JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

No. 38

FONDO DE INVERSIONES DE VENEZUELA (FIV)
THE REPUBLIC OF VENEZUELA

THE FEASIBILITY STUDY OF THE ESTABLISHMENT OF THE COKE PLANT IN THE REPUBLIC OF VENEZUELA

(SUMMARY)

SEPTEMBER 1994

UNICO INTERNATIONAL CORPORATION
MITSUI MINING ENGINEERING

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Executive Summary

Unico International Corporation
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Venezuela is endowed with abundant mineral resources, such as petroleum, natural gas, iron ore, bauxite, phosphate, and coal (general coal in Zulia State) and has plenty water resources which generates low-cost electricity. Also, Venezuela produces various agricultural products, livestock and fishery products due to a variety of weather conditions. The government of Venezuela has been making efforts to utilize the resources in an attempt to reduce overdependence on oil and to develop various regions in a balanced manner, including market liberalization. The proposed coke plant project is designed to produce and export blast-furnace coke using coking coal to be exploited in Tachira State. As a result, it is expected to serve the purposes of economic diversification and regional development.

The study team on the Feasibility Study of the Establishment of the Coke Plant assigned by JICA visited Venezuela between July 4 and August 17, 1993. Its major activities included the study of industrial policy of the Venezuelan government, study on coal and exploitation situation in Tachira State, collection of coal samples, and field investigation on the three proposed project sites. Also, two member of the study team visited in the U.S. and Europe for potential market study. Coal specimens were analyzed and the quality was evaluated as a coking coal in Japan.

Followed by the field survey in Venezuela the result was drawn and shown in the interim report which covered selection of suitable coking coal for blending and blending ratio of the coal to meet the quality to export to the international market. It also cover the assessment of economic viability by economic and financial analysis. The interim report was submitted on January 20,1994.

For the purpose of explanation of the interim report and for supplemental survey, the second field survey was taken place between January 20 to February 6,1994. There had a discussion pertaining the coal exploitation in Tachira. While coal samples were collected from Guasare mines and those were analyzed in Cicasi laboratory. Corpozulia also informed that they are planning the construction of coal stock yard for export purpose in the same area as the coke plant allocated.

On March 8,1994 FIV transmitted the comments on the interim report. Response to the FIV comment was transmitted on May 11,1994

On May 27,1994 the report on the coal exploitation in Northern Lobatera was conveyed.

With inclusion of the second survey result and information received later on, a final draft report was prepared. The objective of the study is to examine the viability of the coke plant using the coking coal from Tachira State. The product are for blast furnace and for export. But it is found that quantities of coal from Tachira state are not sufficient for one million ton of coke production. On the other hand there are abundant of non-coking coal in Guasare in Zulia state. Therefore case study was conducted whether Guasare coal can be utilized for production of blast furnace coke. In addition information of formed coke process are attached which could be applicable for non-coking coal.

1.1 Brief Summary of Study

(1) Properties of Coking Coal in Tachira State and Columbia, Feasibility of Mining, and Selection of Suitable Coking Coal if Imported

There are 5 coal deposits in Tachira State, namely FNO(Franja Nororiental), SAN(San Félix), LOB(Lobatera), HAT(Hato de la Virgen), and LAS(Las Adjuntas). The study on LAS has completed in 1992 under JICA's study as Coal Mine Development in Tachira, and its results have been employed for this study. As for Colombian coal, coal from Boyaca was selected for evaluation since mines are at near the border with Venezuela. As shown in Table 1, it has been confirmed that FNO coal contains medium volatile matter, LAS shows high volatile matter, and Boyaca coal contains low volatile matter. Proven and recoverable reserves of these coals are summarized in Table 2. At the time when JICA's study was under way on coal mine development in Tachira in 1992, FNO's proven reserves was under investigation by the Venezuelan side but was regarded as prospective. Investigation was completed and the unfavorable result was presented during the study team was in Venezuela. As shown in Table 2, it was found that FNO has proven reserves of only 600,000 tons, with annual production of 70,000 tons. Since availability of coking coal with medium volatile matter affect feasibility of the coke plant project, the study team has recommended the Venezuelan counterparts to conduct investigation on how much reserves in the Northern part of LOB.

