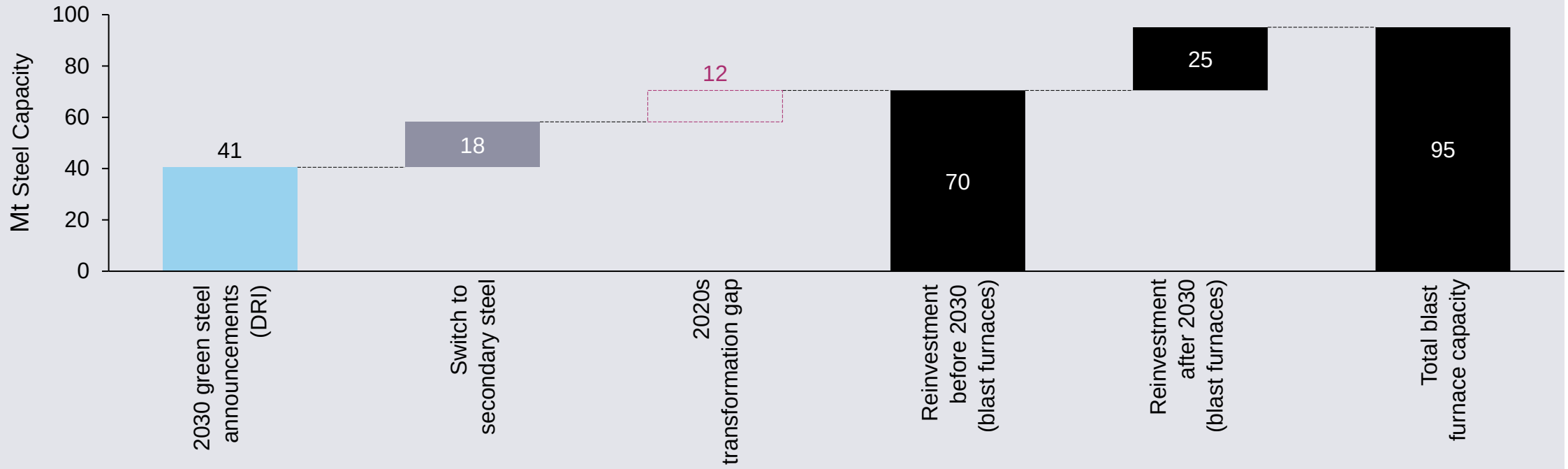
This year the EU ETS CO2 price surpassed 100€/t CO2

Free allocation of CO2 allowances will be phased out by 2034



EU steelmakers are ready to substitute blast furnaces with low-carbon technologies quickly. The first final investment decisions have been taken in 2023.

Announced low-carbon steelmaking projects and blast furnace reinvestment requirements in the EU



Agora Industry, Global Steel Transformation Tracker (July 2023)

The race towards green steel is becoming more global: this needs to be considered for the strategic planning of each country's steel transformation

Steel

ArcelorMittal South Africa Plan Green Steel at Shut Saldanha Plant

ArcelorMittal Saldanha Image Source – News 24

To Foster Eco-friendly Materials Business

POSCO Group to Invest US$40bn in Australia by 2040

By Jung Min-hee | December 2, 2022, 12:47

POSCO Group chairman Choi Jeong-woo (right) speaks at the opening ceremony of the 43rd meeting of the Korea-Australia Economic Cooperation Committee held in Sydney, Australia on Nov. 30.

Jindal Shadeed Group Plans $3 Billion Green Steel Plant in Oman

- Green hydrogen-ready plant output at 5 million tons a year
- New plant to cater to auto consumers in Middle East, Europe

Japan's Top Steelmaker Eyes $700 Million 'Green Steel' Project

- Nippon Steel to replace coal with hydrogen to cut emissions
- Australia or Brazil are possible sites for the new investment

China's Baosteel signs deal with Saudi Aramco, PIF to build 'green steel' plant as part of Belt and Road Initiative

- Baosteel will invest US$437.5 million for a 50 per cent stake in the proposed joint venture with Saudi Aramco and Public Investment Fund
- The partners aim to make project the world's 'most competitive low-carbon emission thick steel plates' plant

Nucor and ExxonMobil have entered into a carbon capture and storage agreement

Halina Yermolenko Читайте українською | Читайте на русском

ExxonMobil will capture, transport and store carbon from the DRI facility in Louisiana

