DIRECT FROM MIDREX

SPECIAL REPORT JULY 2006

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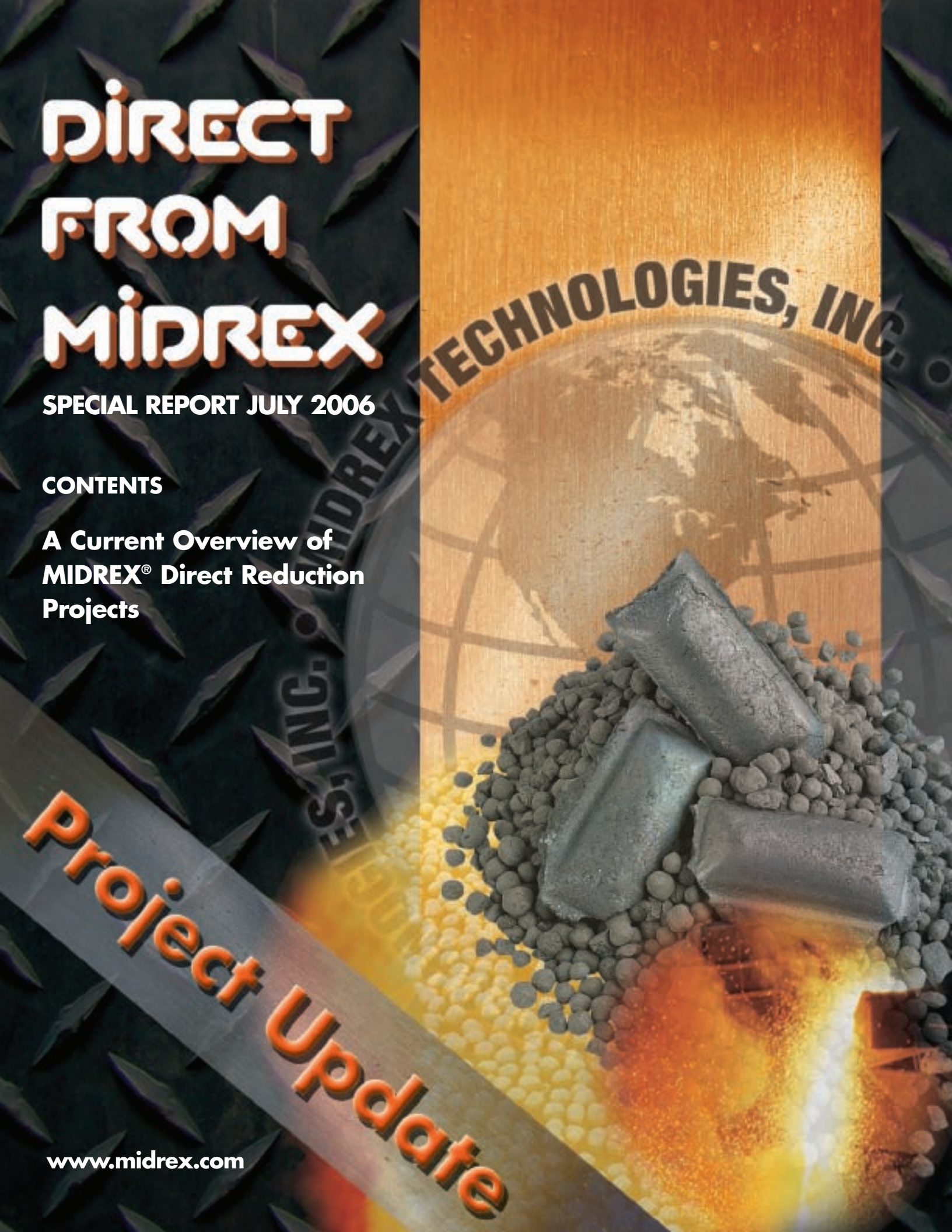
A Current Overview of MIDREX® Direct Reduction Projects



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DFM Special Report

MIDREX® Project Update

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INTRODUCTION

The rise in world steel prices beginning in 2004, combined with the shortage of metallics for steelmakers and availability of inexpensive natural gas in several locations, resulted in unprecedented demand for gas-based direct reduction facilities. From October 2004 through April 2006, Midrex Technologies signed nine contracts, representing over 11 million tons per year (Mtpy) of new MIDREX® Process capacity. In addition, there are MIDREX® Plants being built in India and Iran with a total capacity of 1.8 Mtpy. This 13 Mtpy represents an increase of 50 percent in installed MIDREX Plant capacity. These facilities include eight complete new plants, two relocations, and one expansion that incorporate the latest generation of MIDREX Direct Reduction Technology. A feature of most of these new plants is hot discharge of product, hot transport to the meltshop, and hot charging to the EAF – for greater productivity and energy savings.

This paper first reviews MIDREX Projects that started up from 1996-2005, then reviews the new projects in this latest wave of business, and subsequently contrasts the two groups. The reviews and contrast are followed by details of the new projects. The paper concludes with a summary of the innovations that are included in the latest plant designs and their significance for the market.

