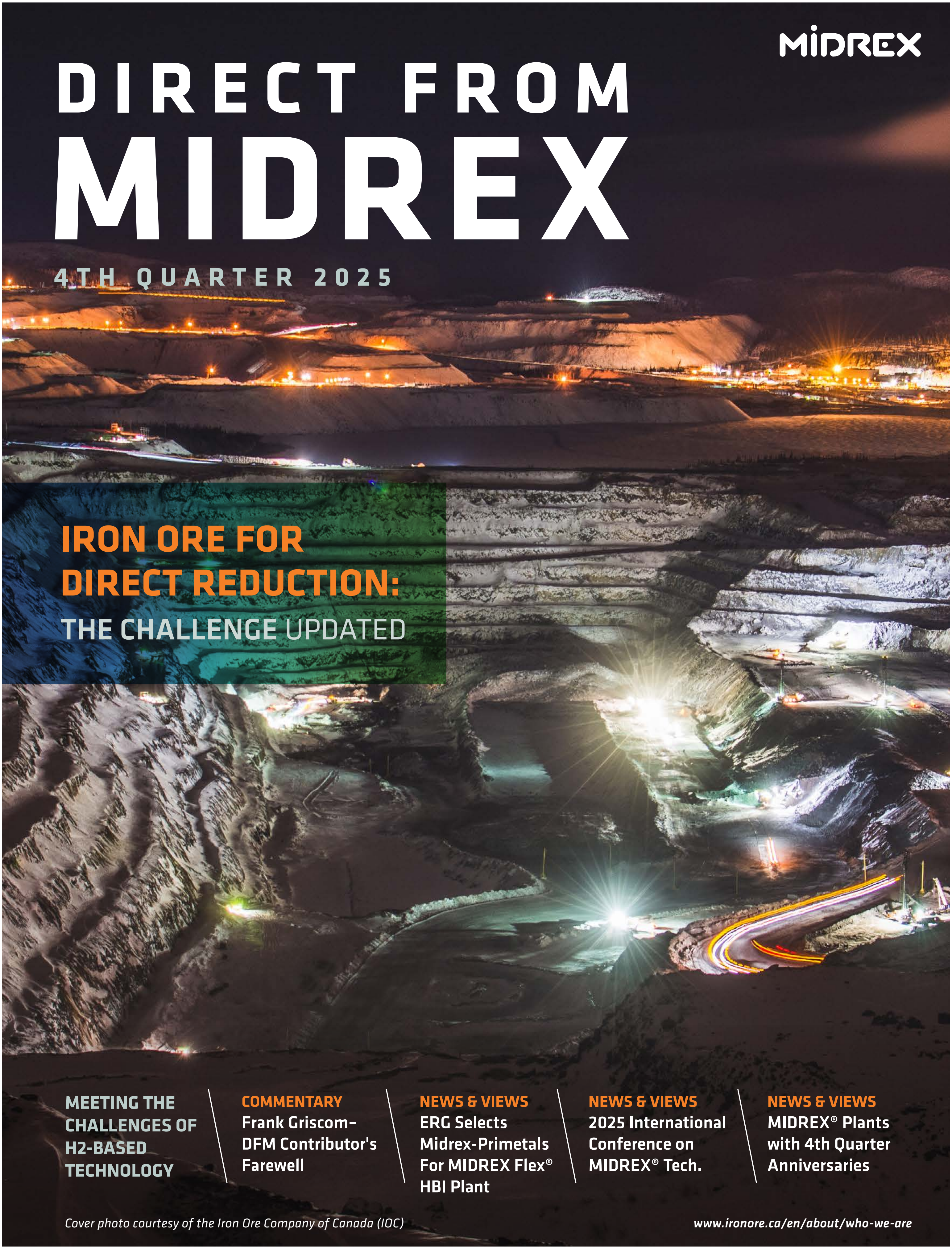


MIDREX

DIRECT FROM MIDREX

4TH QUARTER 2025

IRON ORE FOR DIRECT REDUCTION:

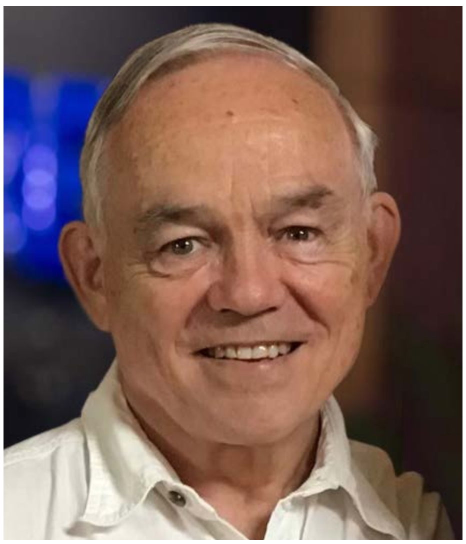
THE CHALLENGE UPDATED

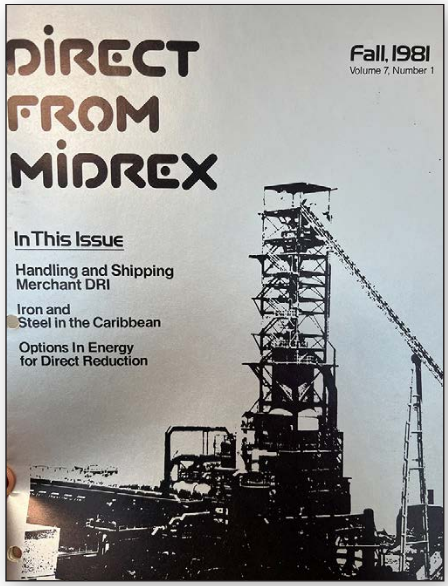
Cover photo courtesy of the Iron Ore Company of Canada (IOC)

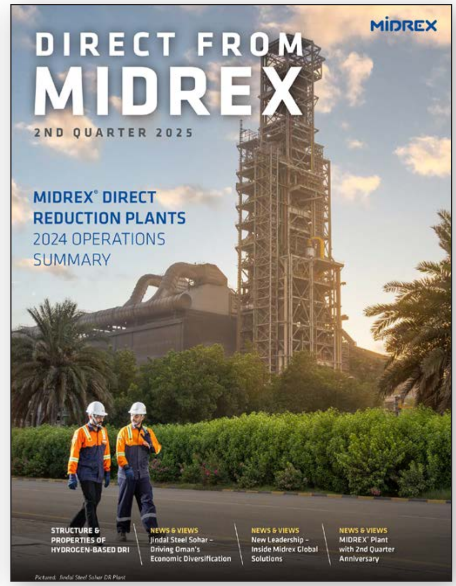
www.ironore.ca/en/about/who-we-are

COMMENTARY

"HAPPY TRAILS, 'TIL WE MEET AGAIN"







Pictured: Frank's initial 1981 issue of ***Direct From Midrex (DFM)*** */ present day* ***DFM*** *issue*

By Frank Griscom
Direct From Midrex Editor (1981-93) and Consultant/Contributor (2013-25)

I have had the pleasure to be associated with *Direct From Midrex (DFM)* since its reintroduction in 3Q1981, which we labeled Fall 1981 before realizing that fall in Charlotte is spring somewhere else. As editor from 1981-1993, and a consultant/contributor since 2013, I was involved in transforming what was a sporadically published collection of Midrex patents and company news into the quarterly journal of direct reduction it is today. I want to thank current DFM editor, Lauren Lorraine, for allowing me to reminisce about my 24-year association with *Direct From Midrex*.

If you were around in 1981, you probably remember when MTV was launched, the home PC was introduced (Commodore 64 with 64kb of RAM!), Britain's Prince Charles and Lady Diana Spencer were married, and former Hollywood actor, Ronald Reagan, became President of the United States. It also was the year that I joined Midrex.

I worked for GE (General Electric) in various marketing communications and public relations roles from 1972-1981, after serving four years as a U.S. Army officer. However, I was tired of being a small part of a huge organization and began looking for other opportunities, preferably in the South closer to where I grew up and went to college (Chattanooga, TN). So, I answered an ad in a public relations trade magazine for a marketing communications manager in Charlotte, NC, for a company called Midrex that was involved in something known as direct reduction in the steel industry.

In 1981, direct reduction and direct reduced iron (DRI) were primarily associated with start-up steel industries in emerging economies. In fact, back then DRI was typically used as a "price buster" for scrap and made up only a small percentage of the electric arc furnace (EAF) charge, if at all. Total DRI production in 1980 was 7.13 million metric tons (Mt), with MIDREX® Plants producing 56% (3.96Mt) of the total. Compare that with 140.8 Mt of global DRI production in 2024, and it's easy to see how far the industry has come. Similarly, MIDREX Plants accounted for 76.2 Mt of all forms of DRI in 2024.

Personal computers were starting to replace electric typewriters and cell phones were still somewhere in the future when I joined Midrex, so there was no such thing as social media. As a result, we published a company newsletter called "Pellet Talk" off-and-on for several years. Midrex employees relied on talking with each other and the company bulletin board to stay informed. Today, Midrex has available a host of sophisticated internal communications tools (thanks to Lauren Lorraine's vision and expertise) designed to support all levels of internal messaging, from executive updates to more casual employee updates.

COMMENTARY

> "Through the years, *DFM* has remained true to its mission – be the journal of direct reduction."

Another aspect of Midrex life was the roller coaster business cycles of the steel industry. Within six months of joining the company, we were plunged into a steel industry downcycle that depressed prices for scrap, DRI, and steel. It lasted until mid-1988, and Midrex was forced into layoffs after staffing up to meet increased business demands in the mid-to-late 1970s. The second downcycle struck in late 1991, but lasted only until mid-1994. The recovery that time looked like it would last forever, but the bottom fell out again in 1998-1999, and by the beginning of 2002, Midrex was down to a core of 50 employees. The steel industry recovered after a few tough years and continues to spur industrial and economic growth. Likewise, Midrex, true to its nature, weathered the storm and has prospered and grown stronger today than ever before.

