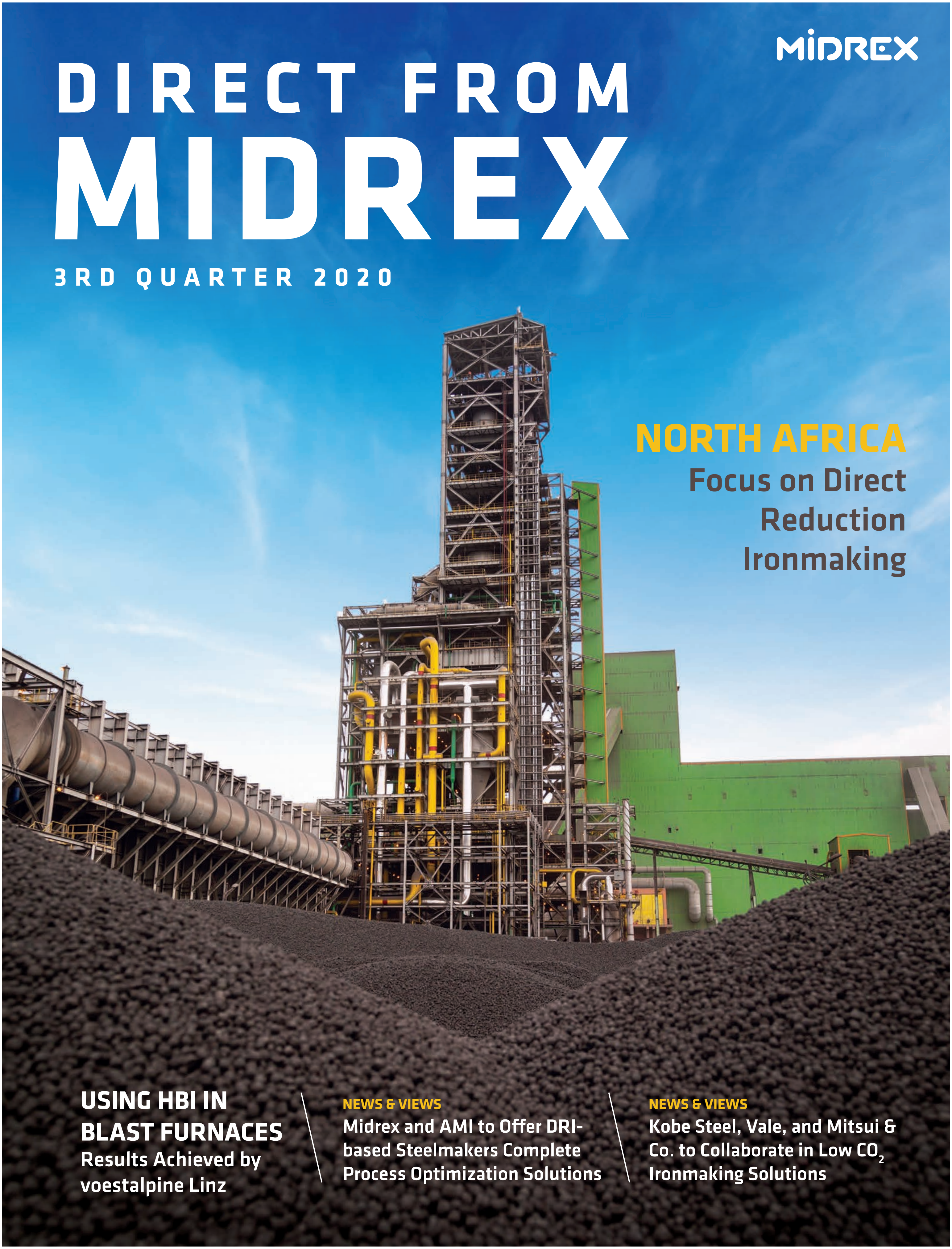
MIDREX

DIRECT FROM MIDREX

3RD QUARTER 2020



NORTH AFRICA
Focus on Direct Reduction Ironmaking

USING HBI IN BLAST FURNACES
Results Achieved by voestalpine Linz

NEWS & VIEWS
Midrex and AMI to Offer DRI-based Steelmakers Complete Process Optimization Solutions

NEWS & VIEWS
Kobe Steel, Vale, and Mitsui & Co. to Collaborate in Low CO_2 Ironmaking Solutions

COMMENTARY

VALUE = BENEFITS/COST

By Mark Boedecker
Director – Sales & Marketing
Midrex Technologies, Inc.

"Delivering value" is something we hear all the time, but what does it really mean? It likely means something different to each of us because our "wants" change depending on our "needs" at a particular time or in a certain situation. Value is the benefit a customer receives measured against the price paid. Usually this is used to evaluate the difference between two or more competing offerings.

The reputation of a company and how it presents itself plus the perception of its technology and the benefits of its products are key considerations in determining an organization's "total market offering." Therefore, value can be defined as the relationship of a company's market offerings to those of its competitors.

We can break down value into four types: functional, monetary, social, and psychological. However, the importance of a type of value depends on the perspective of the customer and the particular purchase. Let's look at each type of value:

- **Functional value** – this is what an offer does for the customer: the solution to a particular want.
- **Monetary value** – this is what it will cost relative to the perceived worth: a trade-off between other values and the price.
- **Social value** – this is how much owning a product or receiving a service allows the customer to connect with or benefit others.
- **Psychological value** – this is how much a product or service allows the customer to express themselves or heighten their effectiveness.

The key to delivering high perceived value is finding a blend of the types that best suits each customer, convincing them that what you are offering exceeds expectation in helping them solve a problem with a solution that produces the desired results at a competitive price and serves as a source of corporate pride in accomplishment.

Midrex is committed to providing sustainable value to its customers through technology innovations and product improvements that are relevant to their requirements; plant designs that are simple, reliable, and embrace technology advancements; interactive information flow; and empowering customers to take ownership of ideas and responsibility for actions.

The active involvement of Midrex in all phases of plant design, supply, operation, and maintenance assures customers that their investment is protected, and their plants will have long and productive lives.

Midrex Global Solutions was created in 2018 as a clear statement of our dedication to providing unsurpassed value for customers. It embodies the Midrex spirit of innovation, opportunity, and cooperation. The Global Solutions team is uniquely capable of providing solutions that are tailored to each customer's wants. As a result, customers receive the knowledge, training, assistance, and aftermarket equipment and services to be successful.

We work hard to provide a "total market offering" that is representative of our commitment to the direct reduction industry and in step with the needs, wants, and demands of our customers.

(Wikipedia article titled, "Value (marketing)" was used as source)

→

This issue of *Direct From Midrex* features articles by Paul Wurth, a Midrex Construction Partner, about the current accomplishments and future potential for direct reduction-based steelmaking in the MENA Region and a detailed report by voestalpine Stahl of the use of HBI in its blast furnaces in Linz, Austria.

NORTH AFRICA
FOCUS ON DIRECT REDUCTION IRONMAKING

Oran, Algeria, looking east toward Tosyali Algérie in nearby Bethioua.

By GUIDO BONELLI
Head of Ironmaking Technical Sales, Paul Wurth Italia

INTRODUCTION

Direct reduction of iron – extracting metallic iron from iron ores without melting the material – is one of the first industrial processes developed by humans. Early ironmakers were unable to achieve the high temperatures required to melt iron ores, so they heated them together with charcoal to produce a pasty, metallic substance which they could hammer into tools and other implements. Today, direct reduction is the fastest growing, most innovative and environmentally clean method to produce high quality metallic iron for steel production.

North Africa is in the forefront of the modern age of ironmaking. Eleven direct reduction modules, with a total rated capacity of almost 14.7 million tons, are either installed or under construction in Algeria, Egypt, and Libya. By comparison, there are only two blast furnaces (one each in Algeria and Egypt), with a total installed capacity of 2.0 million tons ***(TABLE I, next page)***. DRI production in 2019 was 6.46 million tons compared with approximately 0.75 million tons of hot metal.