HISTORICAL PROJECTS (1996 – 2005)

Of the 54 MIDREX® Direct Reduction Modules constructed between 1969 and 2005, representing more than 31.2 million metric tons/year (Mtpy) of rated capacity, only one was constructed with the intention of delivering hot DRI (HDRI) to adjacent steelworks. The remainder produced cold DRI (CDRI). The lone plant producing HDRI was Essar Steel's module IV, which started operations in 2004 with a rated capacity of 1.0 Mtpy. Moreover, only nine of these 54 MIDREX modules, representing approximately 6.3 Mtpy (just 20 percent), have the capability to discharge HDRI. Only Essar Steel discharges HDRI for transport to its adjacent melt shop. Table I is a summary of MIDREX Direct Reduction Plants or significant expansions started up in the past ten years.

MIDREX PLANT	Country	Start-Up	Capacity (tpy)	Product
*OPCO 3-Bay Expansion	Venezuela	1996	170,000	HBI
ANSDK II	Egypt	1997	800,000	CDRI
Mittal Mexico (IMEXSA No. 5)	Mexico	1997	1,200,000	CDRI
*LISCO Module 3	Libya	1997	650,000	HBI
*COMSIGUA	Venezuela	1998	1,000,000	HBI
American Iron Reduction	USA	1998	1,200,000	CDRI
*VENPRECAR Expansion Project	Venezuela	1998	~100,000	HBI
Mobile DRI Relocation	USA	1997/98	800,000	CDRI
Mittal Trinidad Module 3	Trinidad	1999	1,360,000	CDRI
Mittal South Africa (Saldanha Steel)	South Africa	1999	800,000	CDRI
ANSDK III	Egypt	2000	800,000	CDRI
Khouzestan Steel IV	Iran	2001	640,000	CDRI
*Essar Steel IV	India	2004	1,000,000	HDRI / HBI
OEMK Mod. IV OXY+ Expansion	Russia	2005	130,000	CDRI
		TOTAL	**10,450,000**	

*Table I - MIDREX Projects from 1995 - 2005 *(Shaded plants are designed with Hot DRI Discharge)*

MIDREX PLANT	Country	Start-Up	Capacity (tpy)	Product
Nu-Iron Trinidad (Nucor)	Trinidad	2006	1,600,000	CDRI
Al-Tuwairqi Dammam	Saudi Arabia	2006	500,000	CDRI
*QASCO II	Qatar	2007	1,500,000	HBI / CDRI
*Hadeed Module E	Saudi Arabia	2007	1,760,000	HDRI / CDRI
*LGOK Module II	Russia	2007	1,400,000	HBI
*Lion Group	Malaysia	2007	1,540,000	HBI / HDRI
Acindar Expansion	Argentina	2007	250,000	CDRI
*Shadeed	Oman	2008	1,500,000	HOTLINK / HBI
*Al-Tuwairqi Steel Mills	Pakistan	2008	1,280,000	CDRI / HDRI / HBI
		TOTAL	**11,330,000**	

*Table II - MIDREX Projects Contracted October 2004 to April 2006 *(Shaded plants are designed with Hot DRI Discharge)*

Of these projects, five of 14 were intended to discharge HDRI, just 2.9 Mtpy – or 27 percent. Of that amount, 1.9 Mtpy was constructed to produce HBI. Only Essar's MIDREX Module IV, with a capacity of 1.0 Mtpy, had the intention of delivering the HDRI to an adjacent EAF for immediate melting. This is only one-third of all the hot discharge capacity, and barely ten percent of the total installed capacity.

NEW PROJECTS (2006 - 2008)

If we review the current MIDREX Projects underway, with start-ups beginning in 2006, the picture has clearly shifted in favor of HDRI. Table II is a list of projects contracted since October 2004. Hot discharge with hot transport to an adjacent melt shop has taken center stage.

Figure 1 and Figure 2 show the comparison between the past cycle of new DR Plant capacity and the first three years of the current cycle. The capacity shown for the 2006-2009 cycle includes the projects shown in Table II plus those expected to be signed during the next year. In contrast to the 27 percent hot discharge from the previous cycle, 80 percent of this new capacity is designed to discharge Hot DRI at more than 700° C. What is most interesting is that 4.8 Mtpy is available to be delivered into adjacent melt shops at Hadeed, Lion and Shadeed.

The percentage of new DRI capacity that is captive or dedicated to consumption by its owner is similar to the previous cycle. In the previous cycle, 71 percent was captive capacity, with 29 percent as merchant DRI or HBI, while the current cycle is approximately 82 percent captive and 18 percent merchant HBI.

Figures 1 and 2 show the new trend of applying hot DRI as feed to an adjacent melt shop. It is also significant that these projects are underway at both greenfield and brownfield locations, combined with use of existing melt shops or construction of new melt shops. The Project Overview section will describe these projects in more detail.