Through the years, DFM has remained true to its mission – be the journal of direct reduction. Nothing exemplifies this more than the role it played in the 1990s, promoting the idea that DRI should be treated as a supplement to scrap rather than an alternative, with an intrinsic value that far exceeds price alone. Today, not only are EAFs producing the highest quality steel grades by including significant percentages of DRI in the charge, blast furnace (BF) operators are using hot briquetted iron (HBI) to increase productivity while reducing carbon dioxide (CO_2) emissions. And DRI is widely regarded as the most effective way to achieve net-zero emissions in iron and steelmaking.

DFM, as it has for almost 45 years, is promoting the role of DRI in the evolution of the global steel industry by publishing articles that report on leading edge research and testing at the Midrex Research & Technology Development Center, operational achievements by the global family of MIDREX Plants, and featuring commentaries that provide insights and opinions on industry issues.

I have been fortunate to meet, work with, and become friends with many fantastic people during my 40+ years in and around Midrex including Robert Hunter, John Kopfle, and Shohei Manabe. Unfortunately, some of them are no longer with us – Roy Ogden, Franz Sammt, and Don Lyles. Their wisdom, determination, and character are woven into the rich fabric of Midrex and continue to inspire those of us who knew them and all those who follow in their footsteps.

Every phase of my working career - US Army officer, newspaper sports reporter, GE publicist and marketing communications manager, Midrex marketing & sales executive, and iron & steel industry trade association director – has had a formative role in my personal beliefs and principles: be a leader, not a follower; set an example and live it; focus on contributed value; be a promoter not the star. Whatever I have achieved is directly attributable to them, and the enduring role of Direct From Midrex in promoting a sustainable future for the global steel industry is my proudest legacy.

Just as old-time cowboy star Roy Rogers would say as he prepared to ride off into the sunset, "Happy trails, 'til we meet again."

Pictured: Frank Griscom at the 1988 Midrex Operations Seminar in Venezuela.

→

This issue of *Direct From Midrex* features includes an update on the global iron ore market by industry expert and International Iron Metallics Association Fellow Chris Barrington and an article by Midrex Engineering about environmental design considerations for MIDREX Plants. News & Views reports on recent happenings in the global DRI industry and recognizes MIDREX Plants with significant 4Q anniversaries.

IRON ORE FOR DIRECT REDUCTION: THE CHALLENGE UPDATED

Photo courtesy of the Iron Ore Company of Canada (IOC) **www.ironore.ca/en/about/who-we-are**

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

INTRODUCTION

The principal purpose of this article is to provide an update on the iron ore supply to the direct reduction (DR) market, which was last addressed in Direct From Midrex in 2Q2022. To paraphrase the outcome of its analysis of the merchant iron ore pellet supply-demand at the time: ***Whilst there would be adequacy of pellet supply for DR plants by the middle of the 2020s, the picture would change by the early 2030s, by which time most of the then-assumed new DR projects would be in production.*** The analysis suggested a significant shortfall in DR/EAF grade pellet supply, as the capacity of existing pellet plants became fully utilised. Looking to the longer term, i.e., by 2050, the challenge was significantly greater, with DR/EAF grade pellet demand exceeding the current level of global pellet production.

The iron ore-to-steel value chain has certainly embraced the iron ore challenge. However, three and a half years down the track, there have been significant changes in the outlook for implementation of new DR projects, notably ArcelorMittal's various European and Canadian projects being put on hold, which represent about 12 million tonnes per annum (mt/a) annual DRI capacity requiring 17.5-18 mt/a pellets. ArcelorMittal's press release in November 2024 noted:

- green hydrogen is evolving very slowly towards being a viable reductant source and natural gas-based DRI production in Europe is not yet competitive as an interim solution;

- there are significant weaknesses in the EU carbon border adjustment mechanism (CBAM) and trade protection measures need strengthening in response to increasing imports due to overcapacity in China;
- there is limited willingness among customers to pay premium prices for low-carbon emission steel.

There have been delays to the implementation of other merchant ore-based DR projects in Europe and the MENA region, but further new projects have been announced in the meantime. Tosyali SULB's 8.1 mt/a project in Libya (phase 1 contracted with Midrex/SMS), aimed at DRI supply to external users is an example of decoupling the iron and steel production processes by shifting iron production from Asia or Europe to the MENA region with its lower cost energy and natural gas (and eventually hydrogen).

BACKGROUND TO DR/EAF PELLET SUPPLY-DEMAND SCENARIO ANALYSIS

The updated pellet supply-demand scenario analysis covers the period out to 2034, relative to 2024. It must be emphasised that the analysis represents a scenario, not a forecast - a great deal of water will have flowed under the demand and supply bridges by 2034.

The demand-side reflects DRI production in plants using only merchant iron ore, bringing together existing plants and new projects. Not included is possible longer term requirements from India for DR/EAF grade pellets.

Given the uncertainties surrounding the medium term decarbonisation pathway, this time a limited sensitivity analysis has been included with two supply-side and two demand-side scenarios.

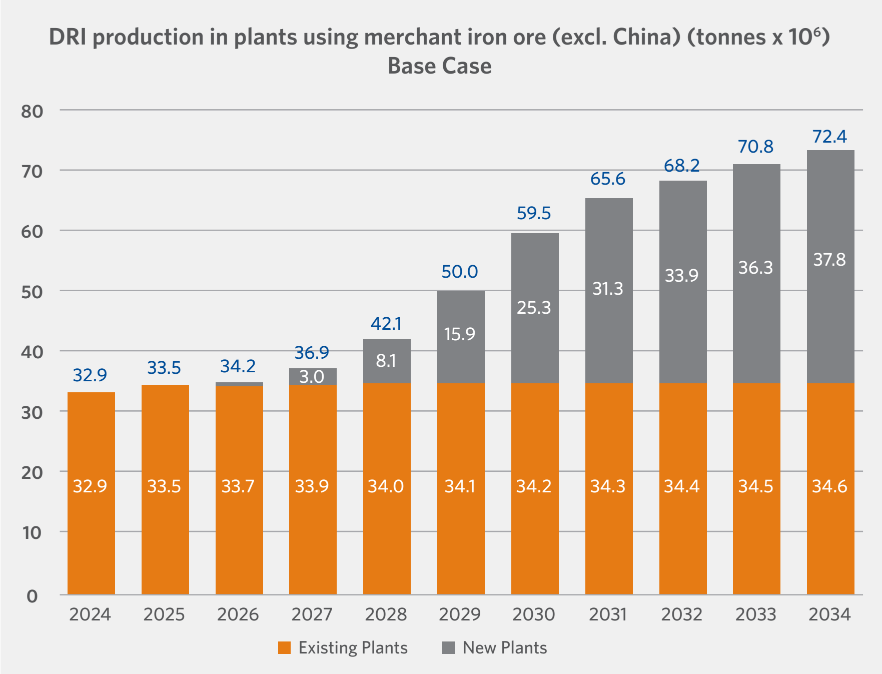


FIGURE 1. *Modelled DRI production – Base Case (historical data from Midrex annual statistics)*

Demand-side scenario

Figure 1 shows the assumed build-up of DRI production between 2024 and 2034 for the Base DRI Case (countries with existing DR plants using merchant pellets: Argentina, Trinidad, USA, Germany, Algeria, Libya, Egypt, Saudi Arabia, Qatar, UAE, Oman, and Malaysia).

The assumed new merchant iron ore-based DR projects are listed in ***Table 1, following page***. The selection of new projects and their ramp-up is based on company and media reports and in some cases judgmental assumptions only. Specific consumption of iron ore (almost 100% pellets) in all cases is 1.45 tonnes, equivalent to a total of 104.9 mt in 2034 for the base case.

New DR plant assumptions	2034
AM Corpus Christi Phase 2, USA	2.0
Baosteel/Aramco, Saudi Arabia	2.5
GravitHy, Fos-sur-Mer, France	2.0
Hydnum Steel, Spain	2.0
Hyundai, Donaldsville, Louisiana, USA	2.5
Jindal Duqm, Oman	5.0
Meranti GS, Duqm, Oman	2.5
Mitsui - Kobe Steel Oman	2.5
Rogesa/Saarstahl, Germany	2.0
Salzgitter Salcos phase 1, Germany	2.6
Stegra, Sweden	2.1
Ternium, Pesqueria, Mexico	2.1
TKS phase 1, Germany	2.5
Tosyali/SULB, phases 1&2, Libya	5.5
Total	**37.8**

TABLE 1. *Assumed new merchant iron ore-based DR projects - mt*

Of course there are many other DR projects at various stages of development, based on both merchant and captive iron ore. In addition, consideration might be given to re-start of several idled DR plants. Midrex's ***2024 World Direct Reduction Statistics*** lists idle merchant ore-based plants with about 9 mt/a capacity. Candidates for re-start include the former AM Point Lisas plant in Trinidad (three modules), Lion DRI and Perwaja Steel in Malaysia, Al Tuwairqi in Pakistan, and Saldanha Steel (AM South Africa) in South Africa. The "Higher" demand-side sensitivity scenario therefore assumes an additional 4 mt DRI in 2034.

Supply-side scenario

To provide context, ***Table 2*** shows global pellet production during the period 2020-2024. The main increases were in India, Iran, CIS, and Brazil. Production outside China and India was 303 mt, about 20 mt above that of 2023. Per International Iron Metallics Association (IIMA) trade statistics, cross-border pellet trade in 2024 was about 114 mt (basis import data). ***Figure 2*** shows merchant pellet supply to DR plants in 2024.

