

DIRECT FROM **MIDREX**

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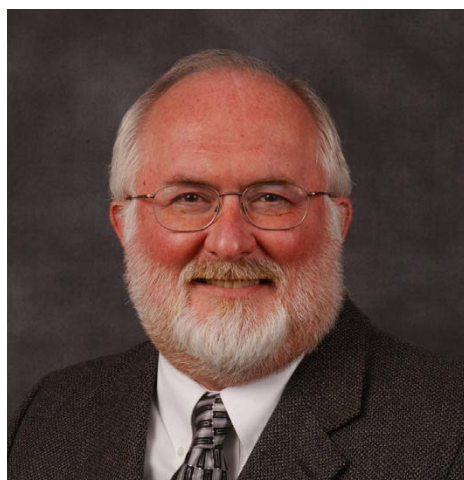
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COMMENTARY

THE DRI INDUSTRY IS STILL **YOUNG** AND DEFINITELY **THRIVING**

By Robert L. Hunter
Market Research Manager



Today everything is bigger. There are over 7 billion people on the planet. There are over 1.2 billion vehicles on the roads, and that number is expected to surpass 2 billion within less than 20 years. Gross world product is over 75 trillion dollars per year. World energy consumption is well over 500 exajoules per year... 1 exajoule is the energy equivalent of 30 million tons of coal! These numbers make the world of our fathers and grandfathers seem miniscule in comparison.

Last year ironmaking exceeded 1.2 billion tons, with DRI making up only about 6% of the total. Although the direct reduction industry seems small when viewed in light of the enormity of modern iron and steel production, it takes on a different appearance when compared to the ironmaking industry of the past, especially when you consider that ironmaking has been around for over 3000 years while the modern direct reduction industry only came into being about 60 years ago.

During most of human history, iron was an expensive commodity, far rarer than it is today. Ironmaking first came about somewhere in the Middle East (likely northern Iraq/southern Turkey) in the centuries before 1000 BC. It was never very large by today's standards. Except for a few centuries during the Qin and Han dynasties in China (roughly the last two centuries BC and the first two centuries AD) when it is believed that China alone made about 100,000 tons, annual iron production during the three millennia since man first made iron probably fluctuated between zero and 100,000 tons, according to the fortunes of the times.

By 1700, cumulative world production of iron was almost certainly below 200 million tons and probably somewhere around 100 million tons. Today, we make that much in a month, and the direct reduction industry alone makes that much in about 16 months.

Let's make a few historical comparisons. DRI production today is between 70-80 million tons per year. It was not until 1912 that global iron production reached 80 million tons, which is about the time Lord Robert Crawley, the 7th Earl of Grantham (for you fans of the Downton Abbey series) lost his fortune

betting on building a railroad in Canada, a steel-intensive project. Today's direct reduction industry makes enough iron to supply all of the railroads built in the world in 1912, as well as all other steel for that year.

HBI production alone currently runs from 5-8 million tons per year. However, it took world iron production until the 1850s to get to that level. This was while the Second Industrial Revolution was well underway in Great Britain and Europe and a number of wars were being fought, notably the Crimean War, the 2nd War for Italian Independence, the 2nd Opium War and India's First War for Independence... armies need iron and steel to fight a war. And the SS Great Eastern, the largest ship ever built at the time of its 1858 launching, used nearly 19,000 tons of iron, which was roughly 3 kg for every ton of iron made in the world that year.

What about cumulative DRI production to-date? In about 60 years, we are slightly past 1.4 billion tons of DRI produced. How long did it take the world to produce its first 1.4 billion tons of iron? As noted earlier, no one really knows how much was being made throughout most of history, but it is certain that the production rate was limited to levels so low that past production is inconsequential relative to modern years. Without a doubt, cumulative world production of iron was less than 1.4 billion tons as recently as 1900... and humanity has been making iron for over 3,000 years. Clearly, the direct reduction industry is off to a fast start and thriving.

By the way, cumulative iron production including DRI recently passed **40 billion tons.** ■



NO. 1 HEAVY DRI: SCRAP RIVAL OR ENHANCER?

By Michael Marley
ISRI Convention • Las Vegas, NV
April 5, 2016

EDITOR'S NOTE:

Direct From Midrex thanks Michael Marley for allowing us to publish remarks he made at the Institute of Scrap Recycling Industries (ISRI) Convention in Las Vegas earlier this year. Mike worked with us to update the information to capture the pulse of the steel and scrap industries through the summer and into the fall.

He has made a long and meaningful career of riding the metallics roller coaster and sharing the knowledge he has acquired and the insights he has developed along the way. So hang on and get prepared for a whirlwind tour through the wild and sometimes wacky world of Mike Marley.

> *The thoughts and views expressed in this article are those of the author and do not necessarily represent those of Midrex.*

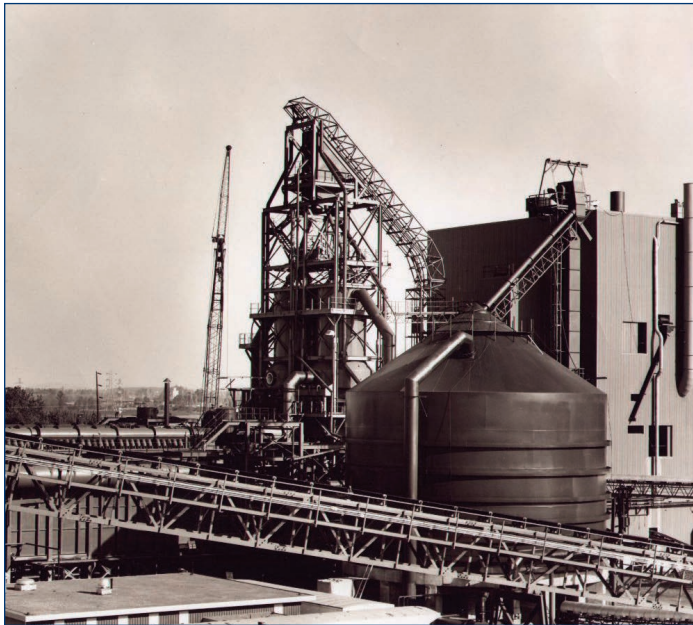
I've spent almost 40 years on the scrap heap. I'm not a junk car or discarded washing machine. I've reported scrap prices and market trends for a few trade publications like the now-deceased Iron Age magazine and the still alive and thriving AMM. Today, I write a weekly newsletter with the eponymous name of Mike Marley's Shredded Power. That's a name bestowed on it by my boss, steel industry analyst Peter Marcus of World Steel Dynamics.

