MIDREX

DIRECT FROM MIDREX

4TH QUARTER 2024

H2 Green Steel is now Stegra

NEW NAME, SAME MISSION– BOLDLY LEADING THE WAY TO A GREEN FUTURE

FUTURE PROCESSING OPTIONS FOR HYDROGEN DRI

NEWS & VIEWS
Dillinger & ROGESA selects Midrex & Primetals New Project

NEWS & VIEWS
Midrex Joins HBI C-Flex Project Advisory Board

NEWS & VIEWS
MIDREX® Plant with 4th Quarter Anniversary

COMMENTARY

TODAY'S PROBLEMS ... TOMORROW'S OPPORTUNITIES

By Todd Astoria
Chief Technology Officer

I love problems. Problems are the easiest way to identify issues that need to be addressed and produce an outcome that is superior to what we had yesterday. Today, ore based metallics and the direct reduction industry face many problems: environmental/carbon intensity, increasing product quality requirements, changing raw materials, new or evolving energy portfolios, shipping and logistics requirements, and more. However, these problems present a fantastic number of opportunities, which is the main reason why Midrex has established the role of Chief Technology Officer (CTO).

In the current market, our customers and partners have more factors to consider than ever before in their planning and decision-making process. What will be the costs related to carbon dioxide in five years? How much hydrogen will be available and at what price in the next three years? How can planners develop a business plan for assets that have a 40+ year life in the midst of such uncertainty?

At Midrex, our goal is to support our customers with the technologies and business solutions that will help make them successful over the full life of their facilities. The role of the CTO is to provide focus for transforming problems into new opportunities that will deliver world-class performance, even in the face of market uncertainty.

Midrex has always been the most flexible and reliable direct reduction technology in terms of fuel sources, raw materials, and product quality. It's the strong history of innovation and the meeting of such challenges in the past that drive our confidence in turning today's problems into tomorrow's opportunities.

Indurated pellets replaced lump ores and revolutionized the feed materials for direct reduction plants. Today, most facilities are continuously looking for raw materials with increased performance, and a new type of cold agglomerate is on the horizon to challenge indurated pellets. Midrex is working with Vale to help develop these pelletizing alternatives and bring this flexibility to meet the needs of our customers.

Midrex is also experienced with new and changing fuel sources. Hydrogen and even ammonia are the latest options that we are making available for direct reduction. Even though options such as coal gasification syngas, coke oven gas, or SMR syngas face their own environmental challenges today, these commercially-demonstrated fuels show the flexibility of the MIDREX® Process.

How do we plan to handle uncertainty? It's simple. We design our technology to be flexible enough to adapt to whatever uncertainties may arise in the future. So If you have a problem, please let me know because I love problems.

→

This issue of *Direct From Midrex* includes articles about how H2 Green Steel (now Stegra) is boldly leading the way to green steelmaking, and future options for processing hydrogen direct reduced iron (Hydrogen DRI). News & Views showcases the latest Midrex contract, Midrex ISO 45001 certification, the recent International Conference on MIDREX® Technology, Midrex joining the HBI C-Flex Advisory Board, and a significant 4Q MIDREX Plant anniversary.

H2 GREEN STEEL IS NOW STEGRA

NEW NAME, SAME MISSION – BOLDLY LEADING THE WAY TO A GREEN FUTURE

By DURGESH GUPTA
Senior Vice President – Global Iron Making Technology, Stegra

INTRODUCTION

Stegra was launched in 2021 under the name H2 Green Steel, to reduce emissions in the steel industry on a very ambitious timeline. By showing that it can be done, the company also aimed to inspire the incumbent steel industry to speed up the pace of change. Having secured funding of €6.5 billion and being well on its way to building the world's first large-scale green steel plant – with start of production in 2026 – the company takes the next steps under the new name: Stegra.

"STEGRA IS A SWEDISH WORD WHICH MEANS 'TO ELEVATE'. IT CAPTURES THE TEAM'S SPIRIT TO RISE IN THE FACE OF CHALLENGES AND ALWAYS CONTINUE TO MOVE ONWARDS AND UPWARDS. IT'S A CONSTANT REMINDER OF THE COMPANY'S PURPOSE AND HONORS OUR SWEDISH ROOTS AND WHERE IT ALL BEGAN IN BODEN."