PELLETS PRODUCTION, mt	2020	2021	2022	2023	2024
EU	28.9	27.4	24.6	24.3	23.8
Other Europe	1.5	1.5	1.5	1.5	1.5
CIS	75.5	78.9	62.3	60.5	65.8
USMCA	59.6	73.9	65.8	70.1	67.9
Brazil	22.1	23.5	32.0	36.3	47.9
Other C&S America	3.2	3.6	3.8	3.4	2.1
Africa & ME	64.7	68.2	79.7	81.7	87.5
India	61.6	75	84.0	94.0	105.0
China	200	195	190.0	189.0	189.0
Japan	3	3	3.0	3.0	3.0
Other Asia & Oceania	3.9	4.1	3.8	3.3	3.5
Total	**521.4**	**554.2**	**550.5**	**567.2**	**597.0**
Excluding China	321.4	359.2	360.5	378.2	408.0
Excluding CHN & IND	259.7	284.2	276.5	284.2	303.0

TABLE 2. *Global pellet production by region or country (data sources: company & media reports, national statistics, personal contacts, author's estimates)*

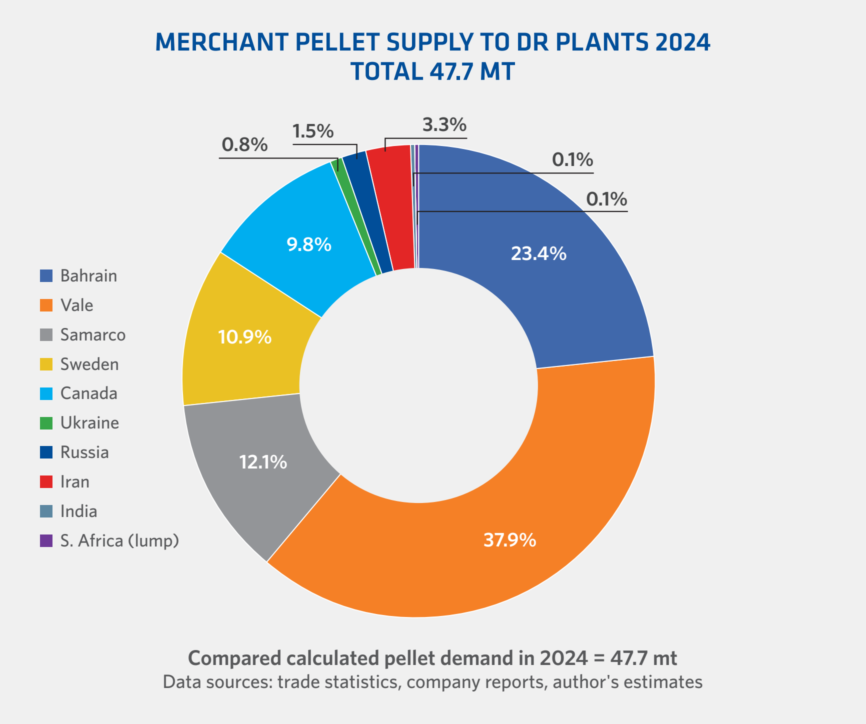


FIGURE 2. *Merchant pellet supply to DR plants in 2024*

Two pellet supply scenarios have been modelled: a "Higher Case" reflecting the assumed maximum potential merchant supply from the various producers and a more conservative "Lower Case." The Higher Case assumptions for 2034 are given below and where applicable the corresponding Lower Case assumptions follow in parentheses. Incremental supply is relative to 2024. Supply-side assumptions are based on a variety of inputs, some judgmental in nature.

- **Iron Ore Company of Canada:** full nameplate capacity of 12 mt/a is achieved with 80% as DR/EAF grade pellets, an incremental 5.4 mt (Lower Case: 11 mt production, 70% as DR/EAF grade, 3.5 mt incremental supply);
- **ArcelorMittal Mines Canada:** full capacity of 10 mt/a available as DR/EAF grade, an incremental 7.5 mt after supply to in-house DR plants in Canada (Lower Case: 9 mt total production available as DR/EAF grade, an incremental 6.5 mt);
- **Vale:** 45% of Tubarão capacity of 31.3 mt/a + 100% of Oman capacity of 9 mt/a, an incremental 5 mt (Lower Case: 40% of Tubarão capacity + 100% of 9 mt at Oman, an incremental 3.5 mt);
- **Samarco:** 65% of full capacity of 26 mt/a, an incremental 11.1 mt (Lower Case: 60% of 26 mt, an incremental 9.8 mt);
- **LKAB:** full 10 mt/a capacity of the Kiruna KK3 and KK4 pellet plants, an incremental 4.8 mt - LKAB has postponed its transition from pellet to "sponge iron" supplier at Kiruna to the 2040s (Lower Case: 8.5 mt total production, an incremental 3.3 mt);
- **Bahrain Steel:** full effective capacity of 13 mt/a, all DR/EAF grade, of which ~2.2 mt/a is supplied to the adjacent SULB DR plant, zero incremental supply;
- **Jindal Steel Oman:** full 6 mt/a capacity of Vulcan Pelletising, all incremental - for the purposes of this exercise Vulcan is treated as a merchant plant as its capacity is not sufficient to supply 100% of Jindal's eventual DR/EAF pellet requirements in Oman (Lower Case: 5 mt total production, an incremental 5 mt);
- **Suez Steel:** full 5 mt/a capacity, all incremental, to be consumed in-house/domestically (Lower Case: 4 mt total production, an incremental 4 mt);
- **Mesabi Metallics:** full 7 mt/a capacity available as DR/EAF grade pellets, an incremental 7 mt (scheduled start-up in 2026) (Lower Case: 6 mt total production, 90% as DR/EAF grade, an incremental 5.4 mt);


Photo courtesy of Samarco, a privately held Brazilian mining company.

- **Ukraine:** the current war with Russia notwithstanding:
  - **Metinvest:** it is understood that, subject to the addition of flotation circuits at its Northern operation, Metinvest could produce 4-5 mt/a DR/EAF grade pellets by the end of the period, an incremental 4.5 mt (Lower Case: no addition of flotation circuits, zero incremental supply);
  - **Ferrexpo:** 0.5 mt/a DR/EAF grade pellets, zero incremental supply; if Ferrexpo could finance the cost of adding flotation to its beneficiation process it could theoretically produce 4-5 mt DR/EAF grade pellets, but for the purposes hereof this is considered not to happen;
- **Blastr Green Steel:** 50% of the planned 6 mt/a capacity would be available to the merchant market (Lower Case: 5 mt total production, of which 2.1 mt available to the merchant market);
- **BF grade pellets for ESF:** 3.5 mt/a for ThyssenKrupp Steel Duisburg (as far as the author is aware, TKS's project has the only firmly committed ESF, although the concept is being widely studied, for example in South Korea and Australia, e.g the Neosmjelt project);
- **Metalloinvest + other Russian producers:** DR/EAF grade pellet production will be consumed by captive/domestic DR plants.

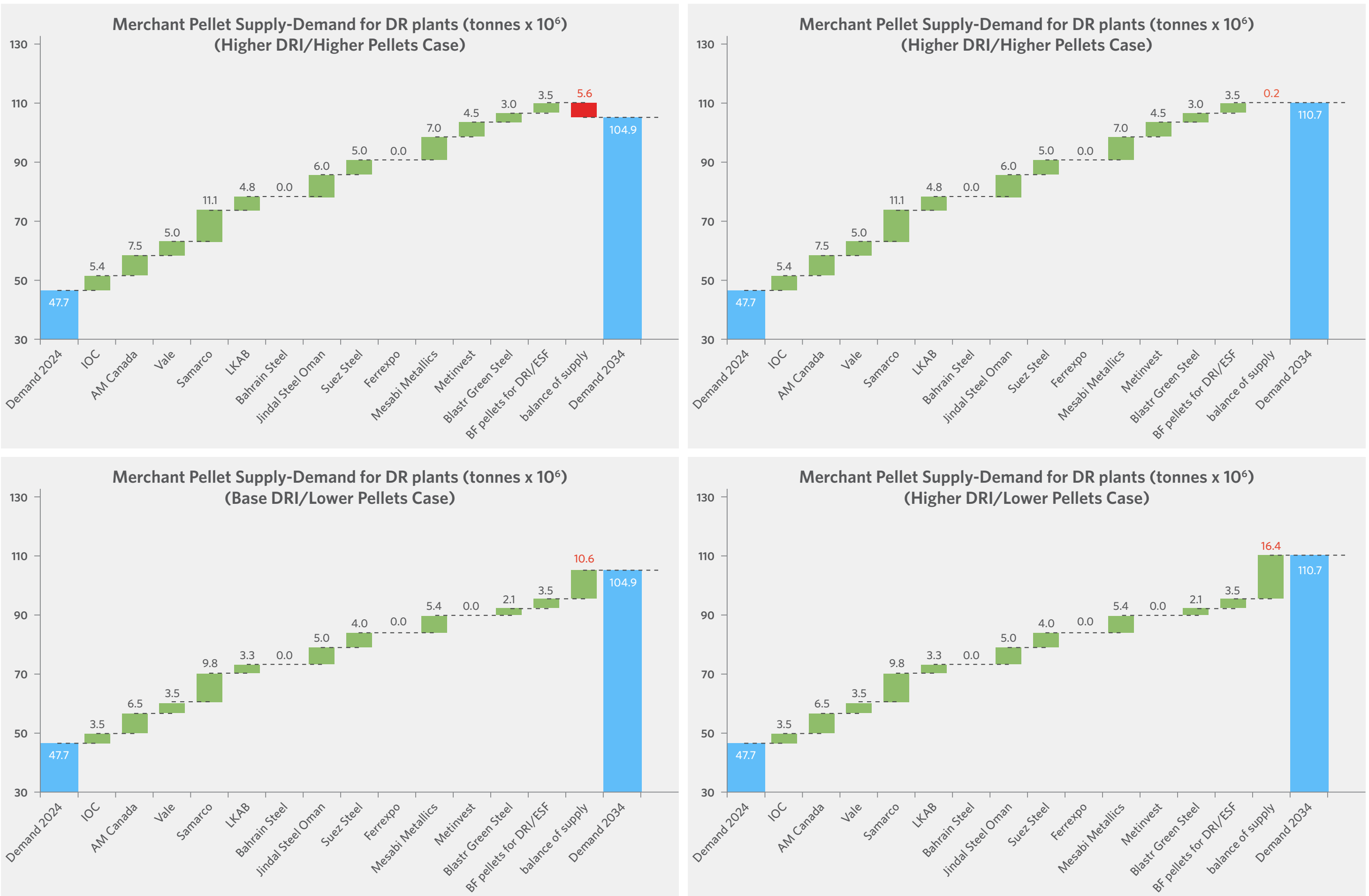


FIGURE 3. *Scenario Analysis Outcomes*

There are several captive pelletising projects at various stages of development (this list is not exhaustive – there are some additional references to pelletising projects in the section on iron ore fines that follows):

- **Tosyali Algerie's** #2 pellet plant is now in operation; Tosyali is developing a 6 mt/a iron ore mine in Angola to support its pelletising operations;
- **Strategic Resources'** planned 4 mt/a plant at the Port of Saguenay, Canada, based on purchased iron ore concentrate and aimed at the DR market (currently working on funding and concentrate sourcing);
- a pellet plant as part of the low-carbon iron hub planned by the joint venture of **Emsteel, Itochu** and **JFE Steel** in the UAE;
- various projects involving **SNIM**, Mauritania;
- **Maegma Minerals'** HBI plant in Lumut, Malaysia will involve "collaboration with a global high grade iron ore supplier which will operate a pelletising plant near the Maegma site..."