While covering the ferrous scrap beat, I frequently talk to traders and buyers about other steelmaking raw materials like pig iron and direct reduced iron (DRI). In those discussions, DRI is often called a competitor or substitute material for ferrous scrap. During one such recent chat with long-time Midrex analyst Robert Hunter, he said something that struck me as

insightful and different from what I often hear from others. If anything, he said, DRI is a complementary material that has enhanced and supported the use of ferrous scrap and not displaced it. There is much to think about in that light when you consider the history of DRI in the U.S. and other steelmaking countries, the current ferrous scrap market and the revived interest in DRI. What has driven that rebirth and what are some of the changes it could bring about?

Midrex didn't invent direct reduction technology. It wasn't even called Midrex in those days. It began with a company called Surface Combustion Corp. in the 1960s. German steel whiz Willi Korf acquired the technology from Surface in the 1970s and launched Midrex as a designer and developer of DRI plants. The technology has been widely used in developing countries that have been blessed with abundant supplies of natural gas.

Prior to the introduction of technologies like direct reduction, much of that gas had little or no value in some countries, unless



First MIDREX® Plants built at Oregon Steel Mills in Portland, Oregon, USA, 1969.



Lebedinsky GOK (LGOK II) is the only HBI producer in Russia and is Russia's largest iron ore production facility.

someone was willing to build a pipeline long enough to carry it to the developed world. Oil companies flared it off in many regions.

What Midrex and its rival DRI builders did was to persuade the gas-rich countries like those in the Middle East and Venezuela to use that energy to make iron and from that iron, they could make steel products like rebar and I-beams to be used by their nascent construction industries.

Midrex found a few risk takers in the U.S. who liked the idea of an alternative iron source. These included mills like Oregon Steel Corp. in Portland, OR and Korf's own wire rod mill in Georgetown, SC. Before they could prove the worth of DRI, these plants were victimized by surging natural gas prices. They subsequently disappeared. Indeed, during my tenure as editor of *Iron Age*, I visited Oregon Steel in the 1980s and toured the steel plant. When we got back to the corporate offices after the tour, I asked one of the company's executives where was their famous DRI plant. It was the first one built in the U.S. He pointed to an empty lot across the street. "It was there till we scrapped it," he said.

There wasn't another such risk taken in the U.S. until the 1990s, when American Iron Reduction built a DRI plant in Louisiana. But that was ill-timed as well. It failed and was sold. The buyer? Nucor Corp., the biggest ferrous scrap consumer in the U.S., if not the world. Nucor executives had the good sense to

dismantle the plant and move it to Trinidad and Tobago, where there are ample supplies of natural gas available at a reasonable cost.

One country where DRI achieved success, at least until a few years ago, was Venezuela, an oil and gas rich nation. It built several captive plants for its own steel industry, as well as merchant DRI/HBI facilities that sold their output to steelmakers in the U.S. and elsewhere around the world. Many of these operated well until the "pink tide" of Latin American Marxism led by the Lt. Col. Hugo Chavez destroyed their efficiency and reliability. It was not unusual to hear buyers at several U.S. mills complain in the past decade because cargoes of HBI from Venezuela were several months, not weeks, late in arriving. The future prospects for DRI production in the U.S. were dim after that. Even the reliability of other offshore suppliers was sometimes in doubt as well.

Then came fracking and its impact on both the supply and price of natural gas. Again, credit Nucor with being bold enough to recognize that opportunity and install a new DRI plant in the U.S., the first in almost 20 years. Back in 2013, before it came on-stream in Convent, LA, I spoke at the ISRI Ferrous Roundtable in Chicago and wondered aloud whether it would herald busheling's last hurrah. I was reaching too far at the time, trying to provoke a reaction from the audience.

Busheling is still the main melt material for all of the EAF-



based flat-rolled mills and others that make formable products like wire rod. But I don't think it would be too bold to say that Nucor's Convent plant has influenced the pricing of prime scrap. Their DRI plants have played a role in minimizing Nucor's appetite for industrial steel scrap and is now helping it to meet the new demand for hot-rolled band from some of the domestic industry's integrated steel mills that have shut down about 5 million tons of their raw steelmaking capacity in the past year.

Nucor chief executive John Ferriola boasted to industry analysts that its use of DRI took about \$100 per ton off the busheling price last year. Now that was a bold claim! Other forces may have had a role. These include the strong pace of auto output, which produces more new steel scrap as well as more cars and trucks, competition from cheap foreign steel, at least prior to the U.S. Commerce Department's decision to impose anti-dumping and countervailing penalties on some overseas steelmakers, and the diminished scrap demand from the integrated mills because of cheaper iron ore prices and the steelmaking capacity cutbacks.

When Nucor-Convent came on-stream, some scrap dealers assumed it would provide a substitute for imported pig iron. They were certain Nucor was only concerned about its dependence on offshore supplies of raw materials, much like some U.S. integrated steel producers were in the middle of the last century. After spending millions of dollars to develop iron mines in Venezuela, some major U.S. steel corporations abandoned those facilities and chose to remain wholly dependent on the ore mines in northern Minnesota and Canada. Ironically, dependence on offshore steel supplies was the basis for Nucor's decision to first get involved in steelmaking back in the 1960s.