—

Henrik Henriksson, CEO

The name Stegra is future proof for the journey ahead, which is based on the three distinct platforms that are being built in Boden:

- **Green hydrogen:** one of the world's largest electrolyzers
- **Green iron:** where the bulk of the emissions are reduced by replacing coal and coke in traditional steelmaking with green hydrogen – emitting water instead of carbon emissions
- **Green steel:** a fully electrified large-scale production facility for near-zero emissions steel

Rendering of Stegra Green Steel Complex in Boden, Sweden

Over the long term, Stegra will explore the potential for growth, leveraging all three platforms and making use of the competence and experience being developed in the flagship plant in Boden.

Stegra has a solid funnel of potential projects outside of Sweden that are being explored as part of a longer-term outlook. They are characterized by locations where the company's customers need help with value-chain decarbonization and which offer abundant access to renewable electricity and strong grid connections. Locations under consideration include Portugal, Canada and Brazil.

THE BODEN GREEN STEEL PROJECT

Why did Stegra choose Boden for its lighthouse green steel project? Boden is a town 45 miles south of the Arctic Circle in the north of Sweden, in an area with one of Europe's lowest energy costs. Green electricity makes up close to 100% of the energy mix, and the site will include one of the world's largest green hydrogen electrolysers, at about 800MW. A direct rail line will connect the Boden site to Luleå port, which can accommodate ships equipped for icebreaking to ensure year-round operations. The plant will employ about 1500 people, making the project a building block for a green society and Sweden's Norrbotten region a world-leader in near zero emission steel production.

SMS group will provide the EAF based melt shop, casting and hot rolling plant as well as an advanced cold rolling and processing complex for the production of a broad product mix including advanced high strength steel and automotive steel grades.

Stegra is pursuing a 5-step development plan for its lighthouse project in Boden, Sweden, with the goal of producing 5 million t/y of green steel:

STEP 1: Giga-scale Electrolysis – using renewable electricity to decompose water into hydrogen and produce enough hydrogen to make 5 million tonnes of high-quality steel annually by 2030.

STEP 2: Hydrogen-based Direct Reduction – using green hydrogen instead of coal or natural gas to react with oxygen in iron oxide pellets to produce highly metallized direct reduced iron (DRI) for steelmaking with steam as the residual, thus reducing CO_2 emissions by up to 95%.

STEP 3: Electric arc furnace (EAF) Steelmaking – using renewable electricity to heat DRI and steel scrap to create liquid steel, with contained carbon in the slag playing an important role in lowering electricity consumption and enabling the transformation of iron to steel.

STEP 4: Continuous Casting and Rolling – allowing energy consumption to be reduced 70% and replacing natural gas in the traditional process.

STEP 5: Downstream Finishing Lines – cold rolling, annealing, and hot-dip galvanizing for adjusting steel thickness, creating desired mechanical properties, and protecting against corrosion, respectively.

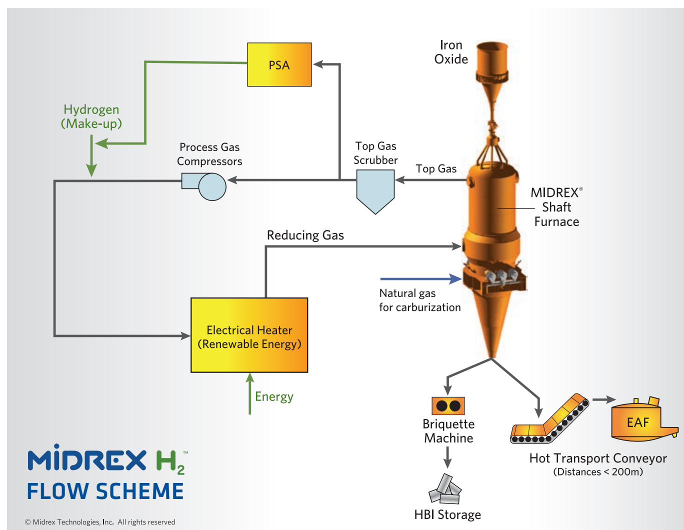
Our journey towards 5 million tonnes of green steel

- June 2023: Full environmental permit approved - in record time
- Beginning 2026: Production start
- 2026-2028: Ramp-up to full production of 2.5mt hot- and cold-rolled steel
- 2028: Expansion - ramp up to full 5mt capacity
- 2030 (earliest 2): Yearly production of 5mt green steel

DRI PLANT PROJECT

Plant Key Features

- Capacity: 2.1 million t/y
- Product Types: HDRI, Merchant HBI
- HDRI Feeding: Continuously charged to EAF via a hot transport conveyor
- DRI Furnace: Proven MIDREX® Shaft Furnace design
- Gas Composition: 100% H_2 capable (DRI carbon optimized with melt shop), 85% H_2 (DRI carbon 1.3%)
- Gas Preparation: Fossil-free electrical heating
- Renewable Energy: Midrex-Tutco Electric Heaters, PSA H_2 Recovery
- CO_2 Emissions: 50 Kg/t DRI (carburized DRI case), 90% or greater emissions reduction