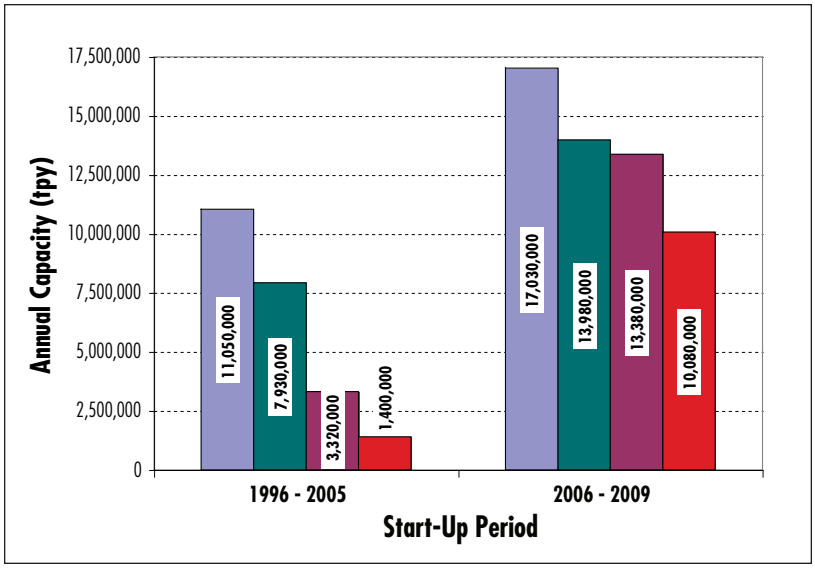

Figure 1 - Comparison of Plant Building Cycles

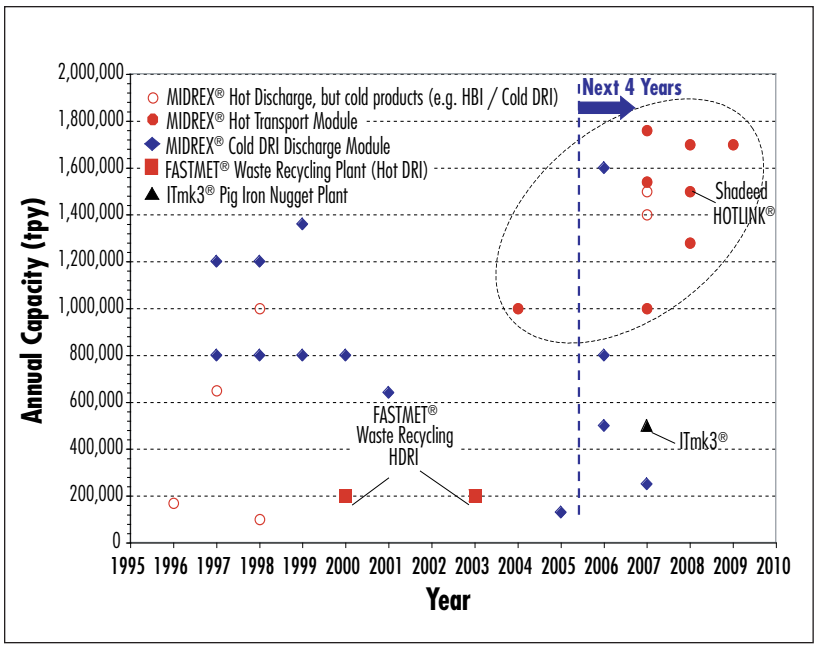

Figure 2 - Plant Capacities by Year and Type

MIDREX Hot Discharge Plant	Capacity (Mtpy)	Start-Up	Plant Builders	Contract
QASCO II	1.50	2007	Midrex / Kobe Steel	Turnkey
Hadeed E	1.76	2007	Midrex / VAI	Turnkey
Lion Group	1.54	2007	Midrex / Lion Group	
LGOK II	1.40	2007	Midrex / VAI / LGOK	
Shadeed	1.50	2008	Midrex / Kobe Steel	Turnkey
Al-Tuwairqi Pakistan	1.28	2008	Midrex / Al-Tuwairqi Group	

Table III - New Hot Discharge Modules

If we consider only the new modules in the current cycle (i.e., excluding relocations and expansions) 100 percent are using the Hot Discharge design (QASCO, Hadeed, Lion, LGOK, Shadeed, and Al-Tuwairqi in Pakistan). These new modules represent 8.98 Mtpy of capacity.

The Essar Steel MIDREX Module IV was the only project in the past ten years intended to deliver hot DRI to an adjacent melt shop. Beginning operations in 2004, it can be considered in this current cycle of projects; therefore, in the period 1996 to 2003, no MIDREX Hot Transport modules were constructed. Between 2004 and 2008, however, 5.8 Mtpy of Hot Transport capacity will be commissioned.

NEW PROJECTS OVERVIEW

Expansions & Relocations • The expansion project (Acindar), and two relocation efforts (Nucor and Al-Tuwairqi Dammam) are not changing product discharge configurations; therefore, it is not necessary to review them in detail. High natural gas prices in the USA have forced closure of the American Iron Reduction (AIR) and Mobile DRI modules. The American Iron Reduction CDRI facility is being relocated by Nucor to Trinidad, and expanded from 1.2 Mtpy to 1.6 Mtpy. This project is remotely captive to Nucor's USA flat products mills and will continue to produce CDRI. The Mobile DRI facilities, previously owned by Corus, were sold to the Al-Tuwairqi Group, and one module is being scheduled for re-commissioning in Saudi Arabia at the Dammam Steel Works for captive supply of DRI. The Acindar 5.5 meter module is being expanded by 0.25 Mtpy.

New Projects – 100 Percent Hot Discharge • All of the six new modules being constructed are hot discharge modules and are listed in Table III. The turnkey projects are identified, while the Lion, LGOK, and Al-Tuwairqi Pakistan projects are being erected by the plant owners themselves. See Table III.

QATAR STEEL COMPANY

Mesaieed, Qatar

Module II, 1.50 Mtpy Hot Discharge Combination Plant (HBI and CDRI)

QASCO started its first MIDREX CDRI module in 1978 (shown in Figure 3) with a capacity of 400,000 tpy, and it is currently producing 800,000 tpy. In 2004, QASCO contracted with Kobe Steel, Ltd. to supply a new 1.50 Mtpy combination plant. The main plant configuration details are listed in Table IV.

