MIDREX

DIRECT FROM MIDREX

2ND QUARTER 2022

Direct Reduction Iron Company Ltd.

DRIC Module 1 sets new annual production record

COMMENTARY

LONGEVITY, PERFORMANCE, AND RELIABILITY: **Hallmarks of MIDREX® Plants**

By Chris Hayes
Vice President – Operations

All you have to do is look at the MIDREX® Direct Reduction Plant owned and operated by ArcelorMittal Hamburg to see an example of all three of these superlatives. The plant was started up in 1971, as one of the first based on the MIDREX Process, and today it has a key role in ArcelorMittal's project to use hydrogen on an industrial scale to produce DRI for its steel production process. Throughout its 51 years, the Hamburg plant has experienced many rides on the steel industry roller coaster, as the global demand for steel responded to fluctuations in economics trends. But whether asked to produce at well over its original design capacity or in a turndown mode, the plant always maintained the high quality of its DRI and its operating efficiencies. The same can be said for most of the other 90+ MIDREX Modules located throughout the world.

Over the years, Midrex has remained focused and committed to the principles on which it was founded:

- Designs must be simple, flexible, and reliable.
- Innovations and improvements must be responsive to client needs.
- Interactive information flow is essential for technology to remain relevant.
- People must be empowered to take ownership of ideas and produce sustainable results.

The Midrex business model is built on the concept of renewable technology – a self-sustaining cycle that blends science, engineering, and commercial expertise with real-world experience to identify business opportunities and transform them into sustainable solutions. A key element is the two-way technology transfer program between Midrex and its customers, in which design improvements and operational expertise are shared throughout the operating life of a plant.

Since the original protype production plant was started up in 1969, Midrex engineers have added to the body of technology with enhancements and upgrades to furnace capacities, reductant and fuel sources, heat recovery, and utilities consumption by working closely with with existing plant operators and engineering partners. As a result:

- Single module plants have increased in capacity from 150,000 metric tons per year (t/y) to 2.5 million t/y.
- Plant designs have been implemented for cold DRI (CDRI), hot DRI (HDRI), and hot briquetted iron (HBI), and any combination of DRI forms on-demand from a single module.
- Various methods for transporting HDRI to a melting furnace to suit any steel mill configuration have been installed.
- Reductant options including 100% natural gas, partial natural gas replacement by hydrogen, and 100% hydrogen are available.
- Widest range of ironbearing materials in either pelletized or natural-occuring lump form can be processed.

Midrex is taking a leading role in the decarbonization of the global steel industry with the backing of our owner and partner, Kobe Steel Ltd (KSL). We are combining the direct reduction technology of Midrex with the blast furnace operation expertise and know-how of KSL to demonstrate an enhanced method of BF operation.

The success of Midrex is founded on the results achieved by plants operating with MIDREX Technology. For this reason, we are dedicated to providing our customer with the most cost-efficient plant designs, based on the most reliable and best-proven technology, supported by highly experienced personnel providing the broadest suite of plant services.

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In addition to an article that summarizes the operation and achievements of MIDREX Plants in 2021, this issue of *Direct From Midrex* includes insights into the Iron Ore Challenges facing direct reduction on the road to carbon-neutral steelmaking by Chris Barrington of International Iron Metallics Association (IIMA). In addition, News & Views contains noteworthy industry-related events occurring during this quarter.

The Iron Ore Challenge for Direct Reduction On Road to Carbon-Neutral Steelmaking

By CHRIS BARRINGTON, *Chief Advisor, International Iron Metallics Association (IIMA)*

INTRODUCTION

To quote Clare Broadbent, Head of Sustainability at worldsteel: "Steel is in the spotlight today, as we're classified as one of the 'hard-to-abate' sectors. It's a really exciting time for the industry. We've never had so much attention before, nor as many people wanting to help the industry reach the targets we're setting for ourselves to become a low-carbon, or carbon neutral industry."

Various pathways to decarbonisation of the steelmaking process are taking shape across the global industry; the ultimate, long-term goal being a transition from the integrated blast furnace/basic oxygen furnace (BF/BOF) route to electric arc furnace (EAF) steelmaking. Much has been written by many on the numerous factors involved in the choice of strategy, and it is not the intention here to repeat what has already been well documented.

What is significant is that decarbonisation represents an enormous opportunity for the direct reduction sector right across its value chain, be it as EAF feedstock, enabling the steel circular economy through dilution of harmful residual metallic impurities in steel scrap, or as BF burden feedstock, enabling reduced CO_2 emissions. However, the opportunity presented by the sheer scale of the transition is not without its challenges, and one of these – the future supply of high-grade iron ore – is the focus of this article.

THE OPPORTUNITY

Work by the International Energy Agency (IEA) provides useful context for this article. IEA's publication, "Energy Technology Perspectives 2020" includes the chart shown as *Figure 1* in its chapter on steel.

Figure 2 shows the direct reduced iron (DRI) data from *Figure 1* per IEA's Sustainable Development Scenario. Production of commercial or conventional DRI maintains positive growth out to 2040, but then starts to fall away with the growth of hydrogen-based DRI and conventional DRI coupled with Carbon Capture, Utilisation, and Storage (CCUS). The total of 411 million tonnes (mt) predicted for 2050 compares with the 108 mt produced in 2019, an increase of 280%.

A more conservative view was presented in October 2020 by World Steel Dynamics (WSD). Its "Global steel production outlook to 2050" estimated DRI production in 2050 at 272 mt.

THE IRON ORE CHALLENGE

Figure 3 (see next page) shows a comparison of the IEA and WSD views and the related iron ore demand of between 400 and 600 mt by 2050, compared to about 160 mt in 2019. From the quantitative perspective, iron ore supply should not be an issue, with BF iron production falling from just under 1.3 billion tonnes in 2019 to 665 mt by 2050 per IEA's SDS *(see Figure 1)*. This is equivalent to about 2 billion tonnes and 1 billion tonnes iron ore, respectively.