NORTH AFRICAN STEEL INDUSTRY SINCE WW2

Since the end of World War II, Egypt and Algeria have been the leading steel-producing countries in North Africa. The Egyptian Iron and Steel Company, founded in 1954, established the region's first classically integrated steel mill based on the blast furnace/basic oxygen furnace (BF/BOF). The philosophy at the time was state involvement for generating profitability in the social sense, while economic profitability was secondary. Since the 1990s, as the private sector was granted more access to the steel industry, there have been huge investments in new technologies with the aim of enhancing economic profitability. As a result, direct reduced iron (DRI) production has taken over as the dominant ironmaking method and the electric arc furnace (EAF) in combination with a DRI plant has become the preferred steelmaking route. Beginning with start-up of the first MIDREX® Module in El Dikheila, Egypt, by Alexandria

TABLE I. *North African Iron Production (DRI vs. HM)*

* Status Codes: O – Operating I – Idle C– Under Contract or Construction

	Company	Location	Capacity	Modules	Product	Start-up	Status*	CUMULATIVE DRI PRODUCTION	2015	2016	2017	2018	2019
DRI PRODUCTION	EZDK I	El Dikheila, Egypt	0.72	1	CDRI	'86	O	EGYPT	2.73	2.82	4.67	5.22(e)	4.05
	EZDK II	El Dikheila, Egypt	0.8	1	CDRI	'97	O						
	EZDK III	El Dikheila, Egypt	0.8	1	CDRI	'00	O						
	ESISCO	Sadat City, Egypt	1.77	1	HDRI/CDRI	'15	I						
	SUEZ STEEL	Adabia, Egypt	1.95	1	HDRI/CDRI	'13	O						
	EZZ ROLLING MILLS	Ain Sukhna, Egypt	1.9	1	CDRI	'15	O						
	LISCO 1 & 2	Misurata, Libya	1.1	2	CDRI	'89 - '90	O	LIBYA	0.45	0.69	0.56	0.61	0.87
	LISCO 3	Misurata, Libya	0.65	1	HBI	'97	O						
	TOSYALI ALGÉRIE	Oran, Algeria	2.5	1	HDRI/CDRI	2018	O	ALGERIA	-	-	-	0.11	1.54
	ALGERIAN QATARI STEEL	Bellara, Algeria	2.5	1	HDRI/CDRI	2020	C		-	-	-		
			14.69	**11**					**3.18**	**3.51**	**5.23**	**5.94(e)**	**6.46**

	Company	Location	Capacity	Modules	Product	Start-up	Status*	CUMULATIVE HOT METAL PRODUCTION	2015	2016	2017	2018	2019
HM PRODUCTION	EISCO	Cairo, Egypt	0.5	1	Hot Metal	1979	O	EGYPT	0.5*	0.5*	0.5*	0.65*	0.6*
	SIDER	El Hadjar, Algeria	1.5	1	Hot Metal	2017	O	ALGERIA	0.6*	0.7*	0.5*	0.20*	0.15*
			2	**2**					**1.1***	**1.2***	**1.0***	**0.85***	**0.75***

* Presumed

National Steel Company (ANSDK) in 1986, the ability to match steel production to market requirements with the EAF and the opportunity to derive added value from natural gas resources with DRI plants has stimulated growth and self-reliance in the North African steel industry. ANSDK went on to add two more MIDREX Modules in 1997 and 2000, which along with the associated steel mill are now owned and operated by Ezz Steel. The company also operates DRI/EAF facilities in Adabia and Ain Sokhna, Egypt, which include HYL/Energiron Plants, bringing the total installed DRI capacity of Ezz Steel to 5.1 million tons.

Libyan Iron & Steel Company (LISCO) began operating two MIDREX Modules in 1989-90 to feed DRI to its new EAF melt shop in Misurata, Libya, and added a MIDREX HBI Plant in 1997, to take advantage of the growing merchant metallics market. Although the DRI/EAF complex has been disrupted by restricted natural gas supply and civil war in recent years, LISCO increased DRI production in 2019 by more than 55% over 2017.

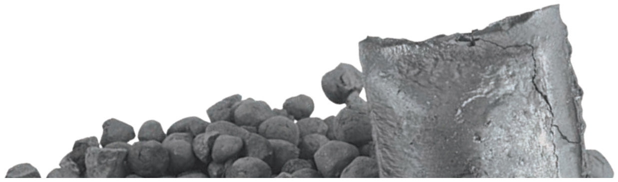
Algeria is the newcomer to DRI/EAF steelmaking in North Africa. Tosyali Algérie, which has been producing steel rebars in Bethioua (Oran), Algeria, since 2013, began commissioning the world's largest simultaneous discharge (hot and cold product) DRI plant in July 2018, and commenced cold DRI (CDRI) operation in November 2018. The first hot DRI (HDRI) was transferred to the nearby melt shop in February 2019, and the 2.5 million tons per year MIDREX Plant set the world record for daily DRI production in July 2019 – one year after start-up. A second 2.5 million t/y simultaneous discharge MIDREX Plant is nearing completion in Bellara, Algeria, for Algerian Qatari Steel (AQS), and is expected to start operation in the near future. Additional details of the two plants are included later in this article.

DRI/EAF STEELMAKING IN NORTH AFRICA

There is no doubt that the technology of the blast furnace/basic oxygen (BF/BOF) route has improved steelmaking efficiency, productivity, and product quality compared to the open-hearth furnace. However, the direct reduced iron/electric arc furnace (DRI/EAF) route is a better option for North Africa and the Middle East-North Africa (MENA) region. What makes the DRI/

EAF combination attractive when compared to traditional BF/BOF steel production?

- Value-added use of associated natural gas
- Capacity sized to market needs
- More flexibility to deal with market conditions
- Lower capital cost
- Fewer emissions, less solid byproducts
- Less water required
- Capable of meeting the most stringent steel specifications



The abundance of natural gas and the low cost of electricity for industrial use are two of the main reasons for the dominance of DRI/EAF steel production in the MENA region. Algeria had the world's third lowest natural gas price in 2018, as shown in ***Figure 1***, and Qatar, Saudi Arabia, and the United Arab Emirates are among the 10 lowest. Egypt had the 26th lowest natural gas price in 2018.

The price of electricity for business in Algeria is $0.036/kWh and $0.073/kWh in Egypt (www.globalpetrolprices.com). However, the reliance on imported iron oxide pellets is a source of concern for the region's steel producers (iron oxide pellets typically make up 70-80% of DRI OPEX). The development of a regional source, such as in Morocco and in Algeria (Gara Djebilet site), is under consideration.