From the outset, the Stegra green steel project has been driven by an aggressive schedule, exemplified by the DRI plant milestones:

MILESTONES	COMPLETION MONTH
Groundbreaking	Aug 2022
Construction Started	Nov 2023
First Concrete Poured	Mar 2024
Structural Erection Start	Apr 2024
MHS Civil Start/First Equipment Delivered	Aug 2024
Process Design Review/Safety Analysis Completed	Sept 2024

A COLLABORATIVE JOURNEY

September 2024 marked a significant milestone in the collaborative efforts between Midrex, Paul Wurth, and Stegra with completion of the final phase of the process design review and safety analysis for the MIDREX H2™ hydrogen direct reduced iron (DRI) plant. This comprehensive initiative, which began over 1.5 years ago following the effectuation of the contract for the first-of-its-kind green steel project in Boden, Sweden, underscores the joint commitment to innovation, safety, and teamwork—core values that are fundamental to our mission of creating a sustainable future for iron and steelmaking.

The final phase of the review took place at Midrex headquarters in Charlotte, North Carolina, following prior sessions in Stockholm, Sweden and Genoa, Italy, which brought together experts from Stegra and Paul Wurth. This geographical diversity enriched the process, highlighting our commitment to a collaborative and inclusive approach by bringing together a wide range of expertise and experience from across the globe.

This multi-phase review involved input from various engineering disciplines – Process, Mechanical, Electrical, Equipment, Safety, and Operations. Each team contributed unique insights to identify potential risks associated with the design and propose necessary mitigations or design changes, ensuring the safety and efficiency of the DRI plant in keeping with Midrex's dedication to operational excellence and continuous improvement.

IMPORTANCE OF ENGAGEMENT & LEVERAGING EXPERTISE

Central to this process were the contributions of our Process and Operations teams, who carried out the "heavy lifting" during discussions. Their deep understanding of the intricacies of design and operation was pivotal in driving the review forward. Their hard work and commitment deserve heartfelt appreciation and special recognition.

In addition to technical discussions, our diverse group – representing approximately 10 nationalities – engaged in teambuilding activities to foster strong relationships and create a cohesive unit poised to tackle the challenges ahead when this core group will be responsible for the commissioning and start-up of the DRI plant.

The synergy created by this collaboration is further amplified by Stegra's extensive exposure to the operation of various MIDREX Plants. Their contribution brought a wealth of knowledge to the learning process, demonstrating the power of leveraging collective expertise to drive innovation.

LOOKING AHEAD

As we look forward to the commissioning and start-up phase of our project, the commitment to safety and operational excellence will remain at the forefront of our efforts. The insights gained from this process review will ensure that our DRI plant operates at the highest standards.

The completion of the Stegra process design and safety review exemplifies the power of collaboration. Through effective communication, shared expertise, and strong team dynamics, we are not only advancing our projects but also cultivating a culture of safety and innovation that will guide us into the future.

FUTURE PROCESSING OPTIONS FOR **HYDROGEN DRI**

(Editor's note: This article is a follow-up to "Impact of Hydrogen DRI on EAF Steelmaking" by these guest authors that was published in *2Q2021 Direct From Midrex*).

PROFESSOR GEOFF BROOKS
Swinburne University of Technology, Melbourne, Victoria, Australia

DR. SARA HORNBY
Global Strategic Solutions, Charlotte, N.C. USA

INTRODUCTION

The last five years have seen a tremendous growth in activity around developing new routes to steel, either by eliminating the use of, or dramatically minimising, carbon. Out of a complex and sometimes confusing set of technological developments, the following key trends can be identified [1, 2]:

Product photo courtesy of Midrex Research & Development Technology Center

a) Existing shaft DRI processes (MIDREX® and ENERGIRON®) can readily produce DRI using either pure hydrogen or gas mixes with very high concentrations of hydrogen.

b) Fluidised bed DRI processes also can be operated with high levels of hydrogen and have been demonstrated at commercial scale.

c) New hydrogen flash reduction DRI processes are another route to producing Hydrogen DRI from fines but are currently at a low Technological Readiness Level (TRL).

d) Smelting reduction processes (HiSmelt, HiSarna, Corus, and others) linked to Carbon Capture, Utilisation and Storage (CCUS) technologies and/or in combination with biocarbon fuel sources are suggested but have yet to be demonstrated at commercial scale.