Figure 3 - QATAR Steel Company

MIDREX Module Type:	MEGAMOD® (6.65 m I.D.) Combination Plant	**Target Market(s):**	50 percent export as HBI, 50 percent captive for consumption by QASCO
Start-Up:	First Half 2007	**Other Projects:**	Expansion of QASCO Melt Shop and new Rolling Mill
Related Works:	Ship Unloading / Loading, Sea Water Pumping, Oxide Storage/Reclaim, Product Storage/Reclaim	**DRI Cooler:**	Up to 100 percent capacity
Capacity:	1.50 Mtpy (187.5 tph)	**Hot Briquetting:**	Three Hot Briquetting Machines (Köppern Maschinenfabrik GmbH)
Reformer:	16 bays (480 x 250 mm tubes)	**Oxygen Use:**	None Required
Target Product(s):	HBI and Cold DRI (approx. 50:50 ratio)		

Table IV - QASCO Details

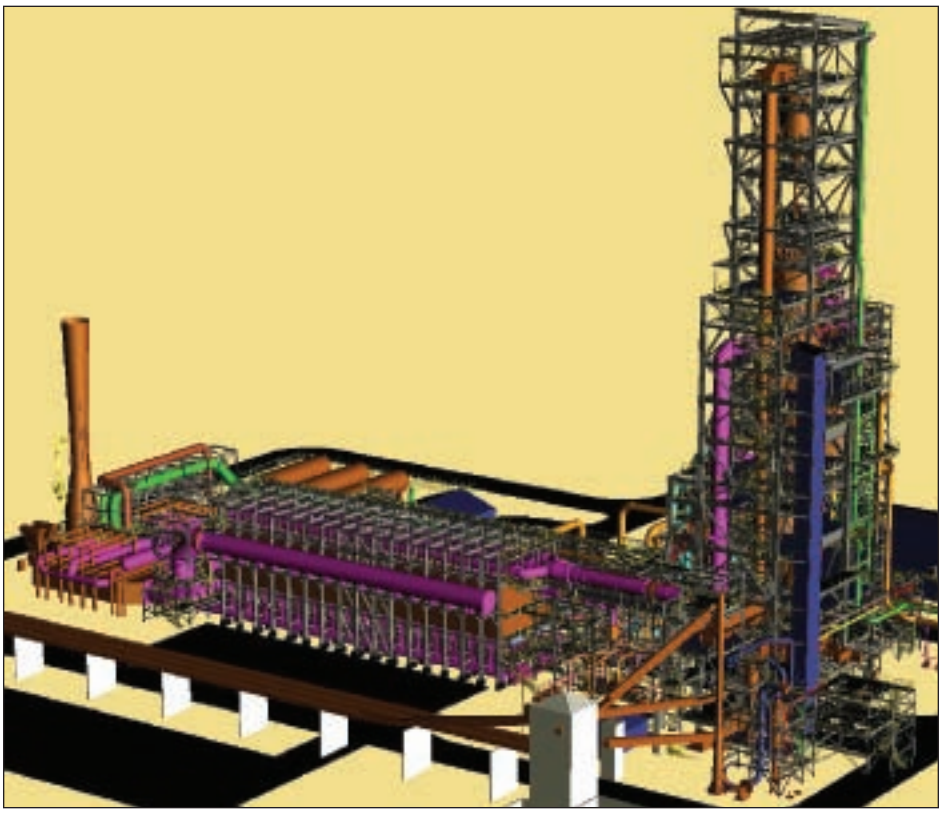

Figure 4 - QASCO – MEGAMOD 1.50 Mtpy Combination Plant

Figure 5 - Hadeed

The QASCO Combination Module shown in Figure 4 is being constructed to serve both QASCO's increased metallic iron demand and to export HBI to the new regional EAF-based melt shops.

The HDRI will be discharged at more than 700° C. The HDRI will then flow by gravity into either: (1) a DRI cooler, or (2) a Hot Briquetting System. The cooler is a standard MIDREX Cooling Zone configuration and is capable of discharging 100 percent of the DRI produced by the process. The HBI system will have three briquetting machines (nominal 50 tph each), and will be capable of discharging up to approximately 70 percent of the HDRI produced by the process as HBI.

HADEED (Saudi Iron & Steel Company) Al-Jubail, Saudi Arabia Module E, 1.76 Mtpy Hot Discharge Plant (HDRI and CDRI)

Hadeed began operations in 1982 with two MIDREX 400 Series Plants (Modules A/B), each producing 400,000 tpy. A third MIDREX Module, Module C, was added in 1992, with a fourth module (HYL) added in 1998. In total, Hadeed produces approximately 3.5 Mtpy of CDRI from these four modules. All the DRI is used on-site and supplemented with scrap steel in a ratio of approximately 70 percent Cold DRI and 30 percent scrap to produce nearly 4.0 Mtpy of steel.

In December 2004, Hadeed contracted with Siemens VAI and Midrex Technologies, Inc. to build the world's largest direct reduction module. It will also feature a MIDREX Hot Discharge Shaft Furnace of 7.0 meters inside diameter (the largest shaft furnace built to-date). The main plant configuration details are listed in Table V.