On May 27, 1994 a report on coal exploitation in Northern Lobatera was conveyed. The report covered only the ongoing result as exploitation is still under way. It is not enough information indicating quantities and quality of the coal. Therefore, the report does not contribute to up-date the existing data about supply capacity.

Based on proven reserves of coking coal with medium and low volatile matter in Venezuela and Columbia, annual coke production is estimated at 110,000 tons only. To ensure an adequate level of production, additional quality coal needs to be imported from other countries. Qualify coal is available from many different countries, but Blue Creek and Pinnacle produced in the U.S. have been selected in consideration with price and geography.

The price of Tachira coal is assumed to be US$35 including inland transportation cost and imported coal US$60.

(2) Blending Ratio of Coal for Coke Production

To produce cokes which will be acceptable to the U.S. user, the optimum mix of various coals has been determined (Table-3) and tested by Box-Tests.

Major findings from the box test are a follows:

1) The blending of Venezuelan coal according to proportion of production, cannot produce blast-furnace coke.
2) By the same token, the blending of Venezuelan and Colombian coals according to proportion of production cannot produce blast-furnace coke.
3) In the blending of Venezuelan and Colombian coals, not based on actual proportion of production, only TI_{25} is 59.6, very close but slightly above the target value of 61.
4) To produce blast-furnace coke to meet specific quality requirements, imported coals, 40% to 65% of total, should be blended with Venezuelan and Colombian coals.
5) Volatile matter of blending coals to produce blast-furnace coke should be set at below 30.0(%, d.a.f.).

(3) Market for Blast-Furnace Coke and By-Product

<Blast-furnace coke>

In Venezuela, there is neither blast furnace to produce pig iron nor plan in the future. Thus, blast-furnace coke to be produced in the project will be entirely export purpose. In the U.S., blast-furnace coke demand is expected to decline in the future, partly due to a decline in production of pig iron itself and partly due to the application of PCI (Pulverized Coal Injection) method to produce crude steel. Yet the production of crude steel is very much depending on the existing blast furnace. The decline of coke supply capacity in the country exceeds that of demand due to the obsolete ovens in the U.S. and pressure from the strict environmental regulations under the Clean Air Act. This will cause the shortage of 5 million to 6 million tons annually in the future. In this context, the U.S. is likely to import 1 million to 2 million tons of coke. The similar trend is expected in Europe, but shortage will be covered by the supply from Eastern Europe. In Brazil, pig iron are produced using coke and charcoal as well. The utilization of charcoal causes the destruction of forest and Brazil is on the verge of selection whether should charcoal utilization continue or change to coke. If all the charcoals currently used are converted to coke, Brazil will require nearly 3.3 million tons annually. The country does not reserve enough coking coal thus has to import if coke is to be produced locally. These factors work favorable for Venezuela, and Brazil may import 1 million tons of coke if competitively produced in Venezuela. Current blast-furnace coke prices in the U.S. are hovering at US$93 partly due to worldwide recession, though the peak price was US$130 at one time. With the imminent shortage of coke supply being expected, the price is expected to rise toward US$130. In fact, the U.S. government has reportedly adjusted the future coke price to US$130 from a US$150 level predicted when the Clean Air Act was enacted. Similarly, the coke price in Brazil is estimated at CIF US$132 and FOB US$122, on the basis of charcoal prices.

<Pulverized coke>

In Venezuela, there is an estimated 30,000-ton market for pulverized coke which is a by-product in the production process of lump coke for blast furnaces. This amounts has been supplied locally, therefore all pulverized coke will be exported. The export price is estimated at US$40.

<Crude tar and light oil>

Among products made from crude tar and light oil, there are domestic markets, although very small, for benzene and pitch. Nevertheless, the amounts of crude oil and light oil produced from a 1 million ton coke oven, 30,000 tons and 10,000 tons respectively, are too small for economical refining. It is therefore recommended to export crude tar and light oil without refining, which are highly demanded in some of European makers.