The incremental iron ore demand of about 440 mt from increased DRI production could be met, assuming adequate replacement of depleted reserves. However, from the qualitative perspective, there is a potentially serious problem. This is the iron ore challenge!

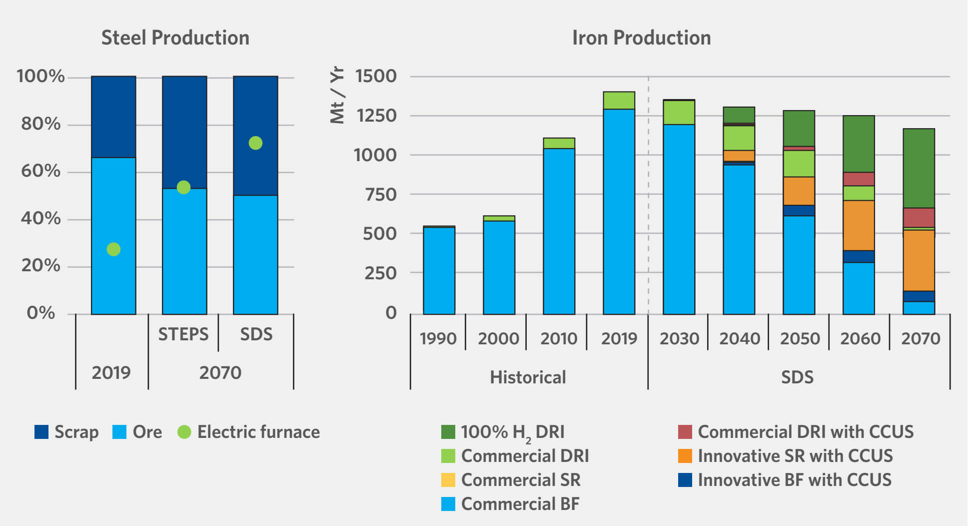


FIGURE 1. *Global Steel Production by route and iron production by technology in the Sustainable Development Scenario (SDS)*

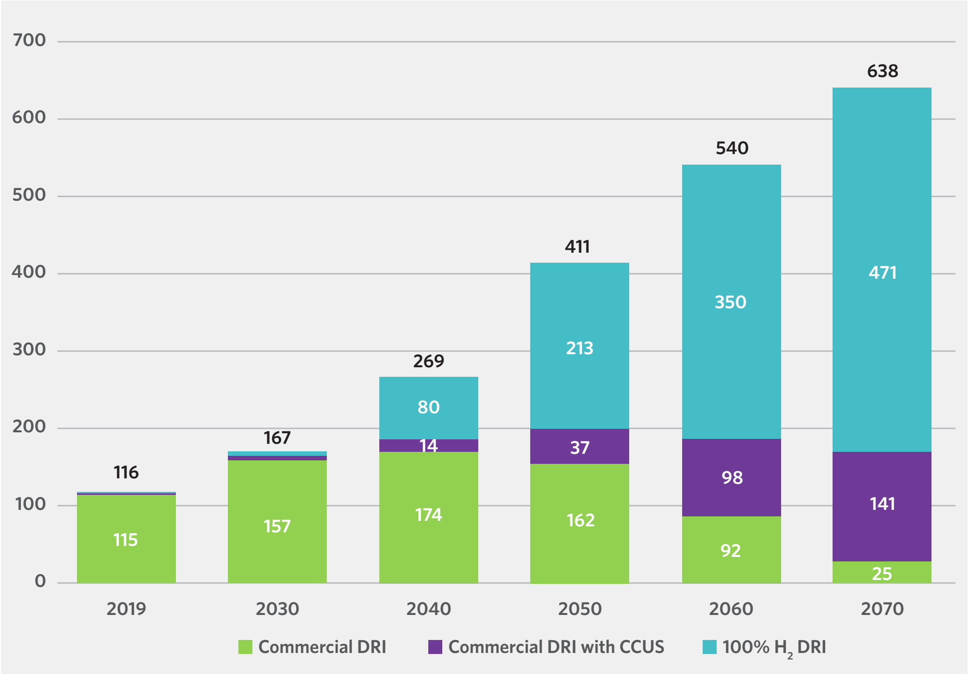


FIGURE 2. *DRI Production by technology in the Sustainable Development Scenario (mt)*

IRON ORE QUALITY

The quality requirements of iron ore for direct reduction are well known and will not be detailed here, but are in essence:

- Fe content as high as possible: minimum 66%, ideally >67%
- acid gangue (SiO_2 + Al_2O_3) content as low as possible: ≤3.5%, ideally, maximum 2%

• Phosphorus (as P_2O_5) as low as possible: ideally ≤0.015% but maximum up to 0.08%, depending on the final steel product

Iron ore quality has deteriorated progressively over the last 20 years or so. Data from Raw Materials & Ironmaking Global Consulting indicate that the average Fe content of a representative group of sinter feed ores fell from 63.9% in 1998 to 61.9% in 2019, while average SiO_2 + Al_2O_3 content increased from 5.11% to 7.08 % and phosphorus content increased from 0.048% to 0.067% over the same period.

Conversely, the quality of seaborne iron ore pellet feed and concentrates over the same period has remained rather constant, as has the quality of seaborne DR grade pellets, although in some cases this masks the need for additional beneficiation and concentration of the source ore in order to maintain grade. The proportion of high-grade iron ore with >67% Fe is relatively small, as shown in *Figure 4*.