Analysis and summary

Figure 3 shows the details of the outcomes and ***Table 3*** summarises the results of the scenario analysis. As the supply-demand balance figures show, for the more conservative lower pellets supply case (lower graphs), there is a pellet supply shortfall for both the base and higher DRI cases, albeit less than suggested by previous analyses. However, for the higher pellets supply case (upper graphs), there is a modest surplus for the base DRI case in 2034, but a more or less balanced supply for the higher DRI case.

Generally speaking, progress by the iron ore industry in recognition that the transition to carbon-neutral steelmaking will require significantly increased supply of DR/EAF grade iron ore should give a degree of comfort to the DR sector, particularly with respect to medium term supply of DR/EAF grade pellets. However, as the scenario analysis suggests, there is no room for complacency and the DR sector should therefore monitor supply-side developments closely and act accordingly.

IRON ORE BRIQUETTES

Vale is making progress with its cold-bonded briquette project. The (first) BT-01 plant at Tubarão started in December 2023, with capacity of 2 mt/a and is now focussed on the domestic blast furnace market. The planned 4 mt/a BT-02 Tubarão plant has been postponed to post-2027. A smaller mobile plant with capacity of 0.16-0.2 mt/a started in September 2024, with focus on production for large scale industrial trials.

Acid and High-Reducibility Briquettes for use in blast furnaces are now considered as developed products. Briquettes for DR applications are under progressive stages of development:

- laboratory tests
- basket tests (kg scale) - 20 campaigns completed
- flash tests (hundred tonnes scale) are ongoing
- industrial trials (thousand tonnes scale) - four completed, two more planned

Vale and Midrex have agreed to cooperate in advancing a technical solution for the use of cold-bonded iron ore briquettes in direct reduction plants.

UK company Binding Solutions is developing a cold-bonded iron ore pellet product, but so far with emphasis on blast furnace use.

LUMP IRON ORE

There is not much new to say on this subject:

- **Kumba's** Sishen super high grade lump ore is the principal source of lump ore for DR plants; Kumba has installed Ultra High Density Magnetic Separation (UHDMS) at the Sishen mine as part of a R3.6 billion project to extend Sishen's mine life to 2038 (with further potential to 2044). UHDMS enables production of >15 mt/a premium 65% Fe lump, as well as increased capability for production of su per high grade lump (65.5-66% Fe). Standard Sishen lump ore grades 64% Fe;
- until it is able to expand its production, **Baffinland Iron Mines** is unlikely to develop a lump product for the DR market in significant volume; in the 2025 shipping season, the company is understood to have delivered about 1.7 mt lump ore grading 67.7% Fe to Europe;
- a possible new supplier is **J & F Mineracão**, which acquired the Santa Cruz and Urucum mines in Brazil's Mato Grosso do Sul state. The company plans to expand production from 12 mt to 25 mt/a and is developing a "natural pellet" product aimed at the DR market.

CASE		DRI PRODUCTION			Pellet demand	Pellet supply	Pellet balance
DRI	Pellets	Existing plants	New projects	Total			
Base	Higher	34.6	37.8	72.4	104.9	110.5	+5.6
Base	Lower	34.6	37.8	72.4	104.9	94.3	-10.6
Higher	Higher	34.6	41.8	76.4	110.7	110.5	- 0.2
Higher	Lower	34.6	41.8	76.4	110.7	94.3	-16.4

TABLE 3. *Scenario Analysis Summary for 2034 (all values MT)*

Pictured (left to right): iron ore briquettes, high grade lump ore

IRON ORE FINES, CONCENTRATES, PELLET FEED

As is clear, the planned increase in pelletising capacity and the development of fines-based DR technology place emphasis on the need for increased supply of fine iron ore (fines, concentrates, pellet feed). It should be noted that where an ore beneficiation plant is integrated with the pellet plant or an ESF is integrated with a fines-based DR plant, there is a much wider range of supply options. This section will focus on existing and potential future sources of high (DR/EAF) grade ore. Information has been gleaned from company reports/press releases and media reports.

Existing supply of merchant DR/EAF grade fines includes:

- **Anglo American's Minas Rio** operation in Brazil (the highest grade material being largely committed to Bahrain Steel under a 20 year contract); an agreement between Anglo American and Vale was announced in February 2024, whereby Vale will acquire 15% of Anglo American Minério de Ferro Brasil (owner of Minas Rio) and the two parties will establish a partnership effectively, combining Minas Rio with Vale's contiguous (and higher grade) Serro da Serpentina reserves; Vale will allocate its share of the production to its own pellet and eventually briquetting plants (initially 3.8 mt/a, but potentially up to 15 mt/a in the longer term); this partnership will enable significant expansion beyond Minas Rio's current 26.5 mt/a capacity, as well as various logistics options (2024 production at Minas Rio was 25 mt and guidance for 2025 has been increased by 1 mt to 23-25 mt).
- Occasional supply from **Samarco** if/when there is an imbalance between pellet feed production and internal demand.
- **Champion Iron's Bloom Lake** operation in Canada, producing 66.2% Fe concentrate (FY 2024 production 14.2 mt).
- **Kaunis Iron** in Sweden, currently producing about 2 mt/a of high-grade concentrate with plans to expand capacity. It is currently reviewing its longer term strategy. A press release in 2024 refers to collaboration with Stegra to establish a pellet plant in Narvik in 2030.
- **Compañia Minera del Pacífico** in Chile produces several high-grade magnetite concentrates, grading up to 69% Fe. 2024 shipments totalled 15.3 mt, including about 12 mt pellet feed. Indefinite closure of CAP's steelmaking operations having been announced in 2024, the group plans major investments to increase high grade iron ore production from 17 mt in 2023 (average 66% Fe) by 38% to 23 mt/a (average 68% Fe) by 2032.

ARE THERE ENOUGH DR/EAF GRADE IRON ORES AVAILABLE FOR THE LONGER TERM?

New projects include the following (this list - in no particular order of priority - is by no means exhaustive):

- **Champion Iron's DRPF project** to upgrade the 7.5 mt/a Bloom Lake Phase 2 plant in Quebec from 66.2% to 69% Fe is progressing on schedule - commissioning is scheduled to start in December 2025 with commercial shipments by the end of H1 2026. Worthy of mention is Champion's past acquisition of the old Wabush pellet plant at Pointe Noire which, if re-commissioned/refurbished, could add about 5 mt/a to DR/EAF grade pellet supply.

Photo courtesy of Samarco.

- **Champion Iron** has entered into a definitive framework agreement with Nippon Steel and Sojitz Corp. for joint ownership and development of the **Kami project** (close to the Bloom Lake mine). The Definitive Feasibility Study (DFS) is scheduled for completion by end 2026. The project construction period is estimated at 48-months following FID (final investment decision). Life-of-mine is foreseen at 25 years, with average production of approximately 9.0 mt/a iron ore concentrate grading >67.5% Fe.
- **Cyclone Metals**' (Australian) **Iron Bear project** in the Labrador trough in Quebec, Canada, has recently announced the launch of a pre-feasibility study, due for completion in Q2 2026. A scoping study, released in August 2025, indicates a potential 25 mt/a magnetite concentrate operation, of which 16 mt/a is BF grade concentrate grading close to 70% Fe and 9 mt/a further processed to to DR/EAF grade pellets grading 71% Fe/1.1% SiO_2. Ramp up is foreseen at 12.5 mt in year 2, 17.5 mt in year 5 (when pellet production would commence) and 25 mt in year 6. Cyclone has executed a Development Agreement with Vale regarding joint development of the

project. FID is foreseen in 2028.

- Other projects in Quebec with DR/EAF grade concentrate potential include **Barlow Metals' Iron Hills, Oceanic Iron Ore's Hopes Advance, Metal Quest Mining's Lac Otelnuk, Cerrado Gold's Mont Sorcier, Red Paramount Iron's Lac Virot** and **High Tide Resources' Labrador West projects** (the last-named may include pelletising).
- **Magnum Mining & Exploration's Buena Vista magnetite project** in Nevada, USA aims to produce DR/EAF grade magnetite concentrate (grading 69.5% Fe). All major development permits have been secured.
- **CSN Mineração's** plans to increase capacity at the Casa de Pedra mine in Brazil from about 30 mt up to 68 mt/a by 2028 with an average Fe content of about 65%. This will include 21.5 mt/a of 67% Fe material, 16.5 mt/a of which as pellet feed from processing itabirite ore and 5 mt/a from processing tailings.
- **ArcelorMittal** is close to completing expansion of capacity for DR/EAF grade pellet feed at its Serra Azul mine in Brazil, from 1.6 mt/a currently to 4.5 mt/a by end 2025.
- **Bahia Mineração** (Bamin), owned by ERG (Eurasian Natural Resouces Group) plans to increase capacity of its Pedra de Ferro mine in Brazil to 26 mt/a to produce 10 mt/a direct shipping ore (DSO) and 15-16 mt/a high grade concentrate + pellet feed with average 67-68% Fe (the latter aimed primarily at producers of DR/EAF grade pellets). Current annual production is reported at about 2 mt/a of 65-66% Fe product. Project capex is €5.7 billion (for the mine expansion, railway and deep-sea port). The first shipment from the expanded operation will probably be postponed from the planned 2027 to Q4 2031 given the investment involved. ERG is seeking new investors and is examining non-binding offers from three different bidders.
- **Cadence Minerals** has signed a conditional Heads of Terms with a prospective offtaker for its **Amapa** magnetite ore project in northern Brazil, involving funding of the refurbishment of its Azteca plant, initially to process the large stock of tailings. The eventual plan is to develop a 5.5 mt/a 67.5% Fe DR/EAF grade concentrate operation.
- **Centaurus Metals** announced in late 2024 that its 100% owned **Jambreiro Iron Ore Project** in Brazil was awarded priority status by the State of Minas Gerais. The company aims to produce a DR/EAF grade pellet feed grading >67.5% Fe. Studies are ongoing.

