# Developments in the Venezuelan DRI Industry

by

**Alberto Hassan**
CEO Orinoco Iron

and

**Roy Whipp**
Project Director Orinoco Iron

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# Orinoco Iron C.A.

## Introduction

Venezuela presently produces around 3 million mt/y of steel, all through EAF steelmaking processes. The percentage of scrap used in the production of steel is about 20% overall, with the rest being provided by direct reduced iron either as DRI or HBI. 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 the leading 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 35 years, and the country now has over 6 million mt/y of installed DR capacity and 3.7 million mt/y in the process of installation or recent startup.

This paper will present a summary of the driving forces for direct reduction development in Venezuela, operating plants, and new project activity there.

## Venezuela's Natural Resources Drive the DR Industry

The Guayana region of Venezuela, where the direct reduction industry is centered, has the ideal combination of natural resources required to make this material. Due to the importance of these natural resources in developing a DR industry, the following section outlines the unique situation in Venezuela:

### Iron Ore Reserves

The iron ore reserves (high and low grade) of the Guayana region are estimated to be around 3.9 billion mt of proven reserves and 12.4 billion mt of total reserves. The proven reserves for mines with at least 64% iron is around to 1.8 billion mt. Venezuela can easily supply its expected metallics demands for more than a century using natural ores and concentrates.

All ore is commercialized by Ferrominera Orinoco (FMO) which is a subsidiary of CVG (the government agency responsible for the development of the Guayana region). The ore mines are located about 100 km from the direct reduction plants. Ore from the open pit mines is shipped to FMO's facility in Puerto Ordaz by train where it is crushed, dried and classified prior to shipping. Of the 17 million mt processed in 1998, about 8 million mt were used locally in direct reduction.

Ore is supplied from several mines and is blended in order to reach the required product specifications. Presently, the most important of these reserves are the Cerro Bolivar, San Isidro, Altamira, Los Barrancos and Las Pailas deposits, which are now being mined. The production was shifted from Cerro Bolivar to San Isidro as the major ore source due to its lower phosphorus content. San Isidro blend is used by all direct reduction plants in Venezuela.

**Natural Gas**
Venezuela is principally known as a petroleum producer. Natural gas is a byproduct of the oil production, and about 89% of the gas produced in Venezuela is associated. The price of natural gas is well below the prices prevailing in most of the countries of the world. Since natural gas is a major cost constituent of DR plant production costs, this is an advantage for the industry.

Present proven reserves of natural gas nationwide are fixed at 4.13 trillion cubic meters. The present production rate is around 59 billion cubic meters per year, which works out to a theoretical life for proven reserves of 70 years. New discoveries are exceeding the increase in consumption, so that the supply of gas appears to be virtually limitless. The consumption in the Puerto Ordaz area is presently around 3.5 billion cubic meters per year. Additional gas lines are being built to supply additional capacity to the Guayana region.

**Electric Power**
The Guayana region, where Puerto Ordaz is located, is the center of hydroelectric power generation of the country, having most of the installed capacity. This is concentrated in the Guri and Macagua dams which have a capacity of 12,000 MW. This will be augmented by an increases of capacity from new dams in the future, one of which, Caruachi, is now under construction. The region's hydroelectric capability will be increased to 16,320 MW over the next decade and eventually to 25,320 MW.

**Transportation**
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 at COPAL (formerly Palua). 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, and the COPAL facility has been modified to allow substantial additional HBI and pellet handling capacity (described later).

**Water Resources**
Industrial water needed by the plants is supplied from a treating station located close to the Matanzas industrial area. The water is taken from the Caroni river, which has a maximum flow of over 10,000 $m^3$/sec. One of the area's advantages is its virtually limitless supply of fresh water from the rivers.

**Infrastructure**
The area has a large infrastructure of services geared to the direct reduction industry, and this includes both fabrication and construction of plants. All of the

major plants in the area have been built by local construction companies. 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. All technical and operational aspects of the plants are handled by Venezuelan personnel, with little dependence upon expatriate manpower.

The highway network in the region is the best in Venezuela, and there are rail lines serving the industrial area where the direct reduction and steelmaking industries are based.

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.

