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Some things in the world of Direct Reduction change and some things remain constant. During the past eight years I had the privilege of both observing and experiencing how true this really is.

I initially came to Midrex in 1979 and believe me, things were very different back then. Everything, and I do mean everything, in the Direct Reduction business was slow; however, little did we know that we were on the brink of a game changing development in DRI.

This new development would more easily open up DRI to the world markets as a merchant product and encourage greater usage and applications within the steel industry. I am, of course, talking about the consistent and quality production of DRI in the form of hot briquetted iron. Although HBI and its use are common place now, it took tremendous efforts to make it so.

By 1984 I had progressed within Midrex and become part of the team instrumental in the development and implementation of the world’s first MIDREX® Hot Briquetted Iron Plant at Antara (formally Sabah Gas Industries) in Labuan, Malaysia. As the Chief Mechanical Engineer I saw the project change from a cold discharge only design to a hot discharge DRI plant producing high quality HBI for the merchant market. This development and change occurred in a span of less than two years.

Although abundant with change, the fundamentals of the MIDREX Plant remained constant, employing the MIDREX® dynamic seal system, MIDREX® Stoichiometric Reformer and high efficiency heat recovery system.

I left Midrex in late 1986 for greener pastures, or so I thought, but only for a brief period, ~18 years!

I returned in April 2004 just as another lull in the steel industry was about to end. The handwriting was on the wall and interest in new DRI facilities was increasing at an exponential rate. Since I had migrated to the commercial side of business and re-entered Midrex as Shaft Furnace Plant Sales Manager.

During the next eight years all records were broken with respect to new plants built, new innovations employed on those plant designs and total increased capacity. Change included highly successful hot DRI (HDRI) transport via: 1) multiple loading station hot transport vessels, 2) the Hot Transport Conveyor, and 3) the MIDREX® HOTLINK Transfer System.

The new plants had a variety of product, flowsheet and capacity options including: 1) HDRI and cold DRI (CDRI), Antara Steel Mills (the first MIDREX Plant designed to make HBI).
COMMENTARY

Continued from page 2

2) HDRI and HBI. 3) the world’s largest HBI plant. 4) the world’s first MXCOL® Plant utilizing a synthesis gas produced by a coal gasifier as fuel for the MIDREX® Process, and 5) plants designed to produce up to 1.8 million tons per year. In addition, we installed the first 1.4 meter HBI briquetters and contracted for the world’s second COREX®/MIDREX® Plant at JSW in India.

All of the new plants built and contracted during this period again employed fundamentals of the MIDREX Process, including the remarkable MIDREX® Shaft Furnace. We now have several options for the use of syngas made from coal in the shaft furnace, including MXCOL and COREX/MIDREX Plants. Obviously some things were changing, but again the fundamentals remained constant.

So why do some things change and why do some things remain constant? The answer is really very simple. When an existing basic process works well, is more reliable, easier and less expensive to install, operate, and maintain, and has longevity exceeding any and all other technologies, it should not be replaced based on novelty.

Midrex has the most comprehensive DRI research and development facility in the world and we are constantly trying to improve our technology in all respects. Nonetheless we refuse to introduce anything based on novelty and/or simple claim. You will find nothing in any MIDREX Plant that was introduced before it passed our rigorous trials and requirements for suitability.

So now as we have jumped into the current decade some things will continue to change and some will remain constant. Midrex will hold true to our standard of providing the best, most productive, most reliable, longest life span, most efficient and most cost-effective DRI Plants in the world. But there are many true innovations on the horizon that are extremely exciting.

As the new Director of Marketing I look forward to discussing these in Direct from Midrex and assure you that we will bring you sound market and technical news from the DRI world, always based on fact, in a timely, dependable and accurate manner. When there is a better DR technology to be built, Midrex will build it.
**REVISITING THE CARBON ISSUE**

Reducing the world steel industry’s carbon footprint through **Direct Reduction & CCS**

By Christopher Ravenscroft

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**Editor’s Note:** In 2009, Direct from Midrex examined the subject of carbon emissions in the steel industry through a three part series that detailed CO₂ savings through the production and usage of DRI and HBI. This article revisits this evolving issue and examines other aspects of the discussion including further reducing CO₂ through carbon capture and storage (CCS).