e) Use of hydrogen injection in the blast furnace (BF) can reduce, but cannot replace, significant quantities of coke. This is due to:

1. The endothermic hydrogen reduction reactions which compromise maintaining an appropriate heat balance.
2. The need to ensure even transfer of gas and heat through the shaft section of the furnace without the presence of a coke layer between ore, pellets, and sinter.
3. The need for coke to support the bed.

f) Strong techno-economic arguments suggest if low-grade iron ores (less than 63 wt.% Fe) are processed through a Hydrogen DRI process, these DRI products be best processed via an Electric Smelting Furnace (ESF) before entering a steelmaking process. Trying to process these ores through an Electric Arc Furnace (EAF) is likely to result in high electrical energy demands (>600 kWh/metric ton liquid steel [kWh/Te_{ls}], very high slag volumes [>300 kg/Te_{ls}], low iron yields [<80% Fe] and higher kWh/Te than usual).[2]

g) Green hydrogen is currently expensive (>$\$_{US}$4 to < $\$_{US}$ 10/ kg) and in short supply (only MW-scale plants are operational). Extensive investment is required to show that GW-scale green hydrogen production routes can be successfully linked to steelmaking plants.

This article assumes that the issues with green hydrogen cost and production can be overcome and that Hydrogen DRI processes begin replacing blast furnace (BF) iron production and ask: What challenges can we expect by introducing large amounts of Hydrogen DRI feedstock into Electric Arc Furnaces (EAFs) and how might they be overcome?

HYDROGEN DRI CHALLENGES

If Hydrogen DRI processing starts to significantly replace blast furnace (BF) production as a source of iron, there will be several impacts on EAF producers when processing these new feed materials, namely:

Slag Volumes

In general, the use of DRI in an EAF will increase the quantity of slag produced compared to scrap-based processes. However, this general trend would be expected to be enhanced because of the shortage of high-grade iron ores (>67 wt.% Fe) as DRI production increases. A recent paper calculated the impact of processing low grades ore using Australian iron ore compositions (largest world iron ore exporter) which are currently sold to BF operators. [2] The calculations show that slag volumes well above 300 kg/Te_{ls} would be generated, which would clearly affect energy consumption and yield. It should be acknowledged that lean ores producing very high slag volumes (>500 kg/Te_{ls}) are unlikely, as these gangue-rich ores would probably be better processed through an ESF. It is still likely that slag volumes produced in future DRI-fed EAFs will be significantly higher than current operations using high-grade ore.

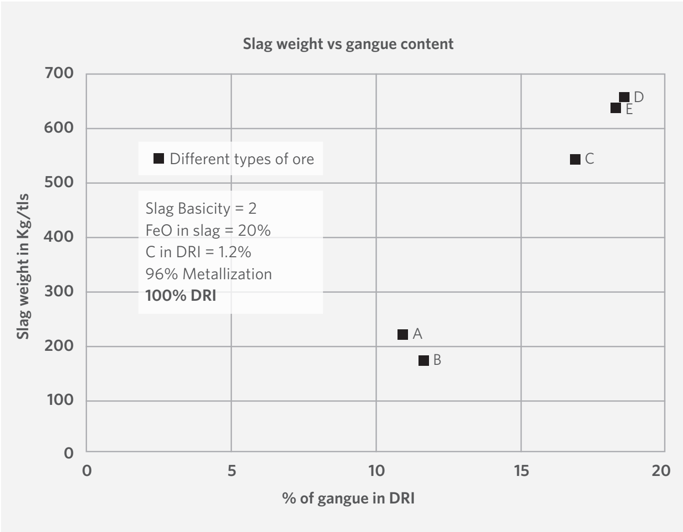


FIGURE 1. *Estimated slag weight from an EAF as a function of gangue content in the DRI, based on Australian iron ore compositions* [2]

IRON ORE	DRI COMPOSITION (WEIGHT %)										
	Fe	FeO	P_2O_5	S	TiO_2	Al_2O_3	C	SiO_2	CaO	MgO	Mn
A	88.11	3.66	0.05	0.02	0.20	3.40	1.16	3.4			
B	87.32	3.64	0.03	0.08	1.48	0.42	1.18	2.69	0.16	3	
C	81.79	3.41	0.27	0.05		3.77	1.2	8.76			0.75
D	79.72	3.32	0.21	0.04		4.82	1.2	9.64			1.05
E	80.16	3.34	0.08	0.06	0.32	4.37	1.2	9.75	0.05	0.09	0.58

TABLE I. *Calculated DRI compositions based on Australian iron ore feed materials used in EAF for thermodynamic modelling* (2)