<Coke–oven gas>

Coke–oven gas is not suitable for export and must be entirely consumed within the country. A thermal power plant near an industrial area in Maracaibo has agreed to use it as its fuel. On the other hand, Puerto Ordaz has no thermal power plant, and availability of natural gas makes the use of coke–oven gas very limited. Consumption is expected at many factories operating in the area. Santo Domingo has no thermal power plant and few factories, therefore one possible way is to generate electricity within the plant and sell excess electricity to outside. In any case, low natural gas prices in Venezuela will inevitably push coke–oven gas prices down accordingly. This is one unfavorable factor against viable operation of the proposed coke plant.

(4) Site Selection of Coke Plant

Three candidate sites for the proposed Coke plant project have been selected, namely Santo Domingo, Puerto Ordaz, and Maracaibo. They have been compared and evaluated, as shown in Table 4. Taking into consideration of critical factors such as whether the site is allowed for coke plant under the law, costs to transport coals and cokes, availability of port facilities for export, possible uses of coke–oven gas, the needs for land preparation and a repair shop, the site at Maracaibo has been selected as the best site.

(5) Locational Advantages of Maracaibo

The site at Maracaibo is strategically located to transport coals from Tachira State and to export the product due to the water front of Lake Maracaibo. Water for plant are available from old wells. A thermal power plant is operating near the site and willing to use coke–oven gas. One unfavorable fact may be the pollution to that Lake Maracaibo. There are special regulations only applicable to Lake Maracaibo. The project intends to clear these regulations and Japanese regulations, as well as those under the Clean Air Act in the U.S.

(6) Type and Size of the Proposed Coke Oven

At present, new technologies are adopted at some plants, such as pre–treatment of coal before being charged to the coke oven in order to minimize consumption of coking coal and to improve coke quality, and non–recovery oven. However, the former presents problems related to the quality of coke in the blast furnace, the increase in construction cost, and the difficulty to operate, while the latter has not been completed as the commercial process, particularly recovery of waste heat. Thus, the project will adopt a conventional type of coke oven which is widely used in many countries, with some design features to comply with environmental regulations.

Since a relatively small amount of Venezuelan coal is available, the increase in plant size leads to an increase in consumption of relatively costly imported coal. On the other hand, if the plant size becomes too small, economy of scale is lost to make the coke production cost less competitive. Based on amounts of coal currently produced in Venezuela and Colombia, and assuming that imported coal will be mixed in proportion required to maintain the specific quality of coke, optimum coke production is estimated at 570,000 tons annually. The production capacity was then compared with the 1 million-ton capacity, and the latter was found to be more economical. (Table 5) As a result, coke production capacity has been set at 1 million tons annually. Note that the coal blending ratio in this case is No.6 in Table 6. Total investment cost for one million ton capacity coke plant is estimated at 662 million US$.

(7) Financial and Economic Analysis

Financial and economic analysis was made for the case where raw coal supply capacity is based on the present known capacity,coke quality to be acceptable to the international market and plant production capacity is one million ton per year. Consequently blending ratio are 32% domestic coal, 65% U.S. coal and 3% Colombian coal.
The result of financial analysis based on internal rate of return shows minus 1.37%. Foreign currency earning during project life is mare 212 million dollars which is only 32% of investment cost.
Summary on financial and economic analysis are attached in Table-7.

(8) Financial and Economic Analysis by Changing Parameter

a) Assumption was made as that domestic coal could be produced in sufficient quantity in future to allow blending in the ratio of 80% domestic coal and 20% Colombian coal. Imported coal from the U.S. will not be used. In this case, financial internal rate of return is improved up to 5.54% yet it is to low to say the project is viable. Base on this case, sensitivity analysis is performed by varying costs of coke, coal and plant cost. Fig.-1 shows its result.

b) Guasare coal has abundant and its quality is good. Ash content and content of total sulfur is low. But there will be limit to blend because of coal with high volatile matter and weak caking capacity. For financial and economic analysis following three cases are made. Production capacity is one million ton per year in all cases.