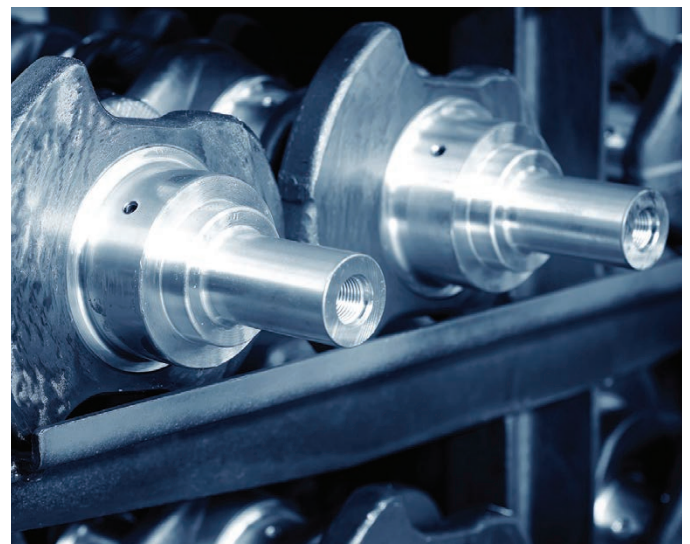
When thinking about what DRI plants produce, it's important to realize they actually make two products, not one. The first is iron; the other is leverage. That can't be weighed or loaded on a barge like the DRI pellets, but it is there nonetheless. In other words, steelmakers and the people that buy scrap for their mills use it as a bargaining chip during the buy week each month, in much the same way that they uses imports of scrap from Europe and pig iron from Brazil and eastern Europe. In other orders, their scrap brokers and buyers might say that instead of buying 3,000 tons of busheling from dealer X this month, the mill only needs about 1,000 tons and will pay \$10 per ton less than last month's price.

Being stuck with 2,000 tons of unwanted busheling is a serious problem for dealers handling mainly industrial scrap,

especially if they are likely to face that same problem next month and the month after that. Scrap dealers can't cut off the flow of industrial scrap by reducing their buying price for that scrap. That works for junk cars that they feed into their shredders, but automotive stampers and other manufacturing plants keep filling up those roll-off containers expecting them to be picked up promptly regardless whether the price of busheling is \$800 per ton, as was the case in 2008, or \$150 per ton last December.

When the busheling prices dropped that low in scrap-rich regions like Detroit and elsewhere in the industrial Midwest, DRI was no longer the bargain it had been. Nucor said in January that it would halt production at Convent. That hiatus didn't last very long. Two weeks, I believe. Some observers believe a spike in demand for hot-rolled coils, not only from domestic steel users but also by the now hot metal-short integrated mills, may have accounted for the change. The EAF flat-rolled mills now euphemistically refer to those sales as the "substrate" market. Integrated mills now buy hot-rolled coils from their EAF flat-rolled rivals and turn it into cold-rolled and galvanized sheet steel. So much for the argument that only blast furnace should be used to make these products.

Prior to the rebound in domestic sheet sales and prices, demand and prices of scrap had fallen for five months in a row in the second half of last year. Prices were off by more than 50 percent from the levels seen at the start of 2015. Such steep cuts do not affect the flows of industrial scrap, but they do impact the intake of obsolete scrap at dealers' yards.



Steel Forgings



The demolition business dried up, auto wreckers started piling up flattened cars in the back of their yards instead of selling them to shredders and peddlers stopped dumpster diving and vanished. If a dealer was only paying \$40 per ton for old appliances and what some call “alley scrap,” it was no longer worth the time to drive around and collect that material. Many peddlers operate with old half-ton pickup trucks. If they get only \$20 for a load of old scrap, that didn’t even cover the fuel cost in these now-cheaper energy days.

But times changed yet again! And it had nothing to do with an old Bob Dylan song. The domestic flat-rolled mills got a late Christmas present: The Commerce Department decided that much of the imported sheet steel was being sold at unfair prices in the U.S. and decided to impose anti-dumping and countervailing duties that would level the playing field. That sent many domestic steel consumers and service centers looking for more sheet from U.S. mills.

Two other forces were at work at the same time. First, as noted earlier, two integrated steelmakers cut raw steel production at some of their mills. These included U.S. Steel Corp’s mills in Fairfield, AL, and Granite City, IL and AK Steel Corp.’s mill in Ashland, KY. In fact, AK Steel said at one time that it would no longer pursue the commodity hot-rolled sheet business. That forced these integrated mills, as well as the steel consumers and warehouses, to turn to the domestic flat-rolled mills.

Secondly, overseas demand for ferrous scrap revived briefly in March and April. This involved stronger demand and higher prices from steelmakers in Turkey, the world largest importers of ferrous scrap, as well as more buying by steelmakers in Taiwan and other nations in southern and southeastern Asia. Much of this was spurred by a spike in steel billet prices in China and decisions by some Chinese steel exporters to withhold billet supplies when overseas steel buyers balked at paying the higher prices.

This put new pressure on some domestic EAF flat-rolled mills in the second quarter. Prices rose by between \$10 and \$15 per ton in the first week of March. But by mid-month, several of the major EAF mills were reaching out to scrap suppliers in distant regions and paying what scrap dealers and steel mills call “springboard prices.” Some paid premiums of as much as \$50 per ton over the prices they were paying their local suppliers for the same grades of scrap. These premiums reflected higher F.O.B. or shipping point price paid to the remote dealers that matched or surpassed what they were getting from mills in these regions,

“ THE DOMESTIC FLAT-ROLLED MILLS GOT A LATE CHRISTMAS PRESENT: THE COMMERCE DEPARTMENT DECIDED THAT MUCH OF THE IMPORTED SHEET STEEL WAS BEING SOLD AT UNFAIR PRICES IN THE U.S. AND DECIDED TO IMPOSE ANTI-DUMPING AND COUNTERVAILING DUTIES THAT WOULD LEVEL THE PLAYING FIELD. ”

as well as higher rail and barge freight transport costs. This upward trend continued into midsummer, with some flat-rolled mills in the South paying as much as \$305 per ton for desperately needed tons of busheling and bundles. It eased in August when, thanks to the stronger U.S. dollar and the Brexit crisis in Europe, some U.S. EAF sheet producers were able to buy several cargoes of bundles from European exporters.