Figure 1 shows the results from thermodynamic modelling of an EAF, predicting the total slag weight generated using a range of Australian iron ores. The calculations were validated against industrial results. The thermodynamic modelling in this study was performed on commercial software and can be easily replicated and altered for different scenarios. The calculated compositions of the DRI used in the modelling are shown in ***Table 1***. The calculations in ***Figure 1*** are based on 20wt.% FeO, which is relatively low compared to many EAF operations (see ***Figure 2***). (3)

One could expect even higher slag weights for low carbon steels, where FeO contents will be above 30wt.%, as shown in Figure 2 (3) The assumed slag basicity (CaO wt.%/SiO_2 wt.%) may also be low for steel sensitive to phosphorous and/or DRI made with high phosphorous ores. In this sense, the slag weights presented in ***Figure 1*** are relatively optimistic.

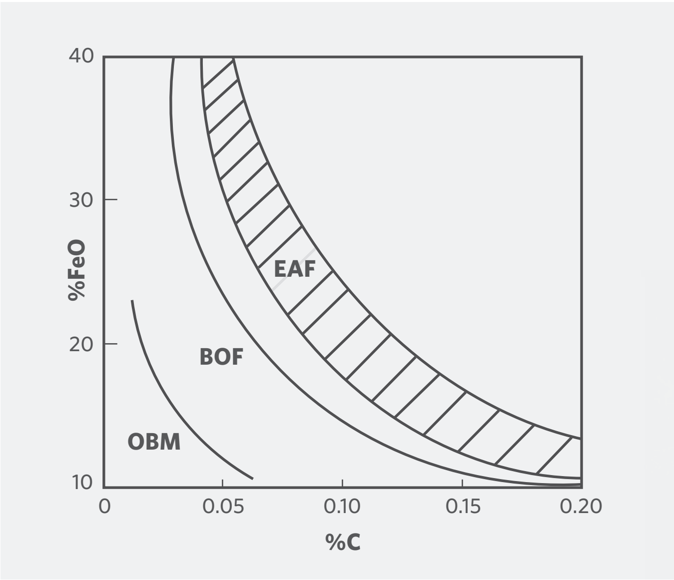


FIGURE 2. *C wt. % level in steel and FeO wt.% slag for OBM, BOF, and EAF technology* (3)

High Electrical Energy

If Hydrogen DRI is the dominant feedstock in an EAF, we can assume there is less in-situ carbon (perhaps even zero from the DRI) (4) entering the furnaces compared to natural gas (NG)-based and coal-based DRI, with between 1.5-3.5 wt.% carbon content. This would increase the use of electrical energy unless some other chemical energy is introduced. This decrease in chemical energy input combined with increased slag volumes would push up the required electrical energy.

Figure 3 summarizes the expected energy consumption from thermodynamic modelling for different gangue-containing DRI, assuming 1.2 wt.% carbon in the DRI and comparing the 50% cold DRI/50% scrap and 100% scrap, 100% cold DRI scenarios. These calculations show that unless chemical energy (i.e more carbon and/or increased burner energy) is introduced and/or some significant saving from optimizing operation, such as minimizing heat losses and utilizing off gas energy, then electrical energy requirements would be expected to increase. In our previous paper *(see 2Q2021 DFM)* (4), clear operational evidence was provided indicating clever operation and optimization of the process can compensate for the extra energy predicted by thermodynamic calculations like that represented in ***Figure 3***. The paper by Sabah, et al.(2) explains the underlying assumptions of these thermodynamic calculations and explores the impact of high FeO contents in the slag on yield and the effect of hot DRI feeding on energy consumptions.

Carbon Requirements

Carbon plays an important role in EAF steelmaking, namely:

a) As an essential alloying agent for steel.

b) Creating reactions with dissolved oxygen in the molten metal bath to produce carbon monoxide (CO) bubbles, which stir the bath and help reduce bath-dissolved nitrogen and hydrogen levels through adsorption into the rising CO bubbles.

c) Providing carbon in the slag layer (or at the slag/metal interface) to produce CO from the reaction with FeO in the slag and/or oxygen gas (injected or entrained from air into the furnace). The CO bubbles formed foam the slag, a vital part of the modern EAF operation, i.e. "foamy slag practice."

d) Controlling FeO in the slag through the reaction C(s) + FeO (slag) = CO(g) + Fe (l). This relationship is shown graphically in ***Figure 2***. [3] The higher FeO content in EAF steelmaking, compared to basic oxygen furnace (BOF) steelmaking reflects the less highly stirred nature of EAF slag/metal. In BOFs, slag and metal are brought into close contact more vigorously through generation of large numbers of metal droplets, which allows the reactions to get closer to chemical equilibrium.