MIDREX Module Type:	MEGAMOD (7 m I.D.) Hot Discharge / Hot Transport Plant	**Target Product(s):**	Hot DRI and Cold DRI
Start-Up:	First Half 2007	**Target Market(s):**	100 percent for captive use by Hadeed
Related Works:	Sea Water Pumping, Oxide Storage/Reclaim, Cold DRI Storage/Reclaim, Hot DRI Conveying, EAF Charging System	**Other Projects:**	New Flat Products Melt Shop & Rolling Mill Expansion
Capacity:	1.76 Mtpy (220 tph)	**DRI Cooler:**	Up to 100 percent capacity
Reformer:	19 bays (570 x 250 mm tubes)	**Hot Transport System:**	Up to 100 percent capacity, charging at or above 650° C
		Oxygen Use:	Approx. 15 Nm3 / t HDRI expected

Table V - Hadeed Details

Figure 6 shows the details of the Hot DRI Conveying and EAF Charging System, using a mechanical conveyor provided by Aumund Fördertechnik GmbH. The conveyor is covered and insulated to minimize temperature loss and prevent oxidation of the hot DRI during transport from the MIDREX Shaft Furnace and into the two EAF hot DRI storage bins.

The new EAF will have a capacity of 1.40 Mtpy of liquid steel as a result of hot DRI feed from the MIDREX Plant. Hot DRI is fed to the EAFs at a minimum of 650° C.

Excess hot DRI, when not consumed by the new melt shop, will be cooled in a DRI cooler in a similar fashion to the new QASCO MEGAMOD and using a typical MIDREX cooling zone system. The two hot DRI buffer bins above the new melt shop are sized to contain at least one complete charge of hot DRI each for the EAF, which facilitates the transition from continuous DRI conveyance to discontinuous EAF charging. As one bin is being emptied into the EAF, the other bin is being filled with fresh hot DRI.

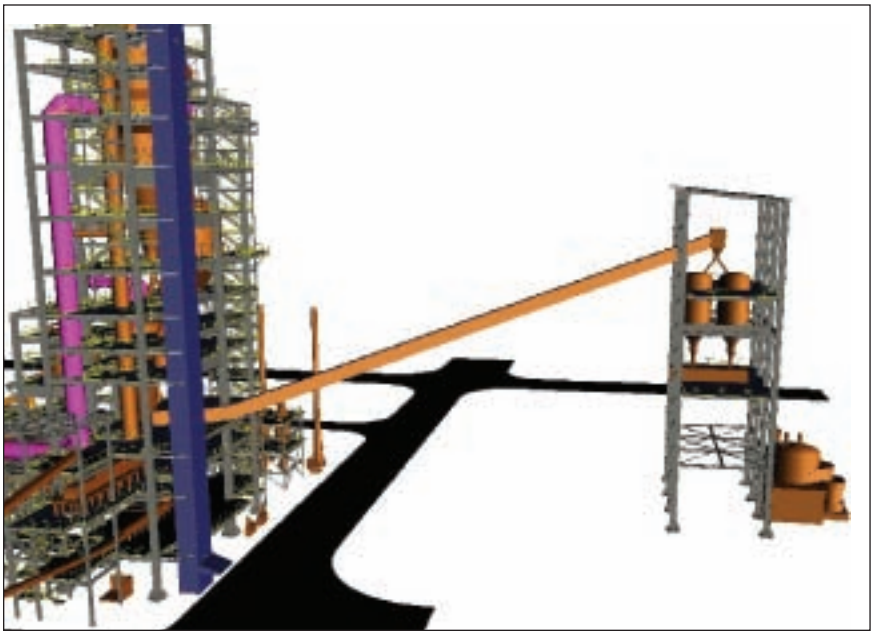

Figure 6 - Hadeed 7.0 meter Hot Transport Plant

Figure 7 - Antara Steel Mills

THE LION GROUP
(MEGASTEEL and Antara Steel Mills) Banting, Malaysia 1.54 Mtpy Hot Discharge Plant (HDRI and HBI)

At its site in Banting, Malaysia, one hour southwest of Kuala Lumpur on the west coast of peninsular Malaysia, the Lion Group is constructing a hot discharge MIDREX MEGAMOD®. The brownfield location hosts three EAFs; two at MEGASTEEL's flat products facility and one at Antara Steel Mills' (ex-Amsteel Mills) long products facility shown in Figure 7. The combined existing liquid steel capacity is approximately 3.5 Mtpy. The Lion Group also owns and operates a MIDREX HBI module in Labuan, Malaysia.

The Lion Group, as principal owner of the steel mills in Banting, is intending to feed hot DRI at 700° C to the MEGASTEEL EAFs in order to improve energy efficiency, increase productivity and quality, and reduce costs of production. Containers were chosen as the transport method due to the fact that the EAF-based melt shops were established, and locating the DR plant within close enough proximity was not possible for conveyors or HOTLINK®. Furthermore, one DR plant will feed multiple EAFs with hot DRI, which favors the use of individual containers, as is proven at Essar Steel in India.

In December 2004, The Lion Group contracted with Midrex Technologies, Inc. to supply a technology package for the direct reduction module. It will feature a MIDREX MEGAMOD hot discharge Shaft Furnace. The Lion Group will do the erection. The main plant configuration details are listed in Table VI.