So in light of later market developments, Nucor’s sudden about-face on idling the DRI plant in Convent doesn’t seem as surprising. Besides the benefit of the favorable trade rulings, the on-going strength of the domestic auto sales and the automaker demand for sheet steel are the fundamental drivers for the market.

It’s a safe bet that Nucor won’t be abandoning that DRI plant in Louisiana anytime soon, even if offered busheling at \$100 per ton. The company won’t stop using prime industrial scrap either, but it won’t be as dependent on that material as it has been in the past.

It would be foolish for Nucor to free up a lot of industrial scrap supply for its rivals, in particular for the new Big River Steel mill expected to come on-stream in Arkansas later this year. I believe there are other steps the steelmakers could take to achieve that, such as trading iron ore futures to minimize their exposure to the ups and downs of pricing in that market. But Nucor in the past has indicated its opposition to futures trading in hot-rolled coil and may be rejecting any role in the futures trading of steelmaking raw materials like ferrous scrap and iron ore to avoid being forced into accepting hot-



rolled coil contracts by some of its customers.

It is unclear whether the costs or lack of capital has deterred other steelmakers from considering construction of new DRI plants. It hasn't discouraged voestalpine, the Austrian steelmaker and steel equipment supplier. Its new DRI plant in Texas will ship half of its output home to its mills in Europe and the rest to Mexican and U.S. steelmakers.

There is still some talk about others building DRI facilities next to existing steel mills or as possible merchant facilities linked to one or more of the iron ore mining companies. The steel industry has seen several "me too" projects pursued after an innovator like Nucor succeeds. Even former Nucor chairman Daniel DiMicco suggested at one time that the company could add a second module in Louisiana and become a merchant producer. Nucor could supply all of the U.S. steel mills that have been frustrated by the erratic behavior of the merchant ironmakers in Latin America. Now that they have acquired a taste for Nucor and other EAF mills' hot-rolled coil, they might respond to such an offer with a polite "thanks, but no thanks."

There is also the possibility that some of the cash-strapped integrated mills might restart part of the hot end of their idled facilities if an iron miner built a merchant plant or two to supply them with DRI. They would not need the coke ovens and blast furnaces and could avoid the current expenses for relining some furnaces and the potential future costs like a carbon tax. If not, the alternative might be a possible takeover or partnership with a foreign steelmaker. One such scenario might involve a Chinese steelmaker buying an American mill and shipping

slab or hot-rolled coil made in China with cheaper Australian iron ore. U.S. Steel Corp has such an arrangement with Posco, the big South Korean steelmaker. Posco has been shipping hot-rolled coils to a U.S. Steel cold mills in Pittsburg, CA, for more than 20 years.

One final thought, and this ties in with Robert Hunter's notion that DRI enhances scrap usage and does not displace it. What's to discourage some rebar and structural mills in the U.S. from using DRI? They do it in the Middle East. The point is simply this: DRI's higher iron content could pave the way for some of these mills to use less desirable but cheaper grades of ferrous scrap. This could include grades like mixed machine shop turnings, which some already use, and, Heaven forbid, even the dregs of the ferrous scrap supply pipeline—burned muni scrap.

Or, and this is purely speculative, what about as another raw material stream when shredded scrap is in tight supply, as has been the situation at times this year when DRI was available at lower or competitive prices? Several of the long products mills tapped the busheling supply last year when shredded was tight. Busheling and bundles were plentiful and available at cheaper prices. This was perhaps the longest period in which busheling and shredded prices were upside-down, as some in the scrap and steel industry might say, or in backwardation, to use commodities markets language. They were that way for close to a year in several key steelmaking cities like Chicago, Detroit and Cleveland.

Again, these are just speculative ideas, or perhaps I should say, they seem to be at this time! ■



INCREASING HBI CAPACITY FOR THE MERCHANT MARKET

by Christopher M. Ravenscroft, Manager –
Global Marketing & Communications



INTRODUCTION

As steel production expands to more and more countries and environmental awareness increases worldwide, the challenge to remain competitive will intensify. Securing the quality and quantity of metallics required for operations within stricter emissions guidelines will be essential.

Natural gas-based direct reduction ironmaking has played an integral role in the industrialization of emerging economies, teaming with the electric arc furnace (EAF) to create national steel industries that could not support the traditional integrated route. The versatility of direct reduced iron (DRI) has allowed the EAF to make any grade of steel products – from reinforcing bars and billets to exposed auto body sheet and has provided steel producers the ability to respond to and take advantage of changing market conditions.

However, not all steel mills included EAFs or were located with a direct reduction plant nearby. Therefore, a form of DRI was needed that could be easily and safely shipped in ocean-going vessels, stored and charged similar to other conventional metallics and possessed sufficient mass and density to effec-

tively penetrate the EAF slag layer or withstand the pressure of the blast furnace (BF). Thus, hot briquetted iron (HBI) was introduced.

Hot briquetted iron (HBI) has been around for decades; however, its true impact has yet to be fully realized by the steel industry. The environmental and productivity gains for integrated steel production coupled with HBI's well documented handling, shipping and storing benefits will result in greater demand for HBI over the next few decades. In fact, including HBI in the blast furnace (BF) charge may be the best chance to keep some integrated steel works in operation for years to come, as its collective benefits lead to greater furnace productivity and reduced CO₂ emissions.

STEEL INDUSTRY EMISSIONS CONSIDERATIONS

In December 2015, China had its first ever red alert for air pollution in Beijing. A red alert is issued when the air quality index is above 300 for three consecutive days ("Heavily Polluted") that is on a scale that tops out at 500 ("Severely Polluted"). During the red alert, PM_{2.5} (fine particulate measured in micrometers)



was 10 times the recommended level. Within days, India experienced a similar situation. Last year the World Health Organization named India as the country having the worst air pollution on the planet. As a result, Delhi has restricted the use of cars to alternating days and is closing a coal-fired power plant. These incidents have caused the media and governments to focus even more on industry emissions. This focus has gone beyond the scope of particulates and has directly shone a light upon greenhouse gases.