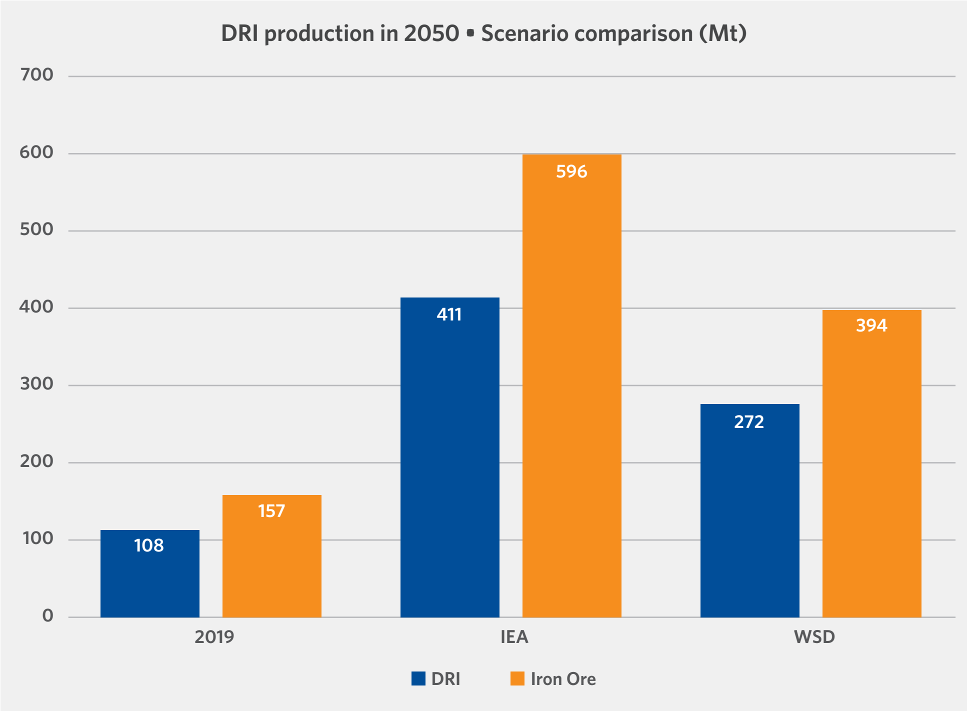


FIGURE 3. *DRI production in 2050*

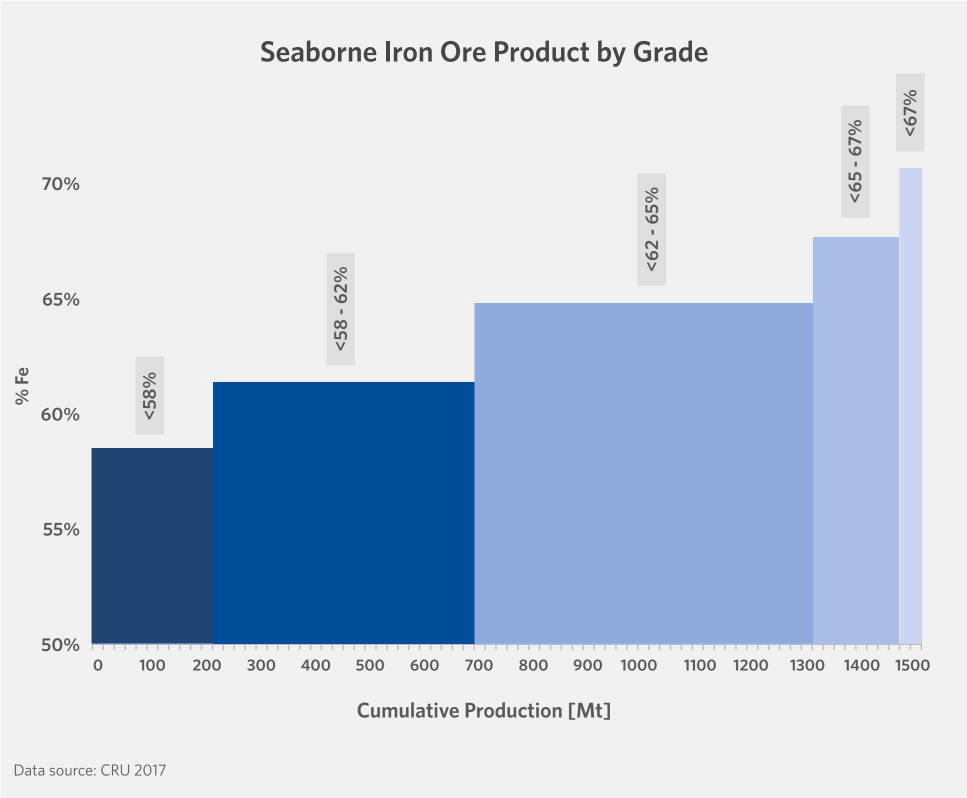


FIGURE 4. *Seaborne iron ore product by grade*

Figure 5 shows the share of DR production by process in 2019 from which it is clear that shaft furnace processes are by far the most significant, the principal feedstock ore being pellets.

DR GRADE PELLETS – SUPPLY-DEMAND BALANCE

IIMA's analysis of demand for pellets by DR plants based on purchased ore, both existing plants and selected new projects, indicates that there should be an adequate supply by the middle of the current decade, despite the current tightness of the market. However, complacency should not be an option, as free supply capacity could quickly disappear if more new projects with short lead times are announced. Also remember that pellet producers have the option to supply the BF and sinter feed markets if demand and margins are more attractive. It is also clear that the current situation in Ukraine could lead to a sustained reduction in supply of DR-grade pellets.