- Canadian company **Black Iron's Shymanivske project** in Ukraine (first phase 4 mt/a, second phase 8 mt/a 68% Fe pellet feed) - most recently, the company signed a multi-year agreement with the city of Krivyi Rih to lease 248 hectares of land which will enable it to complete the research required to renew its special permit for the project's development. The company has also entered into a royalty and offtake agreement with Anglo American.
- **Nordic Iron** plans to produce 1.6 mt/a 68-69% Fe magnetite concentrate at the Blötberget mine in Sweden. Following a strategic review earlier in 2025, a revised DFS is targeted by end 2025.
- In May 2024 **GRANGEX AB** announced completion of the acquisition of the **Sydvaranger mine** at Kirkenes on the Russian border in the far north of Norway. Mining ceased in 2015 when then-owner Northern Iron went bankrupt. Also In May 2024 GRANGEX executed a conditional life-of-mine offtake agreement with Anglo American. In September 2025 GRANGEX announced the completion of a DFS for the restart of operations, to produce 63.3 mt 70% Fe magnetite concentrate over a 25 year mine life, with commercial exports starting in late 2026. FID is expected by end 2025.

- **GRANGEX AB** also intends to restart the **Dannemora mine** in Sweden to produce 1.1 mt/a 68% Fe magnetite concentrate over an 11 year mine life - the company's website includes the DFS report from June 2024, but the current project status is unknown.
- **Beowulf Mining's Kallak North project** in Sweden, is targeting 2029 start-up, to produce about 2.7 mt/a magnetite concentrate at >70% Fe with an initial 14 year mine life; future steps before FID can be taken are PFS, DFS and granting of the environmental permit.
- **Metinvest**, Ukraine is something of a wild card given the current war situation. In 2024, it produced almost 15 mt merchant iron ore, of which 59% was concentrates, 41% pellets. It is understood that, assuming installation of flotation at the Northern operation and the production of 4.5 mt/a pellets, merchant supply of DR/EAF grade concentrates could be about 7 mt/a.
- The **Gara Djebilet** deposit in Tindouf Provine, Western Algeria was discovered in 1952 with estimated exploitable reserves of ~1.7 billion tonnes at >50% Fe. A mine was partially commissioned in mid-2022. The main technical challenge of this ore is to reduce the phosphorus content from 0.8% down to 0.1% - Metallurgical Corp. of China (MCC) is assisting state-owned company SONAREM (Société Nationale de Recherches et d'Exploitation Minières) in developing a roadmap to deal with this issue. China Railway Construction Co. (CRCC) is constructing a 620 km railway to link Gara Djebilet with a deep water port on the Algerian coast, due for completion in 2026. Governmental plans are for initial annual production of 10-12 mt/a by 2032, building up to 40 mt/a by 2040. According to media reports, the first processing plant (crushing, screening, dry separation) will produce up to 4 mt/a, starting April 2026, and be operated by SONAREM.
- The **Simandou** mine in Guinea requires no introduction here. Rio Tinto recently announced that Simfer (the consortium of which it is the leading member) is due to start shipments in November 2025, with 0.5-1 mt by the year-end and 60 mt/a within 30 months. Combined production of the two consortia will reach 120 mt/a. Rio Tinto has reported Mineral Resources exclusive of ore reserves of 1.4 billion tonnes at 66.1% Fe and low impurities. The mine will initially deliver a single fines product with the potential to transition to a dual-fines product offering of BF and DR/EAF grades. Phosphorus content could be an issue with the latter. The government is pushing for domestic processing of iron ore - a recent media report notes that current agreements with the government require the two consortia to study and build a 0.5 mt/a steel plant or a 2 mt/a pelletising plant.

- Mauritanian state-owned iron ore miner **SNIM** exported about 14 mt various iron ore products (but no pellets) in 2024 and reportedly plans to increase production to 45 mt/a by 2031 (of which 20 mt/a from SNIM's existing operations, the balance from JV projects, including El Aouj with Glencore and Takamul with Hadeed) and further to 80 mt/a by 2045. Mauritania is much mentioned as a potential source of "green" DR/EAF grade concentrates/pellets given its abundant solar and wind capacity and thus ideally suited to become a producer of renewable clean energy and green hydrogen at competitive cost. A recent quote from SNIM's CEO suggests that eventual DR/EAF pellet capacity will be between 2.5 and 4 mt/a, dependent on energy availability. SNIM also has several collaborative sustainability initiatives involving DRI/HBI production.
- The **Zanaga** iron ore project in Congo-Brazzaville is a potential source of DR/EAF grade pellet feed. A 30 year mine life is foreseen, with production of 12 mt/a at 66% Fe during stage 1 and 18 mt/a at 67.5% Fe, expanding

to 30 mt during stage 2. The project team is evaluating potential key value-adding operations, such as pelletising. These important preparatory steps will place the project in a position to seek financing and progress to development when market conditions are favourable. Value adding activities also include the establishment of port and power agreements, as well as issue of the environmental permit.

- Stage 1 of **Akora Resources' Bekisopa iron ore project** in Madagascar envisages production of 2 mt/a DSO; Stage 2 envisages upgrading the ore by grinding and magnetic separation to a >67% Fe 75µm concentrate for the DR market.
- **Ivanhoe Atlantic** hopes to start construction at its 85% owned **Kon Kweni (aka Nimba)** project in Guinea in Q1 2026, ore to be shipped via Liberia to a new deep-water port at Didia. The project has a total resource of 751.9 mt DSO, of which 209 mt is high grade ore grading 67.8%.
- Finally **Australia**, which as the world's largest iron ore exporter could justify an article by itself, given the number of "green iron" projects and associated iron ore developments. There are various initiatives aimed at utilising the Pilbara hematite-goethite ores in the decarbonisation process - these ores are difficult and costly to beneficiate as some impurities, such as phosphorus, are bound up in the crystal lattice. One initiative is the **Neosmelt** project which brings together the expertise of BHP, BlueScope Steel, Mitsui Iron Ore Development, Rio Tinto Iron Ore and Woodside Energy. The Project involves the development of a pilot facility to investigate the feasibility of the DRI-ESF route to address the use of Pilbara ores in lower-carbon emission steelmaking with FID planned for mid-2026.
- The other route for Australia involves the use of magnetite ore, from both existing and undeveloped deposits. The former include **FMG's Iron Bridge** operation in the Pilbara and **Karara Mining's** operation in the Midwest region of Western Australia (WA). There are many magnetite projects across Australia including (in no particular order) **Hancock Prospecting's Mt. Bevan, Asia Iron's Extension Hill, Athena Resources' Byro Magnetite** and **MacArthur Minerals' Lake Giles** projects, all in WA, **Magnetite Mines' Razorback**, **Iron Road's Central Eyre Iron (CEIP)**, **Lincoln Minerals' Green Iron Magnetite** and **Grange Resources' Southdown** projects, all in South Australia, **Hawsons Iron's Magnetite** project in New South Wales and **Central Queensland Metals' Eulogie** project (a vanadiferous titanomagnetite deposit).

KEY TAKEAWAYS

- The slowdown in the implementation and ramp-up of some DR projects, coupled with the progress by the iron ore industry in recognizing that the transition to carbon-neutral steelmaking will require significantly increased supply of DR/EAF grade iron ore should have given a degree of comfort to the DR sector where iron ore feedstock is concerned, particularly with medium term supply of DR/EAF grade pellets. However, as the scenario analysis suggests, there is no room for complacency, and the DR sector should therefore monitor supply-side developments closely and act accordingly.
- The prospect of a future shortage of DR/EAF grade pellets has led quite a few DR project developers to consider captive pellet supply, often without a captive or contracted iron ore supply. The many new iron ore projects with scope to supply DR/EAF grade ore should therefore give encouragement to those planning captive pellet supply. Of course, not all these iron ore projects will be successful and prospective pellet producers should monitor developments accordingly.

→ The author wishes to thank friends and colleagues who have helped in preparing this article.

MEETING THE CHALLENGES OF H2-BASED TECHNOLOGY

DESIGN & SAFETY SOLUTIONS FOR NEW MIDREX® PLANTS



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INTRODUCTION

As the steel industry challenges itself to significantly reduce carbon dioxide (CO_2) emissions, steelmakers are placing a greater focus on reducing carbon emissions everywhere in their processes, including sourcing and utilizing larger volumes of lower-carbon raw materials such as direct reduced iron (DRI). The advent of new technologies, such as the MIDREX Flex® and MIDREX H2™, has made available very low-carbon DRI, allowing steelmakers to achieve increasingly challenging emissions targets. These new technologies are heavily focused on transitioning or replacing traditional natural gas (NG)-based direct reduction with hydrogen (H_2)-based direct reduction, while maintaining the safety and reliability standards that have made Midrex the world leader in direct reduction technologies.

Using hydrogen in direct reduction facilities is not a novel concept; however, the transition to hydrogen-based operations introduces complex design and safety challenges. Midrex has taken the lead in adapting its technologies to support the steel industry's initiatives to lower CO_2 emissions and embrace green steelmaking by implementing new standards and engineering solutions in the plant designs for MIDREX Flex and MIDREX H2 technologies to ensure safe and reliable plant operation for which MIDREX® Plants are known.