## Direct Reduction Plant Development in Venezuela

### SIDOR Strategic Udy

The first experience with direct reduction in Venezuela was in 1963, when one of the low shaft furnaces in the SIDOR mill was equipped with a Strategic Udy rotary kiln furnace. This furnace prereduced iron ore fines to about a 50% reduction level with coal fines before they were charged hot to the furnace. The objective of this modification was to double the production of hot metal from the melting furnace. After one year of unsuccessful operation due to continuous difficulties in the low shaft furnace, the experiment was discontinued.

### HIB

The next direct reduction plant installed in Venezuela was the Orinoco Mining High Iron Briquette (HIB) plant. This process was developed by U.S. Steel, of which Orinoco Mining was a subsidiary, and used iron ore fines as a feed material. It had two ore preheat and two reducing fluid bed stages. The briquetted product had a relatively low metallization (75%), and was destined for use as feed to blast furnaces. The plant had three fluid bed modules rated at a total production of 800,000 mt/y.

The first module started up in 1972. The other two modules were started up later, but the plant suffered a number of operating problems and its operation over the next several years was erratic. In 1977 the entire plant was shut down for a major revamp. It was restarted after modifications in 1979, but failed to operate close to design capacity, and was shutdown completely and mothballed in 1981.

The plant used Cerro Bolivar fines as a feedstock during the period it was operational. Even though designed for low metallization, in later years this was increased to slightly over 80%, and the briquettes found some use in EAF shops in Venezuela.

**Operations RDI (Formerly FIOR de Venezuela)**

A second fines based fluid bed plant, FIOR, designed by Exxon and A.G. McKee, was installed in Venezuela after the HIB plant. These were the first two ventures into fines based fluid reduction in the world. The FIOR Process had one ore preheat and three reducing fluid bed stages. The metallization was substantially higher than the HIB process, in the range of 92-93%, and the product was aimed for the EAF market. The design capacity of this unit was 400,000 mt/y.

The company formed to operate the plant, FIOR de Venezuela, was owned by private investors and the state development organization CVG. The SIDETUR Division of SIVENSA acquired FIOR de Venezuela in 1986 as a majority shareholder.

The plant started up in 1976, and suffered a number of mechanical and process problems which limited the production initially. Modifications made in subsequent years resolved most of these problems, finally allowing the plant to reach its design capacity. It is now running at design capacity.

The Operations RDI plant, as it is now known, is using San Isidro grade iron ore fines under 1/2" as a feedstock. It is a merchant plant, and all the briquettes are presently exported. About 2/3 goes to the U.S. for use in blast furnaces, BOF and EAF. It was the pioneer HBI exporting plant, and set the stage for the merchant HBI industry, Since 1978, it has exported over 5.8 million mt of briquettes, and its shipping procedures formed the basis for the present IMO codes.

**SIDOR MIDREX and HYL**

The state owned steel mill SIDOR underwent a major expansion in the mid-1970's, and part of this project consisted of the installation of direct reduction modules to feed the EAF's being installed.

The first unit, a 360,000 mt/y HYL 1 module, was started up in 1976, at the same time as the FIOR plant. SIDOR was also installing a 350,000 mt/y MIDREX® Direct Reduction Plant which came on-line in 1977. By 1979, SIDOR had added three more MIDREX™ Modules of 430,000 mt/y each, and three HYL II modules of 570,000 mt/y (present rating) each. All modules produce DRI, and fines screened out of the product are cold briquetted for use in the mill.

This was the first use of the HYL II process, which was an improved version of the multi-reactor HYL I static bed process. These units suffered a number of operating problems which forced them to be revamped in the mid-1980's. They still have not been able to operate continuously at design capacity, and SIDOR has been investigating modifications to allow their output to be increased.

The four MIDREX modules have process gas and combustion air preheating. These units have been modified to use the AREX technology.

The SIDOR DR modules produce around 4 million mt/y for internal consumption in their EAF shops. Pellets are produced in SIDOR's two line 6.6 million mt/y pellet plant for use in the DR modules and for other clients. The pellet composition is different for the two DR processes used at SIDOR, with the HYL pellets having a higher silica content. The feedstock to the MIDREX and HYL units consists of 100% pellets.