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**INTRODUCTION**

It is clear that there is growing global movement for industries across all sectors to minimize their environmental impact. Industrialization has led to better standards of living and prosperity worldwide, but as the world’s population continues to expand it has also contributed to increased emissions. In terms of greenhouse gases (GHG), carbon reduction, specifically reducing CO₂ emissions, is at the forefront of the discussion as legislation gains traction outside of the EU.

The Iron and steel industry is a major contributor to these global emissions. Over the past few years the industry has taken a greater focus on CO₂ and ways to reduce emissions in anticipation of future policies and restrictions.

Ultimately avoiding production of CO₂ through natural gas based ironmaking is still the best and most effective way to cut the iron and steel industry’s carbon footprint. Carbon sequestration or carbon capture and storage (CCS) has become popular buzz words for the steel industry and is another viable way to further reduce overall emissions; however, looking at CSS as a lucrative venture beyond acquiring carbon credits may not be as realistic as some might lead us to believe.

**THE TROUBLE WITH CO₂ - A GROWING ISSUE ON A GLOBAL SCALE**

Carbon Dioxide (CO₂) has been identified as one of the primary greenhouse gases responsible for trapping heat within the earth’s atmosphere, in turn leading to global climate change. Carbon dioxide is emitted in a number of ways, naturally through the carbon cycle (Figure 1) and by various human activities including the burning of fossil fuels. According to the United States Environmental Protection Agency (EPA) in 2005, global atmospheric concentrations of CO₂ were 35% higher than they were circa 1700, before the Industrial Revolution.

As CO₂ concentrations can be directly traced to human activities, the ultimate fear is that, unregulated, these emissions could continue to increase with adverse effects for the world’s growing population. Data from the 2006 Energy Information Administration International Annual shows emission corresponding with larger industrialized nations (Figure 2).

Since GHG emissions affect the world as a whole, the issue of dealing with the situation creates a bureaucratic and political nightmare with respect to how we efficiently effect industrial change. Despite this seemingly uphill struggle, action is being taken.

Since reducing emissions in almost all cases will either
restrict or impose greater cost to various industries, not all countries or industries are eager to hop on board without assurances that others will do the same. Over that past decade it has more or less created a stalemate on the issue.

The European Union has gained the most momentum on the carbon issue by imposing taxes and strict limits on carbon production. Most recently the EU has caused quite a stir with a carbon emission tax for the airline industry. However, to keep its industries growing, the EU has also embraced “cap and trade” to help industry reduce emissions.

As policy, “cap and trade” imposes a mandatory cap on emissions or rather regulates the amount of CO₂ companies can produce. It rewards them with carbon credits when they produce less than the set capped amount and penalizes them when they do not meet the set capped amount. The idea is that industries will look to new methodology and technology to reduce carbon emissions using carbon credits to offset their own carbon footprint, or to sell others to do the same.

Opponents to cap and trade policies argue carbon taxes are a better method to curb emissions; however, proponents believe that it offers the same emissions net result while promoting business growth. Since current cap and trade policies are not global, the momentum and pricing of these credits are in flux.

Although the EU has taken some of the first steps to curb CO₂ emissions, without support and commitment of major industrialized countries like the United States, global change is likely to stall.

In early February of this year, however, a major step potentially was taken when United States governmental officials announced new proposed rules that could seriously limit carbon emissions from new coal-fired power plants. According to Reuters news service, the current proposal from the Obama administration calls for new coal-fired power plants to capture up to 60 percent of its CO₂ and store it permanently underground. Although critics maintain that this could be largely symbolic, if passed into legislation, it does help set the tone for stricter laws and regulations to come in the near future.

In addition, the EPA released for the first time in January of 2012, comprehensive greenhouse gas (GHG) data reported directly from large facilities and suppliers across the country. This on its own may not seem significant, but this type of reporting will be imperative to CO₂ “cap and trade” within the US and may be a sign of what is to come.
THE ROLE OF IRON AND STEEL IN CO₂

Ironmaking is one of the world’s major sources of anthropogenic carbon dioxide. More than one-fifth of the world’s CO₂ is derived from industrial processes and Ironmaking alone comprises more than one-fourth of the industrial-source CO₂, annually generating approximately 1.8 billion tons of CO₂.