1) Use 10% of Guasare coal. Guasare coal replace partially with US coal.
2) Use 15% of Guasare coal.LAS is replace by HAT
3) Upper limit of Guasare coal blending (23%) disregarding the production from Tachira and Colombia.

Financial internal rate of return on the above three cases are 0.19% ,0.94% and 2.78% respectively.

1.2 Conclusion and Recommendation

Conclusion

The present study is designed to evaluate feasibility of the proposed investment project to produce blast furnace coke by using coking coal available in the state of Tachira. The project is proposed in line with the national policy of Venezuela to decrease the dependency of the Venezuelan economy on oil, while serving the interests of fostering regional development.
The present study has examined the proposed project for two cases; one based on availability of coal and other relevant conditions confirmed at present, and the other based on conditions expected to be satisfied in the future. In addition, the case to use Guasare coal produced in the state of Zulia has been evaluated, although not included in the original study plan. Basic assumptions and considerations common to all these cases are as follows:

1) Venezuela does not have a blast furnace to produce pig iron, nor have any plan to build one in the foreseeable future. On the other hand, demand for blast furnace coke in the U.S., which is expected to decline in absolute terms, will grow relative to supply capacity that will decrease at a faster rate since many coke ovens will shut down due to increasingly strict environmental standards. This creates a good export opportunity for the proposed coking plant, provided that it has international competitiveness. Another market opportunity is identified in Brazil where coke demand is expected to arise in order to replace charcoal for pig iron production. Thus, coke produced by the project is assumed to be entirely exported .

   Also, it is assumed that most of by-products will be exported. In this connection, the price of coke oven gas is evaluated to equivalent of natural gas.
2) The coke oven will be of chamber type that is widely used worldwide from the viewpoint of ensuring the level of coke quality suitable for the U.S. market. The production capacity is set at 1 million tons annually with consideration of the economic scale.
3) The plant site has been selected in Maracaibo among three candidate areas including Santo Domingo and Puerto Ordaz, on the basis of comparison of locational conditions including transportation costs for coal and coke, sales opportunity for coke oven gas, and government regulations.
4) The plant design incorporates environmental considerations based on strict standards applied to Lake Maracaibo, as well as those in Japan and Clean Air Act in the U.S. Environmental assessment related to air pollution was conducted and revealed that the plant would produce a minimum environmental load.

Case 1 Evaluation of feasibility based on verified resource conditions

In Tachira, there are 5 coal deposits, namely FNO, SAN, LOB, HAT, and LAS. Among them, coal from two deposits are considered to be suitable at present, FNO containing medium volatile coal and LAS high volatile coal. Coal reserves in FNO are smaller than expected. Boyaca coal in Colombia is low volatile coking coal, but its production is limited. As a result, U.S. coal must be blended in significant proportion.

Transportation of the Tachira and Colombian coals to Maracaibo is assumed to be done by truck that shows the highest economic advantage.

Finally, the price of coke in the U.S. is currently at US$100 or less. However, supply is expected to become tight in the near future for the reason stated above, so that it is assumed to be US$130 which is the highest level experienced during the previous supply shortage.

Based on the above assumptions, the FIRR is −1.37% to make the project unjustifiable.

Case 2 Evaluation of feasibility based on resource conditions expected in future

In Tachira, coal exploration surveys are under way and the development of medium volatile coal seems to be viable. If the prospect becomes reality, coke for the U.S. market can be produced from Tachira coal as well as the low volatile Colombian coal. Thus, the case assumes that the U.S. coal in Case 1 will be entirely replaced with Tachira and Colombian coals. (Domestic coal 80%, Colombian coal 20%)

As a result, the FIRR has improved to 5.54%. Nevertheless, it is not sufficient to justify the project.

Clearly, the development of coal deposits in Tachira is not a satisfactory condition to justify investment in the coking plant. There are several favorable prospects, however. If a railroad construction project planned between Tachira and Maracaibo is constructed, the coal transportation cost for the Tachira, as well as Colombian coal will decline by around US$2.