The picture changes as we approach the early 2030s, by which time most of the new DR projects so far announced will be in production. IIMA's analysis suggests a significant shortfall in DR-grade pellet supply, as the capacity of the existing pellet producers: Vale, Samarco, Iron of Company of Canada IOC), ArcelorMittal Mines Canada, LKAB, and Bahrain Steel becomes fully utilised. IIMA's view is that by 2030, all Russian and Ukrainian DR grade pellets will be fully utilised in their respective domestic markets.

Looking to the longer term, with global demand for DRI reaching 411 mt by 2050 according to the IEA sustainable development scenario, the challenge is significantly greater, with potential pellet demand exceeding 2019 global pellet production of 463 mt, of which almost 40% was in China and India.

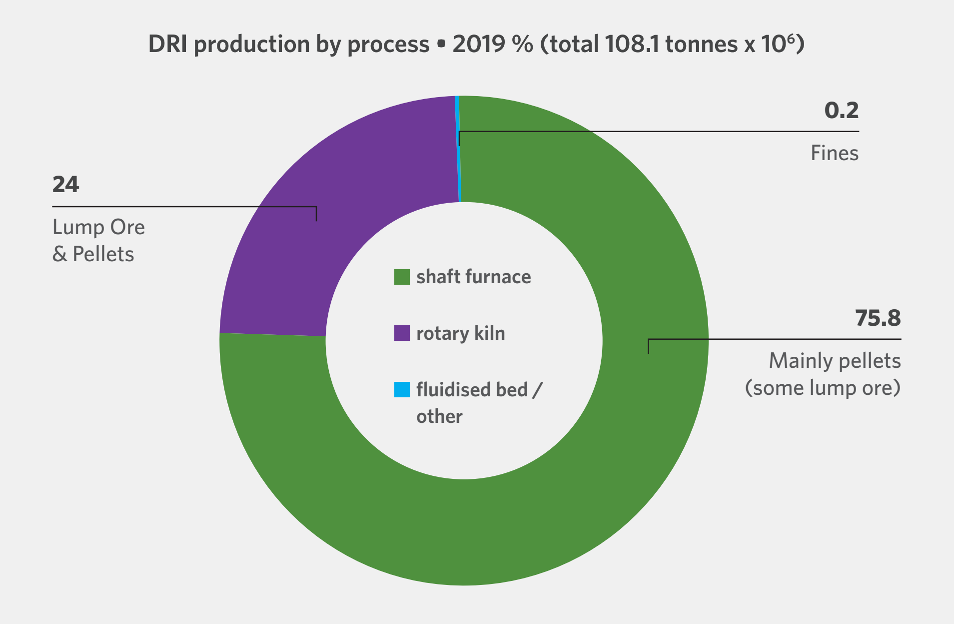


FIGURE 5. *Share of DR production processes in 2019*

SOLUTIONS TO THE CHALLENGE

It is abundantly clear that the challenge is by now well recognised along the iron ore and steel value chain, with a variety of co-operation agreements in place between the major iron ore producers and their customers to explore solutions to the challenges of decarbonisation. The issue of DR-grade iron ore is also on the agenda of the World Steel Association's Raw Materials Committee. IIMA doesn't pretend to have all the answers but offers the following thoughts.

Short-to-Medium Term (out to the late 2020s)

Increased production from existing suppliers such as Samarco will add to the supply. As the available supply becomes committed, the simplest answer is increased use of lower grade pellets as DR feedstock. However, the result is lower grade DRI. Lower grade DRI/HBI is problematical from the EAF perspective with significant value-in-use demerits, but not so where the more flexible BF is concerned.

Scope for increased use of lump ore is limited by the availability of suitable material, with Kumba's high grade Sishen lump being the principal internationally traded material. There is the potential for production of a DR-grade lump product by Baffinland Iron Mines in the far north of Canada, but this is dependent on the company obtaining approval for its expansion project.

Introduction of an electric smelting step between the DR plant and the steel shop is a technology already offered by several suppliers and plant builders. For example, thyssenkrupp Steel plans to produce "electric hot metal" by smelting DRI prior to charging it to its BOF converters. Such technology

offers a possible longer-term solution for the Pilbara iron ore producers in Western Australia, whose ore is difficult and costly to beneficiate to DR quality.

As the transition from BF/BOF to DR/EAF takes effect, some pellet producers out of necessity shift supply from the BF to the DR sector. Some already have upgraded their beneficiation plants to enable production of DR-grade pellets, notably in the CIS countries. However, given existing and planned DR projects in the CIS, it seems likely that by the late 2020s all or most CIS-produced DR feedstock will be consumed domestically, with the exception of pellets from Ukrainian producer Ferrexpo, which is well-located to supply European DR plants.

Both Canadian pellet producers, IOC and ArcelorMittal Canada, have plans to increase supply to the DR sector. ArcelorMittal recently announced plans to upgrade 100% of its 10 mt pellet capacity at Port Cartier to DR-grade.

Vale's cold-bonded briquette product offers significant potential, but its suitability as DR feedstock has yet to be demonstrated. Vale has three briquette plants already under construction in Brazil and has the eventual goal of 50 mt briquettes, including a plant in Oman.

LKAB merits mention. It has announced its longer-term strategy of transitioning from a supplier of pellets to a supplier of HBI, with six DR plants planned from the late 2020s to the mid-2040s, three each at Malmberget and Kiruna. This would mean progressive withdrawal of about 7 mt DR-grade pellets from the international market. Part of the HBI would be destined for SSAB's steel plants in Luleå and Raahe (LKAB is a partner, together with SSAB, in the HYBRIT project, which aims at fossil-free steel production).

Longer-Term

More pelletising capacity will be required, both brownfield and greenfield. There are a few failed pellet projects with DR quality capability which could be revived; for example, New Millennium Iron's LabMag and KeMag projects in eastern Canada, Mesabi Metallics' project in Nashwauk MN, and various joint venture projects in Mauritania. Other projects doubtlessly will emerge.