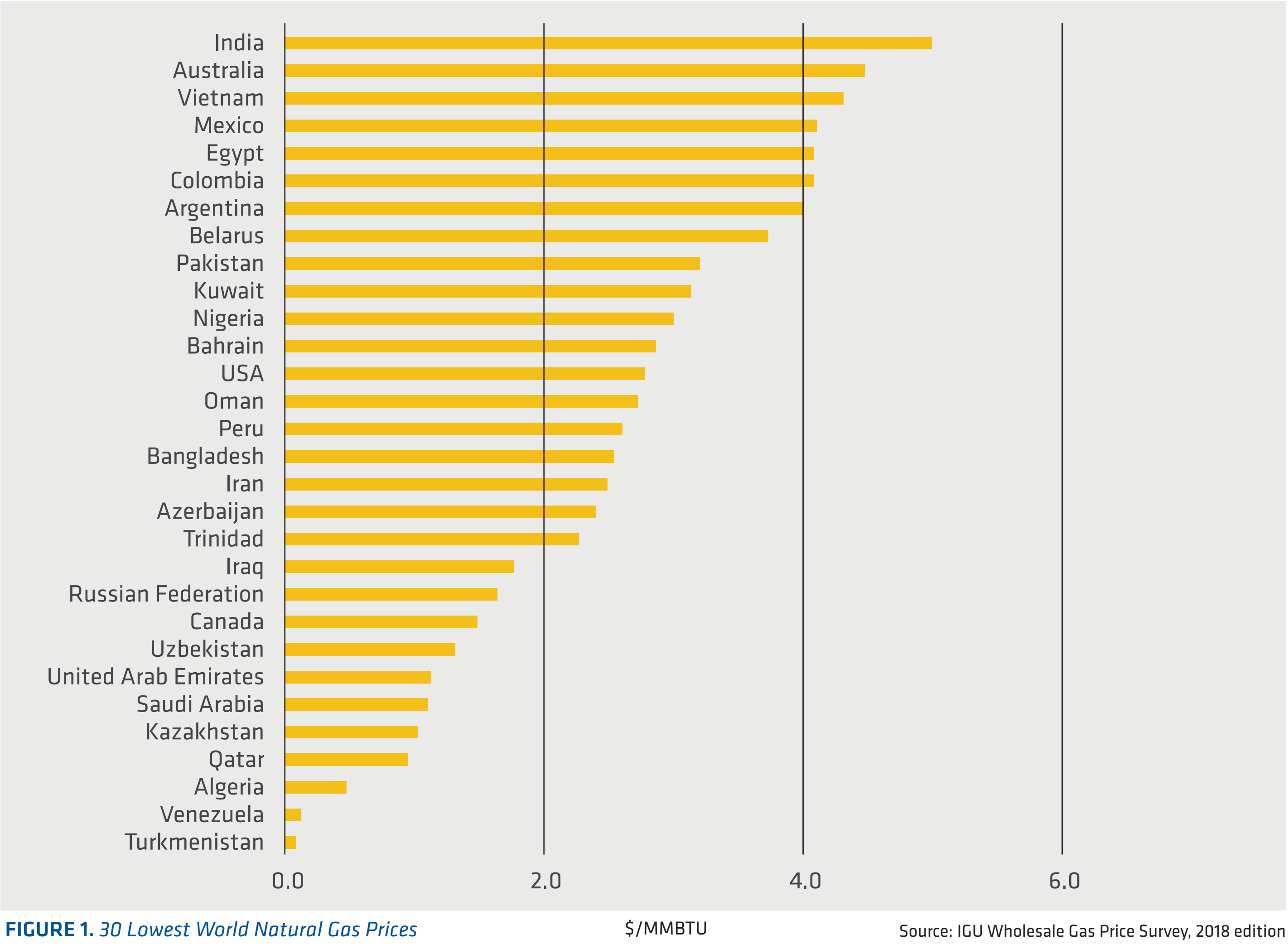


FIGURE 1. *30 Lowest World Natural Gas Prices*

Source: IGU Wholesale Gas Price Survey, 2018 edition

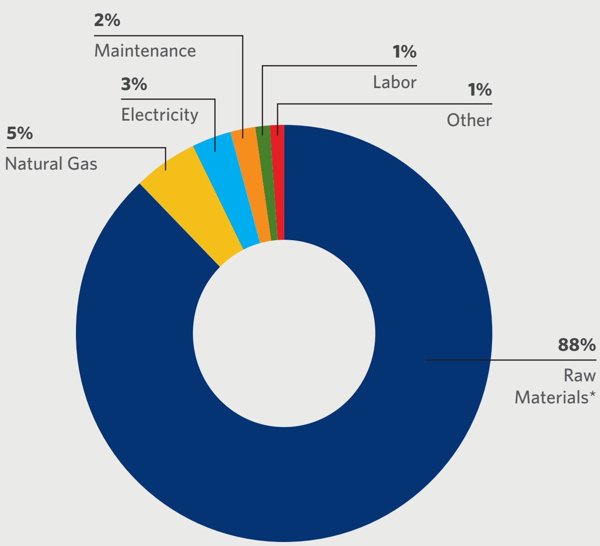
ALGERIA - THE RISING STAR IN DRI PRODUCTION

Reasons Algeria is in ascendency:

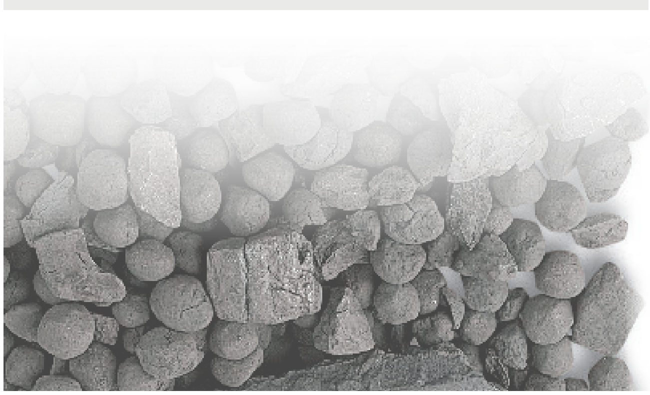
1. Political stability to boost confidence of foreign investors
2. Availability of natural gas resources – weight of NG cost in a traditional DRI OPEX *(Figure 2)*
   - Algeria has world's third-lowest wholesale NG price (only Venezuela & Turkmenistan are lower)
3. Strong governmental policies favoring the industrial sector
   - Competition with exporting natural gas at higher prices (revenues for the state) vs. using it for national industry development
   - Long-term pricing policies for electrical energy for the industrial sector

FIGURE 2.

ESTIMATED DRI OPEX IN ALGERIA



[*70-80% Iron Oxide Pellets]



ALGERIAN DRI PROJECTS

TOSYALI ALGÉRIE

Main Features:

- World's largest combination HDRI/CDRI plant
- 7.65 meters diameter MIDREX MEGAMOD® furnace
- 8 rows x 18 bays MIDREX Reformer

Tosyali Algérie, a subsidiary of Turkey's Tosyali Holding, started production of steel rebar in Bethioua, near Oran, Algeria, in 2013, using scrap as feedstock. It subsequently added 500,000 t/y of wire rod production capacity, which was started up in 2015. The decision was made to add a direct reduction plant, which was commissioned in 2018 and began production in 2019. It is the world's largest single module MIDREX Plant (2.5 million tons/year) in operation.

A 4 million tons/year pellet plant was constructed to produce iron oxide pellets for use in the DRI plant and went into effect at the end of 2018. The pelletizing and DRI facilities will significantly contribute to the economy of Algeria by efficiently using the country's subterranean mineral resources.

ALGERIAN QATARI STEEL (AQS)

Main Features:

- World's largest combination HDRI/CDRI plant
- 7.65 meters diameter MIDREX MEGAMOD® furnace
- 8 rows x 18 bays MIDREX Reformer

AQS, a joint venture between Qatar Steel International; SIDER, an Algerian investment group; and the National Investment Fund of Algeria, contracted with Midrex and Paul Wurth to supply a 2.5 million tons/year direct reduction plant capable of producing cold DRI (CDRI) and hot DRI (HDRI). The MIDREX Plant is part of an integrated EAF-based steel mill in Bellara, Algeria, 375 kilometers east of Algiers. Construction of the DRI plant was affected by the COVID-19 pandemic in spring 2020, and is expected to begin production in the near future.

WHAT'S NEXT FOR DRI IN NORTH AFRICA

Algeria

If the Algerian Government keeps supporting local industry by selling natural gas at low prices, there is the real possibility to have new plants in Algeria for DRI/HBI production in the mid-term. The possibility of exploiting local iron ore deposits, such as Gara Djebilet in Tindouf Province would further reduce the OPEX for DRI production.

Egypt

The strongest, fastest growing economy in North Africa already has about 8 million t/y of DRI capacity and many years of operating experience, both producing and using DRI. In recent years, production was increased from 30% to almost 60% of rated capacity. However, the issue of natural gas shortages will need to be solved for full utilization of the existing DR plants and the possibility of new construction.

Libya

With an abundance of natural resources, its economic future depends on stabilizing the political and social structure in the next years.

Morocco

As one of the highest rated countries for political stability in the region, it could have a future as a DRI producer thanks to new gas resources found in the southeast (Tendrara, with near-term potential up to 3-4 trillion cubic feet of gas ***(Figure 3)***.

FIGURE 3. *Natural gas resources in Morocco*
Source: World Energy News, 2015

Opportunities:

- Abundant natural gas resources
- Close to Mauritanian iron ore mines
- Development of automotive industry (PSA, Renault, Fiat)

Challenges:

- Availability of natural gas for iron & steel industry
- Economics of exporting natural gas to Europe vs. internal use (pipelines in place)

OPPORTUNITY ARISING FROM EU CO_2 REDUCTION GUIDELINES

A major challenge for all industries worldwide is how to comply with more stringent environmental emissions standards. The Paris Agreement, which entered into force on 4 November 2016, has a goal to increase the global response to the "threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels" [1]. Reduction of carbon dioxide (CO_2) emissions by the industrial sector is widely recognized as a key to achieving these targets, especially in the iron and steel industry, which is among the largest contributor of greenhouse gas emissions. Iron and steelmaking accounts for almost 7% of mankind's entire carbon footprint [2]. Ironmaking alone constitutes 80-85% of iron and steel's total CO_2 output. Integrated mills are the largest producers of CO_2 by both volume and percentage.