**OPCO**

After the HIB plant was shutdown in 1981, several companies made offers to Minorca, a CVG subsidiary who is owner of the plant, to convert it into a different direct reduction process. A technical offer made by MIDREX along with a operating proposal submitted by a Kobe led consortium was finally accepted, and the plant was modified to a steam reforming MIDREX® Direct Reduction Process with hot briquetting. The plant modification was financed by the consortium, and their Venezuelan operating company, OPCO, will lease and operate it until 2004, when it will be turned over to Minorca.

The plant used much of the existing HIB installation. The original reactor system and structure was removed and was replaced with a MIDREX™ Shaft Furnace and hot briquetting lines. It had a capacity of 830,000 mt/y when it was started up in 1990. Most product is exported, with the exception of a small amount used in the SIDOR steel mill. OPCO uses FNP pellets supplied from the SIDOR pellet plant, and San Isidro lump in varying ratios, with a maximum of 35% lump.

The plant has several technical innovations that set it apart from previously constructed MIDREX plants. It was the first to use the 6.5 meter diameter shaft furnace. The largest diameters used prior to the OPCO installation were 5.5 meters. Since the plant used the existing HIB facilities, the reducing gas was initially produced by steam reforming rather than by the conventional MIDREX™ Stoichiometric Reformer. This was the first use of steam reforming in a MIDREX™ Shaft Furnace. Later, in 1997, a conventional MIDREX™ Reformer was added to increase plant capacity so the shaft furnaces is being supplied with gas from two separate reformers. It now has a capacity of 1 million mt/y.

**Venprecar**

Sivensa decided to increase its direct reduction capacity by building the Venprecar facility in Puerto Ordaz. The plant was originally built as a 600,000 mt/y MIDREX unit with hot briquetting. Since it was designed for use with a high percentage lump charge, it has a sulfur removal system in the gas circuit to remove sulfur compounds from the recycled top gas, and this was the first use of

such a system in a MIDREX plant. It was constructed alongside a new 400,000 /y billet mini-mill, Casima, which can use an 85% HBI charge.

Venprecar plant started up in late 1990, and reached design yearly capacity by 1993. It was shut down for a month in October 1994 for capacity increase

then 715,000 mt/y. briquetter and higher capacity gas handling equipment were incorporated, raising the mt/y.

The plant uses a mixture of SIDOR pellets and San Isidro lump. The typical product is briquetted and at

the adjacent Casima mini-

## Venezuela's New DR Project Development

The ore supplier CVG
projects. This is one of the few world iron ore mining companies that is

potential for direct reduction as a fixed consumer of its iron ore, and as a way to increase its local market. As a result, it has designed a strategy to promote direct Guayana area, and to increase its HBI production and exporting capacity of a value added product.

Cuchillo industrial park. This installation is configured to accommodate two pellet plants and mt/y capacity each. The Punta Cuchillo
Venezuela.

The first pellet plant has been constructed, and began operating in 1994. For the

use its product. The strategy also includes an increase in the capacity of the SIDOR plant to 8 million /y. This would increase the area's pelletmaking mt/y, and would reach around 15 million /y with the installation of the second pellet plant at Punta .

There are three new direct reduction plants in Venezuela that have been

These were all initiated prior to the turndown in the steel industry, and are well poised to take advantage of the recovery that is projected to occur in the short

by different investment groups.

## COMSIGUA

The first DR plant destined to be built in the Punta Cuchillo Industrial Park in Puerto Ordaz, Venezuela is the COMSIGUA MIDREX module. The company is a joint venture of a consortium of Japanese traders, FMO, Kobe Steel, Tamsa and the IFC. The cost of the plant, including port facilities and finance charges, was $260 million.

This plant has a 1.0 million mt/y MIDREX® MEGAMOD module and produces HBI for export. The groundbreaking was held on November 16, 1996, and the plant was started up in 1998.

For the first 5 years of operation the feedstock will be a mixture of FMO lump (20%) and pellets (80%), and afterwards the lump will be reduced to 10%. The pellets are produced at FMO's 3.3 million mt/y pellet plant located next to Comsigua.

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 COPAL port on the Orinoco River.

## Posven

Another pellet based plant, Posven, using the HYL III process in the startup phase. This plant has one steam reformer and two 750,000 HYL III reactors and produces HBI for the merchant market.