The model adopted by Tosyali Algerie of installing a pelletising plant alongside its DR plant is one that should be considered by prospective producers of DRI. SULB/Bahrain Steel is a similar example. Tata Steel's planned DR plant at IJmuiden in the Netherlands will utilise pellets from the existing on-site pelletising plant. The concept of captive pellet supply can of course manifest itself in other ways, such as joint ventures with iron ore producers, for example the recently announced MoU between Emirates Steel Industries and iron ore producer SNIM in Mauritania.

Investing in a captive pelletising plant shifts the sourcing to pellet feed. Currently, the current commercial availability of DR quality pellet feed is limited to a small number of suppliers, notably Anglo American's Minas Rio operation in Brazil (under contract with Bahrain Steel), Kaunis Iron in Sweden (producing about 2 mt of high-grade concentrate with plans to expand production), Champion Iron in eastern Canada (with a strategy to increase the share of DR-grade concentrate in its production) and CMP in Chile, which produces several high grade magnetite concentrate products. Tosyali Algerie's model of addition of a captive ore beneficiation plant will give it considerable flexibility in sourcing pellet feed.

There are various new projects at different stages of development aimed at production of high-grade iron ore concentrate including Black Iron's Shymanivske project in Ukraine (first phase 4 mt, second phase 8 mt, 68% Fe pellet feed concentrate), several projects in Scandinavia (Nordic Iron Ore and Beowulf Mining in Sweden, Tacora Resources in Norway), and various magnetite projects in Australia (including Grange Resources' Southdown project, Hawsons Iron, and Magnetite Mines).

Finally, consideration should be given to fines-based DR processes, of which Circored and HYFOR are examples, the former using fines 0.1-2 mm, the latter using concentrates up to 150 µm.

MIDREX® Direct Reduction Plants

2021 OPERATIONS SUMMARY

Pictured: Cleveland-Cliffs

Though the COVID-19 pandemic persisted throughout 2021, MIDREX® Plants produced 71.52 million tons of direct reduced iron (DRI), which is 9.0% more than the 65.7 million tons produced in 2020. The production total for 2021 was calculated from the 41.68 million tons confirmed by MIDREX Plants located outside of Iran and the 29.84 million tons for Iran reported by the World Steel Association (WSA). Approximately 9.7 million tons of hot DRI (HDRI) were produced by MIDREX Plants, which were consumed in nearby steel shops and assisted them in reducing their energy consumption per ton of steel produced and increasing their productivity.

MIDREX Plants have produced a cumulative total of more than 1.25 billion tons of all forms of DRI (cold DRI, CDRI; hot DRI, HDRI; and hot briquetted iron, HBI) through the end of 2021.

MIDREX Technology continued to account for ~80% of worldwide production of DRI by shaft furnaces in 2021. At least seven MIDREX Modules* established new annual production records and at least six established new monthly production records. Twelve additional modules came within 10% of their record annual production and 15 operated more than 8,000 hours.

The Venezuelan plants (COMSIGUA, Ferrominera Orinoco, Sidor and Venprecar) operated during 2021 at reduced capacities, but production details were not made available. No detailed production information has been received from Iran. The following plants did not operate in 2021 due to commercial or market conditions: ArcelorMittal Point Lisas, ArcelorMittal South Africa, Delta Steel, ESISCO, Lion DRI, and Tuwairqi Steel Mills.

** A MIDREX Plant can include one or more modules*

NEW PLANT CONTRACTS

Mikhailovsky HBI, jointly established by USM and Mikhailovsky GOK (part of Metalloinvest), signed a contract with Midrex and its consortium partner Primetals Technologies Limited for a 2.08 million ton/year HBI plant in Zheleznogorsk, Kursk region, Russia. Start-up was expected in the first half of 2024, at contract signing.

Metalloinvest has contracted with Midrex and consortium partner Primetals to supply a third MIDREX HBI Plant (HBI-4) at Lebedinsky GOK (LGOK) in Gubkin, Belgorod region, Russia. The plant will be designed to produce 2.08 million tons/year of HBI. Full production was expected to become operational in the first half of 2025, with first product in December 2024, at contract signing.

Tosyali Holding awarded Midrex and its partner Paul Wurth a contract to build a second DRI plant at the Tosyali Algerie steelworks in Bethioua (Oran), Algeria. The new DRI plant will produce 2.5 million tons/year of HDRI and CDRI, similar to the original plant, with the capability to operate with the addition of hydrogen in the future.

Mikhailovsky HBI contract signing


Tosyali Algerie

2021 PLANT HIGHLIGHTS

ALGERIAN QATARI STEEL (AQS)

Despite the ongoing pandemic, AQS started up in March 2021 and set its highest monthly production record in August while ramping up production to meet its steel shop's requirements.

ANTARA STEEL MILLS

The first MIDREX HBI Module operated under its annual rated capacity due to poor market conditions in the Far East in 2021. Total iron of its HBI product was the highest of all MIDREX Plants, averaging 92.83% for the year. All production was shipped by water to third parties

ARCELORMITTAL ACINDAR

In its 43rd year of operation, ACINDAR's module operated below its maximum annual capacity due to local market conditions while logging 8,153 operating hours and over 95% metallization in their product. With almost 33 million tons of CDRI produced, ACINDAR has achieved the most production from a 5.5-meter MIDREX Shaft Furnace to date.


Algerian Qatari Steel (AQS)


Antara Steel Mills


ACINDAR

ARCELORMITTAL CANADA

After a lackluster 2020 due to Covid, Module 1 set a new annual production record operating 8,481 hours in the year, while Module 2 set a new monthly production record in December. The combined production from both modules was just 1.4% shy of their 2018 production record. AM Canada's modules have produced just over 40 million tons of CDRI since the start-up of its first module in 1973.