Mitigating CO_2 emissions is becoming critical, especially in Western Europe, as the cost of CO_2 emissions continues to increase. For example, emission allowance prices quadrupled in 2018 ***(see Figure 4)***. The general consensus is that emissions restrictions will get tighter globally and this will severely affect the sustainability of many industries, particularly traditional integrated steelmakers because of their reliance on refined coal (coke) as both an energy source and a reductant to produce high carbon (~4.5%) metallic iron from iron ore.

European ironmaking is largely based on the traditional integrated route (BF/BOF). Based on the world steel industry's coal consumption, it is estimated that BF ironmaking (including the processing step to make the coke from metallurgical coal) generates approximately 1.8 tons of CO_2 for every ton of iron produced. As no proven carbon capture system exists for blast furnaces, the best way for integrated steelmakers to reduce CO_2 emissions is simply by not creating the emissions in the first place.

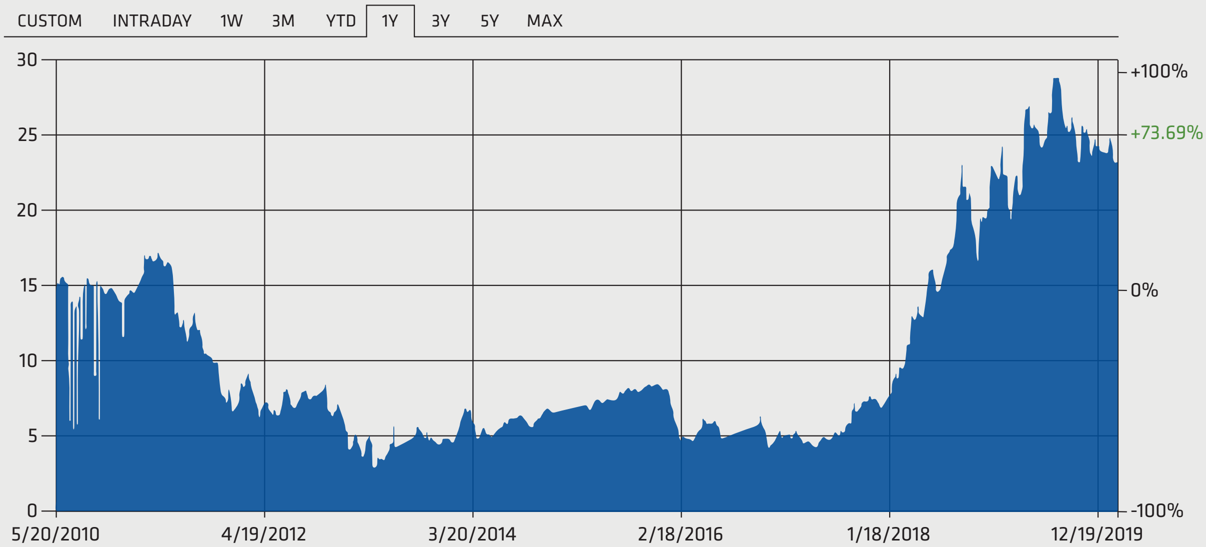


FIGURE 4. *European CO_2 Emissions Allowances Prices* (Source : https://markets.businessinsider.com/commodities/co2-emissionsrechte)

Shuttering a certain percentage of BF capacity will no doubt be necessary in the next few decades, but economics will prevent simply replacing BF/BOF works with DRI/EAF mills. A practical way to keep efficient BFs operating is needed. The solution would still involve the benefits of DRI but from an operational standpoint rather than as an outright replacement of BF capacity.

European Union (EU) steelmakers have started to make plans for a gradual shift over the next 20 years to EAFs but there is serious concern about scrap availability. Steel produced with end-of-life (obsolete) scrap in an EAF has the lowest CO_2 emissions; however, a plateauing of steel stocks in mature economies coupled with a strong demand growth for steel in developing economies means that scrap supplies are sufficient for only approximately a 22% share of metallic input for global steel production. Scrap supplies are forecasted to grow but the availability of obsolete scrap lags steel demand by 10-50 years following production, depending on the application [3]

A long-term solution is to produce DRI with hydrogen to supplement scrap supplies. However, a near-to-mid-term solution is available now – merchant HBI produced in North Africa for use in the BFs and EAFs of the EU ***(Figure 5)***.

FIGURE 5. *HBI trade routes from North Africa to the EU*

PAUL WURTH AND MIDREX - A POWERFUL RELATIONSHIP

Midrex has a long and successful history of partnering with leading international companies to develop, finance, and construct DRI plants based on the MIDREX Process. These companies are acknowledged leaders in their fields – from design and engineering of iron and steelmaking equipment to development and management of full turnkey iron and steel plant projects. Midrex partners are highly regarded for their technical expertise, adherence to project schedules, and exceptional performance.

Tosyali Algérie and Algerian Qatari Steel, the two largest and most recent MIDREX Plants were supplied by the consortium of Paul Wurth and Midrex. Paul Wurth, headquartered in Luxembourg since its creation in 1870, has developed over the course of its history into an international engineering company. Its considerable know-how and effective policy of innovation has made the Paul Wurth Group one of the world leaders in the design and supply of the full-range of technological solutions for the primary stage of integrated steelmaking ***(Figure 6)***. Paul Wurth has been a member of the SMS group since December 2012 and a Midrex Construction Licensee since 2014.

The Paul Wurth scope of supply for the two Algerian projects included engineering (basic for civil and buildings; detail for piping, structural steel, and electrical), equipment and materials supply, and local services.

SUMMARY

North Africa is emerging as a focal point of direct reduction-based ironmaking. Algeria and Egypt are transitioning from the blast furnace/basic oxygen furnace (BF/BOF) steel production route to take advantage of the economy of scale of EAF-based steelmaking and the operating cost advantages of producing and using DRI. Algeria is a rising star in the world of DRI production, with the two largest MIDREX Plants in the world located in the steelworks of Tosyali Algérie and Algerian Qatari Steel (AQS) in Bethioua (Oran) and Bellara, respectively. The potential exists for Morocco to emerge as a significant player due to its natural gas resources, proximity to iron ore mines in Mauritania, and political stability. The guidelines for CO_2 reduction in the European Union (EU) could have a positive effect on North African DRI production, as the use of HBI in the blast furnace presents an immediate-to-medium term solution for EU steelmakers. Libya already exports HBI to Europe, and producers in Algeria and Egypt could follow suit. The partnership of Paul Wurth and Midrex has the local experience and proven track record to continue assisting North Africa in its emergence as a direct reduction ironmaking region.

References:

1. United Nations Climate Change website (https://unfccc.int/)
2. ArcelorMittal Climate Action Report 1 2018, page 10.
3. Robert L. Hunter, "Massive Savings in CO_2 Generation By Use of HBI," Direct From Midrex, Midrex Technologies, Inc., Charlotte, NC, 3-4Q 2009, pp 9-11.