MIDREX Module Type:	MEGAMOD (6.65 m I.D.) Hot Discharge Plant	**Target Market(s):**	100 percent captive for consumption by MEGASTEEL and Antara
Start-Up:	First Half 2007	**Hot Transport System:**	60 t containers (batch mode), charging at or above 650° C
Related Works:	Ship Unloading, Oxide Storage/Reclaim, HBI Storage/Reclaim, Hot Transport System	**Hot Briquetting:**	Two Hot Briquetting Machines (Köppern Maschinenfabrik GmbH)
Capacity:	1.54 Mtpy (192.5 tph)	**Oxygen Use:**	Approx. 15 Nm^3 / t HDRI expected
Reformer:	17 bays (510 x 250 mm tubes)		
Target Product(s):	HDRI and HBI		

Table VI - Lion Group Details

The Lion Group hot discharge MEGAMOD is shown in Figure 8 with rail tracks in the foreground. The large roadway separates the MIDREX Plant from the melt shops.

While containers are routinely used by Essar Steel in India, the transport system will be unique to the Lion Group, as will the hot DRI feeding system located above the EAFs in the two melt shops of MEGASTEEL and Antara Steel Mills.

The hot briquetting machines are newly designed by Köppern, and will be the highest capacity machines at approximately 70 tph each.

It is very likely that all of the hot DRI will be consumed by the adjacent melt shops and very little HBI will be produced.

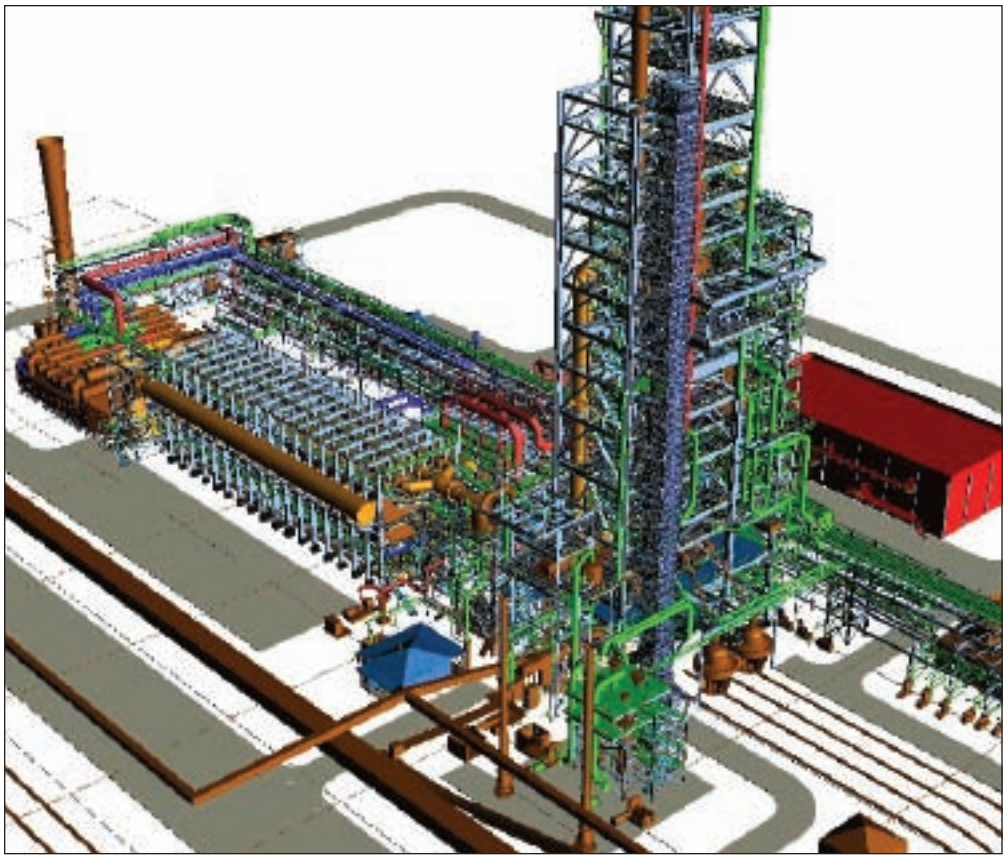

Figure 8 - The Lion Group Hot Discharge MEGAMOD

LEBEDINSKY GOK (LGOK)
Gubkin, Russia
1.40 Mtpy HBI Plant

LGOK has operated an HYL HBI module rated at 0.9 Mtpy since 1999. In June 2004, LGOK signed a letter of intent with Siemens VAI and Midrex Technologies to design and supply a new MIDREX HBI module rated at 1.40 Mtpy (180 tph). Engineering began in September 2004, and the formal contract was signed in February 2005. Figure 9 shows LGOK with the HYL HBI Plant in the background.

The intention is for the plant to produce HBI for export, using iron ore pellets manufactured at its own facility. The main plant configuration details are listed in Table VII.

This HBI plant at LGOK will be the largest single HBI module in the world, and will be the first MIDREX Module to utilize five briquetting presses.

Figure 9 - LGOK

MIDREX Module Type:	MEGAMOD (6.65 m I.D.) HBI Plant	**Reformer:**	17 bays (510 x 250 mm tubes)
Start-Up:	First Half 2007	**Target Product(s):**	HBI
Related Works:	Oxide Storage/Reclaim, HBI Storage/Reclaim	**Target Market(s):**	100 percent merchant HBI
Capacity:	1.40 Mtpy (180 tph)	**Hot Briquetting:**	Five Hot Briquetting Machines (Köppern Maschinenfabrik GmbH)

