VENEZUELA'S ROLE IN THE MERCHANT DRI MARKET

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Introduction

The use of scrap substitutes for EAF steelmaking worldwide, is rapidly increasing. Although it is generally conceded that there will not be a scrap shortage due to the large amount of obsolete scrap available, this type of scrap is of poorer quality than is generally required for higher grades of steels, and scrap substitutes will have to be used to control residuals for these grades. There are a number of new EAF steelmaking projects that are planned, this additional EAF capacity will further increase the demand for both scrap and scrap substitutes.

At present, direct reduced iron in the form of DRI and HBI is the major source of scrap substitutes worldwide. As an example in the United States, about 1.56 million mt of DRI and HBI were used in 1994, of which 1.12 million mt were imported, principally from Venezuela. The amount of additional scrap substitutes required for the North American market is estimated to be in the range of 5 to 8 million mt/y by the year 2000.

US Pig iron imports have been on a dramatic increase, this indicates that pig iron is filling the deficit between demand and supply for DRI in North America at present. However, it is unlikely that that pig iron will be a long-term competitor in the scrap substitute market due to its inherently higher production cost when compared to DRI and HBI.

North American steelmakers are actively evaluating how to acquire the additional scrap substitutes they will require. This includes evaluation of construction of their own plants, joint ventures with producers, and long term contracts with suppliers. In addition, both iron ore mining companies and scrap suppliers are interested in this growing market. The United States is now being considered for new direct reduction (DR) ventures.

Venezuela currently produces around 4 million mt/y of steel, all through EAF steelmaking processes. The percentage of scrap used in the production of steel is about 25% overall, with the rest being provided by direct reduced iron. The steelmaking industry depends heavily upon direct reduction as a source for metallics units, and over the years the direct reduction industry in Venezuela has also become export oriented, making the country a principal exporter of HBI.

Venezuela has more experience with direct reduction processes than any other country in the world due to the diversity of processes, which have been installed

there. Its experience covers more than 30 years, and the country now has over 6 million mtpy of installed DR capacity.

This paper will present a summary of the present situation in the Venezuela DR industry, the status of new projects, and the direct reduction development activity in order to play an important role as a reliable supplier of HBI.

Direct Reduction Capacity in the Americas

There are a total of 32 direct reduction plants located in North and Latin America ranging in capacity from 30,000 to 830,000 mtpy as shown in Figure 1. The total design capacity of these units is 13.18 million mtpy. All are gas-based with the exception of the 3 SL/RN units operated by Siderperu in Peru and the Piratini SL/RN plant in Brazil. The design capacity is broken up by process as follows: MIDREX®, 47.8%; HYL, 45.8%; FIOR®, 3.0%; Iron Carbide, 2.3% and SL/RN, 1.1%.
At present time only 2 of the 32 plants are fully merchant based; the FIOR de Venezuela and OPCO plants located in Venezuela.There are two plants partially exporting HBI, Venprecar located in Venezuela and DRI from Ispat in Trinidad. The Nucor iron carbide plant in Trinidad is mainly for export to Nucor mills in the USA, but is not expected to supply product into the merchant market

. **Figure 1. North and Latin American DR Plants**

Plant	Country	Process	Actual Cap.	Market
ACINDAR	Argentina	MIDREX	600,000	Captive
SIDERCA	Argentina	MIDREX	400,000	Captive
Piratini	Brazil	SL/RN	60,000	Idled
Usiba	Brazil	HYL III	310,000	Captive
SIDBEC 1	Canada	MIDREX	400,000	Captive
SIDBEC 2	Canada	MIDREX	600,000	Captive
Hylsa 2P5	Mexico	HYL III	630,000	Captive
Hylsa 2M5	Mexico	HYL III	250,000	Captive
Hylsa 3M5	Mexico	HYL III	500,000	Captive
Hylsa 4M	Mexico	HYL III	675,000	Captive
Imexsa	Mexico	HYL III	4 x 500,000	Captive
Tamsa	Mexico	HYL I	280,000	Idled
Siderperu	Peru	SL/RN	3 x 30,000	Captive
Caribbean Ispat Ltd.	Trinidad	MIDREX	2 x 420,000	Captive
Nucor	Trinidad	Iron Carbide	320,000	Captive
Georgetown Steel	USA	MIDREX	400,000	Captive
Fior de Venezuela	Venezuela	FIOR	400,000	Merchant
OPCO	Venezuela	MIDREX	1,000,000	Merchant
SIDOR HYL 1	Venezuela	HYL I	360,000	Captive
SIDOR HYL 2	Venezuela	HYL II	3 x 570,000	Captive
SIDOR MIDREX 1	Venezuela	MIDREX	500,000	Captive
SIDOR MIDREX 2	Venezuela	MIDREX	3 x 525,000	Captive
VENPRECAR	Venezuela	MIDREX	715,000	Mixed