Brazil's Vale to develop HBI hub in Middle East

Published date: 02 November 2022

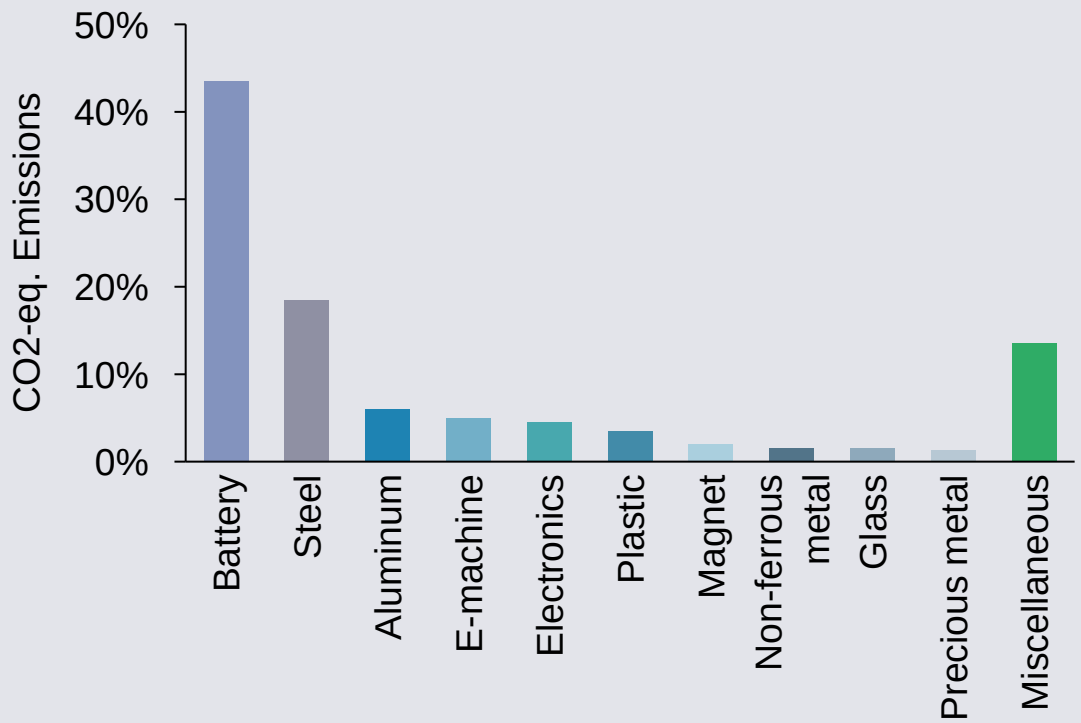
Many carmakers are at the forefront of demanding green steel in a push to decarbonise their supply chains - conventional steel is 2nd largest CO2 source after battery in EV supply chain…

Green lead market cooperation (vehicle manufacturers only)

Companies that have announced a cooperation to produce…	…and consume low-carbon steel	Start of cooperation
Nucor	General Motors	2022
SSAB	Volvo Group	2021
H2GreenSteel	Scania	2024
H2GreenSteel	Daimler Group	2025
Salzgitter Flachstahl GmbH	Daimler Group	2021
Big River Steel	Daimler Group	2020

Agora Industry, 2021

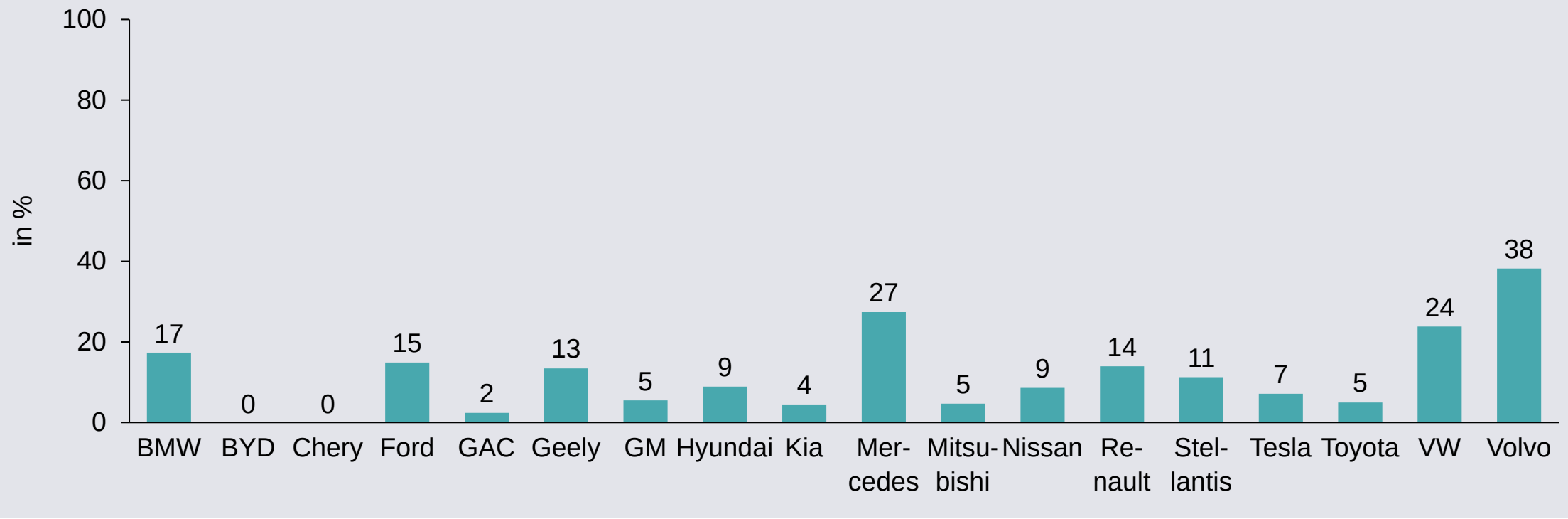
Life-cycle emissions battery-electric vehicles



Agora Industry based on Volkswagen ID3, 2021

… but to date carmakers across the globe have shown different levels of ambition in decarbonising their EV supply chain

Automakers in comparison: Fossil-free and environmentally sustainable supply chains score according to Lead the Charge (in % of 100)



Lead the Charge, 2023

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