This article explains how Midrex leverages its expertise in DRI plant design and optimization to mitigate these risks and hazards and provide DRI plants that can be safely operated with up to 100% H_2 to help the global iron and steel industry achieve net zero-carbon goals.

HYDROGEN PROPERTIES

Molecular Weight	2.016
Chemical Family	Flammable gas
Chemical Name	Hydrogen
Chemical Formula	H_2
Appearance and Order	Colorless and odorless
Physical State (at N.P.T.)	Gas
Specific Gravity (water = 1) (liquid)	0.071 (at boling point)
Boiling Point	-423°F (-252.8°C)
Freezing Point	-434.6°F (-259.2°C)
Specific Gravity (water = 1) (gas)	0.0696 (at 0°C/32°F)
Gas Density	0.00521 lb/ft^3 (0.08342 kg/m^3) [at 21.1°C/70°F]
% Volatile (by volume)	100
Liquid Density	4.428 lb/ft^3 (70.96 kg/m^3) (at -423°F /-252.8°C)

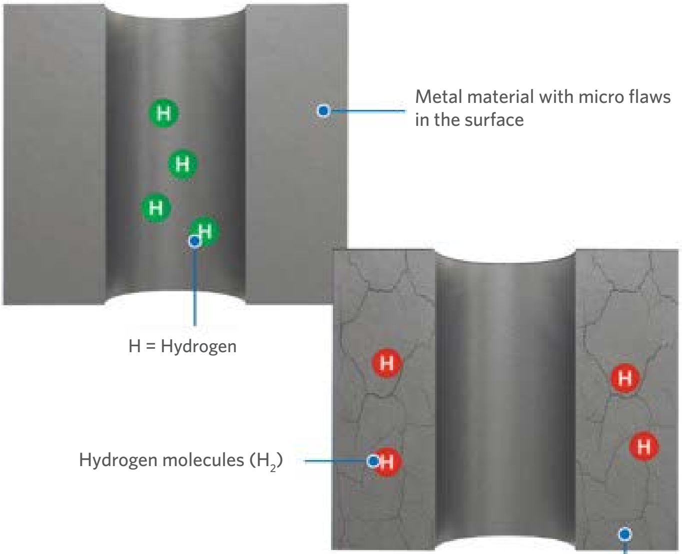
Hydrogen presents unique hazards including hydrogen embrittlement, hydrogen permeation, and the risk of hydrogen-related fires, explosions, and asphyxiation.

Hydrogen, the lightest gas, diffuses rapidly and poses unique challenges due to its high flammability and nearly invisible flame. Though non-corrosive in its pure state, its small molecular size increases the risk of leaks in gas-tight systems. Even minimal energy sources, such as static discharge, can ignite hydrogen, requiring rigorous containment and detection strategies. Additionally, a hydrogen atom's small size can allow it to penetrate or permeate metals and create stress, cracks, and catastrophic failures if appropriate measures are not incorporated into the design.

The two most common impacts from the use of high percentages of H_2 are embrittlement and permeation, especially in regard to instrumentation.

HYDROGEN EMBRITTLEMENT

Hydrogen embrittlement, also known as hydrogen-induced cracking or hydrogen attack, can significantly affect the integrity of metals in contact with H_2, leading to structural instabilities and risk of failure. Materials such as high-strength steels and certain alloys are particularly vulnerable, especially at low temperatures (< 100˚C).



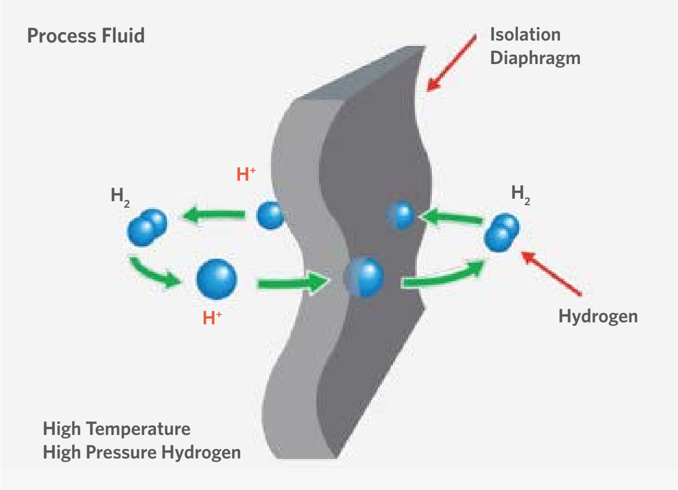
Pictured: Hydrogen embrittlement

Material selection is paramount in mitigating hydrogen-related degradation. Midrex ensures the materials for plant piping and equipment are chosen based on the process conditions and are specially designed to protect against the presence of hydrogen in the system. Instrumentation is also carefully selected to resist the negative effects of H_2 in the process. Most notably, instruments used in hydrogen service need special considerations for wetted parts that come in contact with the process. These wetted parts typically are required to be manufactured from 316L stainless steel, plated Alloy-400, or Alloy C-276. Special O-rings may also be required for complete isolation of hydrogen from the non-wetted parts of the instruments.

HYDROGEN PERMEATION

Hydrogen permeation occurs primarily in instrumentation that uses thin metal diaphragms, such as pressure transmitters or diaphragm seals. The small size of H_2 atoms allows them to diffuse through the steel diaphragms and combine with other atoms to displace special sensing fluid in the instrument, causing measurement drift. If left unchecked, measurement instrumentation inaccuracies can lead to process inefficiencies or instabilities, or possible safety hazards. Hydrogen permeation effects are magnified by higher pressures, elevated temperatures, or even the presence of hydrogen sulfide (H_2S) in the gas stream.

Hydrogen permeation through instrumentation membranes is typically prevented by proper material selection, such as gold-plated 316L stainless steel diaphragms. Although these instruments can be 40-60% more costly than non-plated options, the prevention of instrument measurement drift quickly justifies the additional expense in process streams with high H_2 compositions. Additional engineering design mitigations, such as shifting diaphragms away from high temperature areas, also can reduce the risk of hydrogen permeation through critical instrumentation in the plant.



Pictured: Hydrogen permeation

EFFECTS ON PROPRIETARY EQUIPMENT

Refractory Materials

The transition from conventional refractory materials used in NG-based operations to those suitable for high-H_2 environments (exceeding 80%) presents significant challenges due to hydrogen-induced corrosion at elevated temperatures. Hydrogen aggressively attacks and degrades the oxide compounds commonly employed in refractory manufacturing, compromising structural integrity and longevity. In conventional MIDREX Plants (i.e., NG-based), the reformed reducing gas typically contains approximately 55% H_2, exposing components such as the reducing gas duct, including the reheat duct, and the furnace linings to moderate levels of degradation. However, as H_2 concentrations increase, the rate of refractory erosion and corrosion accelerates markedly.

A comprehensive series of tests were conducted under controlled conditions to evaluate the long-term performance of refractory materials exposed to high concentrations of hydrogen. Multiple physical properties were assessed before and after exposure, revealing that hydrogen induces weight loss in refractory bricks, with degradation severity directly linked to phosphate content. Phosphate-bonded bricks experienced substantial density reduction over a short exposure period, while non-phosphate bonded bricks retained nearly all the original density and physical integrity. High alumina-burned, phosphate-bonded bricks exhibited poor performance due to chemical instability under elevated hydrogen conditions. Hydrogen actively leached silica (SiO_2) and phosphate (P_2O_5) from the refractory matrix into the gas stream, resulting in increased porosity, reduced density, and diminished mechanical strength.

These findings highlight the critical vulnerability of phosphate-bonded refractories in hydrogen-rich environments and underscore the need to upgrade the hot face lining to compositions containing 75–85% alumina, which offer enhanced resistance to hydrogen-induced degradation and maintain structural reliability under aggressive operating conditions.

REFORMER

In MIDREX Flex and MIDREX H2 plants, hydrogen is supplied "over the fence" by external providers and must be heated prior to entering the reduction furnace. In the MIDREX Flex configuration, hydrogen operations repurpose the conventional reformer as an H_2 heater, utilizing low NO_x burners to minimize emissions. For existing installations, retrofit low NO_x burner solutions are available through Midrex Global Solutions to support this transition.

In contrast, the MIDREX H2 plant employs specifically-designed electric heaters rather than a traditional NG reformer, aligning with decarbonization goals. Hydrogen introduces unique operational challenges due to its low molecular weight, which complicates sealing and containment, and its nearly invisible flame, which poses safety risks in the event of a leak. These factors necessitate specialized design considerations and safety protocols to ensure reliable and secure H_2 integration across Midrex technologies.

Hydrogen operations require rigorous risk mitigation strategies and careful material selection to ensure safe and reliable performance under demanding conditions. Technically tight calculations for flange connections and hazardous gas sealing areas must be performed to ensure proper configurations of components. Installation of bolted and gasketed connections must be performed by trained and certified technicians following detailed procedures. Quality assurance is critical during both construction and ongoing maintenance, supported by engineered safeguards, operational controls, and designated exclusion zones. Compliance with standards such as ASME B31.12 for Hydrogen Piping and Pipelines ensures structural integrity and safety. Base materials are thoroughly evaluated for susceptibility to embrittlement, particularly in environments prone to High-Temperature Hydrogen Attack (HTHA), which occurs at pressures above 10 bar and temperatures exceeding 100°C.

To address these risks, new reformer tube designs have been developed with metallurgical and mechanical properties tailored to hydrogen service. These tubes are engineered to operate outside the Nelson Curve risk zones—exposed to high temperatures but not high pressures—thereby minimizing the likelihood of HTHA and extending operational life in hydrogen-rich environments.

PROCESS DESIGN CONSIDERATIONS

One of the most critical aspects to consider is how to handle

a higher concentration of H_2 in the process flowsheet. During plant operations, the plant is initially pressurized with nitrogen (N_2) or seal gas, which has a molecular weight (MW) of around 28-30 g/mol. After establishing natural gas reforming, the reducing gases, H_2 and carbon monoxide (CO), are generated, decreasing the MW in the process gas to ~17 g/mol; almost half of the original inert gas. Reducing gas derived from NG reforming contains a significant amount of CO, however, the hydrogen concentration is still higher in the mix (i.e., H_2/CO ratio higher than 1.5), resulting in a net decrease of the molecular weight. During the H_2 transition, CO is further replaced by hydrogen as reducing agent, generating a gas with a molecular weight of ~8 g/mol at higher hydrogen replacement stages.