Secondly, the coke price in the U.S. – assumed to be US$130 in Case 1 – may go up to US$150 if supply shortage becomes more serious than expected.

If these factors are timely realized, the FIRR may rise to a feasible level.

Case 3 Evaluation of feasibility based on the use of the Guasare coal available in Zulia.

Guasare coal is found near Maracaibo. It has large reserves, can be exploited economically by open mining, and has relatively low ash and sulfur contents. From the viewpoint of coke production, however, Guasare coal has a low coking capacity and a very high volatile content. Evaluation on the use of Guasare coal to a maximum extent in response to the request of the state of Zulia and is made.

1) Experiments have been conducted to find the maximum practicable blending ratio of Guasare coal to replace U.S. coal in Case 1, which is estimated at 10%.
2) If the blending ratio is raised to 15% as proposed by the Venezuelan side, the required quality of coal can be maintained by using a sufficient amount of HAT coal in place of LAS coal.
3) The maximum blending ratio of Guasare coal, obtained by reducing or replacing the Tachira coal where necessary, is estimated at 23%.

The FIRRs for above three cases are 0.19%, 0.94%, and 2.78% respectively. One reason for the low FIRRs is relatively a small difference in price between coking and non-coking coal. In the third case, the FIRR does not improve significantly because of an increased percentage of U.S. coal to compensate for the high volatile Guasare coal.