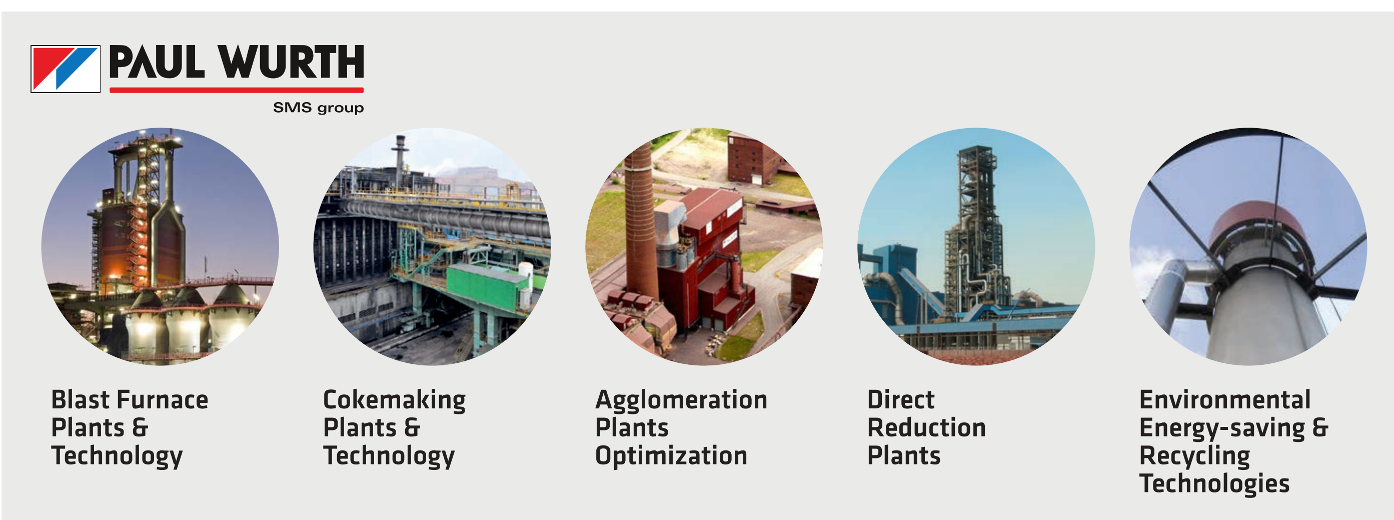


FIGURE 6. *Paul Wurth technological solutions for primary steelmaking*

USING HBI IN BLAST FURNACES

Results Achieved by voestalpine Linz

By ANNA GRIESSER & THOMAS BUERGLER,
voestalpine Stahl GmbH

INTRODUCTION

The Paris Agreement, with the objective of a maximum global increase in temperature of 2˚C by the end of the century compared to the pre-industrial period, is undoubtedly an important step toward true global climate protection. The European Green Deal is a response to these challenges and defines strategies to transform the Union into a modern, resource-efficient, and competitive economy. The overarching goal of the Green Deal is to make Europe the first GHG-emission neutral continent by 2050.

TOWARD CO_2 EMISSION-FREE STEELMAKING

Where do the challenges lie in the decarbonization of steelmaking? CO_2 emissions originate from the coke/coal-based blast furnace (BF) and basic oxygen furnace (BOF) process route, which—still today—is the global standard for 72% of worldwide steel production ***(see Figure 1)***. Carbon is needed in the production of hot metal in the BF as a reducing agent for iron oxides and supplies the process energy required for gasification. The carbon contained in the hot metal must be oxidized through top blowing in the BOF converter. Carbon and oxygen together form carbon dioxide. A reduction of process-related CO_2 emissions can only be achieved by partially (or even completely in the long term) replacing carbon with hydrogen.

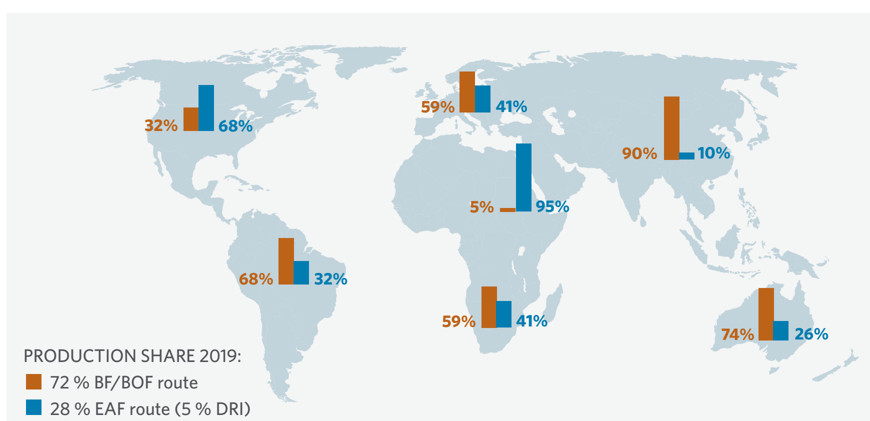


FIGURE 1. Global steel production routes *[www.bir.org (11th Edition World Steel Recycling)]*

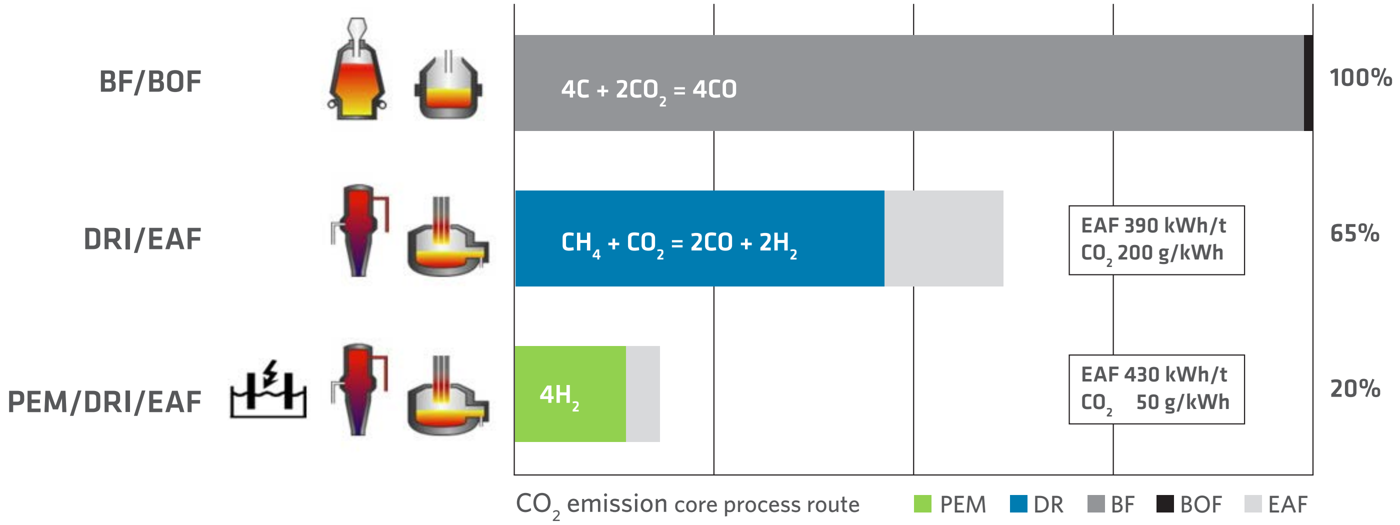


FIGURE 2. *CO_2 emissions of steel production routes*

GRADUAL DECARBONIZATION

From today's perspective, the scenario to achieve the climate targets includes a gradual decarbonization of steelmaking with a long-term vision of completely replacing CO_2 with hydrogen. The interim technology relies on the direct reduction (DR) process where natural gas is used to produce direct reduced iron (DRI) in the densified form of hot briquetted iron (HBI). With respect to the core process of DR, this results in a CO_2 reduction of 50% when compared to the BF process. Depending on the generation capacity for power used to melt scrap in the electric arc furnace (EAF), a reduction of around 35% can be achieved by the DR/EAF process when compared with BF/BOF route. It is thought that CO_2 emissions could be further reduced to 20% of the BF/BOF route when Proton Exchange Membrane (PEM) electrolyzers are used with the DRI/EAF route ***(see Figure 2)***.

HBI FOR BF OPERATION

The potential for HBI to be used in the BF/BOF steelmaking route rather than just EAF-based steelmaking, with which the use of all forms of DRI is usually associated, could play a significant role in the future of European iron and steelmaking with the target of CO_2 reduction. HBI has been used successfully by steelmakers in the USA for 25 years, so there is no technology risk associated with using it compared with breakthrough technologies.

voestalpine in Linz, Austria uses HBI from its own plant in Corpus Christi, Texas, USA, ***(Figure 3)*** in its blast furnaces. This article will discuss the influence of the usage of HBI in the blast furnaces on the consumption of reducing agents, productivity, blast furnace operation, and hot metal quality.