Table VII - LGOK Details

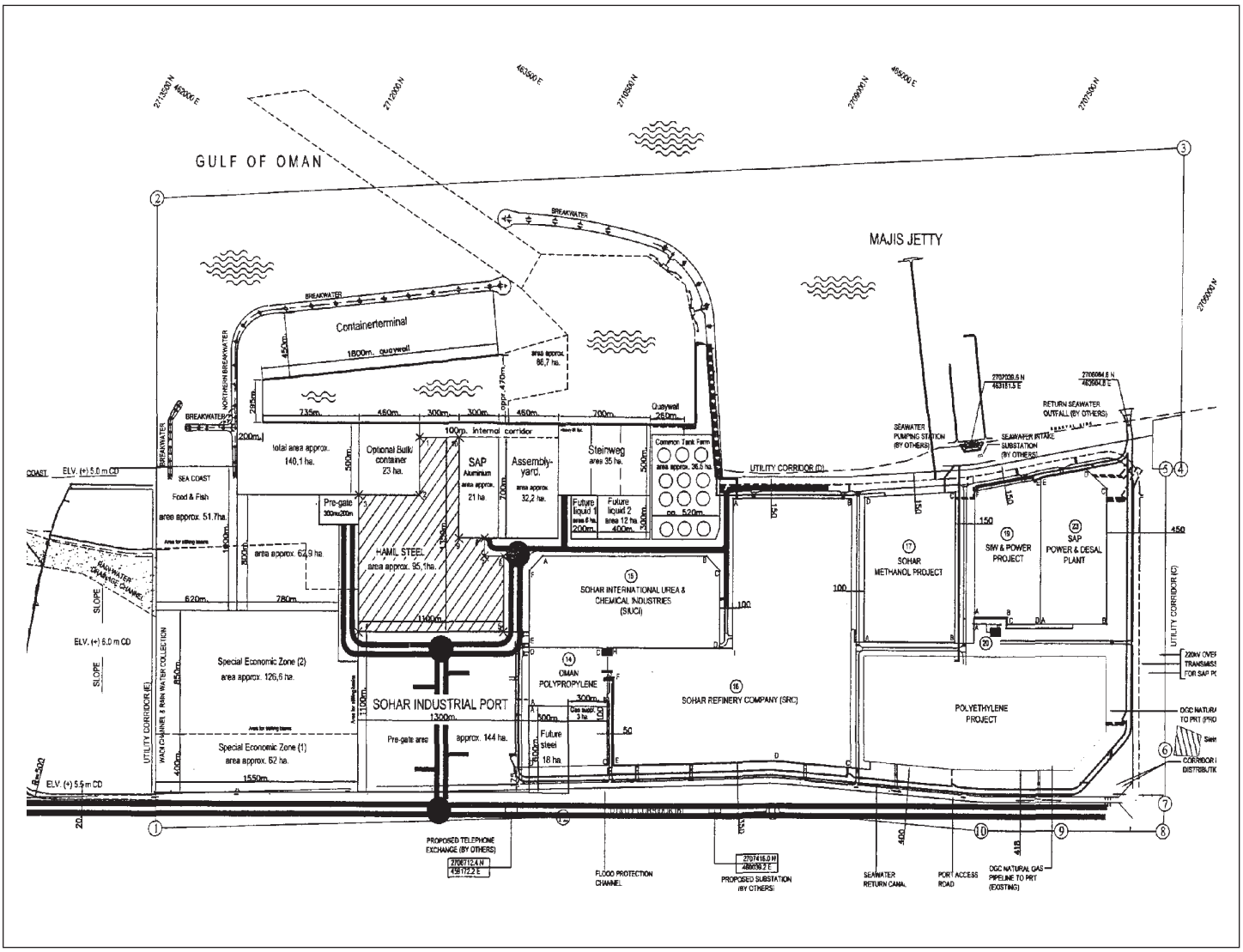

Figure 10 - Port of Sohar, Oman

SHADEED IRON AND STEEL COMPANY

Sohar, Oman

1.50 Mtpy Hot Discharge HOTLINK® Plant (HDRI and HBI)

The first mini-integrated steel plant to be built in Oman will be constructed by Al-Ghaith Holdings, the owner of the Shadeed Iron & Steel Company. The new facility will benefit from deep water access at the Port of Sohar, capable of receiving cape-size vessels. (See Figure 10)

In February 2005, Shadeed Iron & Steel signed a contract with Midrex Technologies, Inc. for the world's first HOTLINK Plant, rated at 0.72 Mtpy. Since then, the plant configuration has been changed and the contract structure has also been modified. In September 2005, the client upgraded its commitment by changing the plant capacity to 1.50 Mtpy and signing a contract with Kobe Steel on a turnkey basis. The main plant configuration details are listed in Table VIII.

MIDREX Module Type:	HOTLINK® MEGAMOD (6.65 m I.D.) Combination Plant	**Target Product(s):**	Hot DRI and HBI
Start-Up:	First Half 2008	**Target Market(s):**	75 percent hot DRI captive, 25 percent merchant HBI
Related Works:	Sea Water Pumping, Oxide Storage/Reclaim, HBI Storage/Reclaim	**Other Projects**:	New Siemens-VAI/Fuchs EAF-based melt shop
		Hot Briquetting:	Three Hot Briquetting Machines (Köppern Maschinenfabrik GmbH)
Capacity:	1.50 Mtpy (187.5 tph)	**Hot Transport System:**	MIDREX proprietary HOTLINK™ gravity feed system, charging at or above 700° C
Reformer:	16 bays (480 x 250 mm tubes)		

Table VIII - Shadeed Details

Figure 11 shows the 3D concept of the mini-integrated iron and steel facility to be constructed at Shadeed's site. In addition to the MIDREX HOTLINK Module, Shadeed has signed a contract with Siemens VAI/Fuchs to construct a new melt shop. This melt shop contract is now being redefined to better match the new MIDREX HOTLINK Plant capacity.

