Direct Reduction for decarbonization: The New Age of HBI

Direct reduction based on natural gas or hydrogen offers considerable emission reduction potential, as compared with prevailing ironmaking processes based on coal. Decarbonization pressures will increase the demand for pig iron and HBI. HBI is the preferred merchant material for steelmaking, due to the avoidance of re-oxidation, its safe shipping possibilities and reduced fines generation. The steel industry is experiencing a new age of HBI. Production is concentrated in locations with low energy costs and high availability of raw materials, whilst shipping is possible with only limited precautions required.

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FUTURE PROOFING THE STEEL INDUSTRY

As the reality of carbon neutrality as a global trend unfolds and pressures of net zero carbon initiatives increase, it is evident that, despite these developments, the global economy cannot do without the versatile material of steel. In its *Iron and Steel Technology Roadmap*, published in 2020 the International Energy Agency (IEA) projected global steel demand to rise by 10% by 2050, noting how deeply engrained steel is in our society, from construction to infrastructure and transportation **[1]**. The report also pointed out that many technologies for the net zero energy transition rely heavily on steel, such as wind turbines, solar panels and carbon capture and storage. In their most recent *Iron and Steel Tracking* publication from November 2021, the IEA reported that steel demand has increased by 3% per year, with only a slight drop of 0.9% in 2020 **[2]**.

This projected increase in demand, coupled with rising pressure to reduce carbon emissions, requires the industry to search for efficient, adaptable, low-carbon solutions on the path to net zero emissions by 2050. As these projections confront the status quo of the iron and steel industry, several aspects of future proofing strategies have emerged: decreasing integrated steel production (using the blast furnace and basic oxygen furnace), increasing electric steelmaking (using the electric arc furnace – EAF) and increasing scrap usage. The use of direct reduction, for both direct reduced iron (DRI) and especially hot briquetted iron (HBI), is also set to increase.

REDUCED CARBON EMISSIONS AND A FLEXIBLE PRODUCT

As the steel industry moves toward carbon neutrality in response to increasing pressures to decarbonize, the application of DRI and HBI will see immediate benefits for steel producers. HBI is an exceptionally flexible product. Taking the place of traditional pig iron for primary steel production, HBI can supplement lower-grade scrap to produce higher-grade steel products. The supplementation of HBI for lower-grade scrap dilutes the metallic impurities often found in scrap-based steelmaking and can even, for example, allow for the production of flat products, which have historically been exclusively offered by integrated steel works, using virgin materials.

HBI has also made a name for itself beyond its ability to reduce carbon emissions and its versatile applications, namely in its ability to be shipped far and wide. Re-oxidation is not an issue for HBI. This means that regions rich in raw materials with low energy costs can readily produce HBI and ship this valuable material to steelmaking facilities worldwide. However, some countries have begun establishing barriers to compensate for carbon emissions through carbon pricing on selected imports, such as the E.U.'s Carbon Border Adjustment Mechanism to tackle climate change **[3]**. Thankfully, since natural gas-based HBI has a significantly lower carbon footprint than traditional blast furnace based hot metal, these new trade regulations should not impact HBI as a global commodity. Moreover, carbon pricing schemes coupled with carbon border taxes will only make merchant DRI more competitive worldwide.

The global growth of annual DRI output already reflects the future competitiveness and impact of these developments. In 2019, DRI production hit a record 108.1Mt, 7.3% more than the previous year. Most of this increase was in India, Iran and Algeria. In 2021, DRI production reached 119.2Mt, up by 10.2% from 2019 **[4]**. The growth of output in India, the world leader in DRI production, was due to productivity growth in coal-based rotary kilns. The gains posted by Iran and Algeria all came from the newly installed capacities of natural gas-based MIDREX plants. In Algeria specifically, DRI production bounced back in 2021, with Tosyali Algerie setting a record for DRI production at 2.28Mt **[5]**. According to estimates in its 'Sustainable Development Scenario', the IEA projects