FIGURE 3. voestalpine Texas HBI plant

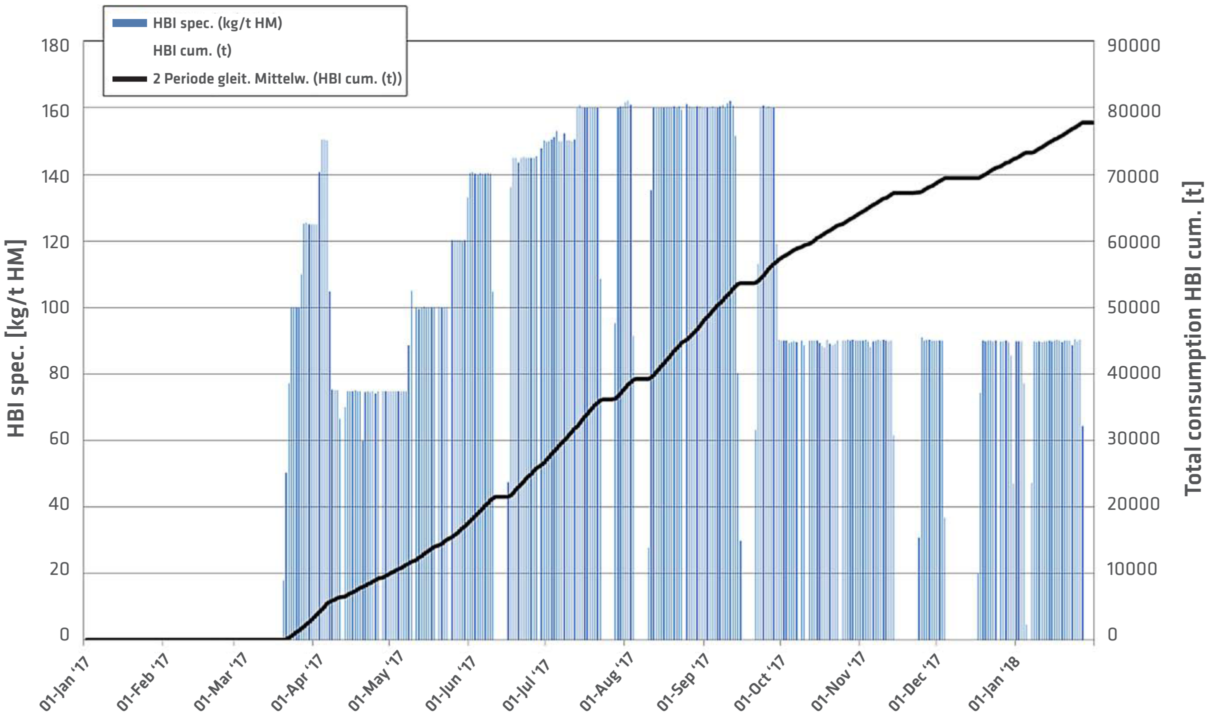


FIGURE 4. *HBI quantity used in BF operation*

Blast Furnaces 5 and 6 at voestalpine Linz have a hearth diameter of eight meters and on-average produce 2500–2700 tons of hot metal per day. The specific quantity of HBI used in the blast furnaces for a selected period and the total cumulative consumption are shown in *Figure 4*. The HBI quantity peaks were at 160kg/t HM. The briquettes are charged with the burden in the blast furnace.

INFLUENCE OF HBI ON REDUCING AGENTS AND MELTING RATE

Typically, HBI contains over 90% Fe and the metallization degree is higher than 90%. These metallics only need to be melted and hardly reduced; therefore, HBI in BF operation decreases the consumption of reducing agents. In our experience, if 100kg HBI/t HM is used, the reducing agent rate (coke equivalent) can be decreased by approx. 25kg/t HM, as shown in *Figure 5*. The colors indicate

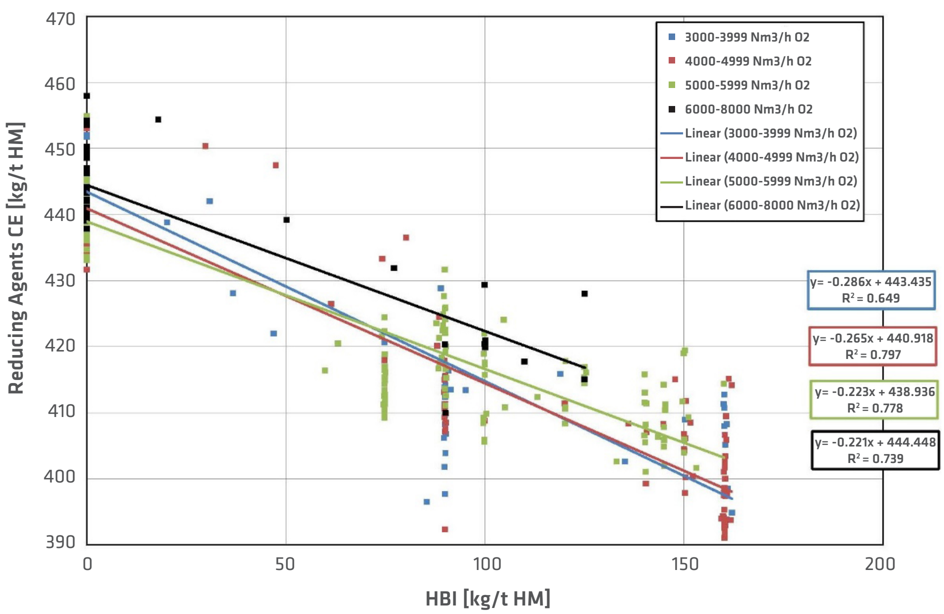


FIGURE 5. *Development of reducing agents with HBI*

the amount of oxygen in the hot blast, and the amount of oxygen lies between 4000–6000Nm3/h for more than 60% of the data points. If the coke rate is reduced, the rate of PCI (pulverized coal injection) has to be adapted. Coke can never be eliminated (although HBI is used) because coke has to provide the structure and the permeability in the shaft. Therefore, a minimum coke rate has to be guaranteed.

The productivity (melted iron [t] per hour) can be increased if HBI is charged in the BF. Productivity can be raised up to 10% per 100kg HBI/t HM ***(Figure 6)*** at constant oxygen level.

INFLUENCE OF HBI ON TOP GAS CONDITIONS

The gas utilization decreases between 0.5-1% per 100kg HBI/t HM ***(Figure 7)***. So, the percentage of CO_2/H_2O in the gas decreases, while the percentage of CO/H_2 rises. HBI is a pre-reduced material; therefore, there is less iron oxide to be reduced in the BF. Because the percentage of CO and H_2 in the gas is higher with the use of HBI, the calorific value increases slightly, up to 1.5%.

No significant correlation was found for the top gas temperature. During the different test periods, there was no influence of HBI on the cooling capacity and no significant gas flow was on the BF walls.

Permeability of the shaft has not shown any negative or positive reaction when HBI was in the burden. This is also a sign that HBI does not trigger gas flows along the walls in the furnace or influence the furnace operation in a negative or positive way.

INFLUENCE OF HBI ON HOT METAL QUALITY

An indication of high hot metal quality is high carbon content and low sulfur content. Reducing agents have high sulfur content (coke has approximately 0.5–0.7%) and the sulfur blocks the carburization of hot metal. The coke rate can be decreased if HBI is charged in the BF. ***Figure 8*** shows the S-content of hot metal at an HBI charge of 100–150kg/t HM. A lower S-content of hot metal is reached with an HBI charge.

But the S-content of hot metal does not depend only on the rate of reducing agents but also on slag rate, use of recycling material with high amounts of sulfur, and the melting rate (at higher melting rates, the coke stays in the hearth short-time).