The reason for such a high percentage is that the majority of iron produced in the world is produced using fuels that are carbon based and thus generate significant amounts of CO₂ as a by-product.

Today coke-fueled blast furnaces produce well over 90 percent of the world’s iron. Natural gas (methane) is responsible for about five percent of the world’s iron, coal for about two percent (primarily in rotary kilns) and only about one percent, or less, is made with charcoal.

All of these fuels, except for natural gas, share one important characteristic in that they are carbon based.

In blast furnace ironmaking (including the processing step to make the coke from metallurgical coal) approximately 1.8 tons of CO₂ are produced along with every ton of iron. Different sources give figures varying from 1.6 tons of CO₂ to 2.2 ton of CO₂ for this value. The differences evolve from how one accounts for other by-products of coke making. For example, if some of the coke oven gas is used to generate electricity, the CO₂ produced by burning that coke oven gas should not be counted against the iron. Thus in 2010 blast furnaces produced nearly 900 million tons of iron per year yielding 1.8 or more tons of CO₂ per ton of iron.

Natural gas-based direct reduction plants also produce CO₂, but far, far less. This value is approximately 0.5 tons of CO₂ per ton of steel versus the aforementioned 1.6 to 2.2 for the conventional carbon only based steel making routes. Obviously methane is a far cleaner fuel.

To reduce iron with coke or charcoal, each atom of oxygen in the iron oxide (iron ore) requires one atom of carbon. In a blast furnace, the carbon from the coke or charcoal is first partially oxidized to carbon monoxide (CO) using gaseous oxygen (O₂). This oxygen is provided by the blast air (heated air enriched with additional oxygen, then injected into the blast furnace). This CO diffuses into the highly porous ore and collects an additional oxygen atom from the iron oxide (Fe₂O₃), creating metallic iron (Fe) and forming CO₂. To free two atoms of Fe, you must remove three atoms of oxygen which requires three atoms of carbon. The atoms of carbon in this scenario bond with oxygen atoms to form CO₂ molecules.

When methane is used, each molecule of CH₄ is first reformed into one CO molecule and two hydrogen (H₂) molecules. Each molecule of CO takes one oxygen atom (O) from the iron oxide (Fe₂O₃). The products of the reduction reaction are two Fe atoms, two water molecules (H₂O) and one carbon dioxide molecule (CO₂). Only one-third as much CO₂ is generated compared to the previous route.

From a strict emissions volume point of view, the most effective way to introduce change is to replace capacity that relies on burning of coals and charcoal with methods that utilize natural gas, namely natural-gased-based DR plants. New technology is bringing on line reserves of natural gas throughout the world in volumes that have already dramatically lowered prices. In addition, new reserves are continuing to be found globally and are expected to bring on a new steady supply of lower-cost natural gas for decades to come. In North America alone it has made the feasibility of building natural gas-based DR plants a possibility in a market where high natural gas prices crippled the industry a decade prior.

CARBON CAPTURE AND STORAGE (CCS) AND THE UTILIZATION OF RECOVERED CO₂

Carbon sequestration or more commonly carbon capture and storage (CCS) is the process of removing carbon from the atmosphere and securely storing it to prevent release back into the atmosphere. Naturally this occurs as CO₂ is removed from the atmosphere through absorption by seawater and photosynthesis by ocean plankton and terrestrial plants and trees. In the case of industrial applications such as in the steel industry, it more typically refers to the separation and capture of CO₂ from flue gas and permanent storage to prevent the CO₂ from returning to the carbon cycle.

There are four stages of Carbon sequestration (CCS):

1. **Capture** - Separating and capturing CO₂ from industrial processes such as coal-fired power plants; Blast Furnaces, etc.
2. **Transport** - Taking the captured gas to a permanent reservoir
3. **Storage** - Storing in a manner that prevents the gas from re-entering the atmosphere
4. **Monitoring** - To confirm the gas is not leaking back to the atmosphere
Several companies are looking at the feasibility of capturing CO$_2$ from blast furnaces to reduce emissions in scenarios where possible, but these are still in the development phase and it is unclear how much CO$_2$ can be captured. For the natural gas-based DR industry, capturing CO$_2$ is not the major issue as the two main technology providers for natural gas-based direct reduction both offer technologies to capture CO$_2$.