The installed plant capacities and the 1997 production figures are shown broken down by country in Figure 2. Of the 14.01 million mt of direct reduced iron produced in the Americas, 12.76 million mt were produced in Latin America and

1.25 million mt in North America. Of the total Latin American production, 43% was produced in Venezuela, which is presently the largest producer of direct reduced iron in the world.

Figure 2
1997 Estimated DR Production by Country
North and Latin America

Country	Capacity Million mt	1997 Production, million mt
Argentina	1.00	1.10
Brazil	0.36	0.30
Mexico	4.93	3.95
Peru	0.09	0.02
Trinidad	1.14	0.99
Venezuela	5.60	5.47
Total Latin America	**11.78**	**12.77**
Canada	1.00	0.77
USA	0.40	0.48
Total North America	**1.40**	**1.25**
Total Both Americas	**13.18**	**14.02**

The DR production in Venezuela listed in Figure 2 are presently considering the increase of the installed capacity of the Midrex modules at SIDOR after retrofitting with the AREX® technology. Although some future capacity increase is available through expansion and restarting of idle plants, any major capacity increases in the future will have to come from the installation of new DR plants.

There is no doubt that the future merchant DR expansion will certainly occur in the Latin American region. The low energy costs prevailing there coupled with the proximity to the North American market make this a natural location to produce direct reduced iron

The potential for increased direct reduction capacity in Latin America totals 7,2 million mtpy as shown in Figure 3. The expansion will occur principally in Venezuela where three projects are being developed. All of these projects are in the construction stage, with a merchant capability of 4.7 million mtpy via the Orinoco River.

Figure 3
Planned DR projects in Latin America

Project	Location	Process	Add. Capacity	Status
Cliff & Assoc.	Trinidad	Iron Carbide	300,000	Construction
Comsigua	Venezuela	Midrex®	1,000,000	Construction
Comsigua II	Venezuela	Midrex®	1,000,000	Study
Orinoco Iron	Venezuela	Finmet®	2,200,000	Construction
Posven	Venezuela	HyLIII	1,500,000	Construction
Ispat	Trinidad	Midrex®	1,000,000	Construction
Ispat	Mexico	Midrex®	1,500,000	Construction

Direct Reduction Situation in Venezuela

Venezuela is the largest and the lowest cost producer of DRI/HBI country in Latin America and the world, due to its availability of low priced, abundant resources. The situation in Venezuela is of particular interest due to its present DR capacity, and its future potential growth. The following summarizes briefly the situation in that country in regard to the availability of resources required for direct reduced iron production.

The iron ore reserves of the Guayana region of Venezuela, where the DR industry is located, are estimated to be around 1.8 billion mt of proven reserves and 14 billion mt of total reserves.

Present proven reserves of Venezuelan natural gas are 3.6 trillion cubic meters. The present consumption rate is around 30 billion cubic meters per year, which works out to a theoretical life for proven reserves of over 100 years

The Guayana region is the center of hydroelectric power generation in Venezuela, having an installed capacity at the Guri and Macagua dams of 12,000 MW and within the next 8 years the Caruachi dam with 2000 MW.

Rivers provide ample water supplies and transportation. Vessels of up to 80,000 DWT can load during the period when the Orinoco river is high (during the May-October rainy season) and vessels of around 40-50,000 DWT can make the passage to the Atlantic fully loaded during the low stage. Industrial water needed by DR plants is supplied from the Caroni River, which has a maximum flow of over 10,000 m3/sec.

The area has a large infrastructure of services geared to the direct reduction industry, and this includes both fabrication and construction of plants. Local construction companies have built all of the major plants in the area. The concentration of DR plants in the Guayana region has led to the formation of a

skilled local labor force knowledgeable in the operation and maintenance of direct reduction plants. Venezuelan personnel handle all technical and operational aspects of the plants, with little dependence upon expatriate manpower.

In summary, this combination of resources located in a small geographical area led to the concept to base the Venezuelan steel industry on direct reduced iron.