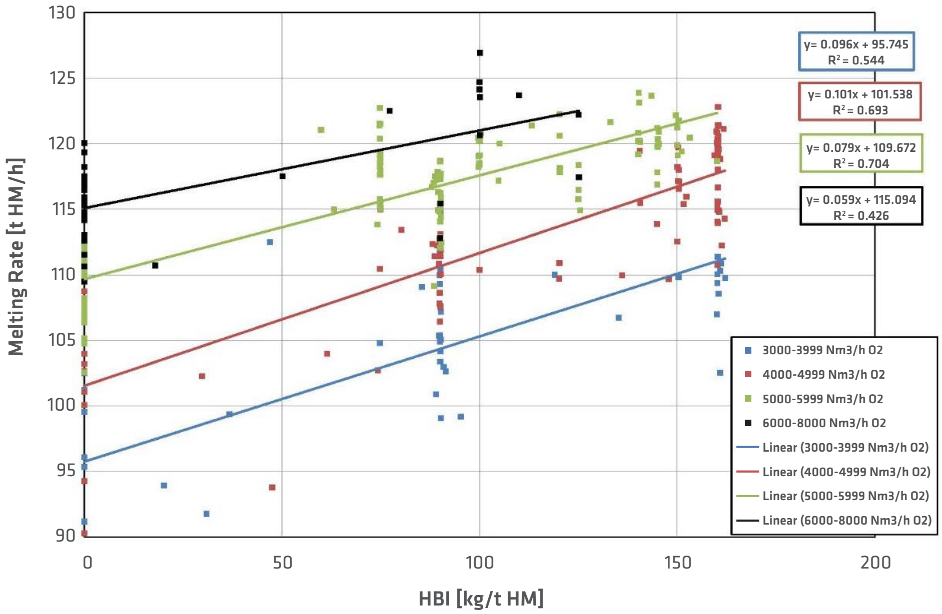


FIGURE 6. *Development of melting rate with HBI*

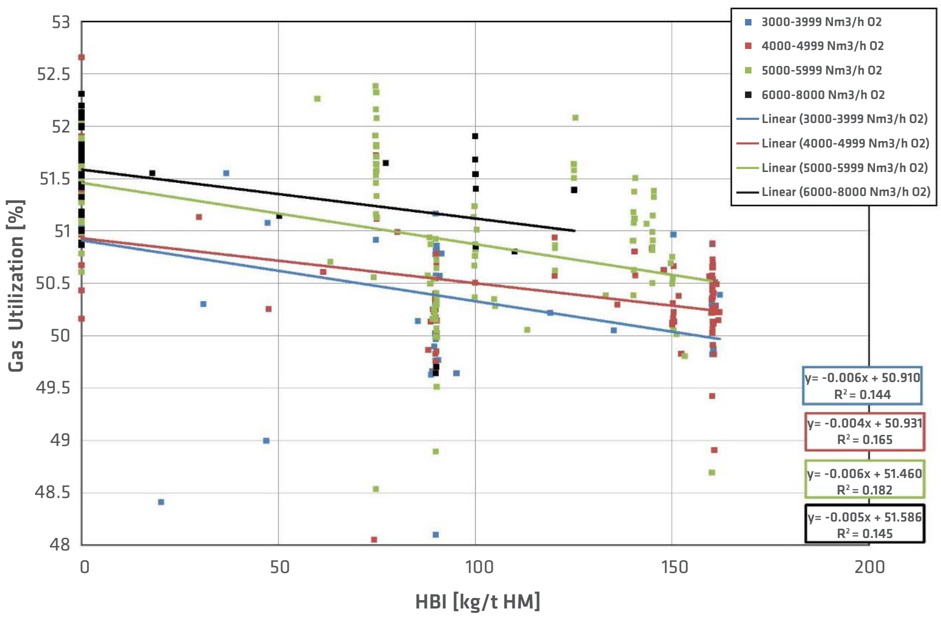


FIGURE 7. *Development of gas utilization with HBI*

A higher C-content of hot metal is achieved with an HBI charge of 100–150kg/t HM ***(Figure 9)***. Sulfur retards the carbon solution in hot metal; therefore, there is a higher carbon content in HM (=less sulfur input in case of HBI).

CONCLUSIONS

The use of different charging rates of HBI from the voestalpine Texas plant in Corpus Christi, Texas, in BFs at voestalpine Linz was examined over the period from 2017-01-01 to 2018-01-31 based on daily average data. When 100 kg HBI/t HM is charged to the BF, the following conclusions can be drawn:

1. Reducing agents (CE) can be decreased by 21.9 - 27.5 kg/t HM, whereas the coke rate can be decreased by 10.9 - 18.1 kg/t HM.
2. Productivity can be increased up to 7.3 - 10.1% at constant oxygen levels.
3. Gas utilization drops by approximately 0.4 - 1.1% because HBI is a pre-reduced material and less oxide is charged to the BF. The decrease in quantity of charged oxide also reduces the quantity of CO and H_2 which are transformed into CO_2 and H_2O.
4. The calorific value of top gas rises by 12.3 - 23.5 Wh/Nm3 due to the higher contents of CO and H_2.
5. A correlation between the top gas temperature, cooling capacity, and permeability and the use of HBI cannot be seen.
6. The S-content of hot metal is lower and C-content higher (high quality) with a charge of 100 - 150 kg HBI/t HM compared to when no HBI is charged. The S- and C-content in hot metal does not depend only on the charged HBI quantity, which reduces the sulfur containing reducing agents, but also on other factors, such as the slag rate, the quantity and nature of the high S-content recycling material, and the melting rate.