Once captured, the CO$_2$ must be transported to its permanent place of storage via pipeline. Another means of transport via shipping has been suggested, but currently there are no vessels existing to handle CO$_2$ in large quantities as would be captured. The primary method for permanently storage of CO$_2$ is geological storage by pumping the gas deep within the earth or under the oceans to contain the gas (figure 3).

Ultimately, if a “carbon sequestration” system has no way or no place to store its collected CO$_2$, then it is forced to release the collected CO$_2$ into the atmosphere, thus no actual carbon sequestration or savings. A carbon sequestration option gains the steel producer no offset if a strategy is not in place to store the gas.

The Global Carbon Capture and Storage Institute, Ltd. reported at the end of 2011 that there were eight large scale CSS projects in operation globally with six more under construction; however, none of these projects were in the iron and steel sector.

To capitalize on the CSS industry to offset steel CO$_2$ production or to profit from the carbon credits will require investment in infrastructure to transport and store the product.

**POTENTIAL REVENUE STREAMS FOR CO$_2$ (Part 1)**

The main idea of CCS currently is to offset CO$_2$ production and/or gain carbon credits. As stated previously, this will require infrastructure and thus many are looking to offset the cost of implementing a CCS system through potential revenue streams. In speculation, there are several potential markets and
applications for CO$_2$ recovered from the process stream by a CCS system; however, the practicality of these applications has been exaggerated over the reality of the situation.

Although inventive usages for CO$_2$ have been discussed, most markets are simple too small to support the gases generated from the steel industry. Over the years people have floated various ideas for using captured CO$_2$ (Figure 4). Unfortunately most of these applications are either too small and/or too widely distributed to be feasible. Others are either far too small and/or still in the very early stages of research. Practical utilization would require markets that utilize much larger volumes of CO$_2$. Worldwide, the urea industry consumes on the order of one hundred million tons of carbon dioxide per year, but it purchases none as all of its needs are met by CO$_2$ produced by the ammonia plants which are part and parcel of the urea plants.

The beverage carbonation industry does offer application for utilization of CO$_2$; however estimated worldwide total usage is between one and two million tons* per year of CO$_2$. *Note: Because most beers are self carbonating, and most beers also have additional carbonation added; the exact number is difficult to estimate.

In theory, a single natural gas-based DR plant making two million tons per year of DRI could potentially generate one million tons of CO$_2$. Obviously it is clear that this market is not large enough to accept new suppliers on such a large scale. There is currently more than 50 million tons of natural gas-based DR capacity in the world. Because of the dispersal of brewing companies, at best case, only a portion of the CO$_2$ of a single DR plant could be sent to a brewing application.

It is also interesting to note that even if the carbonation of

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**FIGURE 4  Theorized applications for captured CO$_2$**

Source: The National Energy Technology Laboratory (NETL), part of DOE’s national laboratory system, is owned and operated by the U.S. Department of Energy (DOE). NETL supports DOE’s mission to advance the national, economic, and energy security of the United States.
beverages was a viable option for the large volumes of CO₂ captured, it would by definition not be considered CSS as the carbon is transferred to another application instead of being stored. Thus, it would also be ineligible for potential carbon credits.

**POTENTIAL REVENUE STREAMS FOR CO₂ (Part 2)**

There is only one likely and potentially profitable application for recovered CO₂: use in the Enhanced Fuel Recovery industries. Enhanced Fuel Recovery industries are the only markets large enough to accept the very large quantities of carbon dioxide that would be generated by producers of iron and steel and also provide a storage method for the captured gas. There are three possibilities: Enhanced Oil Recovery (EOR), Enhanced Gas Recovery (EGR) and Enhanced Coal Bed Methane Industry (ECBM). Out of the three, EOR seems the most profitable and is the only one currently in practice.