Venezuela Direct Reduction Capacity

Venezuela is the largest DR producing country in the world, with a production of 5.4 million mt in 1997, or 16% of the total world production. The present status of the Venezuelan plants is shown in Figure 4. There are 11 modules in operation at present.

Figure 4-Venezuelan DR Plant Status

Plant	Startup	Design Cap.	1997 Prod.	Status
HIB	1974	800,000	0	Converted
FIOR®	1976	400,000	390,010	Operating
SIDOR HYL 1	1976	360,000	336,000	Operating
SIDOR MIDREX 1	1977	(1) 350,000	479,500	Operating
SIDOR MIDREX 2A	1979	(1) 430,000	491,410	Operating
SIDOR MIDREX 2B	1979	(1) 430,000	443,857	Operating
SIDOR MIDREX 2C	1979	(1) 430,000	565,998	Operating
SIDOR HYL 2A	1980	(2) 570,000	346,388	Operating
SIDOR HYL 2B	1980	(2) 570,000	280,136	Operating
SIDOR HYL 2C	1981	(2) 570,000	305,648	Operating
OPCO	1989	1,000,000	1,090,000	Operating
VENPRECAR	1990	715,000	747,114	Operating

Note:
(1) Modified to operate with AREX ® DR technology (hot air or oxygen enriched air injection).
(2) - Original capacity was 3 x 700,000 mt/y modules, down-rated to 570,000 mtpy.

Most DRI produced in Venezuela is used for steelmaking within the country. There are two dedicated merchant plants, Fior de Venezuela and OPCO, and part of the Venprecar plant production is being exported. The Venprecar plant capacity was increased from 660,000 to 715,000 mtpy last year and will be increased to 800,000 mtpy by 1999, this will free up additional tonnage of HBI for the export market.

The export of HBI from Venezuela is taking an increasingly more important role, and new plants are now planned for the export market rather than for internal

consumption. Last year, over 1.5 million mt were exported from the FIOR, OPCO, and Venprecar plants. New plants that are planned will add another 4.7 million mt/y of export HBI to this figure in the near future, as will be discussed later.

Venezuela's Three New DR Projects

There are three important direct reduction projects underway in Venezuela at present, and others are being planned. The following describes the three scheduled to be operational before the year 2000:

Orinoco Iron

A new company has been formed to build and operate a 2.2-million mt/y FINMET® plant in Puerto Ordaz, Venezuela. The company is called Orinoco Iron C.A. and was formed by a 50-50 partnership of IBH and the Australian company BHP. Orinoco Iron owns and will operate both the existing 400,000 mtpy FIOR® plant and the new FINMET® plant. Sivensa and CVG Ferrominera and external shareholders are the principal owners of IBH.

The plant will use the FINMET® Process, which has a series of 4 fluidized beds where iron ore fines are contacted with reducing gas. It will have four 550,000 mtpy reactor trains located in two separate modules. The modules will each have one steam reformer to produce reducing gas. All services will be in a common area.

Ore for the plant will be minus 12 mm iron ore fines supplied by FMO. Ore will be delivered to the plant by train via a new rail spur.

Voest Alpine Industrienlagenbau along with two Venezuelan engineering companies has completed detailed engineering for the Orinoco Iron plant. Earthmoving was completed, and civil works are well on its way and the plant is expected to begin production in the last quarter of 1999. It is estimated to cost $ 690 million not including port facilities or finance charges.

The new plant will produce HBI for export only as is the case with FIOR™. The new company will have about 2.6 million mt/y available for export from the two plants. Orinoco Iron has been signing long term contracts with European and US steelmakers for about 1.8 million mt/y of production. The rest will be sold on the spot market.

Comsigua

The second project is the 1 million mtpy Comsigua plant which utilizes the MIDREX ® technology. Construction and plant commissioning is expected to be completed late this year. The plant is located in the Punta Cuchillo industrial park

developed by CVG Ferrominera where a new 3.3 million mtpy pellet plant came on line. Feed for the plant would be supplied directly from the pellet plant. A new project, Comsigua II, for an additional 1 million mtpy MIDREX® DR plant at Punta Cuchillo is now being evaluated.

The plant is a pure merchant plant and the product is destined mainly for the US market. Product will be shipped by rail from Comsigua to the Palua port on the Orinoco River.

Posven

Another pellet based plant, Posven, using the HYL III process is being built in Puerto Ordaz. This plant will have one steam reformer and two 750,000 HYL III reactors and will produce HBI for the merchant market. The majority will be shipped by Posco to Korea, and much of the remaining product will be for the US market.