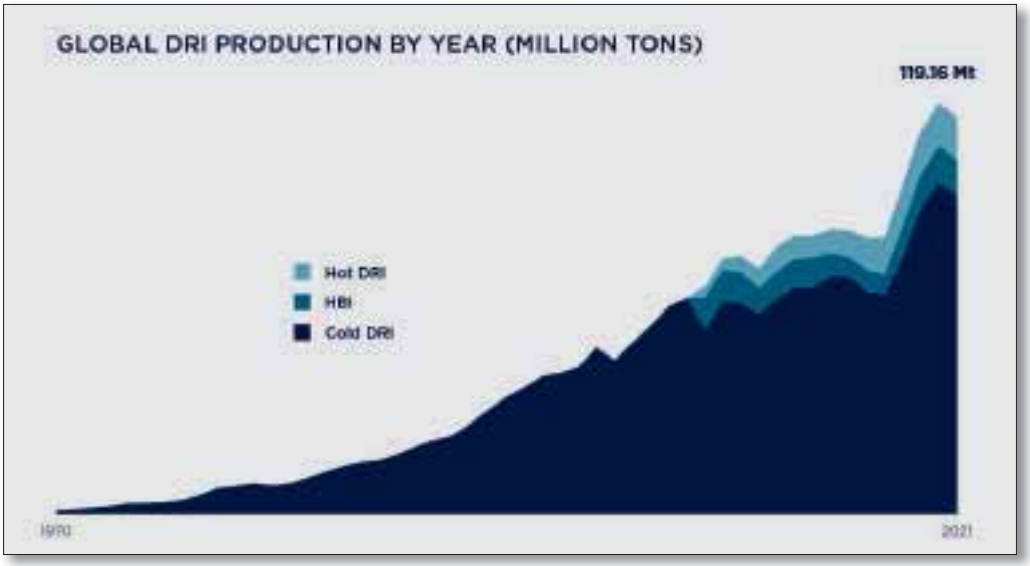

Fig 1 **DRI and HBI production (*World Direct Reduction Statistics*, Midrex Technologies 2021)**

Fig 2 **Geographical spread of DRI production (*World Direct Reduction Statistics*, Midrex Technologies 2021)**

the market for commercial DRI to continue its growth from 115Mtpa in 2019 to 157.3Mtpa 2030. At the same time, the IEA expects that gas-based DRI will account for 8% of steel production by 2030 **[6]**. Growth in DRI and HBI production from 1970 to 2021 is shown in *Figure 1*.

REGIONAL PRODUCTION FOR GLOBAL ADVANTAGE

To fully harness the potential of DRI, it will take production increases that only an entire fleet of new HBI plants can handle. New HBI plants must be situated in areas with access to iron ore and natural gas, or hydrogen. Regions such as Canada, Sweden, and Western Australia, with vast ore deposits and a high potential for renewable energy, seem to be exceptionally well-placed in this regard. Regional policymakers and industry leaders have identified this potential and acted accordingly. Primetals Technologies has also recognized this potential and joined the Heavy Industry Low-Carbon Transition Cooperative Research Centre (HILT CRC), established by the Australian Government, to explore the tremendous opportunities in this field **[7]**. The geographical spread of DRI production is shown in *Figure 2*.

Meanwhile, the U.S.A. and China are two countries ▷

Fig 3 **Corpus Christi HBI plant**

that stand out for different reasons in the race toward carbon neutrality and HBI capacity. These countries have significant EAF steelmaking capabilities, but little HBI capacity. Although there are now two HBI plants in the U.S.A., China has no HBI plants, despite investing heavily in its EAF capacity over recent years. Additionally, China has announced a 2060 net zero target. As the largest steel producer globally, China will not meet its goal solely by relying on scrap, which is already in short supply. Instead, investment and expansion in electric steelmaking requires an increase in merchant HBI capacity.

Some steel producers in regions with high energy costs, such as in Europe, are increasingly looking for new solutions to improve cost efficiency. For example, in 2016, Austrian steel producer voestalpine began operating a HBI plant near Corpus Christi, Texas, with a plan to export the HBI back to Austria (*Figure 3*). By signing off-take agreements with HBI producers or even building their own HBI plants in areas with lower energy prices and transporting the HBI for use in their domestic operations, these producers have found solutions to meet current demands. Despite initially smaller scale increases in HBI production in 2021, including Cleveland Cliffs' HBI plant in Toledo, Ohio, the demand for HBI will undoubtedly multiply over the coming decades. Thus, current production capacities will struggle to meet the growing demand.

HYDROGEN-READY: A KEY PART OF THE FUTURE

While global growth in HBI production is undoubtably on the horizon, producers looking to increase capacity run the risk of increasing their carbon emissions. However, as renewable technologies expand in adoption worldwide and alternative energy sources contribute to an expanding hydrogen economy, HBI has one key advantage, namely, the possibility for future hydrogen-based production. According to the IEA's projections, fully hydrogen based DRI will account for 3.9Mt of global production by 2030, and 212.6MT by 2050.

Based on these projections, hydrogen-based DRI and smelter reduction, coupled with carbon capture and storage, will continue to grow until they dominate ironmaking by the 2070s **[8]**. The IEA's projections are not just theoretical dreams but reflect an international trend toward low-CO_2 HBI and DRI systems that are hydrogen-ready today. A breakdown of iron production by various technologies is shown in *Figure 3*.