When oil fields are developed, the oil is first produced by using the pressure of the overburden rock to push the oil to the surface. This is termed primary extraction and will usually only bring up a small fraction of the oil present in the deposit. Next, pumps are employed to assist. Much more oil can be produced this way. Finally, if economic, tertiary means are used to recover the oil. These usually involve forcing of other fluids into the source rock to displace the oil. EOR can often bring a significant additional fraction of the oil to the surface.

CO₂ is the preferred fluid for approximately half of all current EOR operations. It functions in two ways once within the petrofer. At highly elevated temperature and pressure, the CO₂ mixes with the oil greatly decreasing its viscosity, so that it flows more readily through the source rock. At lesser temperature and pressure, the CO₂ is immiscible with the oil and can be used to drive the oil toward the wells.

EOR is also recognized by government organizations as an acceptable method to permanently store CO₂. Worldwide, the market for EOR is growing; however, to capitalize on the industry will take investment in infrastructure to transport the product to client for utilization. It is unclear if this will be a profitable venture within the steel industry without the benefits of carbon credits. The cost of the current infrastructure needed is not easily available as current projects have not made the costs public.

There are five EOR projects that utilize the product of CCS; all five are located in North America.

**CONCLUSIONS**

It is perceivable that strong governmental intervention throughout the world regarding CO₂ generation is likely on the horizon. Alternative solutions and better methodology are working their way into common steel industry practice as the threat of legislative action and financial penalties loom off in the distance. Ultimately avoiding production of CO₂ through natural gas based ironmaking is still the most dramatic way to cut the iron and steel industry’s carbon footprint. Carbon sequestration or carbon capture and storage (CCS) has the potential to further reduce overall emissions; however, at the moment this is not a viable solution for capturing CO₂ from blast furnaces, which is the industry’s major emitter of the green house gas. Systems are available for natural gas based direct reduction facilities to capture CO₂ emissions, but in order to gain potential carbon credits the installation must also transport and permanently store the gas. EOG is one way to store while creating a potential revenue stream; however, other business sectors will be exploring these opportunities as well.

Looking at CSS as an immediate lucrative venture beyond acquiring carbon credits may not be realistic for the Iron and steel industry in the short term. EOR will require infrastructure investment and continuing research. This is a very intense, complex and voluminous topic that will continue to evolve as government involvement increases.

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**Recommended Reading & Websites**

- The US Environmental Protection Agency’s site on Climate Change – [www.epa.gov/climatechange](http://www.epa.gov/climatechange)
THE ECONOMICS OF LONGEVITY

By Robert Hunter

Let’s imagine. You buy an automobile. After five years, its maintenance and repair costs get really high and the car no longer performs well. Sounds like you didn’t get a very good deal. What if it lasts for ten years, instead of five years? Well, that’s certainly better, but nothing to brag about. And, what if it lasts for twenty years? That was a good purchase!

IRON MAKING VIA BLAST FURNACES

Now, instead of automobiles, let’s think about reduction plants; plants that make iron from iron ore. Most of the world’s iron is made in blast furnaces. People generally think of blast furnaces as lasting forever because they do last for a very long time. According to Vdeh (Stahlinstitut Vdeh - Verein Deutscher Eisenhüttenleute), there are over 850 functional (operating or being held in reserve) blast furnaces in the world. Of these, Vdeh has data for about 640 showing the age of the furnaces. 175 of them are over 40 years old. The other 465 were built since 1971. Most of the currently operating blast furnaces were built in two surges of capacity addition, 1965-1980 and 1995-present. The latter surge is primarily the building of many furnaces in China and also quite a few in India.

But, from time to time, blast furnaces must be relined, and often a relining is a major project tantamount to building a new furnace. Today, it might cost from $100 up to $300 million to reline a furnace. The cost of a blast furnace reline is comparable to the total cost of a direct reduction furnace, so, obviously blast furnace owners strive to reline as rarely as possible; that is, to extend the life of each campaign. As recently as the 1970’s, blast furnace campaigns typically lasted only about five to seven years. But, today, with improved maintenance techniques and improved materials, campaigns easily extend beyond twenty years.