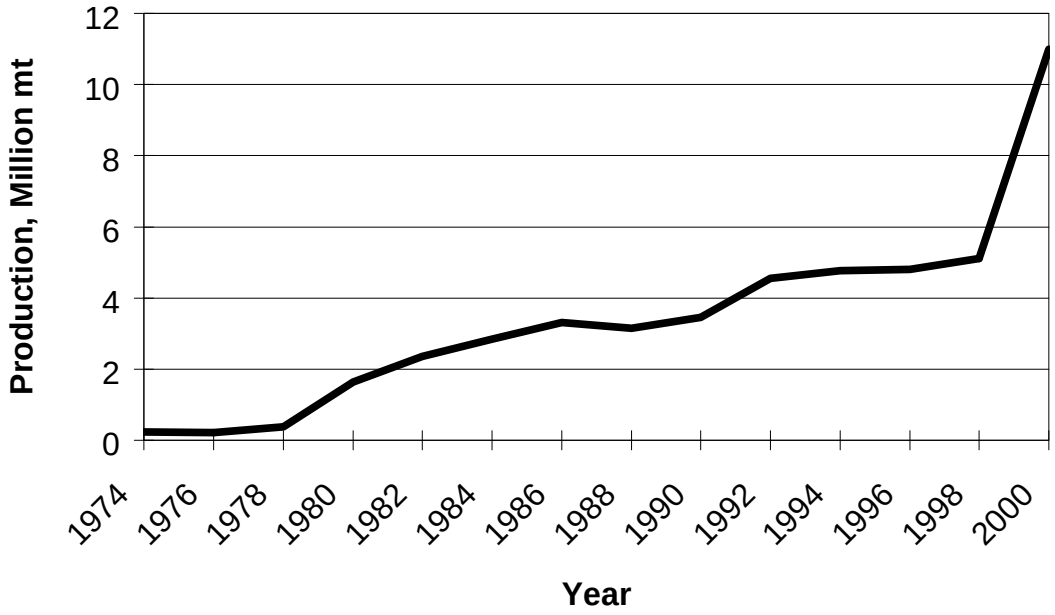
The plant, like Comsigua, will be supplied with San Isidro pellets and lump, with the pellets coming from the adjacent pellet plant. The product will be shipped by rail to Palua, where it will be loaded onto ships for export.

The plant has an investment cost of $326 million not including port facilities.
No earthmoving is required, as the site had already been laid out to accommodate several DR plants. Civil and erection works was started during the second half of 1997. The plant will begin production in 1999.

These three plants, once constructed, will produce HBI for the export market only. They would increase the Venezuelan HBI availability for export from the present level of about 1.5 million mtpy to about 6.5 million mtpy. Much of this would probably be destined for the North American and the European market, and could supply a substantial part of the expected increase in scrap substitute demand there.

The planned increase of the DRI/HBI production is shown in Figure 5.

Figure 5
Planned Increase in Venezuelan DR Production



Production costs

To illustrate the effect of producing DRI in Venezuela, Figure 6 contains a simple comparison of the raw material and labor costs for a typical pellet-based direct reduction process for Venezuelan and US locations. Capital charges and overheads are not included, but would be similar in both locations.

Figure 6
Comparison of Production Costs for DRI
Venezuela vs. USA

	Units Required	Unit Cost USA	Prod. Cost USA	Unit Cost Venezuela	Prod. Cost Venezuela
Pellets	1.5 mt	$40.00	$60.00	$25.00	$37.50
Natural Gas	10 MMBtu	$2.00	$20.00	$0.600	$5.00
Electricity	125 kwh	$0.03	$3.75	$0.016	$2.00
Water	2 m3	$0.10	$0.20	$0.030	$0.06
Labor	0.4 mh	$25.00	$10.00	$8.00	$3.20
	Subtotals		$93.95		$47.76
Shipping			$0.00		$20.00
	Totals		$93.95		$67.76

The difference in production cost will vary somewhat depending upon details of the process and the unit costs at a specific location, but in general would be around $25/mt. For US Gulf Coast sites, the difference would be larger since

shipping costs would be closer to $15/mt instead of $20/mt assumed in the above analysis.