As carbon pricing and other regulatory measures impact ironmaking, the reality of competitive hydrogen-based production on the global marketplace may be closer than we assume. Access to, or at least a long-term perspective for, low-carbon, or green hydrogen from renewable energy, will be decisive for industry leaders. While carbon neutrality

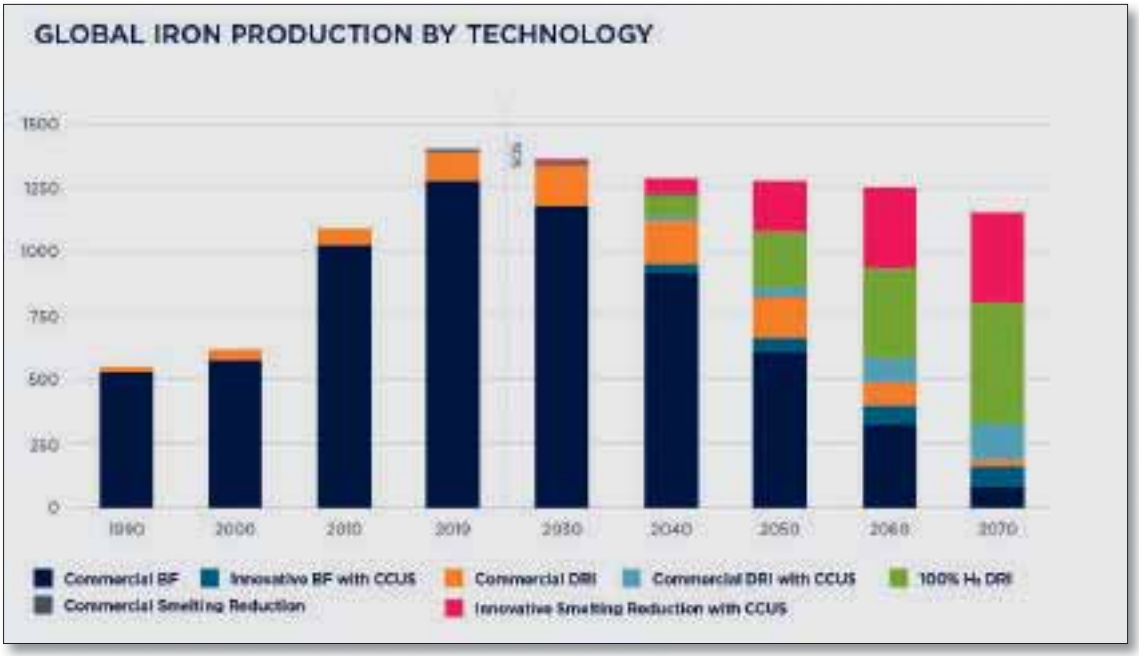

Fig 4 Global iron production by technology in the Sustainable Development Scenario (SDS) from 2020 onward according to the IEA

and hydrogen technologies become more than mere talking points, some analysts now expect the price of hydrogen to drop much sooner than anticipated. Additionally, increased production capacities for green hydrogen from electrolysis, using electricity to obtain hydrogen from water with renewable energy, and turquoise hydrogen from pyrolysis, using natural gas to yield both hydrogen and black carbon and producing fewer carbon emissions, will drive down the cost of hydrogen-based production.

THE FUTURE OF THE INDUSTRY AND THE NEW AGE OF HBI

With an eye toward the future, Midrex Technologies and Primetals Technologies can produce high-quality HBI with the most environmentally friendly technology for ore-based ironmaking. The natural gas based MIDREX direct reduction process releases 50% fewer carbon emissions than blast furnace ironmaking. Combine this technology with green hydrogen and smelting and there is potential to decrease carbon emissions even further.

The realities of climate change alongside net zero initiatives worldwide will continue to pressure the steel industry to transition to low-carbon steel production sooner rather than later. With regional limitations based on natural resources and energy costs, the ability of steel producers to transition without a global perspective is limited. Seeing the potential of an easily transportable product, such as HBI, Primetals Technologies realizes the potential of DRI for emissions reduction in the steel industry.

The MIDREX Direct Reduction Process combined with hydrogen and smelting technologies means steel producers can act early and economically to transform their production processes to meet future demands.

Increased carbon prices will make fossil fuel-based production more costly, while the growing hydrogen economy and investment in renewable clean energy worldwide will shift the focus to electric steelmaking.

These production routes demand more than 'design scrap' to meet the requirements for ever-increasing demand and essential steel grades, some of which are vital to other industries, including expansions in e-mobility and the energy sector. To meet these demands, HBI is available as a viable, market-ready raw material. With the development of renewable energy infrastructures, combined with ironmaking technologies that anticipate low carbon and carbon neutral iron and steel production, Primetals Technologies, alongside Midrex Technologies and partners, are paving the way for the new age of HBI. MS

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