The Korean steelmaker POSCO, and two subsidiaries POSEC and POSTEEL, will have 60% ownership of the plant. CVG Ferrominera will be a 10% owner of the plant, while Raytheon will have 10% ownership, and in addition will engineer, supply equipment, and construct the plant. HYLSA, Hyundai and Dongbu will have minority shares. All partners, except for Raytheon, will share the offtake. POSCO is presently trying to sell its shares in the project.

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 COPAL, where it will be loaded onto ships for export.

The plant cost $326 million not including port facilities. Groundbreaking began in May 1997, and commissioning began in 1999. The plant will begin production in 2000.

## Orinoco Iron

A new company was 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 is formed by a 50-50 partnership of IBH and the Australian company BHP. Orinoco Iron will own and operate both the existing 400,000 mt/y Operations RDI plant and the new plant. Sivensa and CVG Ferrominera are principal owners of IBH.

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

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

The civil work for the plant began in January 1998, and mechanical erection began in July 1998. Commissioning activities began in November 1999 and the ore drier was commissioned to supply Operations rDI in January 2000. Initial production is targeted for March 2000.

The new plant will produce HBI for export only. Orinoco Iron will have about 2.6 million mt/y available for export from the two plants. The product is being exported from the COPAL port

Photos of these three plants are included in Attachment 1.

**Venezuela Direct Reduction Capacity**

Venezuela is the third largest DR producing country in the world, with a production of 5.06 million mt in 1998, or 14% of the total world production. There are 18 trains in startup or operation at present with a total capacity of 10.6 million mt/y. The present status of the Venezuelan plants is shown in Figure 1.

The export of HBI from Venezuela is taking an increasingly more important role, and new plants are now being planned for the export market rather than for internal consumption. In 1998, 1.8 million mt were exported from the Comsigua, rDI, OPCO, and Venprecar plants.

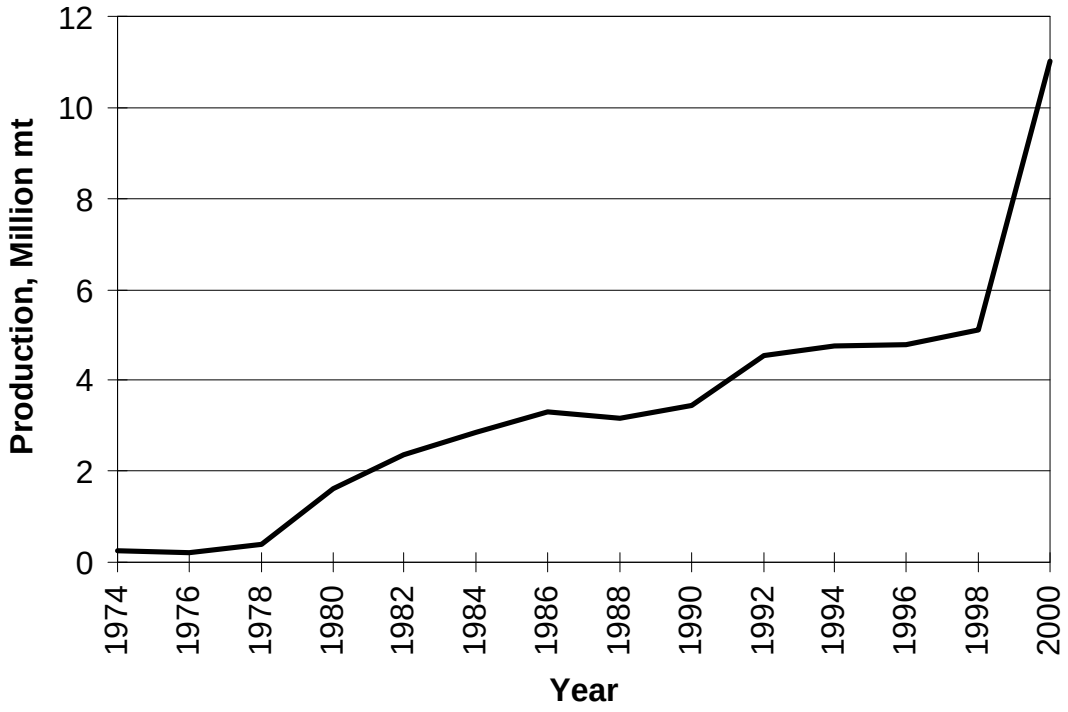
**Figure 1**
**Venezuelan DR Plant Status - 1999**