If low, or 0%, carbon DRI is produced from Hydrogen DRI processes, as is expected, then controlling the introduction of carbon into the EAF to fulfill these various roles will become important. Biocarbon sources, which can be shown to be sustainable (i.e. their use is matched by natural growth), are logical replacements to coke and coal-based carbon sources currently used in EAF steelmaking.

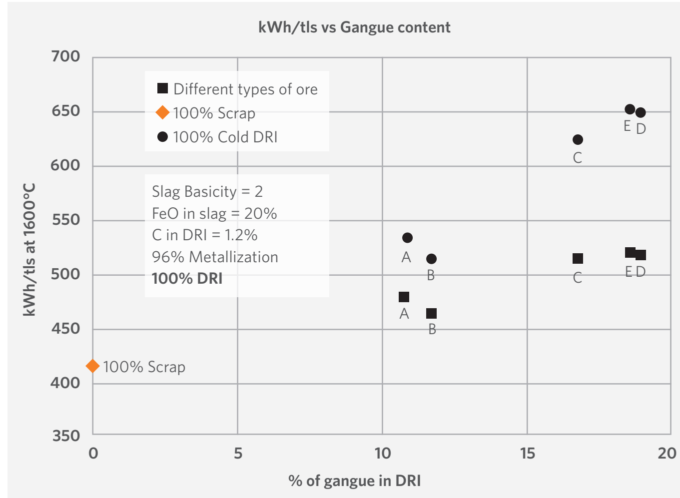


FIGURE 3. *Electrical energy consumption for Hydrogen DRI fed EAFs for different gangue contents, assuming 1.2 wt.% carbon in the DRI material* [2]

These current carbon sources are normally injected into the slag with oxygen for slag foaming or into the bath for CO generation and dissolution in the metal, but they have been seen in the past to be inefficient, averaging 50%, ***(see Figure 4)*** due to a large proportion of the carbon burning in the freeboard. [4,5] Recent steel plant trials at VSB in Brazil (100% charcoal) and Nucor plants in the USA (Aymium biochar and baghouse dust from pet coke production) have shown 98% efficiency using a constrained stream resulting from supersonic carbon injection using a TSCi™ injector from Tallman Technologies in Canada ***(see Figures 5 & 6).*** [5] The constrained stream penetrates to the slag/metal interface.

Figure 4

Figure 5

Figure 6

FIGURES 4-6. *Demonstration of injection efficiency changes when a constrained injection method is used (Note: pictures all resized & notes on figures input)*

Finer material makes more efficient FeO + C → Fe + CO and has shown $_{US}2 to $_{US}6 savings from lower kWh, electrode wear, refractory use, greater efficiency, and water-cooled panel life (savings will be higher if carbon taxes are included for EU, Canada, etc.). Interestingly, this TSCi™ system has the capability of re-carburizing the steel and functions without carbon co-injection, as shown (unless biochar is in short supply, of course!).

OneSteel, an Australia-based steelmaker, now known as Infrabuild, in close co-operation with the SMaRT Centre of the University of New South Wales, has developed and commercialized Polymer Injection Technology (PIT). PIT has improved slag foaming and hence, furnace efficiency at several mills (OneSteel Sydney and Laverton; UMC Metals, Thailand; SeAH Besteel, Korea; and Celsa plants in the UK and Norway) saving 1.6%-5.1% kWh/Te billet, 6.3%-16.2% kg C/heat, reducing FeO in the slag by 1.5%-3%, and increasing yield by 0.17%-0.3%.(6) (Note: slag chemistry should be close to identified correct chemistry for foamability when attempting to create a foamy slag regardless of foaming agent).

In 2016, Mousa, et. al. concluded a thorough review of the various options and concluded that biocarbon can be readily utilized in steelmaking for carburization and reduction of components in slags.(7) However, often supply challenges, and the cost of the biocarbon supply chain, limit uptake of these materials.

Over 300,000 tonnes of 0% carbon Hydrogen DRI was produced on an industrial scale at the Circored Plant in Trinidad (8) via a two-stage fluidized bed process. Melting trials of some of the HBI material were conducted at North Star Steel Texas, and the results published.(9) This industrial experience showed that zero carbon DRI provides various challenges in industrial operation, some already described in this article, though most were more fully analyzed the earlier article by the authors (4).