According to a 2014 report by the Intergovernmental Panel on Climate Change (IPCC), carbon dioxide (CO₂) makes up 76% of global greenhouse gas (GHG) emissions – 65% from fossil fuel and industrial processes and 11% from forestry and other land uses (Figure 1). Industry accounts for more than 20% of GHG emissions by economic sector and ironmaking alone comprises more than one-fourth of industrial-source CO₂ (Figure 2). The reason for such a high percentage is that the majority of iron produced in the world is made using fuels that are carbon-based and thus generate significant amounts of CO₂ as a by-product.

Total production of CO₂ by human activities is currently around 35 billion tons per year. Iron and steelmaking account for almost 7% of mankind's entire carbon footprint. Ironmaking alone constitutes 80-85% of iron and steel's total CO₂ output.

Integrated mills are the largest contributor of CO₂ by both volume and percentage, with coke-fueled blast furnaces currently producing well over 90% of the world's iron.

A PRACTICAL WAY TO KEEP BFS OPERATING

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 CO₂ for every ton of iron produced. As no proven carbon capture system exists for blast furnaces, the best, although totally impractical way for integrated steelmakers to reduce CO₂ emissions is simply by not creating the emissions in the first place. A practical way to keep BFS operating is to take advantage of the benefits of direct reduction ironmaking.

Natural gas-based DRI plants produce 1/3rd the amount of CO₂ as BF iron production per ton of product. Even more striking is that the natural gas-based DR plant/EAF steelmaking route produces ½ or less CO₂ as the BF/BOF route per ton of product.

Feeding HBI to the BF will reduce an integrated mill's carbon footprint by decreasing the coke required and increasing productivity. The rule of thumb is for each 10% increase in burden metallization there is an 8% production boost, and the coke rate is reduced by 7%. A reduction of the coke rate will

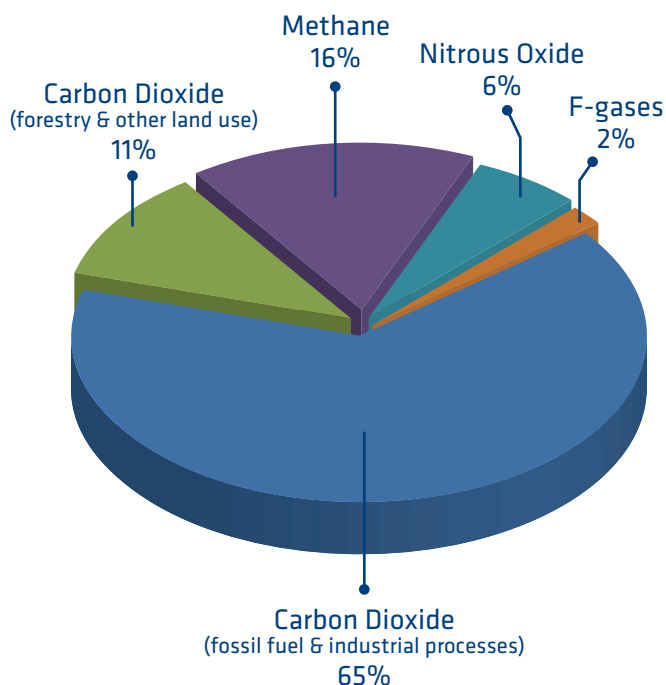


FIGURE 1. Global greenhouse gas (GHG) emissions by gas (Source: Intergovernmental Panel on Climate Change, 2014).

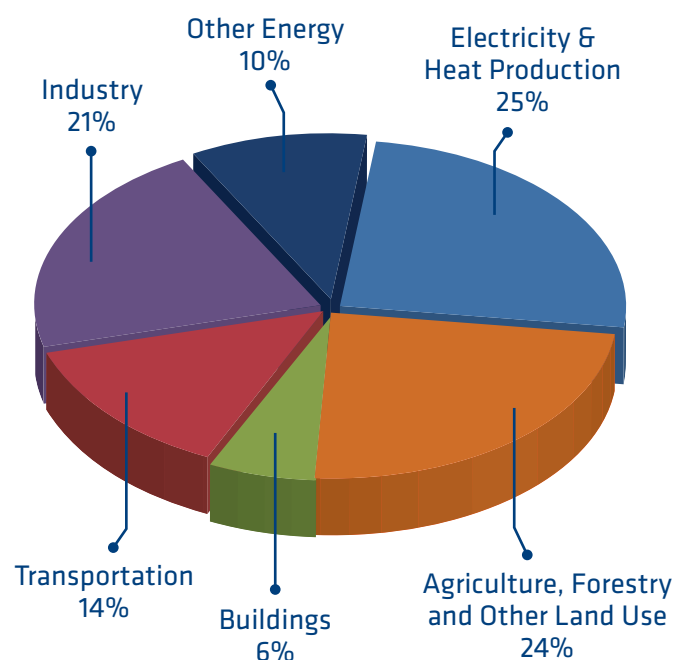


FIGURE 2. Global greenhouse gas (GHG) emissions by economic sector (Source: Intergovernmental Panel on Climate Change, 2014).



result in significantly lower CO₂ emissions.

SOURCING HBI

If we accept that the most effective, currently available means of lowering the amount of CO₂ generated by the steel industry is to use HBI produced by a natural gas-based direct reduction plant in the blast furnace, the important question becomes: “How does a mill source HBI?”

HBI can be sourced two ways by an integrated steel mill:

1) buy HBI from a dedicated merchant HBI plant or from a DRI plant with the capability to produce HBI; or 2) build a natural gas-based DRI plant with HBI capabilities either onsite or near operations or off-shore where there are sufficient supplies of reasonably priced natural gas.

For most BF producers, merchant HBI plants are the most obvious sources of supply. Merchant HBI allows those who do not wish to own and operate their own plant to purchase material in the open market. To date, blast furnace operators have chosen to obtain HBI in this manner. HBI plants dedicated to merchant supply exist in Venezuela, Libya, Russia and Malaysia. With the exception of Russian HBI supply, in recent years political and economic issues have limited the activities of several of these HBI suppliers.