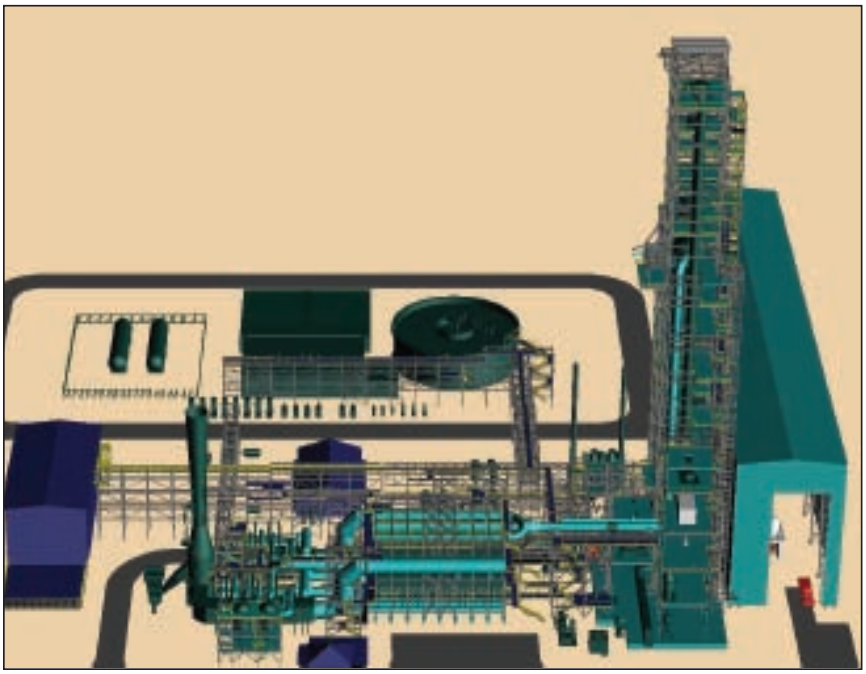

Figure 11 - Shadeed MEGAMOD HOTLINK® Plant

Excess hot DRI, when not consumed by the new melt shop, will be hot briquetted in three Köppern hot briquetting machines in a similar fashion to the new QASCO MEGAMOD. The two hot DRI buffer bins above the new melt shop are sized to contain at least one complete charge of hot DRI each for the EAF. This facilitates the transition from continuous DRI conveyance to discontinuous EAF charging. As one bin is being emptied into the EAF, the other bin is being filled with fresh hot DRI. The hot DRI is sealed from the atmosphere using seal gas and nitrogen. Hot DRI flows by gravity through the HOTLINK system into the EAF below. The feed rate is controlled by the EAF operator as required.

AL-TUWAIRQI STEEL MILLS
Karachi, Pakistan
1.28 Mtpy Hot Discharge Plant (CDRI, HDRI, and HBI)

The Al-Tuwairqi Group is building a new steel complex at Bin Qasim in Karachi, Pakistan; a contract was signed in April. The first phase of the project, which will include a MIDREX Module of 1.28 Mtpy capacity, will produce CDRI initially, but is being designed for later conversion to HDRI or HBI. The second phase will be the steel mill that will produce steel billets. Groundbreaking for the MIDREX Plant was held in April. See Table IX.

MIDREX Module Type:	MEGAMOD (6.65 m I.D.) Cold Discharge Plant with provision for Hot Discharge	**Capacity:**	1.28 Mtpy (160 tph)
Start-Up:	First Half 2008	**Reformer:**	16 bays (480 x 250 mm tubes)
Related Works:	Oxide Storage/Reclaim, DRI Storage/Reclaim	**Target Product(s):**	CDRI, HDRI, and HBI
		Target Market(s):	
		Other Projects:	Melt shop

Table IX - Al-Tuwairqi Details

CONCLUSIONS

During the present cycle of MIDREX Plant contracts, plant capacities have continued to increase, and the technology developments to be implemented are quite significant. A major innovation has been hot discharge and hot transport of DRI product, along with hot charging to an EAF. The energy and productivity benefits this provides are outstanding, and clients the world over have realized the benefits of linking a MIDREX Plant with a nearby EAF. Following is a summary of the significant technological developments that are included in the plants starting up from 2006-2008:

- Higher capacity shaft furnaces– up to 1.76 Mtpy of DRI
- Seven meter I.D. furnace
- Centrifugal compressors applied to the process gas loop
- Nineteen bay reformer
- Hot transport options – containers, conveyor, and HOTLINK gravity feed
- Higher capacity briquette machines – up to 70 tph
- HBI slow cooling conveyor
- DRI cooler
- SIMPAX Expert Control System – enables prediction of DRI metallization and carbon levels

MIDREX gas-based direct reduction technology continues to evolve and gain wider acceptance. Progress is being made on equipment and higher and higher levels of productivity; however, the most important of these improvements is not in the process itself, but rather in the application of the product. Hot DRI is now beginning to find a home in new projects. As the industry learns more about how to best utilize the HDRI, this knowledge will be used to further optimize the entire material flow from beneficiation and pelletizing through the production of liquid steel and continuous casting. With the increased sophistication of process control systems, it will soon be possible to consider the adaptation towards continuous steelmaking.