SUGGESTED STRATEGIES

This analysis of the challenges and recent developments surrounding Hydrogen DRI and EAF steelmaking leads us to propose:

a) In the case of low carbon DRI (<1.5 wt.%) or zero carbon DRI being produced in the future, pig iron and/or specially produced high carbon DRI should be introduced into the feed materials to promote the generation of CO for stirring the bath, chemical energy, and removal of nitrogen and hydrogen.

b) Injection of biochar materials into the slag at high efficiency should be further developed to provide carbon for slag foaming. Demonstrating sustainability of this material will be critical to its long-term viability in a steel industry under pressure to be "green". There already is a large body of work showing how different biomasses can be used in this fashion.

c) In the case where carbon is hard to place in situ in the DRI during production, some consideration should be given to introducing carbon into the pelletizing (fines) and/or briquetting step(s) after production. Once again, this would ideally be a demonstrably sustainable biocarbon material; i.e., use is matched by growth.

d) Given that slag volumes will increase as low-grade ores become more common as the feedstock for DRI production, some consideration should be given to slag cleaning to recover Fe from the slag. This could be done by:

- Processing the slag separately next to the EAF; for example, where biochar is injected into the molten slag to reduce iron from the liquid. The recovered iron could either be poured back into the furnace or cast as a feed material for the EAF.
- Having a side arm to the main furnace into which slag is semi-continuously fed and subjected to biochar injection, again with reduced Fe being reintroduced to the furnace directly. In such a scenario, the slag could be removed semi-continuously from the side arm using a weir system or some form of controlled tapping. The risk of this approach would be the threat of having oxidizing conditions in the main furnace volume with a chemically reducing zone nearby that might interfere with efficient EAF operation, resulting in problems such as phosphorus reversion. It should be acknowledged that existing copper and nickel production processes have slag cleaning steps included in their flowsheets; therefore, it should be possible to transfer the idea to steelmaking.

e) Improved EAF charge management (using value in use of materials including scrap, pig iron, hot metal, and DRI/HBI) and beneficiation of scrap could help address these issues through better control of incoming gangue (DRI and scrap) and carbon into the furnace, which would compensate for lower carbon in the DRI feed materials.

CONCLUSIONS

If Hydrogen DRI becomes a major ironmaking technology and EAF technology evolves to include new feed materials, we can expect:

- EAF operators will have higher levels of gangue and lower incoming carbon in their process.
- The potential of using sustainable biocarbon to replace the carbon could be a critical partial solution to this problem.
- Clever management of charge quality and the use of pig iron and/or high carbon DRI could also assist with solving this problem.

And slag cleaning to recover FeO from high slag volumes should be investigated.

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Midrex News & Views

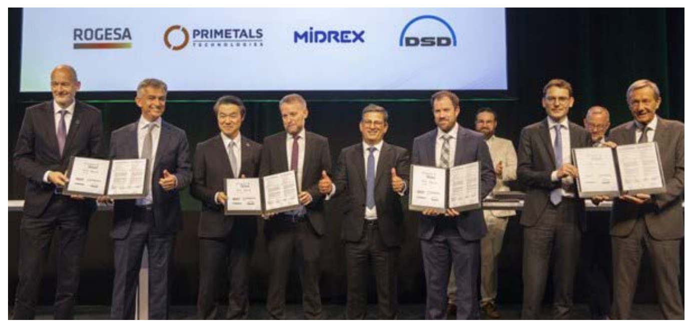
The full news articles are available on **www.midrex.com**

Dillinger and ROGESA selects Midrex and Primetals for Major Decarbonization Project

MIDREX Flex® Plant to produce 2.0 million tons of DRI per year

German steel producer Dillinger and ROGESA signed a contract with Midrex Technologies, Inc. (Midrex) and Primetals Technologies for the supply of a new production complex, including a direct reduced iron (DRI) plant and an EAF Ultimate electric arc furnace plant. The solutions from Midrex and Primetals will support Dillinger's goal of reducing CO_2 emissions by 4.8 million tons per year within six years.

Dillinger and ROGESA, a part of the SHS – Stahl-Holding-Saar (SHS), has launched an ambitious green steel transformation project to replace its current blast furnace-based production route in Dillingen. Having one supplier for the complete range of ironmaking and steelmaking facilities comes with several benefits for Dillinger and ROGESA, especially related to implementation works and tailormade design features to accommodate the new plants alongside existing equipment.



"This partnership with Midrex and Primetals represents an important building block on the way to climate-friendly steel production here in Germany," said Dr. Peter Maagh, Chief Technical Officer at Dillinger. "We are convinced that we can successfully launch our Power4Steel decarbonization project on schedule with such an experienced and reliable partner."