Although DRI plants equipped with briquetting machines have the capability of producing HBI, their first priority is to supply hot DRI (HDRI) to their own steel operations. Therefore, BF operators would be subject to the uncertainty of the spot market.

To have greater control of HBI supply, without having to rely on merchant sources would require building a dedicated facility, as many EAF steelmakers have historically done. In regions where natural gas is not readily available or sufficiently allocated for HBI production, off-shore sourcing may be a practical option.

One steel company has already chosen this route. This year voestalpine of Austria began operations at its new 2 million metric tons per year MIDREX® HBI plant near Corpus Christi, Texas, USA. The company is capitalizing on the low natural gas prices in North America to supply its BFs in Linz and Donawitz, Austria. Current plans are for about half of the plant's output to be supplied to voestalpine's steel plants, with the remaining HBI to be sold to parties interested in supply over the long-term.

When Wolfgang Eder, CEO and Chairman of the Management Board of the voestalpine Group, announced the decision to invest in the HBI plant in Texas (*Figure 3*), he pointed out that the use of a natural gas-based reduction process will significantly improve the overall carbon footprint of voestalpine and serve as an important step in achieving the Group's ambitious internal energy efficiency and climate protection objectives.

Europe is the first to pursue the off-shore HBI sourcing solution, but it will not be the last. BF producers in India and China, who are faced with limited or high cost natural gas, much like in Europe, have an even greater incentive to search for ways to decrease smog derived from the burning of coal.



FIGURE 3.
View of voestalpine Texas LLC HBI plant site near Corpus Christi, Texas, USA.



HBI DEMAND FORECAST

What is the potential for BF operators to use HBI in their furnace charge and how much tonnage would it represent? We have attempted to forecast the percentage of metallic iron (HBI) in the BF charge looking out to 2020, 2030 and 2040 and to equate the percentages to how many tons of HBI would be required. In each scenario we used the World Steel Association's statistics for tons of BF iron produced in 2015 as the basis.

The first scenario, shown in **TABLE I**, is a conservative forecast, with HBI being used in the BF only in the European Union (EU) and North America in 2020, and there only as 1.5% of the BF burden. HBI usage would expand to all regions except the C.I.S. and South America by 2030, and the percentage of use would increase significantly in the EU and North America. By 2040, BF operators throughout the world would be using HBI, with it making up 10% of the BF charge in the EU, North America and Oceania. Although the percentage is modest in Asia (3%), the tonnage is impressive (26.73 million), primarily due to China. This is a projected major share of the world - 41.8 million tons.

The second scenario (**TABLE II**) is an aggressive forecast, again showing HBI being used in the BF only in the European Union (EU) and North America in 2020. HBI usage would expand to all regions except the C.I.S. by 2030, with Oceania exceeded only by the EU in percentage of HBI used in the BF. By 2040, HBI use would have spread to all regions of the world. BF operators in North America and the EU would be using HBI as 15% of their charge with Oceania close behind at 12%. However, Asia would dwarf all other regions in forecasted tonnage used (62.36 million), primarily due to China; in this scenario world tonnage is projected at 88.9 million tons.

If we continue the trend lines out to 2050 and 2060 (**TABLE III**, *next page*), integrated steelmakers in the EU, North America and Oceania could be using HBI as ¼ of the BF burden by 2060, with all other regions at 15-20%. The tonnage that represents is staggering – 185.7 million, with Asia accounting for 133.64 million of the total.

LOW	Tons of BF iron produced (million/t)	% metallic iron in the BF burden			
		in 2015*	2020	2030	2040
European Union (28)	93.0	1.5	5.0	10.0	
Other Europe	11.9	0.0	1.0	3.0	
C.I.S.	77.9	0.0	0.0	1.0	
North America	35.8	1.5	3.0	10.0	
South America	31.4	0.0	0.0	2.0	
Asia	890.9	0.0	1.0	3.0	
Oceania	4.3	0.0	2.0	10.0	
Total	1145.2				

TABLE I
Conservative forecast of potential HBI use in the BF (2020-2040)
** source: World Steel Association*

HIGH	Tons of BF iron produced (million/t)	% metallic iron in the BF burden			
		in 2015*	2020	2030	2040
European Union (28)	93.0	1.5	10.0	15.0	
Other Europe	11.9	0.0	2.0	10.0	
C.I.S.	77.9	0.0	0.0	5.0	
North America	35.8	1.5	5.0	15.0	
South America	31.4	0.0	2.0	5.0	
Asia	890.9	0.0	2.0	7.0	
Oceania	4.3	0.0	7.0	12.0	
Total	1145.2				

TABLE II
Aggressive forecast of potential HBI use in the BF (2020-2040)
** source: World Steel Association*



The logical question is, “How much HBI capacity exists?” And, even more important is, “How much HBI is currently produced?”

COMMISSIONED HBI CAPACITY VS. PRODUCTION

There are over 20 million tons of HBI capacity installed or under construction worldwide; 13 using MIDREX® technology, 3 HYL/ENERGIRON® and one each FINMET®, CIRCORED® and FIOR®. However, much of that capacity is not available as merchant HBI, either because of owner decision (in the case of dual product plants) or operational issues (natural gas price/availability, oxide pellet shortage, etc.) that limit some or all of production (TABLE IV).



