Steel's green makeover: swapping coal for gas and scrap

Steel firms are reshaping their future. The high cost of green hydrogen and the scalability challenges that come with it limit its potential as an alternative to coal in the near term. Shifting from coal to gas or recycling scrap to make steel are more cost-effective options but still present challenges and come with complex trade-offs

Shifting away from coal

The steel industry stands at a pivotal crossroads. With traditional coal-dependent production methods contributing significantly to global carbon emissions, industry leaders are actively exploring ways to reduce their carbon footprint.

In a previous article, we looked at various strategies to mitigate the CO_2 emissions stemming from this carbon-intensive procedure. We focused specifically on the capturing and storage of CO_2, a solution that integrates seamlessly with existing steelmaking methods. We also examined the use of green hydrogen in steel production, which could revolutionise the process by eliminating reliance on fossil fuel.

Many executives in the steel industry agree that hydrogen-based steelmaking is essential for a net zero economy. But they are cautious about its near-term viability due to the nascent state of the hydrogen market, particularly for green hydrogen. As a result, they are considering gas-based alternatives as a transitional solution towards the ultimate green hydrogen method.

For example, Geert van Poelvoorde, CEO of ArcelorMittal Europe, said to HydrogenInsight that it cannot operate its European plants using green hydrogen, despite being granted billions of euros in EU subsidies to install equipment to do so, because the resulting green steel would not be able to compete on international markets. Instead, the Luxembourg-based steelmaker appears to be intending to use fossil gas. While other steelmakers emphasise the future shift to green hydrogen, they are less outspoken about the fact that their transition plans heavily rely on natural gas for at least the next 10 to 15 years.

Moreover, the industry's transformation is driven not solely by concerns over carbon emissions and costs but also by the principles of a circular economy. In the UK, for example, both Tata Steel and British Steel plan to replace the last coal-based blast furnaces at Port Talbot and Scunthorpe with electric arc furnaces that solely melt scrap steel into new steel. This shift is further influenced by external entities, such as NGOs, advocating for a complete transition from carbon-intensive production of virgin steel to steel recycling.

Reflecting on the feedback we received from our previous article, we have now included data on gas-based steel production and recycling in our analysis. We find that both approaches can significantly reduce emissions relative to traditional coal-based methods without CO_2 capture and storage. They also present a more economically viable alternative to the costly green hydrogen approach. However, they are not without their own drawbacks, such as increased reliance on gas and lower steel quality.

75%

Reduction in emissions

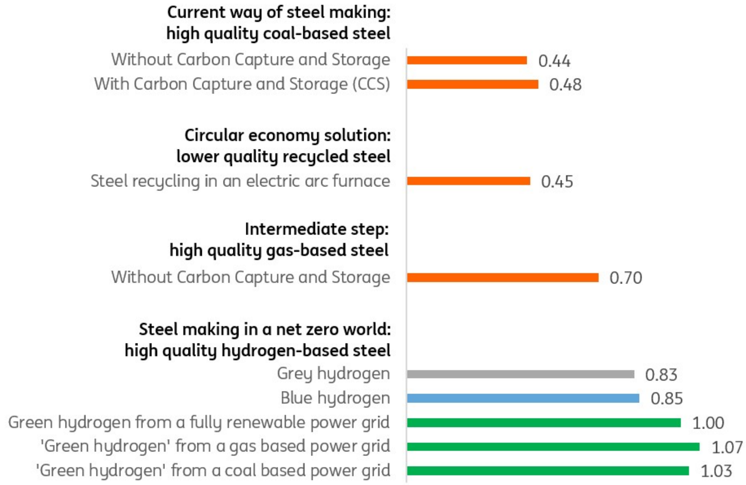
By transitioning from coal-powered steel plants to gas

Gas-based steelmaking could be an intermediary step, but comes with a geopolitical cost

Simplifying the technical jargon, both gas and hydrogen methods reduce iron ore to pure iron to manufacture various steel types in quite similar ways. Yet gas remains a more affordable option than green hydrogen. Currently, producing steel using gas is approximately 70 euro cents per kilogram in Europe, markedly less than the cost of over 1 euro for green hydrogen-based steel. While costlier than coal-based methods, gas-based steelmaking offers a narrower price differential and benefits from more established technology than its green hydrogen counterpart.

From a purely financial perspective, the shift from coal to scrap or natural gas is more cost-effective than hydrogen

Indicative unsubsidised and pre-tax cost of steel in €/kg for different steel production technologies