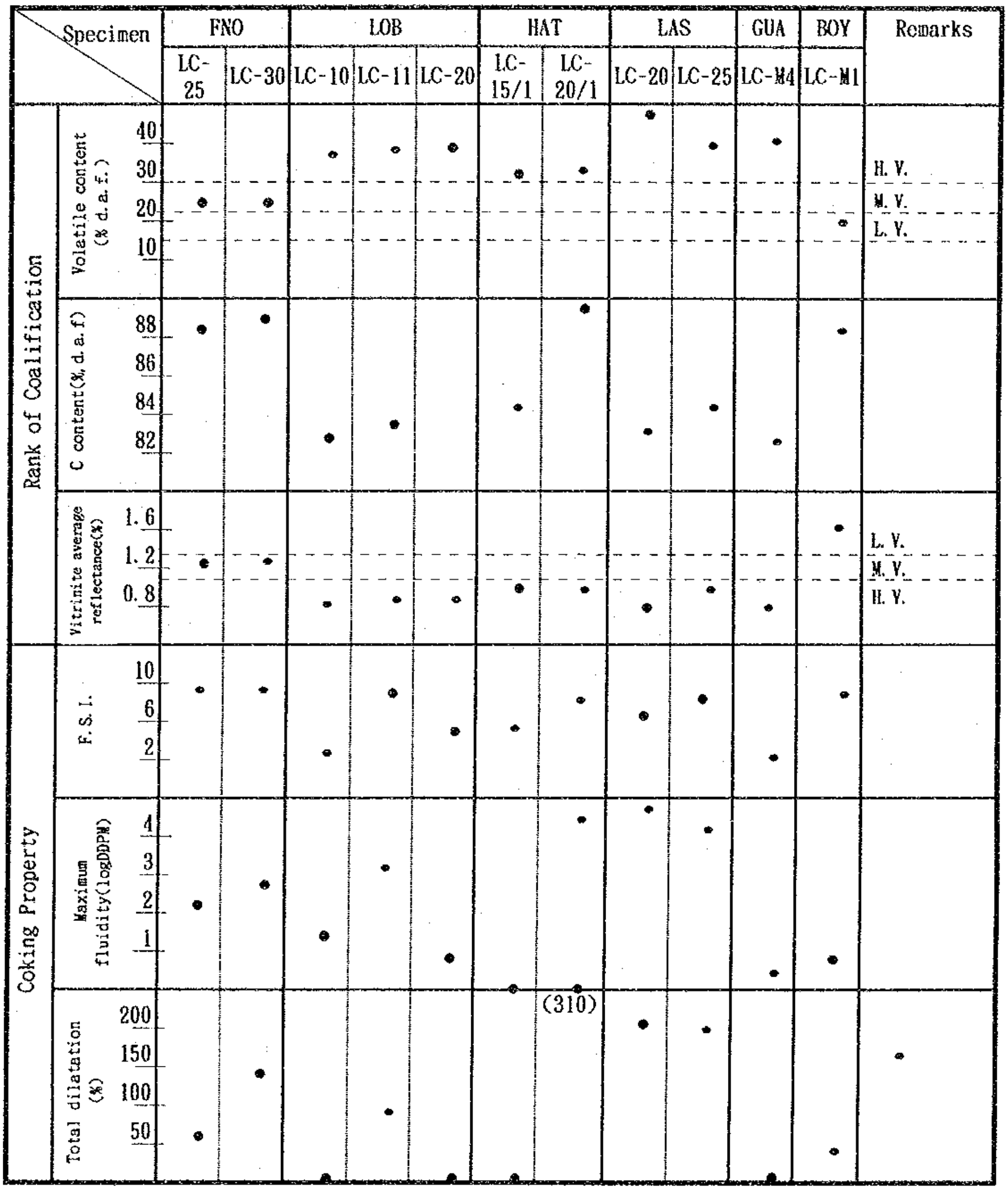
Recommendations

The study has examined financial feasibility of the coke oven project using coal available in Tachira. The result shows that the project is not suitable for investment under the currently confirmed resource conditions. There are various reasons for this: the need for exporting all the products; a large percentage of U.S. coal to secure the required coke quality; and the high construction cost partly due to strict environmental considerations.

However, if coal resources in Tachira are developed as expected, and other conditions are improved simultaneously, the financial prospect for the project will improve, possibly to an acceptable level. Thus, it is desirable to conduct an additional feasibility study when the development of coal resources in Tachira reaches a commercial level.

Although Guasare coal has advantages in availability, quality, and price, it has very low coking capacity and high volatile content, not suitable for coke production at the conventional coke oven. The development of the process to produce blast furnace coke by using non- or slightly coking coal has been carried out worldwide. The continuous formed coke process has been developed from such development efforts. In Japan, production tests have been conducted at a 200-ton/day pilot plant, and formed coke produced from the plant has been used in a 4,500m3 blast furnace. Also, the feasibility of commercial production at 3,000 tons daily (equivalent to 1 million tons annually) has been successfully evaluated. The analysis of the technology and its applicability to the project, therefore, will be one promisting area to be examined in more detail.

Table-1 COMPARISON OF PROPERTIES OF CHANNEL COAL



Note: Carbon content varies due to maceral composition and weathering of coal and becomes low in relation to volatile content.

H.V.=High volatile content coal M.V.=Medium volatile content coal

L.V.=Low volatile content coal

Table-2 PROVEN RESERVE AND PRODUCTION CAPACITY

Deposits	Production (ton/year)	Proved Reserve (L.C.Formation)	Coal Qualiry (Rank fo V.M.)[1]	Period (year)
FNO : Block-1	60,000	476,000	M	7.8
Blok-A	9,600	101,700	M - H	10.4
Northern LOB Under exploration				
HAT Under exploration	100,000		M - H	54.4
LAS	400,000	12,222,250	H	30.6
Colombia				
(Boyaca, M-1)	120,000[2]	1,000,000	L	8.3
(Socota,M-20,10)	30,000	400,000	M	13.3

Notes: 1) Rank of V.M. : L - Low volatile matter M - Medium volatile content
H - High volatile matter

2) Possible export quantity is 50,000ton/year

Table-3 COAL AND COKE TEST
BLENDING CONDITIONS FOR THE BOX TEST (%)