This important change in composition of the gas presents two challenges to overcome during the compression stage: a decrease in the compression ratio from the compressor, resulting in a lower pressure rise, and the need for a higher process gas (PG) flow to sustain furnace conditions due to the endothermic nature of the H_2 reaction. These two factors directly affect the design of the PG compressors. To meet the increased flow and pressure demands, a third compression stage becomes necessary. This additional stage is a centrifugal compressor, similar to the units typically used in the MIDREX NG flowsheet.

Figures 1A and 1B show the impact of the MW in the compression ratio for the same set of compressors, given that they could develop up to 6 barg max pressure when running with N_2 and only up 4 barg when the MW drops to 19 g/mol. The green line mimics the system curve (pressure requirements by the PG loop) and it shows how the two align as the MW drops to the typical operating values.

Instruments and valves also get affected by the wider operational range for the molecular weight. Gases with different molecular weight generate different ΔP (Greek symbol delta, denotes small but significant change in pressure) readings through an orifice which need to be considered in order to have accurate control of the process. This is why it is so critical to consider changes, not only in MW (specific gravity), but also in pressure and temperature. All this is accomplished by applying temperature, pressure, and specific gravity compensation for flow indications which might suffer variations in those parameters. This is not a new concept in the Midrex design, but becomes critical when talking about hydrogen transition. *Figure 2* shows a P&ID representation of the concept.

The transition also impacts some of the main equipment in the flowsheet, particularly the reformer, which also serves as process gas heater. As hydrogen replacement increases, the overall energy requirement of the reformer decreases. This is because hydrogen is introduced from an external source and reduces the need for endothermic reduction reactions. Similarly, as the concentration of carbon-bearing components declines in the MIDREX H2 flowsheet, the energy requirements continue to drop, further lowering the thermal load on the external heater.

In contrast, the top gas scrubber experiences an increase in cooling load as hydrogen replacement progresses *(see Figure 3, next page)*. This is primarily due to the higher flow rate and moisture content in the top gas, both of which result from the reduction reactions. Consequently, the overall cold water demand increases with hydrogen introduction, prompting several additions to the flowsheet, such as cooling tower and associated pumps. The internal components of the top gas scrubber - including the throat, packing and mist eliminators - can be designed to accommodate the full range of operating conditions.

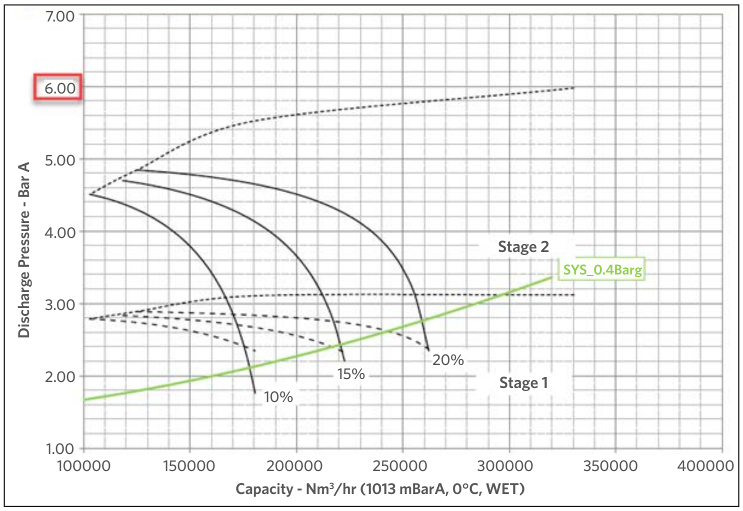


FIGURE 1A

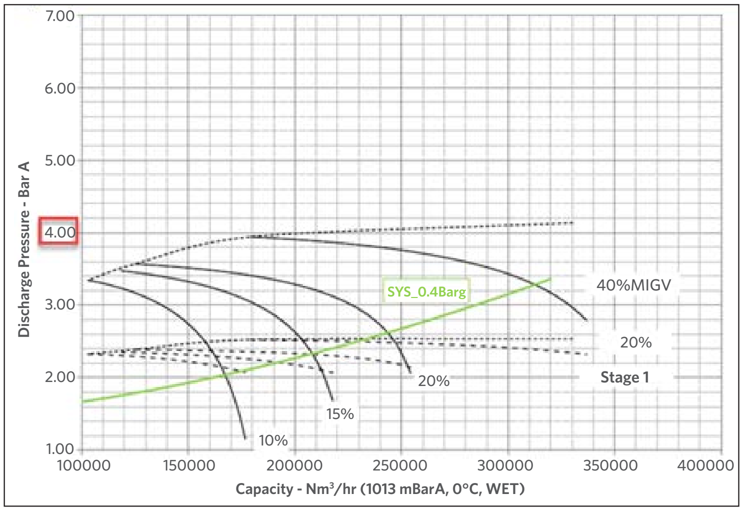


FIGURE 1B

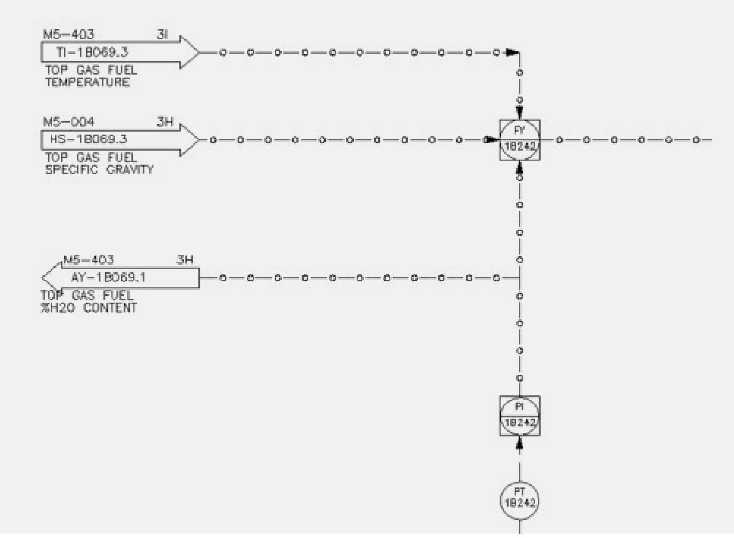


FIGURE 2. *Mass Flow Correction*

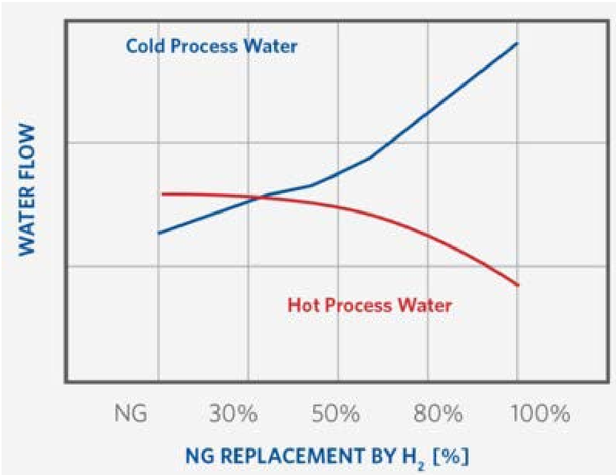


FIGURE 3. *Top Gas Scrubber Reaction to H_2 Increase*

In regard to the furnace, the higher gas flow per ton of product affects the sizing of both the furnace and the bustle ring nozzles. Proper sizing is essential to ensure proper gas distribution and to prevent potential fluidization issues during operation.

HYDROGEN SAFETY CONSIDERATIONS

When designing industrial plants that utilize combustible gases in the process, it is important to properly define the hazardous area classifications for the facility to ensure equipment, instrumentation, and materials used in the design will not create additional risks of fires or explosions in the event of a gas release. Hydrogen is classified under NFPA (Class 1, Div 2, Group B) and ATEX (Zone 2, IIC or IIB+H2) as requiring a larger hazardous zone compared to natural gas due to its volatility and lower ignition energy requirements ***(see Figures 4 and 5)***. Midrex evaluates and incorporates these hazardous area designations into the plant engineering process, thus ensuring appropriate selection of equipment, instrumentation, and ventilation systems based on gas composition and release scenarios.

Hydrogen has a wide flammability range (from 4-75% concentration in air) and a low energy requirement to initiate combustion. It burns with a pale blue flame with low radiant heat, which make it almost invisible in daylight and difficult to sense from a distance. Therefore, adherence to good practices of guarding and monitoring are necessary in enclosed locations of areas of potential leaks.

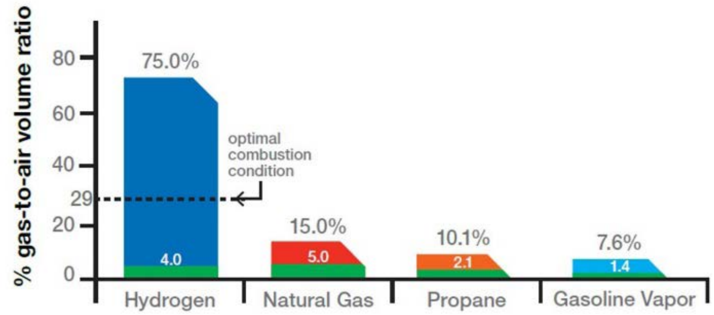


FIGURE 4. *Flame Range*

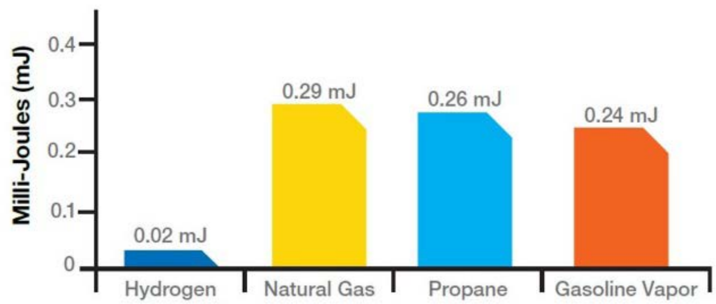


FIGURE 5. *Ignition Energy*

Hydrogen also can become an asphyxiation risk, as it displaces oxygen in the air. However, due to its light density, H_2 tends to dissipate quickly and can accumulate in higher areas of buildings. Gas monitoring is one of the most important considerations in the plant, either by four-gas monitors and/or localized analyzers. Applying a proper confined space procedure is also extremely important before entering to any vessel during shutdowns.