ARCELORMITTAL HAMBURG

In its 50th anniversary year, the longest-serving MIDREX Module operated above its annual design rated capacity. Its annual average electricity consumption was the lowest of all MIDREX Plants at 82 kWh per ton.

ARCELORMITTAL LÁZARO CARDENAS

AMLC produced 17% over its annual rated capacity of 1.2 million tons in its 24th year of operation using mostly oxide pellets made in its adjacent pellet plant. Its 6.5-meter reduction furnace has produced over 36 million tons of CDRI, the most by a single module to date.

ARCELORMITTAL/NIPPON STEEL INDIA

Under new ownership, AM/NS India (formerly Essar Steel) produced over 5.3 million tons of DRI, breaking its previous multi-module annual record set in 2018 by over 9%. More than 2.9 million tons (or 89% of production) were in the form of HDRI from the four HDRI/HBI modules. All six modules combined have produced over 80 million tons of HDRI, HBI, and CDRI since the start-up of the first two modules in 1990. Modules 5 and 6 operated using CO_2-scrubbed off-gas from AM/NS's COREX Plant for ~16% of their energy input.

CLEVELAND-CLIFFS

After starting in 2020, Cliffs rapidly ramped up production and consistently operated well above rated capacity from June onwards. The 1.6 million ton per year plant located in Toledo, Ohio, produces HBI, mainly for consumption by internal Cleveland-Cliffs steel companies in the region.

ArcelorMittal Canada

ArcelorMittal Lazaro Cardenas

ArcelorMittal Hamburg

ArcelorMittal/Nippon Steel India (Formerly Essar Steel)

Cleveland-Cliffs

DRIC

Both of DRIC's modules in Dammam, Saudi Arabia, operated above rated capacity and were back into full production in 2021, just 1.1% shy of their 2019 combined module production record. Module 1 set a new annual production record, operating 8,455 hours. Output from Module 2 was within 3% of its annual production record.

EZDK

In its 35th anniversary year of operation, EZDK's Module 1 exceeded rated capacity while operating 8,385 hours, as did Module 3 while operating 8,432 hours in the year. Production was limited most of the year due to market conditions which started to improve in the last two months of 2021. Average annual product metallization was 95% or higher from all three modules.

HADEED

All four of Hadeed's MIDREX Modules in Jubail, Saudi Arabia, produced at or above rated capacity. Combined, the modules surpassed the 100-million-ton production milestone in 2021. Module C operated 8,294 hours and was within 7% of its production record. With almost 24 million tons produced, Module E has attained the most production from a 7.0-meter MIDREX Shaft Furnace to date. Hadeed also owns an HYL plant (Module D).

JINDAL SHADEED

Jindal Shadeed's 2021 production of 1.7 million tons, over 1.6 million tons of which were consumed as HDRI in its attached steel shop, was less than 3% below the 2019 annual production record. In addition to operating over 8,000 hours in the year, Jindal Shadeed's HOTLINK® Plant broke its March 2020 monthly production record in the month of November and again in December, reaching 226 t/h. Jindal Shadeed has operated over 8,200 hours per year on average for the full 11 years since its start-up. The single module plant, located in Sohar, Oman, is designed to produce mostly HDRI, with HBI as a secondary product stream.

DRIC

EZDK

Hadeed Module E

Jindal Shadeed

JSPL (ANGUL)

Jindal Steel and Power Limited's (JSPL) MxCol® Plant in Angul, Odisha State, India, handily broke its previous annual production record in the seventh year in operation. This is the first MxCol Plant using synthesis gas from coal gasifiers to produce both HDRI and CDRI for the adjacent steel shop. HDRI production was 69% of total production, and coke oven gas (COG) use in the DR plant continued throughout the year, averaging ~19% of energy requirements in the plant.

JSW STEEL (DOLVI)

In its 27th year of operation, JSW Steel's CDRI module handily exceeded rated capacity and operated over 8,200 hours. Approximately 10% of this plant's energy requirement is coke oven gas (COG) injected to the shaft furnace to reduce natural gas consumption. JSW Steel (Dolvi) has averaged 8,032 hours of operation per year since its initial start-up.

JSW STEEL (TORANAGALLU)

JSW Steel's HDRI/CDRI module in Toranagallu, Karnataka State, India, using COREX export gas as energy input, operated over 8,000 hours and increased its production compared to 2020. This is the second plant of its kind, the first being Arcelor Mittal's COREX/MIDREX plant at Saldanha, South Africa.

LEBEDINSKY GOK

LGOK's MIDREX HBI Modules 2 and 3, located in Gubkin, Russia, both operated above rated capacity and only 3% and 2%, respectively, less than their annual record productions set in 2020. Module 3 holds the record of the highest annual production by an HBI module and from a 7.0-meter MIDREX Shaft Furnace, with over 2.0 million tons, set in 2020. The combined production of both modules surpassed the 30-million-ton milestone, and Module 2 surpassed the 20-million-ton milestone. LGOK HBI-1 is an HYL plant.


JSPL (Angul)


JSW Steel (Dolvi)


JSW Steel (Toranagallu)


LGOK HBI-2


LGOK HBI-3

LISCO

Thirty years after the start-up of module 2, production by LISCO's two DRI modules and one HBI module in Misurata, Libya, continued restricted to less than 50% of rated capacity by factors outside the company's control.

NU-IRON

In its 15th anniversary year, after breaking monthly production records in 2019 and 2020, Nucor's module in Trinidad and Tobago operated above rated capacity again in 2021. Nu-Iron surpassed the 20-million-ton milestone early in 2021 and operated ~5% below its annual production record established in 2019. Average metallization for the year was the highest of all MIDREX Plants, at over 96.3%, with 2.75% carbon in the DRI.