Blended Coal No.		Production (t/y)	Box 1	Box 2	Box 3	Box 4	Box 5
FNO	(Venezuela)	70,000	15	13	40	8	5
LAS	(Venezuela)	400,000	85	77	50	46	27
Boyaca	(Colombia)	50,000		10	10	6	3
Pinnacle	(U.S.A.)					16	25
Blue Greek	(U.S.A.)					24	40
Total (%)			100	100	100	100	100
Total coke production (mil.t/y)			0.32	0.32	0.11	0.57	1

Box 1: Blending of Venezuelan coals according to proportion of production

Box 2: Blending of Venezuelan and Colombian coals according to proportion of production

Box 3: Blending of Venezuelan and Colombian coals, at which quality requirements for blast-furnace coke are expected to be satisfied

Box 4: Blending of Venezuelan and Colombian coals, added by the minimum required amount of imported coal to meet quality requirements for blast-furnace coke

Box 5: Blending required to produce 1 million tons of coke annually

Table-4 COMPARISON OF CANDIDATE SITES

	Santo Domingo	La Cañada	Pto. Ordas
1) Site Name		Municipio de la Cañada de Urdaneta en la Zona de la Ensenada de Urdaneta	Urbanisumo Industrial Cana Veral
2) Zoning	None-industrial area	Heavy industry zone	Heavy industry zone
3) Current Site Condition	Undeveloped	Subdivision/site preparation completed	Subdivision/site preparation completed
Site Area		6,800ha	562ha
4) Land Cost	Land acquisition incomplete 2,500-10,000Bs/ha	Land acquired 260/Bs/sq.m	Land acquired 597/Bs/sq.m
5) Coal Type	Tachira Coal	Guasare Coal	None
6) Coal Transportation cost	383Bs/ton (4.3US$/ton)	1,485Bs/ton (16.5US$/ton)	3,813Bs/ton (42.4US$/ton)
Coke Transportation Cost	1,315Bs/ton (14.6US$/ton)	0	0
7) Coke Shipping Point	Puerto Ordaz or Maracaibo	The port within the site	The port planned to be constructed in the industrial park
8) Domestic Market for Coke	None	None	For anode production and ferro-silicon
9) Coke Oven Gas (COG)	Fuel for private power plant	Sold to the thermal power plant as fuel	Industrial use
10) Domestic Market for By-products	No market for crude tar, benzene and ammonia. Ammonia can be used to produce fertilizer through reaction with another by-product, sulfuric acid.	No market for crude tar, benzene and ammonia. ammonia may be sold to the Zulia complex, and certain market can be expected for sulfuric acid.	No market for crude tar, benzene and ammonia. Ammonia can be used to produce fertilizer through reaction with another by-product, sulfuric acid.
11) Industrial Water	Water in the nearby Uribante River or its underground flow	Well water 2.75Bs/m ^{3}	Well water 0.125Bs/m ^{3}
12) Electricity	8.0Bs/KWH	1.2 Bs/KWH	1.2 Bs/KWH
	2.0Bs/l	3.5 Bs/Nm ^{3}	1.4 Bs/Nm ^{3}

	Santo Domingo	La Cañada	Pto. Ordas
13) Labor Force	Highly available, but skills not unknown.	Available from surrounding areas in terms of number and skills.	Available from surrounding areas in terms of number and skills.
14) Environment	Surrounded by agricultural and livestock farming areas. Mostly undeveloped. Adjacent to Santo Domingo Airport, and design consideration may be needed to avoid disturbance with air traffic	Reserved as industrial land. Typical undeveloped savanna.	Reserved as industrial land. Subdivision mostly completed.
15) Other Industries	Primitive coke ovens, small-scale cement and ceramic factories.	Near a petrochemical complex, a cement mill, a beer brewery, and numerous oil drilling and loading facilities.	Near a steel mill, aluminum smelting works, ferro-silicon plant, and power plant.
Maintenance Services	Not available locally, requiring own maintenance shop.	Maintenance shops for the above facilities are available.	Maintenance shops for the above facilities are available.