Source: ING Research

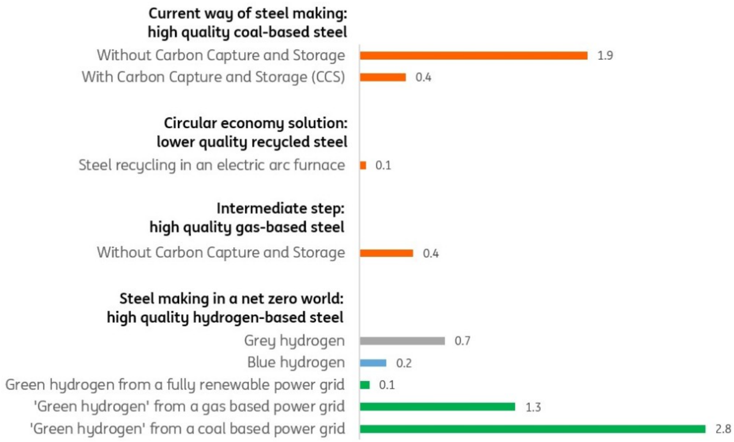
Costs are calculated from a European perspective and based on the following assumptions. Hydrogen costs are calculated based on a gas price of €35/MWh, a power price of €85/MWh for a gas-based grid (the benchmark), €76/MWh for the coal-based grid (-10%) and €68/MWh for the renewables-based grid (-20%). We use alkaline electrolysers with an efficiency of 70% and 95% runtime (capacity factor). This yields green hydrogen prices of roughly €4.80/kg, €4.30/kg and €3.90/kg respectively. Note that these production costs assume on-site hydrogen production and hence zero transportation costs. Transportation costs can double the hydrogen price for far away locations, escalating the steel price to €1.50/kg for the green hydrogen option. Furthermore, we've used a CO2 price of €70/ton and assume that all CO2 is taxed (no free allowances). Gas and carbon prices result in grey hydrogen costs of around €2.10/kg and blue hydrogen costs of €1.95/kg, again for on-site production. The coal and oil price are set at $120/ton and $85/barrel, the iron ore price at 110$/ton and steel scrap prices at 170$/ton. All dollar prices are converted to euros with an exchange rate of 1$=0.92€. We have applied a CCS capture rate of 85% for blue hydrogen and 80% for coal-based steel production in blast furnaces.

The economics and availability of natural gas compared to hydrogen support the industry's view that gas can serve as a transitional phase towards hydrogen-based steel production. The latest gas-based steel mills are often dual-fuel facilities capable of switching from gas to hydrogen—preferably green hydrogen—once it becomes widely available and economically viable, which experts anticipate could occur between 2035 and 2040.

Meanwhile, transitioning from coal-powered steel plants to gas-powered ones could cut emissions by an impressive 75%, from approximately 1.9 kilograms of CO_2 per kilogram of steel to around 0.4 kilograms, according to our models. While this shift from coal to gas is beneficial for the climate and supports Europe's move away from coal, it also increases the region's reliance on gas. A comprehensive move from the critical steel sector to gas highlights the complex trade-offs and challenging decisions inherent in reality, where one dependency (coal) is exchanged for another (gas). Green hydrogen ultimately provides the opportunity to decrease both dependencies.

A shift from coal to gas can significantly reduce emissions, while the adoption of entirely recycled steel provides CO2 advantages on par with those achieved by green hydrogen

Indicative emissions for different steel production technologies in kilogram CO_2 per kilogram steel



Source: ING Research

Indicative emissions to produce a kilogram of steel. We look at scope-1 and scope-2 emissions by steel producers only, so not the scope-3 emissions from the use of steel by companies or consumers. The CCS capture rate is assumed to be 80% for coal-based steel making and 85% to produce blue hydrogen. We have taken grid emissions from Sweden to resemble a fully renewables-based power grid (10 kgCO2/MWh), the Netherlands to resemble a gas-based power grid (325 kgCO2/MWh) and Poland to resemble a coal-based power grid (735 kgCO2/MWh). We assume that steel recycling happens in an electric arc furnace that is powered from a gas-based power grid, which implies that emissions can be lowered further if it entirely runs on low carbon sources like wind, solar, hydrogen or nuclear power. We show emissions per kilogram of steel so that numbers are comparable across production techniques and fuel types.

Steel recycling is cost-effective and environmentally friendly, but falls short for high-grade steel applications

Recycled steel offers a significant reduction in CO_2 emissions, with scrap steel melting processes potentially being powered by electricity, further reducing the carbon footprint. Emissions stand at around 0.1 kilogram CO_2 per kilogram of steel compared to 1.9 kilogram for coal-based steel. So steel recycling is already as green as hydrogen-based steel can be in the distant future when it is fully made with green hydrogen.

However, the presence of impurities in scrap steel, such as copper, zinc, and chrome, can compromise the material's integrity, leading to reduced strength. Consequently, while recycled steel is an excellent choice for rail track construction materials like concrete reinforcement, it is not yet suitable for high-demand uses like automobiles, aeroplanes, and precision machinery.

While the UK intends to close its remaining coal-based steel facilities and replace them with electric furnaces to produce steel entirely with scrap steel, this has not yet gained traction on the continent. Executives at European steel manufacturers outside the UK are cautious about modifying their product offerings to include steel of a lower quality, as the competition in those market segments is more intense. Product quality still provides them with a competitive advantage in the global market, even with Europe's higher energy prices. Yes, they do blend recycled steel into the current production process to the extent that quality is not compromised, sometimes up to levels of 30%. But they insist on making high quality steel from scratch, which requires the use of coal, gas or hydrogen.

Conclusion

Green hydrogen is often touted as the future of steel production, especially within a net-zero economy. Yet, its prohibitive cost and scalability issues currently hinder its ability to replace coal-based methods. Thankfully, a variety of transitional technologies are available to fill this void. An examination of the economics and business cases for these key technologies reveals encouraging news: they align with the societal objective of reducing emissions in the steel sector. However, the stark economic truth is that these technologies either incur substantially higher costs or necessitate a reduction in steel quality, challenges that are not easily surmounted. Consequently, steel industry leaders are faced with tough decisions that extend beyond mere economics and cost considerations. Government subsidies can steer these decisions, but considering the significant cost disparity and the years required for transformation, a long-term commitment is essential.

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