The oldest blast furnace in the United States is at RG Steel (the old Wheeling-Pitt) near Steubenville, Ohio. It was built in 1904, but relined as recently as 1987. The only parts of the furnace that dates back to 1904 are portions of the foundations. Similarly, the oldest operating blast furnace in the world is the Ural Mining and Metallurgical Company (UGMK) furnace at Serov in Russia. Though originally built in 1897, it was most recently relined in 2006.

Vdeh lists eight blast furnaces worldwide that predate World War II, but only one operating with a lining older than 1971.

Incidentally, of the two dozen oldest blast furnaces operating worldwide, twenty of them are either in the United States or in Russia.

Figure 1 is a chart of the operating blast furnaces in the world plotting the annual capacity of the furnaces against the year they were built. A few points are obvious; first, the dearth of furnaces from prior to 1940. This is not because there were not furnaces then. Actually there were more than there are now. When US Steel was formed in 1901, it alone operated 78 blast furnaces. But, as one might suspect, those furnaces were old and small, typically only about 100 thousand tons per year each and they were built and operated with what is now antiquated technology. The second point is that there was a huge surge of capacity building in the late-1960’s and throughout the 1970’s. Then there was an absence of new capacity added as the aftermath of the oil crisis struck the steel industry and it almost completely stopped growing. A second surge occurred as the Chinese steel industry grew at unforeseen rates. Today, China produces more than half of the world’s hot metal, and more...
than two-thirds of the world’s hot metal is produced in four East Asian nations, China, Japan, South Korea and Taiwan.

**IRON MAKING VIA DIRECT REDUCTION**

With that background in mind, how long does a direct reduction furnace last? Figures 2 and 3 are charts showing the lifespan of the two major direct reduction processes. These two processes represent more than 99% of last year’s gas-based DRI production.

*Figure 2, MIDREX® Direct Reduction Plants, shows clearly that a MIDREX Plant continues to operate, almost without end. The two original demonstration plants built for Oregon Steel Mills at Portland, Oregon ceased operating after the cost of natural gas to the plants rose to more than ten times the original cost. Similarly, the oldest full scale plant at Georgetown Steel, now ArcelorMittal Georgetown, stopped operating when the price of gas rose to a multiple of original costs. Even though it is now dismantled, much of the plant and equipment from Georgetown continues to operate at sister ArcelorMittal MIDREX Plants (for instance, the reformer tubes were moved to a sister plant). With the exception of the two plants in Nigeria which are located on a site that is economically very difficult to operate (no vessel larger than 5,000 tons can dock at the site), every

**FIGURE 2 NOTES:**

- Two modules ceased operations when the cost of their natural gas exceeded ten times the cost when the modules were constructed. They were later scrapped.
- One module ceased operation when its gas supply got to eight times original cost. It was later used for parts at sister plants.
- One module is idled because the steel works has two modules but is no longer producing at a rate sufficient to require both modules to operate simultaneously.
- Two modules were moved from Germany to India.
- Two modules were constructed in an uneconomic location where vessels no larger than 5,000 t can navigate.
- Two modules were moved from Scotland to the U.S. and then moved again to Saudi Arabia.
- One module was moved from the U.S. to Trinidad.
other MIDREX® Plant ever commissioned is still in operation. In fact, in a few cases, when gas prices have risen too high, MIDREX Modules have been moved to other sites and continue to operate. There are seven cases of MIDREX Modules being transported to other sites in order to take advantage of more favorable economic conditions. Two modules were in fact moved twice! Originally built for The British Steel Corporation at Hunterston, Scotland, after the gas price rose by four-to-one, they were transported to Mobile, Alabama in the U.S. where they were operated by Corus Steel, but again relocated when the price of gas rose multifold. The modules are now in operation at Dammam, Saudi Arabia where they produce MIDREX Iron for Al-Tuwairqi Steel.

The oldest MIDREX Module in operation (or reserve) is the one at Hamburg, Germany run by ArcelorMittal Hamburg. Commissioned in 1971, it has been in operation for more than 40 years. First designed to produce 320 thousand tons per year, it was later expanded by the addition of two reformer bays to make 400 thousand tons per year. To date, it has made over 13.5 million tons of MIDREX Iron. That is not the maximum production by a single module. Being relatively small compared to more modern modules, the Hamburg facility has been surpassed by at least 13 other MIDREX Modules. Currently the record holder is the module at Acindar in Villa Constitucion, Argentina which is approaching 25 million tons.