Midrex Receives ISO 45001 Certification Recommendation

ISO 45001 CERTIFIED

In late October, external DQS auditors finished the last round of audits to ISO 45001 – Occupational Health and Safety Management System (OHSMS) and will recommend Midrex for certification.

One of the strengths that was noted in the report is the understanding of the OHSMS program by Midrex teammates that was observed by the auditors.

Midrex News & Views

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

2024 International Conference on MIDREX® Technology

Midrex Process Licensees along with Kobe Steel, Ltd., Primetals Technologies, Paul Wurth S.A., and Midrex suppliers came together recently in Prague, Czech Republic, at the International Conference on MIDREX® Technology. Day one featured keynote speakers from Boston Consulting Group. Nicole Voigt presented "Green Steel Market Overview," and Mara Kronauer discussed "Limitations of Green Power and Different Approaches in (Green) Steelmaking." Day two was devoted to insightful presentations from various Process Licensees and Midrex experts. It was a fantastic opportunity to rekindle old connections and forge new ones.

About the International Conference on MIDREX® Technology

Each year, Midrex invites plant operators to gather for a week to share their expertise and experience with their counterparts and interact with Midrex engineers and technologists. This two-way technology sharing prepares operators of MIDREX Plants to respond to the changing realities of global iron and steel markets and helps Midrex anticipate the needs of its current and future customers.

Midrex News & Views

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

Midrex Joins HBI C-Flex Project Advisory Board

Midrex is one of 14 global companies involved in the Hot Briquetted Iron (HBI) supply chain that will provide knowledge and expertise in support of the International Iron Metallics Association (IIMA) HBI C-Flex Project as a member of the Supportive Advisory Board. The goal of the 3.5-year project is to determine the reoxidation behavior and stability of Direct Reduced Iron (DRI) and hot HBI with variable iron and carbon content to promote safe handling and transport for future decarbonized steel production. The project is coordinated by K1-MET of Austria and the advisory board is led by the IIMA.

The project is funded by the European Union's Research Fund for Coal and Steel program and consists of 10 steel producers, RTOs, technology providers, and universities from Austria, Germany, Belgium, France and Netherlands. Each participant has specific knowledge, skills, and equipment to demonstrate direct reduction followed by hot briquetting of various iron ores including lower-grade ores typically not used in the direct reduction process.

Thus far in 2024, the HBI C-Flex team has conducted a market analysis with quantitative data obtained from a literature review including information and data concerning iron ore mining companies, DR-grade pellet suppliers, HBI production, shipments of DRI and HBI, as well as HBI/steel producing companies and global crude steel production. Qualitative data was derived from deep-dive interviews with stakeholders along the supply chain, focusing on the industry, competitive landscape, requirements, market gaps, and barriers.

→ For more information, go to the HBI C-Flex Project website **hbi-c-flex.eu** and follow the project on LinkedIn.

Midrex News & Views

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MIDREX® Plant with 4th Quarter Anniversary

Midrex is known for designing, engineering, and servicing reliable direct reduction plants, as well as for making certain that these plants have long and successful operating lives. This issue of *Direct From Midrex* recognizes JSW Steel (Dolvi).

JSW (DOLVI)

JSW (Dolvi) was started up 30 years ago in 4Q.

LOCATION:
Dolvi, Mahasrashtra, India

PRODUCT:
CDRI

RATED CAPACITY:
1.0 M t/y

Read more about JSW Steel (Dolvi) at:
www.jswsteel.in/dolvi-works

30 YEARS

JSW Steel's DR plant handily exceeded its rated capacity in 2023 and operated 8198 hours. The plant has averaged 8044 hours of operation per year since its initial start-up in 1994, and 8149 hours per year in the last 8 years. Approximately 10% of its energy input came from COG injected to the shaft furnace to reduce natural gas consumption.

The MIDREX Plant is part of a 10 Mt/y integrated steel works located on the west coast of India in Maharashtra State. JSW Steel's Dolvi Works produces hot rolled coils for use in automotive and industrial products and consumer durables.

JSW Steel has a strategic collaboration with JFE Steel of Japan and is the only Indian company to be ranked among the top 15 global steel producers by World Steel Dynamics for 13 consecutive years since 2008.

Lauren Lorraine: **Editor**

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The processes and equipment depicted in this material are subject to multiple patents and patents pending in the U.S. and internationally.

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CONTACTING MIDREX

General E-mail:
info@midrex.com

Phone: (704) 373-1600
3735 Glen Lake Drive, Suite 400
Charlotte, NC 28208

General Press/Media Inquiries
Lauren Lorraine
LLorraine@midrex.com
Phone: (704) 378-3308

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