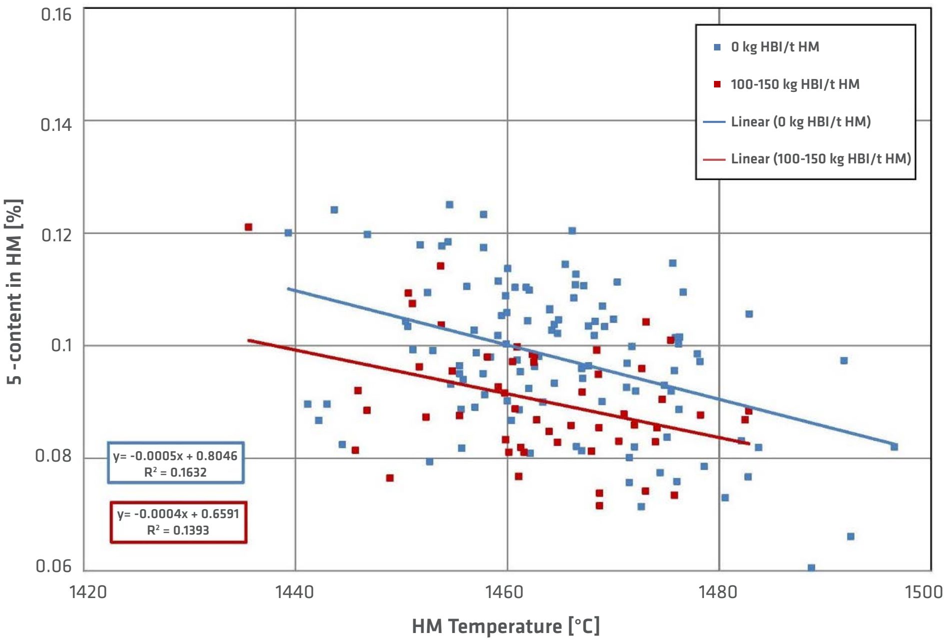


FIGURE 8. *Sulfur content in hot metal*

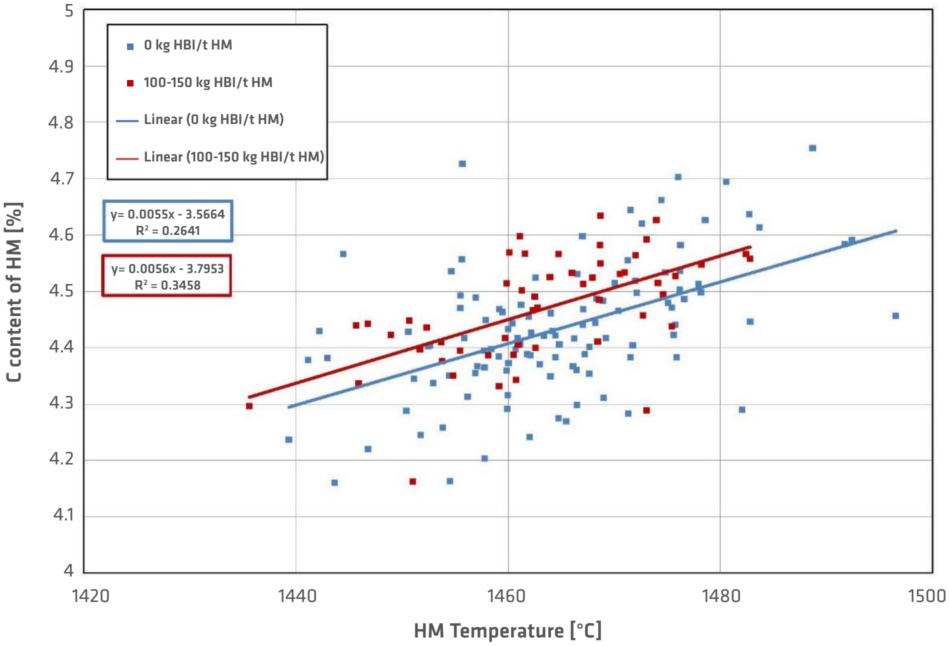


FIGURE 9. *Carbon content in hot metal*

Midrex News & Views

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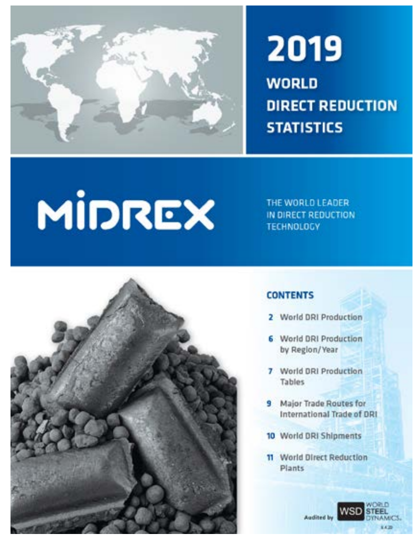
World DRI Production Exceeds 108M Tons in 2019

SETS FOURTH CONSECUTIVE ANNUAL RECORD



Global direct reduced iron (DRI) production eclipsed 100M (million) tons in 2019 for the second consecutive year and set a new production record for the fourth consecutive year, according to 2019 World Direct Reduction Statistics. The annual publication of direct reduction industry data and information is compiled by Midrex Technologies, Inc. and audited by World Steel Dynamics.

DRI output was up 7.3% over 2018 production to 108M tons. Since 2015, world DRI production has increased 35.5M tons, or nearly 49%.

2019 World Direct Reduction Statistics is available for download on the Midrex website: **www.midrex.com** as a resource for the global iron and steel industry.

Midrex Global Solutions Realigns To Better Serve Customers

Mark Boedecker, Director – Sales & Marketing has announced structural changes to Midrex Global Solutions that better aligns the aftermarket and engineered services team with the wants and needs of its customers to deliver meaningful results. Assuming new roles in Global Solutions are Brad Cantrell, Program Manager - MidrexConnect™; Dale Powell, Manager - Equipment Sales; Jim Rublee, Manager - Global Solutions Operations, and Dilcia Giron, Buyer/Expeditor. David Durnovich will continue in his role as General Manager – Global Solutions, providing insights into plant operations and maintenance based on his extensive field experience.

MIDREX GLOBAL SOLUTIONS

Team Roles

BRAD CANTRELL
Program Manager - MidrexConnect™

DALE POWELL
Manager - Equipment Sales

JIM RUBLEE
Manager - Global Solutions Operations

DILCIA GIRON
Buyer/Expeditor

DAVID DURNOVICH
General Manager - Global Solutions

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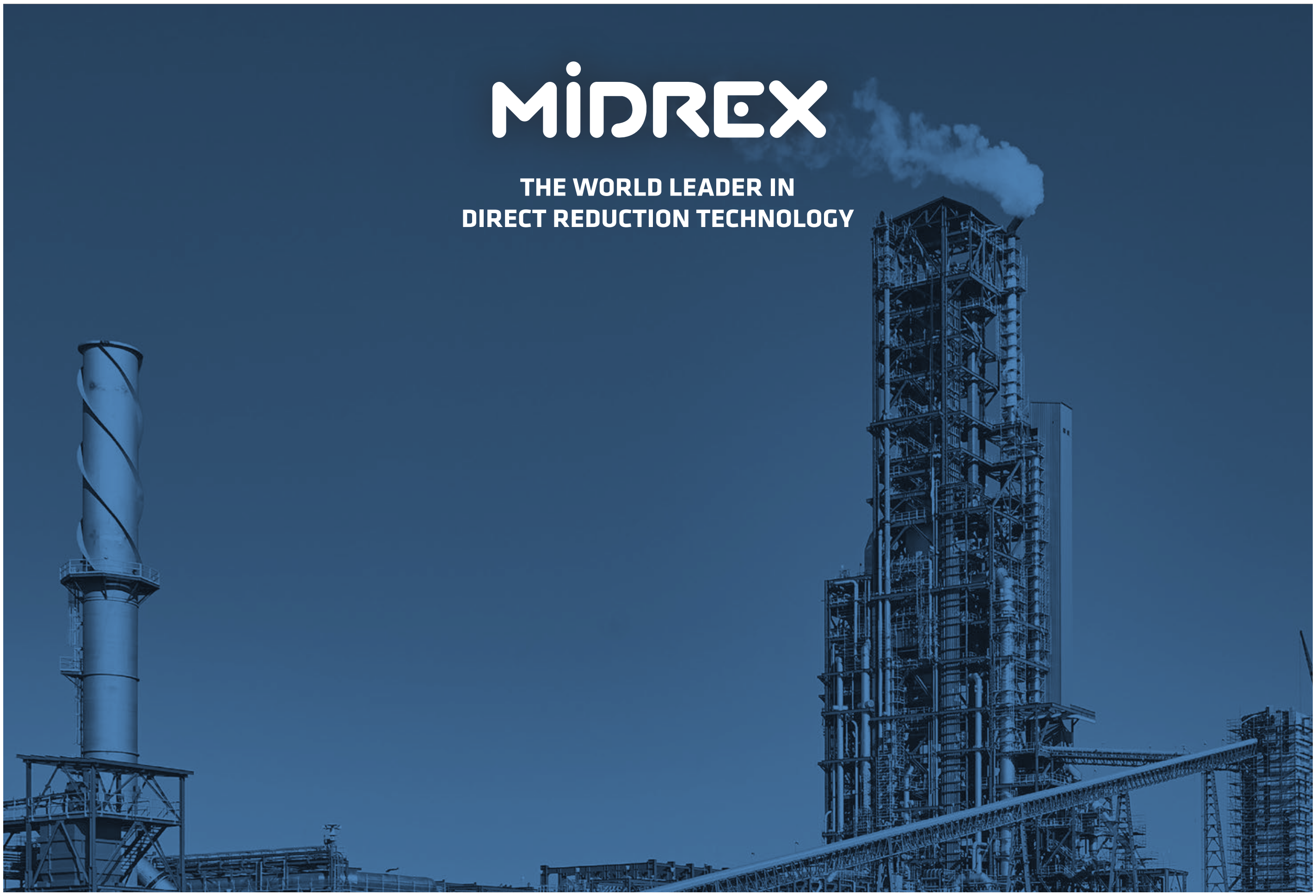
→ Midrex and AMI to Offer DRI-based Steelmakers Complete Process Optimization Solutions

Midrex Technologies, Inc., and AMI Automation have agreed to combine their respective expertise in DRI and EAF process optimization to enable integrated DRI-EAF steelmakers to achieve the highest levels of performance at the lowest conversion cost. By combining their proven digital solutions, Midrex and AMI will be able to provide seamless optimization of the complete production process – from iron ore to liquid steel.

→ Kobe Steel, Vale, and Mitsui & Co. to Collaborate in Low CO_2 Ironmaking Solutions

Kobe Steel Ltd. of Japan, the parent company of Midrex Technologies, Inc, has reached a non-binding agreement with Vale S.A., the world's largest iron ore producer, and Mitsui & Co., Ltd., a global trading and investment company with a diversified business portfolio, to collaborate in providing low CO_2 metallics and ironmaking solutions to the global steel industry.



Lauren Lorraine: **Editor**
Vincent Chevrier, PhD: **Technical Advisor**

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Midrex Technologies, Inc.

All references to tons are metric unless otherwise stated.

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