| Plant | Startup | Capacity 1000 mt/y | Trains | Status |
|---|---|---|---|---|
| Operations rDI (FIOR) | 1976 | 400 | 1 | Operating |
| SIDOR HYL 1 | 1976 | 360 | 1 | Operating |
| SIDOR MIDREX 1(1) | 1977 | 350 | 1 | Operating |
| SIDOR MIDREX 2 (2) | 1979 | 1290 | 3 | Operating |
| SIDOR HYL 2 | 1980 | (3) 1,700 | 3 | Operating |
| OPCO | 1989 | (4) 1,000 | 1 | Operating |
| VENPRECAR | 1990 | (5) 815 | 1 | Operating |
| COMSIGUA | 1998 | 1,000 | 1 | Operating |
| POSVEN | 2000 | 1,500 | 2 | Startup |
| Orinoco Iron | 2000 | 2,200 | 4 | Startup |

Note: (1) – Modified with AREX technology
(2) – Modified with AREX technology
(3) - Original capacity was 2,100,000 mt/y, downrated to 1,710,000 mt/y.
(4) - Original capacity was 830,000 mt/y, expanded to 1,000,000 mt/y in 1996.
(5) - Original capacity was 600,000 mt/y, expanded to 715,000 mt/y in 1995 and to 800,000 in 1998.

The startups of these new plants will increase the Venezuelan direct reduced iron production by a factor of two as shown in Figure 2 below. This will allow Venezuela to continue to be the world leader in terms of total DR production. Since the three new plants all export their product, the HBI export potential of the Guayana area will be over 6 million mt/y.

**Figure 2**
**Planned Increase in Venezuelan DR Production**




**Port Capacity for HBI Export Increased**

With the startup of these three export plants, the shipping requirements of the existing port facilities would not have been adequate. The owners of the new plants entered into a consortium arrangement with CVG Ferrominera to modify the existing iron port of Palua to allow it to handle 6.2 million mt/y of HBI. This work began in June 1997 and was completed in December 1998. The modified facility is called COPAL.

The cost of the installation was $15.4 million. Comsiga owns 19% of the facility, Posven 29%, and Orinoco Iron/Venprecar 52%.

All HBI is shipped to the port by rail except for that shipped from the Venprecar plant. It is discharged into concrete hoppers from the bottom dump rail cars, and transported to storage piles. From there it is loaded by front end loader onto conveyor belts, is screened, and is loaded into bulk carriers with a soft loading system to avoid breakage while loading.

Photos of the dock facility are contained in Attachment 1.

## Future Ore Upgrading Project

Ferrominera at present has undertaken an international bidding process for the supply and installation of a friable low grade ore (>55% Fe) concentrator of 8 million mt/y of product, which will be in operation in 2003. This will will be the first stage of a larger concentration complex that will include, as a second stage to be completed in 2005, a hard low grade ore concentrator with a capacity of 4 million mt/y of product.

With this additional beneficiation-by-concentration capacity of 12 million mt/y, Ferrominera will warranty its clients, domestic and foreign, a quality supply of ore at a rate of 28 to 30 million mt/y for more than 30 years.

## Conclusion

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. Its steelmaking industry is based upon an overall mix of 80% DRI/HBI and 20% 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 35 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. Venezuela has a number of process development activities underway at present.

The DR production capacity of Venezuela will increased by 3.7 million mt/y by the year 2000 after the second two of the three new plants are on line. This represents a major increase in the world DR capacity, and will ensure that Venezuela continues to be a leader in direct reduction in the future. Expansion in the production of high quality ore fines by 12 million mt/y will enable Venezuela to continue to provide a reliable supply of fines to its domestic and foreign customers.

## Acknowledgement:

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# Attachment 1 – Photos

## COPAL Port Facility
## Orinoco River

## Posven Plant
## HYL III Process

## Comsigua Plant
## MIDREX Process

## Orinoco Iron Plant
## Finmet Process