HIGH	Tons of BF iron produced (million/t)	% metallic iron in the BF burden	
	in 2015*	2050	2060
European Union (28)	93.0	20.0	25.0
Other Europe	11.9	15.0	20.0
C.I.S.	77.9	10.0	15.0
North America	35.8	20.0	25.0
South America	31.4	10.0	15.0
Asia	890.9	10.0	15.0
Oceania	4.3	20.0	25.0
Total	1145.2		

TABLE III
Aggressive forecast of HBI use in the BF (2050-2060)
* source: World Steel Association

Plant Location	Rated Capacity (Mt/y)	Product	Status*
MIDREX® Process			
Antara Steel Mills, Labuan Island, Malaysia	0.65	HBI	O
Essar Steel I & II, Hazira, India	0.88	HBI/HDRI	I
FMO, Puerto Ordaz, Venezuela	1.00	HBI	O
VENPRECAR, Matanzas, Venezuela	0.82	HBI	O
Essar Steel III, Hazira, India	0.44	HBI/HDRI	I
LISCO 3, Misurata, Libya	0.65	HBI	O
COMSIGUA, Matanzas, Venezuela	1.00	HBI	O
Essar Steel IV, Hazira, India	1.00	HBI/HDRI	I
Essar Steel V, Hazira, India	1.50	HBI/HDRI	O
LGOK 2, Gubkin, Russia	1.40	HBI	O
Qatar Steel II, Mesaieed, Qatar	1.50	CDRI/HBI	O
Lion DRI, Banting, Malaysia	1.54	HDRI/HBI	I
Jindal Shadeed, Sohar, Oman	1.50	HDRI/HBI	O
MIDREX Total	13.88		

Data taken from 2015 World Direct Reduction Statistics

* Status Codes: O – Operating I – Idle



Plant Location	Rated Capacity (Mt/y)	Product	Status*
HYL/ENERGIRON® Process			
JSW Steel, Raigad, India	0.75	HBI/CDRI	I
Lebedinsky GOK, Gubkin, Russia	0.90	HBI	O
Briqven (BriqOri), Matanzas, Venezuela	1.50	HBI	I
HYL/ENERGIRON Total	3.15		
FINMET® Process			
Orinoco Iron, Matanzas, Venezuela	2.20	HBI	I
CIRCORED® Process			
Mittal-ISC Trinidad, Point Lisas, Trinidad & Tobago	0.50	HBI	I
FIOR® Process			
Operaciones RDI, Matanzas, Venezuela	0.40	HBI	I
Total Installed HBI Capacity	20.13		

* Status Codes: O – Operating I – Idle

TABLE IV Installed HBI capacity by process (operating and inactive)

Data taken from 2015 World Direct Reduction Statistics

In order to make a more accurate accounting of available HBI merchant capacity, we have to start by subtracting the dedicated HBI plants (i.e., whose sole product is HBI) that were idle in 2014: Briqven (BriqOri), Orinoco Iron, Circored and FIOR, which represent 4.6 million of installed capacity. Other currently installed HBI capacity has been impacted in various ways:

- Essar Steel made the decision to switch entirely to HDRI production (3.82 million tons) before they were idled due to natural gas price/availability.
- Qatar Steel has increased internal usage of CDRI (1.5 million tons) and no longer makes HBI.
- JSW Steel (0.75 million tons) has been idled due to natural gas price/availability.
- HDRI has become the primary product for Jindal Shadeed (1.5 million tons)
- HBI plants in Venezuela (FMO, COMSIGUA and VENPRECAR), with a total installed capacity of 2.82 are severely limited due to a shortage of iron oxide pellets.

- Lion DRI (1.54 million tons) is now closed
- LISCO 3 (0.65 million tons) is still recovering from the civil war in Libya.
- Chinese steel exports have so lowered the value of iron and steel products in their natural market region, that Antara Steel (0.65 million tons) has been forced to limit production.

So arguably that leaves the world with approximately 4.3 million tons of reliable merchant HBI capacity (LGOK & voestalpine Texas). Another 1.8 million tons is scheduled to come on line in 2017 with startup of LGOK III.



voestalpine Texas

Corpus Christi, Texas



voestalpine TEXAS

OVERVIEW:

- Capacity: 2,000,000 tons/year
- Location: Corpus Christi, Texas, USA
- Product: HBI
- First HBI plant built primarily to supply BF's
- Approximately 1 million tons of HBI will be shipped to voestalpine's integrated mills in Linz and Donawitz, Austria
- Additional HBI for merchant market

PROJECT STATUS:

- Start-up September 2016



LGOK III

Gubkin, Russia



LGOK III

OVERVIEW:

- Capacity: 1,800,000 tons/year
- Location: Gubkin, Russia
- Product: HBI
- Second MIDREX® HBI Plant and 3rd HBI plant on site

PROJECT STATUS:

- Engineering nearly complete
- Equipment delivery ongoing
- Construction underway
- Start-up in 2017

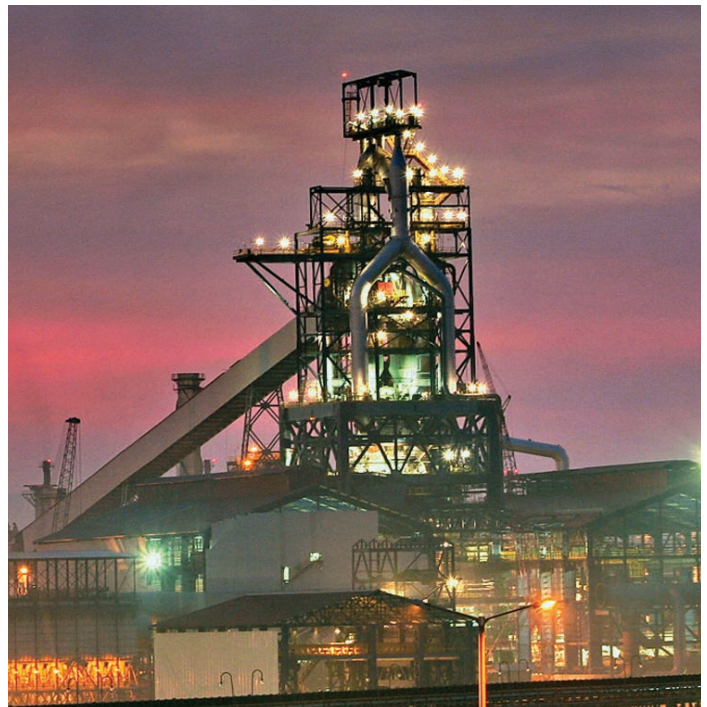


CONCLUSION

Sustainability is ultimately the key issue for every steelmaker going into the future. DRI products, which until recently have been viewed by integrated steelmakers as an EAF-specific charge material, may actually present a long-term, scalable solution going forward. The use of Hot Briquetted Iron (HBI) as a charge material in the blast furnace is now being seen as an effective way to help displace CO₂ emissions while increasing hot metal production of the BF.