In sharp contrast, the modules built by the major competitor shown in Figure 3 have not shown the same ability for long lasting production. First commissioned in 1957, none of the modules built prior to 1980 remain in operation and only four of the sixteen modules commissioned in the 1980’s continue to run. Altogether, out of 39 modules commissioned by 2011, 25 have been shuttered. It is completely opposite of the situation where MIDREX® Plants, when confronted with difficult natural gas costs, tend to be moved, these plants, once old, tend to be abandoned in favor of replacement with new modules and/or conversion to incorporate newer technology.

So let’s return to the automotive example. In case of Blast Furnaces, technically they could last forever; however, there may not be a single original part left after a certain period of time. If a BF was a classic car it might still look the same and perhaps perform even better with these overhalls, but at a significant cost. And sometime down the road (sorry for the pun) you’ll have paid to keep the vehicle a few times over depending on

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1. **Lifespan of Modules using Competitor’s Technology**
2. **Notes:**
   - In a few cases (earlier modules) the color fades rather than ending abruptly. This is because we are not certain of the exact year the module ceased operation.
   - Four modules were demolished and scrapped.
   - Five modules were replaced/converted.
   - Three modules originally rated at 2.1 million tons per year, total, are being replaced by a single module rated at 0.8 Mt/yr.
   - Four modules were destroyed by war.
   - Two modules have been abandoned by their owner. There is talk of possibly rebuilding or replacing one module.
   - Two modules have not been operated for the past two to three years.

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**Figure 3: Lifespan of Modules using Competitor’s Technology**

<table>
<thead>
<tr>
<th>Year</th>
<th>In Operation</th>
<th>Not In Operation</th>
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<tbody>
<tr>
<td>1960’s</td>
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<td>1970’s</td>
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<td>1990’s</td>
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<tr>
<td>2000’s</td>
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</tbody>
</table>

**Notes:**
- The closure of the module was not reported; the module is not in operation, but the exact year of closure is an estimate.
long you do run it. If DR Plants, were automobiles you’d see variance just like with many makes and models of cars today. All would require regular maintenance to run well, but you will notice that some cars depreciate and need to scrapped sooner than others. Others apparently never seem to die. Put on some new tires, replace the 8-track with satellite radio and a few of these cars will last for generations.

People will continue to buy ironmaking plants for various reasons. Some may be for looking for short term opportunities, other looking for many many years to come. In the field of direct reduction, MIDREX® plants top annual production every year and more remarkable than that is that there are MIDREX® Plants that are more than 40 years old and in many cases can outperform newer competing technologies- that is the definition of a good deal.

![Lifespan of Midrex Modules Compared to the Main Competitor](image-url)
MIDREX News & Views

Midrex announces new Marketing Director

Henry P. Gaines, JR., P.E., has been named Director of Marketing for Midrex Technologies, Inc. in charge of promotion of Midrex’s Ironmaking technologies worldwide. It is a fitting position for the veteran of Midrex who has had a long history with both Midrex and its direct reduction technologies.

Gaines first came to Midrex initially in 1979 as Chief Mechanical Engineer and was responsible for the original Midrex HBI Briquetting Machines installed at Labuan Malaysia. During this period he was also a member of the key Midrex Team that assisted Siemens VAI (formally Voest Alpine Stahl) with their first MIDREX® Plants. He departed Midrex in 1984 but returned in 2004 and joined the Shaft Furnace Plant Sales Group as Manager and then Director.

As Shaft Furnace Plant Sales Director, he assisted with and guided that group through Midrex’s most powerful period of growth. This period saw the development of Midrex’s larger furnaces and newer hot transport systems.

Gaines studied at Clemson University and holds a degree in Mechanical Engineering. He maintains his credentials as a Licensed Professional Engineer. He has also been employed at The Dow Chemical Company and was Vice President of Controls Southeast, Inc. prior to his return with Midrex Technologies, Inc.