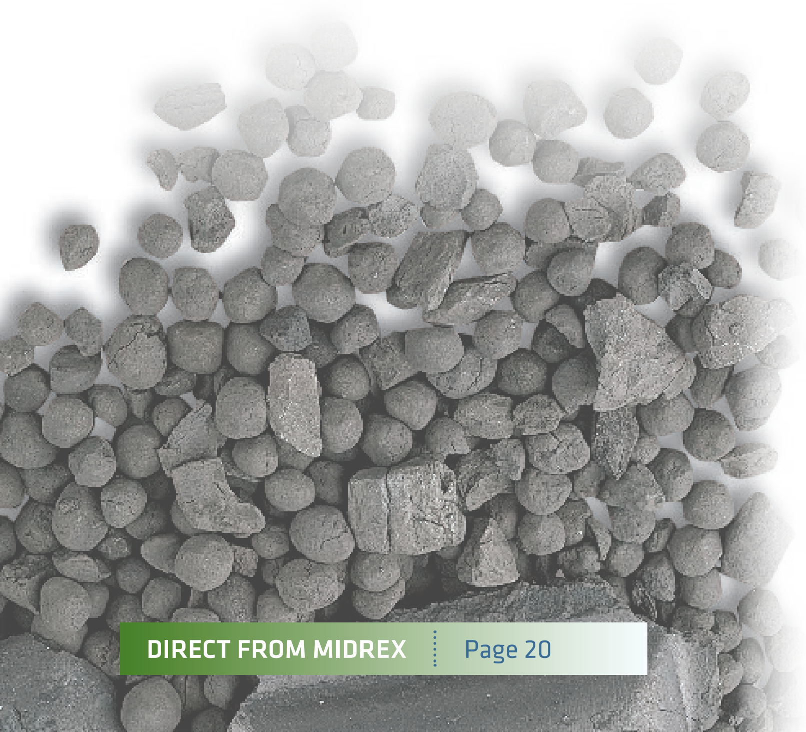
Process Hazard Analysis (PHA) and Hazard and Operability (HAZOP) studies are integral to Midrex's safety strategy for plant design. These evaluations, conducted by cross-disciplinary teams of engineering experts, assess operational deviations and ensure safe responses from the process in the event of risks to personnel, equipment, or environmental emissions. The methodology used is independent of gas composition, focusing instead on process knowledge and engineering design, and thus ensuring safe plant designs regardless of which MIDREX Plant design is being evaluated.

HYDROGEN – NOW & IN THE FUTURE

The best option for reducing the steel industry's CO_2 footprint is transitioning ironmaking from the blast furnace to direct reduction and ultimately moving from natural gas to hydrogen as the energy source and reductant for producing DRI. Existing natural gas-based MIDREX Plants can incorporate up to 30% hydrogen replacement without needing any significant equipment or instrument modifications, thereby offering a pathway to reduced carbon emissions for well-established DRI facilities.

MIDREX Flex technology provides immediate CO_2 reduction for new plants and a stepwise approach for transitioning from natural gas to nearly 100% hydrogen with minimal equipment modifications and limited changes to operations.

Designing plants that operate on 100% hydrogen (MIDREX H2 technology) introduces complex challenges. However, through a combination of process modeling with proprietary furnace modeling and CFD software, innovation engineering-driven designs, and in-house laboratory testing Midrex can provide full-scale commercial plants that meet the high safety standards and operational reliability for which MIDREX Plants are known.



Midrex News & Views

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

ERG of Kazakhstan Selects Midrex-Primetals For 2 MT/Y MIDREX Flex® HBI Plant

Eurasian Resources Group (ERG), a global metals and mining company, has signed a strategic contract with the consortium of Primetals Technologies (Primetals) and Midrex Technologies, Inc. (Midrex) for construction of a 2-million metric tons per year hot briquetted iron (HBI) plant in Rudny, Kazakhstan. The hydrogen-ready MIDREX Flex® plant will be one of the largest next-generation metallurgy facilities in Central Asia, producing HBI with metallization of at least 93.5% and iron content of ≈90% and designed for seamless transition to hydrogen when it becomes commercially viable.

The HBI plant construction project will be carried out by ERG subsidiary, QazIron ERG LLP. The plant will process iron oxide pellets produced by JSC SSGPO, a part of ERG. Commissioning is scheduled for 2029, and the project will create over 1,000 jobs in the region.

Representatives from ERG, Primetals Technologies, and Midrex Technologies at contract signing

(Seated left to right):
Aashish Gupta, *Chief Sales and Strategy Officer, Midrex;* ***Sergey Kuzmenko,*** *Head of Iron Ore Division, ERG and General Director of SSGPO JSC;* ***Thomas Marton,*** *Senior Vice President Ironmaking, Steelmaking & ECO Solutions, Primetals; and* ***Norbert Petermaier,*** *Executive Vice President and Head of Sales & Marketing, Primetals.*

Midrex News & Views

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2025 International Conference on MIDREX® Technology

Each year, Midrex brings together plant operators from around the world for a week of collaboration, knowledge sharing, and technical exchange with Midrex engineers and technologists. This two-way forum is essential for advancing MIDREX® technology and strengthening the global network of plant personnel and partners. It helps prepare MIDREX Plant operators to navigate the evolving dynamics of the global iron and steel markets while enabling Midrex to anticipate the needs of current and future customers.

In September, MIDREX Plant Operators, along with representatives from Kobe Steel, Ltd., and partners Primetals Technologies and SMS/Paul Wurth, convened in Amsterdam, The Netherlands, for the 2025 International Conference on MIDREX® Technology. The annual event featured keynote speaker James Campbell, CRU Head of Finished Steel Analysis, who provided strategic insights into global steel markets, pricing trends, and the industry's journey toward decarbonization and green steel. The conference also offered valuable opportunities for networking and collaboration among participants.

Awards and Recognition

Three plants received awards for achieving cumulative production milestones:

- **Libyan Iron & Steel Company 3** – 10 million tons
- **ArcelorMittal Nippon Steel India V** – 20 million tons
- **ArcelorMittal Lazaro Cardenas** – 40 million tons

Numerous plants were recognized for achieving plant records in 2024:

- Record Annual Production – 5
- Record Production rate – 4
- Record Metallization – 2
- Record Electricity Consumption – 6
- Record Natural Gas Consumption – 4
- Record Annual Operating Hours – 8

Midrex News & Views

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

Midrex Passes First Integrated ISO Audit

Midrex UK Successfully Completes ISO 45001

On October 30, Midrex Technologies Inc. successfully completed its first integrated ISO 45001 (Occupational Health and Safety) and ISO 9001 (Quality Management) audit with no nonconformances reported. The Midrex approach to mentorship was highlighted by DQS, a leading global certification body, as a notable strength and an example of how the company invests in its people and promotes continuous learning.

Midrex UK was successful in its ISO 45001 audit completed by DQS on November 10, with no nonconformances cited. The company was recognized for its business planning – documentation information system.

MIDREX® Plants with 4th Quarter Anniversaries

We are proud to celebrate these notable milestones with our customers – **15 years** since initial start-up of **Jindal Steel Sohar** and **5 years** for **Cleveland-Cliifs Toledo HBI**!

JINDAL STEEL SOHAR

15 YEARS

Formerly JindalShadeed and Shadeed Iron & Steel Company (aka Hamil Steel)

Location: Sohar, Oman

- Start-up: December 2010
- Product: HDRI/HBI
- Rated Capacity: 1.5 Mt/y

Jindal Steel Sohar is the largest privately-owned integrated steel producer in the Gulf Cooperation Council (GCC) region. In 2023, the Jindal Group acquired Sohar Steel after it had been shut down for several years.

The first-of-its-kind MIDREX HOTLINK Plant is designed for charging HDRI by gravity flow at 600-650° C to the adjacent electric arc furnace (EAF) melt shop and is equipped with briquetting machines to produce HBI as a secondary income source. Jindal Steel Sohar has produced more than 22 million metric tons of DRI products since 2010, and set numerous production records in 2024: annual (1.951+ Mt), monthly (169,646t in March), and daily and hourly (5,610t and 233.75t, respectively, on 16 March), as well as operating hours (8,725+ of 8,784 available, a worldwide record for MIDREX Plants).

Read more about Jindal Steel Sohar at **www.jindalsteel.om/jindal-steel-sohar**

MIDREX® Plants with 4th Quarter Anniversaries

CLEVELAND-CLIFFS TOLEDO HBI

Location: Toledo, OH, USA

- Start-up: December 2020
- Product: HBI
- Rated Capacity: 1.6 Mt/y

Hot-briquetted iron (HBI) is a compact, high-quality metallic feedstock that serves as a premium alternative to prime scrap and imported pig iron. The Cleveland-Cliffs Direct Reduction facility, the first of its kind in the Great Lakes region, produces HBI that is used throughout the company's operations, including in blast furnaces, basic oxygen furnaces, and electric arc furnaces, as well as supplied to third-parties

The production and use of HBI are integral to Cleveland-Cliffs' greenhouse gas reduction strategy. With its low-cost production advantages, alignment with the steel industry's decarbonization goals, the shrinking supply of domestic prime scrap, and the continued expansion of electric arc furnace (EAF) capacity in the United States, the Toledo Direct Reduction Plant is positioned to deliver significant and lasting value for the company.

Read more about Cleveland-Cliffs Toledo HBI at **https://www.clevelandcliffs.com/operations/steelmaking/toledo-dr-plant**

Lauren Lorraine: **Editor**

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