OEMK

OEMK's four MIDREX Modules set a new combined annual production record of 3.28 million tons in 2021, with Module 1 setting a new annual production record (averaging over 114 t/h), and the remaining three modules operating within 1.5-4.0% of their respective production records. All four modules operated an average of 8,363 hours, achieved through short duration annual shutdowns. Module 1 set a new monthly production record in March, and Module 4 set a monthly production record in July. Module 2 surpassed the 20-million-ton milestone in the 4th quarter of 2021.

QATAR STEEL

Qatar Steel's dual product (CDRI/HBI) Module 2 remained shut down for all of 2021 due to poor market demand, while Module 1 (CDRI only) operated within 10% of its production record. Qatar Steel's Module 1 has produced over 28.3 million tons of DRI since its start-up in 1978, the most for a 5.0-meter shaft furnace.

LISCO

Nu-Iron Unlimited

OEMK

Qatar Steel Module 1

SULB

SULB's 1.5 million t/y combination module (simultaneous HDRI/CDRI production) in Bahrain operated above rated capacity, with 1.2 million tons of HDRI going to the adjacent steel shop and over 180,000 tons exported by sea. The SULB module's production was within 5% of its annual record, and it operated 8,158 hours in 2021.

TENARISSIDERCA

In its 45th anniversary year, TenarisSiderca's CDRI module in Argentina restarted production in February to satisfy the DRI demand from its steel shop. The module's DRI metallization percentage was the second highest of all MIDREX Plants at 95.64%.

TOSYALI ALGERIE

Tosyali Holding's 2.5 million tons/year combination (HDRI/CDRI) module, located in Bethioua, near Oran, Algeria set a new annual production record for the third consecutive year (more than 2.28 million tons in 2021), while operating just under 8,000 hours. Over 69% of production went to the adjacent steel shop as HDRI. Together with Algerian Qatari Steel (AQS), this is the largest capacity MIDREX Module built to date, with a 7.5 m diameter shaft furnace.

voestalpine TEXAS

In its fifth year in operation, the production from the 2.0 million t/y HBI module located near Corpus Christi, Texas, USA was 9% less than its production record set in 2019.

(Editor's note: voestalpine Texas was a 100% subsidiary of voestalpine AG in Austria through 2021. In April 2022, ArcelorMittal became majority shareholder, acquiring 80% stake in the HBI plant.)

SULB

TenarisSiderca

Tosyali Algérie

voestalpine Texas

Midrex News & Views

The full news articles are available on **www.midrex.com**

Midrex Top Executive Addresses Singapore Iron Ore Forum 2022

Stephen Montague, President & CEO of Midrex Technologies, Inc., spoke at the Singapore Iron Ore Forum 2022 on May 18, on the topic "Hydrogen: A new frontier in steelmaking. How to get there from a DRI perspective." Montague said decarbonization of the global steel industry will be a long journey, with several mountains to climb. The winners will be those who start the journey early, are willing to break from traditional industry norms, and select the best technologies.

He said MIDREX® Direct Reduction Technology is actively engaged in reducing CO_2 emissions. A MIDREX NG™ (natural gas) plant already uses 55-75% hydrogen in its reducing gas. With hydrogen addition, which can be achieved with little or no modification to the plant, up to 100% of the natural gas can be replaced. The MIDREX Reformer is designed to convert high percentages of CO_2 into reusable reducing gas. For plants built to operate on 100% hydrogen from the outset, MIDREX H2™ is available with a specifically-designed electric heater.

Montague provided a glimpse into the future of iron and steelmaking. He said direct reduction has a leading role to play in decarbonizing the industry. He said we should expect the first large-scale "lighthouse" projects using hydrogen-based direct reduction technology to begin construction in the next 12-24 months. These projects will utilize electric heaters and produce green HBI/green steel. A new market will also develop for using HBI in existing blast furnaces as a transitional solution to lower CO_2 emissions in existing blast furnaces. A new large-scale melter, optimized for direct reduced iron (DRI) produced from lower Fe pellets, also is not far away, possibly in the next 12-24 months.

He closed his presentation with a suggestion that it is time for more iron ore companies to venture downstream and participate in large-scale direct reduction projects to supply low CO_2 metallics to steelmakers around the world. Likewise, more of the existing ironmakers should become involved in offshore ventures where energy and logistics can be optimized to produce low CO_2 metallics.

Midrex News & Views

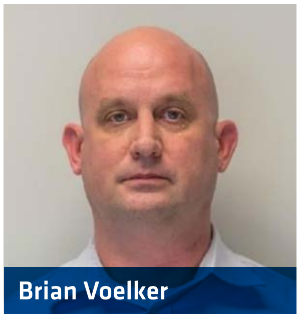
The full news articles are available on **www.midrex.com**

Midrex Technologies Presents & Exhibits at AISTech 2022 in Pittsburgh

The results achieved by MIDREX® Plant operators when charging hot DRI (HDRI) and the potential role of direct reduction in navigating the future uncertainties facing the global iron and steel industry were the subjects of two paper presented by Midrex engineers in the technical sessions of the recent AISTech 2022 Conference. Midrex also presented an exhibit booth during the concurrent exposition.

OPERATIONAL RESULTS OF HOT CHARGING DRI

By Brian Voelker, *Chief – Engineering Improvement* & Sean Boyle, *Key Account Manager – North America/Europe*


Brian Voelker


Sean Boyle

One could say that the electric arc furnace (EAF) and direct reduced (DR) have grown up together, "coming of age" in the production of the highest quality steel grades in market-sized quantities. The introduction of the hot discharge furnace led to the development of methods for transporting and charging hot DRI (HDRI) in an EAF to increase productivity and yield, as well as to reduce the need to inject carbon to balance the EAF heat, thus lowering carbon dioxide (CO_2) emissions.