Investing in natural gas-based direct reduction plants, either directly or through long-term supply contracts, in strategically located sites around the globe is no longer a hypothetical scenario, as the first direct reduction plant built specifically to supply HBI to blast furnaces in Austria has begun operations on the Gulf Coast of Texas in the US. The voestalpine Texas plant is opening a promising new market for HBI.

The BF market shows tremendous potential for merchant HBI sales. However, the amount of HBI available to the merchant market is extremely limited. In order to meet even the conservative estimate of potential future demand, additional HBI plants need to be built. Midrex has been the leading supplier of HBI technology since the early 1980s and new MIDREX® HBI plants are on the way; however, more capacity will be needed to meet future projected demand. ■





MIDREX News & Views

voestalpine Texas LLC HBI Plant Inaugurated

By Frank Griscom

The first hot briquetted iron (HBI) plant in the United States, owned by voestalpine Texas LLC, was officially opened by an inauguration ceremony on October 26, 2016. The plant, which is located outside of Corpus Christi, Texas, was started up on September 27, 2016, and within little more than 24 hours, it was in stable operation at around 160 metric tons per hour producing on-grade briquettes.

During the ceremony, Wolfgang Eder, Chairman of the Management Board of voestalpine AG, said, "Today's opening of the direct reduction plant in Corpus Christi is an important step for—and into—the future of our company. The new plant will not only secure the Austrian voestalpine sites by supplying premium pre-materials for steel production, it will also contribute significantly to further strengthening our position in the NAFTA region. Furthermore, over the long term it offers us new technological options for decarbonizing steel production."

OTHER RECENT VA TEXAS NEWS

Just a few months prior to completion of its state-of-the-art HBI plant, voestalpine Texas signed an offtake agreement with the new US steelmaker Big River Steel that will run for the next four years. Big River Steel is currently building an ultra-modern steel mill in the state of Arkansas, which will specialize in the production of sophisticated flat-rolled products. Beginning in 2017, the mill will take annual delivery of up to 240,000 metric tons of HBI from voestalpine Texas LLC.

The Big River Steel mill site fronts on the



Pictured: Dr. Wolfgang Eder at the newly commissioned voestalpine Texas LLC HBI facility

Mississippi River. Therefore, HBI delivery from the voestalpine Texas LLC waterfront location will be highly efficient and cost-effective, eliminating the need for any additional handling or transshipment en route.

“THESE SEAMLESS LOGISTICS MEAN CONTINUOUS DELIVERIES OF HIGH-QUALITY HBI CHARGE MATERIAL, ENSURING THAT WE CAN MEET OUR CUSTOMERS' EXACTING DEMANDS OVER THE LONG TERM.”

DAVID STICKLER, CEO OF BIG RIVER STEEL

In 2016, voestalpine has signed long-term HBI supply contracts with other customers including steel producer TYASA, based in Orizaba, in the state of Veracruz in the south of Mexico, for

several hundred thousand metric tons. The company has recently increased its crude steel capacity significantly and is expanding its product portfolio with sophisticated steel grades. In addition to its existing product range, TYASA will produce high-quality flat steels which require the use of ore-based charge materials such as HBI from voestalpine Texas LLC.

“WE CAN ACHIEVE A JUMP IN PRODUCTION QUALITY BY USING VOESTALPINE HBI IN THE MODERN ELECTRIC ARC FURNACES AT THE SITE IN ORIZABA. WE ALSO REDUCE OUR DEPENDENCE ON MEXICO'S VOLATILE SCRAP MARKET AND IMPORTS OF SCRAP FROM THE USA,”

OSCAR CHAHIN TRUEBA, CEO OF TYASA



News & Views *(cont'd.)*

With the TYASA contract, a total of around 80% of the production volume was placed even before the plant even went into production. In total, 60% of the planned annual production will be supplied to third parties, primarily steel-making companies within the NAFTA zone. The remaining 40%, amounting to around 800,000 metric tons annually, will be shipped to the voestalpine operations in Linz and Donawitz, where it will be used in metallic charge to the mills' blast furnaces.

“ THE GROWING TREND TOWARD HIGH-QUALITY STEEL PRODUCTION IN THE UNITED STATES DEMANDS ADDITIONAL VOLUMES OF IRON-ORE-BASED CHARGE MATERIALS SUCH AS HBI. THESE ORDERS NOT ONLY UNDERSCORE THE GROWING MARKET POSITION OF THE VOESTALPINE GROUP, IT ALSO SECURES FULL CAPACITY UTILIZATION OF THE

DIRECT REDUCTION PLANT, EVEN BEFORE IT IS PUT INTO OPERATION.”

WOLFGANG EDER, CHAIRMAN OF THE
MANAGEMENT BOARD OF VOESTALPINE AG

voestalpine in the NAFTA region

Over the next 10 years, the voestalpine Texas LLC, site is expected to create up to USD 600 million in value for the Corpus Christi region and provide 150 long-term jobs. The plant uses natural gas instead of coal, as well as the latest dust prevention and water processing technologies, making it an environmental benchmark both in the NAFTA region and beyond.

The investment in the voestalpine Texas LLC. HBI plant represents another important step in voestalpine's expansion in the NAFTA region. The company is consistently driving forward

its strategy of internationalization in markets outside Europe, with its focus on the NAFTA region (Canada, USA, and Mexico) where it aims to triple current revenue levels to around EUR 3 billion by 2020.

The voestalpine Group already has 64 sites and around 3,000 employees in the NAFTA region, which generated revenue of more than EUR 1 billion during the past business year. This represented 9% of the voestalpine Group's total revenue. The key growth industries in this market are the automotive industry and the railway infrastructure sector. The voestalpine Group is also well positioned in the special steel, oil & gas, and aerospace industries. Moreover, around 13% of voestalpine shares are currently held by North American investors. ■

Christopher M. Ravenscroft: Editor

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to “tons” are metric tons.

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