Venezuelan Export Capacity

There are two docks in the area, which presently have bulk loading capabilities that can handle HBI. These are located at the FMO facilities at Puerto Ordaz and Palua. Loading rates of up to 1500 mt/h of HBI are possible. Vessels of up to 80,000 DWT can load during the period when the Orinoco River is high (during the May-October rainy season) and vessels of around 40-50,000 DWT can make the passage to the Atlantic fully loaded during the low stage. All exports are presently made from these two docks. Since the three new plants all export their product, the HBI export potential of the Guayana area will be around 6.5 million mtpy. In order to accommodate the shipping of this volume of product, the existing FMO port facility of Palua is being expanded to allow delivery of HBI by bottom dump rail cars and storage for shipping. These modifications will provide the additional HBI shipping capacity required for the near future.

Future Direct Reduction Development Strategy

The future of the Venezuelan mining industry will be closely linked to the development of the direct reduction industry there. With demand for iron ores peaking worldwide, and competition becoming stronger, Venezuela sees the necessity to produce a value-added product such as HBI for export, thereby guaranteeing a market for its iron ores.

The government owned iron ore supplier CVG Ferrominera Orinoco (FMO) is active in the promotion of new DR projects. This is one of the few mining companies that is participating in the construction and operation of DR plants. It realizes the potential for direct reduction as a fixed consumer of its iron ore. As a result, it has designed a strategy to promote direct reduction in the Guayana area, and to increase its HBI production and exporting capacity.

The first step in their DR development program was the construction of the Punta Cuchillo industrial park. This installation is configured to accommodate two pellet plants and three DR plants of 1 to 1.5 million mtpy capacity each. The Punta Cuchillo Park is the location of two of the three plants now being constructed in Venezuela.

The first pellet plant was constructed, and began operating in 1994. For the second plant, FMO is planning to develop the project with partners who would use its product. Their strategy also includes an increase in the pelletizing capacity of the SIDOR plant to 8 million mtpy. This would increase the area's pelletmaking capacity to over 11 million mtpy, and would reach around 15 million mtpy with the installation of the second pellet plant at Punta Cuchillo.

Final Remarks

Venezuela is the world's largest direct reduced iron producer, and a leader in the export of HBI. It has the advantage of possessing all the natural resources at one location, which are required to produce this commodity. It's steelmaking industry is based upon an overall mix of 75% DRI/HBI and 25% scrap.

FMO has taken a very active role in promoting development of direct reduction projects in the Puerto Ordaz area. In addition to the promotional activities, it is also a partner in all three new projects now underway.

Venezuela's direct reduction experience has been developed over the last 30 years with a number of different direct reduction processes. Although not all of them have been successful, the ones that are in service today have passed the test of time, and in some cases have formed the basis for new DR processes such as FINMET® and AREX ®.

The DR production capacity of Venezuela will almost be duplicated by the year 2000 once the three new projects are completed. This represents a major increase in the world DR capacity, and will ensure that Venezuela continues to be a leader in direct reduction and HBI exports in the near and long term future.

Sivensa has been leader within Venezuela in the development of direct reduction processes and in the production of Hot Briquetted Iron for export. It is now operating both FIOR® and MIDREX® processes, and starting 1999 will be operating a new plant based upon the FINMET® technology which is its own development. In addition, our experience in the use of HBI in EAF steelmaking is unsurpassed. Orinoco Iron expects to be in the forefront of direct reduction processes development and HBI production and use in the future as well.

Conclusions

1. There will be a substantial increase in quality oriented EAF steelmaking over the next 5 years.

2. The proportion of higher residual obsolete scrap used will increase, since the availability of high quality scrap will not increase.

3. More scrap substitutes such as DRI and HBI will be required to dilute the residuals to levels allowed for high quality steel. The increase in scrap substitutes in the U.S. alone is estimated to be 5 to 8 million mtpy.

4. There is not adequate DR capacity in the Americas at present to meet this increased demand, and merchant based plants will have to be completed by 1999 to supply the required metallics.

5. Pig iron will probably not continue to fill in the scrap substitute deficit in the future.

6. Fines based DR processes can be expected to play an increasing role in DR production in the future, providing an outlet for fines available from iron ore suppliers.

7. The possible DR expansion in Latin America over the next 3 years could total up to 7.2 million mtpy. However, export oriented projects that are now in progress will only add about 4.2 million mtpy of capacity. On the low side, this capacity might not be adequate to totally meet the increase in demand.

8. Finally, Venezuela, and specially Orinoco Iron, will continue to be the major DR supplier to the Western Hemisphere merchant market with the new projects is under execution.