In DR/EAF steelmaking, hot transport/hot charging is an effective means of lowering the cost per ton of liquid steel by reducing power and electrode consumption and increasing EAF productivity. The MIDREX® Shaft Furnace can be equipped with one of the three systems to transfer HDRI to a meltshop: HOTLINK®, Hot Transport Conveyor (HTC), and Hot Transport Vessel (HTV).

In their paper, Voelker and Boyle looked back at the development, history, and two decades of experience to share valuable lessons learned from over 15 operational installations. Additionally, they discussed the advantages and disadvantages of each of the three methods of HDRI transport and explained the key factors that go into selecting the best options for steelmakers.


Todd Astoria

DIRECT REDUCTION DEALING WITH AN UNCERTAIN FUTURE

By Todd Astoria, *Director – Research & Development*

The steel industry today is faced with exciting opportunities – new fuels, new technologies, and new raw materials – and major challenges, such as the need to mitigate greenhouse gas (GHG) emissions. All of these are provoking discussions of ideas that would not have been possible even a few short years ago.

However, new opportunities carry with them new uncertainties which can complicate decisions that have long investment timelines. The direct reduction of iron ore using MIDREX® Direct Reduction Technology can help navigate these uncertainties by providing unparalleled flexibility of raw materials, fuels and reductants, and metallic products.

In his paper, Astoria discussed the evolving market opportunities and the accompanying uncertainties and showed how MIDREX Direct Reduction Technology can help meet these future challenges.

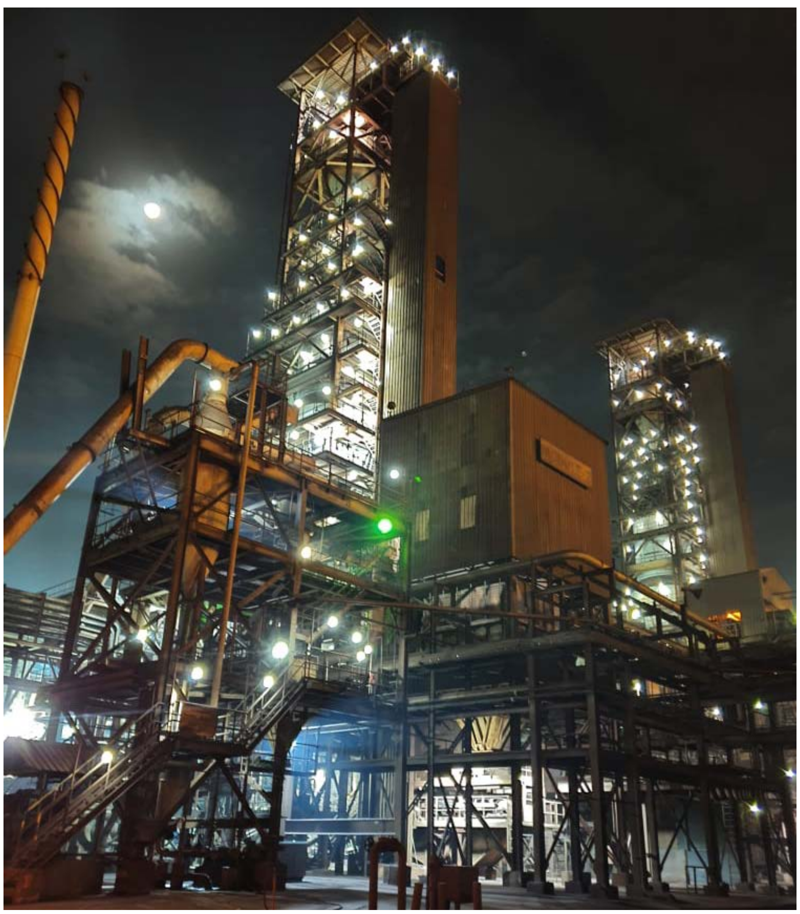
Midrex News & Views

The full news articles are available on **www.midrex.com**

MIDREX® Plant with 2Q Anniversary

Midrex is known for designing, engineering, and servicing reliable direct reduction plants, as well as for making certain that these plants have long and successful operating lives. In this issue, ***Direct From Midrex*** recognizes the start-up of DRIC-1, the first of two modules operated by Direct Reduction Iron Company Ltd. In Damman, Saudi Arabia.

DRIC Module 2 continued to exceed its annual rated capacity in 2020 after setting its all-time production record in 2019 (534,643 tons). DRIC-2 produced almost 525,000 tons of CDRI in 2020, with plant availability of 99.6%. Together, DRIC 1 and 2 have produced over 10 million tons of DRI since start-up in 2007, following relocation from Mobile, Alabama, USA.



DRIC is a subsidiary of Arab Steel Company, which is part of Al Ittefaq Steel Company (ISPC). Read more about DRIC and Arab Steel Co. on the Al Ittefaq Steel Co. (ISPC) website ***https://www.ispc.com.sa.***

DIRECT REDUCTION IRON COMPANY LTD.

DRIC 2 completes 15 years of operation in the second quarter

Location:
Damman, Saudi Arabia

DRI plant:
MIDREX (2 modules)

- Number of years: 15
- Start-up: May 2007 (module 1), December 2007 (module 2)
- Flowsheet: MIDREX NG™
- Product: CDRI
- Capacity (Mt/y): 1.0 (total)

Lauren Lorraine: **Editor**

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The publication is distributed worldwide by email to persons interested in the direct reduced iron (DRI) market and its growing impact on the iron and steel industry.

All references to tons are metric unless otherwise stated.

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