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Decarbonization challenge for steel

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Steel production accounts for almost 10% of global CO_2 emissions. The article describes different strategies to face this issue with a particular focus on the use of H_2, showing the steps towards the decarbonization of the industry and highlighting the necessary conditions (technology- and cost-wise) and the implications.

RELEVANT ISSUES

Technology landscape for decarbonization in steel production

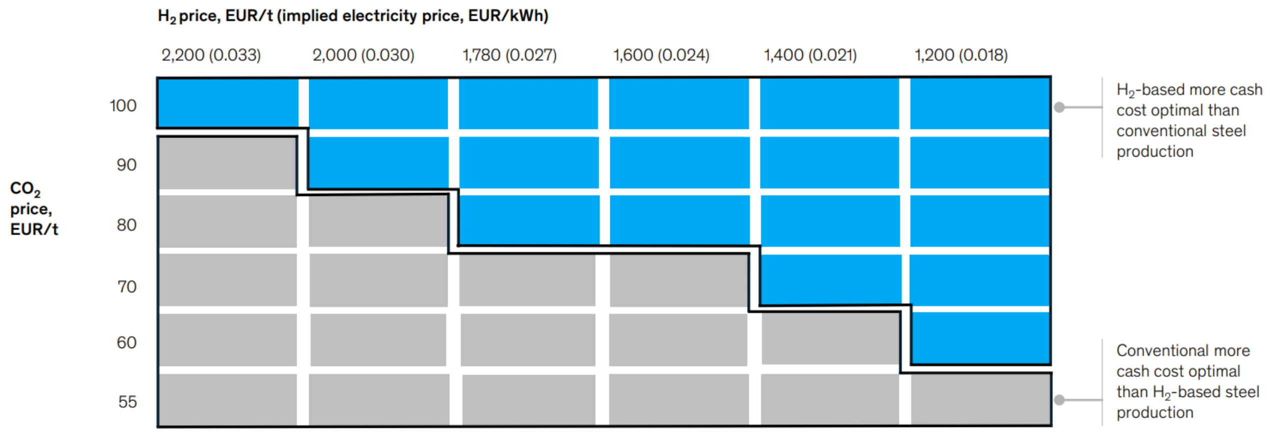
_ Steel can be produced via two main processes: either using an integrated BF/BOF or an EAF. [Current share is 72% BF/BOF and 28% EAF; only 6% of total production comes from DRI].
_ There are several decarbonization strategies:

Strategy	Examples	Current Outlook
BF/BOF efficiency programs	Maximize the iron content in raw materials to decrease the usage of coal as a reductant (DRI, scrap); Increase the use of fuel injection through PCI, natural gas, plastic, biomass or H_2; Use coke oven gas in the BF as an energy source.	Technology readily available at competitive cost
Biomass reductants	Use biomass (*e.g.* dried sugar, energy cane, etc.) as an alternative reductant or fuel.	Possible in South America and Russia, due to biomass availability
Carbon capture and usage	Use emissions to create new products for the chemical industry (*e.g.* bioethanol, etc.) or to store CO_2.	Not available on an industrial scale
Increased share of scrap-based EAFs	Shifting to EAF-based steel production requires the future supply of renewables to be commercially available, and supply of high quality steel scrap. [Electricity fluctuations in the power supply to be furtherly investigated].	Technology readily available at competitive cost
Optimize DRI/EAF	DRI-based reduction emits less CO_2 than the integrated method and enables the production of high-quality products in the EAF. DRI needs cheap natural gas. Some European steelmakers import HBI to use either in the BF or in the EAF	Technology readily available
DRI/EAF + H_2	Use H_2 as a reductant element in DRI and scrap in combination with EAFs (*e.g.* Tenova-HYL for Hybrit).	Technology available at high cost

Green Hydrogen-based steel production as a silver bullet?

_ H_2 can be used as an alternative injection material to PCI in BF, with up to 20% CO_2 emission reduction.
_ DRI/EAF route to be (nearly) carbon neutral involves: Green H_2 production; DRI production, where DR pellets (whose production is still not carbon-neutral) are reduced with H_2; Raw steel production using EAF that needs electricity from renewable sources to be carbon-neutral.
_ The biggest cost differences between “traditional” EAF process and H_2-based DRI are the generation of H_2 (then electricity costs for electrolysis) and running the EAF and caster on renewable energy.

_ The tipping point where green is more competitive than grey H_2 is forecasted in 2030. The decline in price for green H_2 is driven by falling costs for renewable electricity and electrolyzers, while grey H_2 will suffer increasing penalties for CO_2 emissions. The price outlook for blue H_2 is stable (to be investigated).
_ The average price of CO_2 in EU was 25€/ton in 2019. Germany will increase prices to 55-65€/ton after 2026. By 2050 CO_2 prices will be in the range of 100-150€/ton in Europe.



_ Further, the cost competitiveness assessment of H_2-based steel is only viable if the capex implications (depreciation) are excluded, as conventional steel production assets are largely written off. The extended use of scrap-based EAFs must accompany the transition to reduce investment needs and enable carbon-neutral steel production.

Potential path forward for steel players in Europe

_ There is a variety of interdependent factors that will determine when the decarbonization tipping points will occur in the steel industry:
  - Power supply: the total energy required to produce 2 Mt of H_2-based steel is about 8.8 TWh (the output from 300 to 1,100 wind turbines).
  - Hydrogen supply: Producing 2 Mt of H_2-based steel requires a green H_2 amount of 144,000 tons, then a capacity of 900 MWh (or nine of the world's largest planned electrolysis plant).
  - Raw material: changes are necessary and will especially increase demand for DR pellets.
  - Production technology: switching the natural gas-feeded DRI/EAF process to an entirely H_2-powered process is technically feasible, although the overall cost is still high.
  - Willingness to pay and regulation: a legislative intervention that takes the balance of benefits and extra cost must be taken into account, via measures such as carbon dioxide pricing and carbon border tax to avoid carbon leakage, and provision of start-up capital and subsidies for initial investments to compensate for the capex requirements of the technological shift.

_ The road map to carbon-neutral steel must combine long-term goals with actionable quick wins to allow for a gradual shift toward decarbonization that keeps all stakeholders on board.

FUN FACTS

_ Every ton of steel produced in 2018 emitted on average 1.85 tons of carbon dioxide, equating to about 8% of global CO_2 emissions.

GLOSSARY & CONVERSIONS

_ BF/BOF: integration of blast furnace and basic oxygen furnace.
_ DRI/EAF: direct reduced iron and electric arc furnace.
_ PCI: pulverized coal injection
_ HBI: Hot Briquetted Iron, a less reactive and therefore transportable form of DRI.