Table-5 SCALE MERIT STUDY

	Unit Condition	Unit Cost	Case 1 Domestic Coal 30$/t-coal Improted Coal 60$/t-coal		Case 2 Domestic Coal 30$/t-coal Improted Coal 60$/t-coal		Case 3 Domestic Coal 30$/t-coal	
Production	ton-dry/Y		1,000,000		600,000		1,000,000	
Charging Coal	ton-dry/Y		1,332,000		827,000		1,395,000	
	ton-wet/Y (moisture=9%)		1,464,000		909,000		1,533,000	
Consumption								
Domestic	ton-wet/Y (moisture=9%)	30$/ton-wet	520,000	35.5%	520,000	57.2%	1,533,000	100.0%
Import	ton-wet/Y (moisture=9%)	60$/ton-wet	944,000	64.5%	389,000	42.8%	0	0.0%
Volatile Matter	[%]		26.39		29.36		30.38	
Cokes Production Rate	[%]		75.06		72.57		71.71	
VARIABLE COST			Unit ¥1,000	¥/t-coke	Unit ¥1,000	¥/t-coke	Unit ¥1,000	¥/t-coke
Raw Coal Domestic	ton-wet/Y (moisture=9%)	3,150¥/ton-wet	1,638,000	1,638	1,638,000	2,730	4,828,950	4,829
Import	ton-wet/Y (moisture=9%)	6,300¥/ton-wet	5,947,200	5,947	2,450,700	4,085	0	0
Total			7,585,200	7,585	4,088,700	6,815	4,828,950	4,829
Fuel Gas	NG =3.50Bs/Nm3	1.58¥/Nm3-COG	314,183	314	188,510	314	314,183	314
	(11,000kcal/Nm3)							
	COG=1.43Bs/Nm3							
	(4,500kcal/Nm3)							
	198.85Nm3-COG/t-coke	(45% of produced)						
Electricity	2.28Bs/kwh	2.52¥/kwh	154,526	155	92,716	155	154,526	155
	61.32kwh/t-coke							
	7,000kw							
Industrial Water	2.75Bs/m3	3.04¥/m3	10,427	10	6,256	10	10,427	10
	3.43m3/t-coke							
Chemical/Other			150,000	150	90,000	150	150,000	150
Sub-total				8,214		7,444		5,458
FIXED COST								
Labor Cost	No. of Labor 700	15,000¥/ /M	126,000	126	126,000	210	126,000	126
Depreciation	100mil.t Investment:	60,000mil.¥	5,400,000	5,400	3,974,490	6,624	5,400,000	5,400
		0.6 exponential						
	10 Year Depreciation	10 years						
Maintenance	3.0% of Equip. Cost	3.0%	1,800,000	1,800	1,324,839	2,208	1,800,000	1,800
Basic Electricity	230Bs/kVA/Month	254.21¥/kVA	21,354	21	12,812	21	21,354	21
Others Cost			200,000	200	200,000	333	200,000	200
Sub-total				7,547		9,396		7,547
BY-PRODUCT								
COG	NG =3.50Bs/Nm3	1.58¥/Nm3-COG	697,570	-698	418,542	-698	697,570	-698
	(11,000kcal/Nm3)							
	COG=1.43Bs/Nm3							
	(4,500kcal/Nm3)							
	441.5Nm3-COG/t-coke							
Coarse Tar	30kg/t-dry coal	11,000¥/ton	439,560	-440	272,910	-455	460,350	-460
Coarse Light Oil	10kg/t-dry coal	22,000¥/ton	293,040	-293	181,940	-303	306,900	-307
Ammonia Sulfide	11.64kg/t-dry coal	12,000¥/ton	186,054	-186	115,515	-193	194,854	-195
Sub-total				-1,617		-1,649		-1,660
Total				14,144		15,191		11,345
Interest	10% (Avr. 5%)	5%	3,000,000	3,000	2,208,050	3,680	3,000,000	3,000
Grand Total	¥/ton-dry coke			17,144		18,871		14,345
	$/ton-dry coke			163.28		179.72		136.62

Exchange Rate: $1=105Yen
$1=95Bs.

Table-6 CALCULATION OF MINIMUM PROPORTION FOR IMPORTED COAL

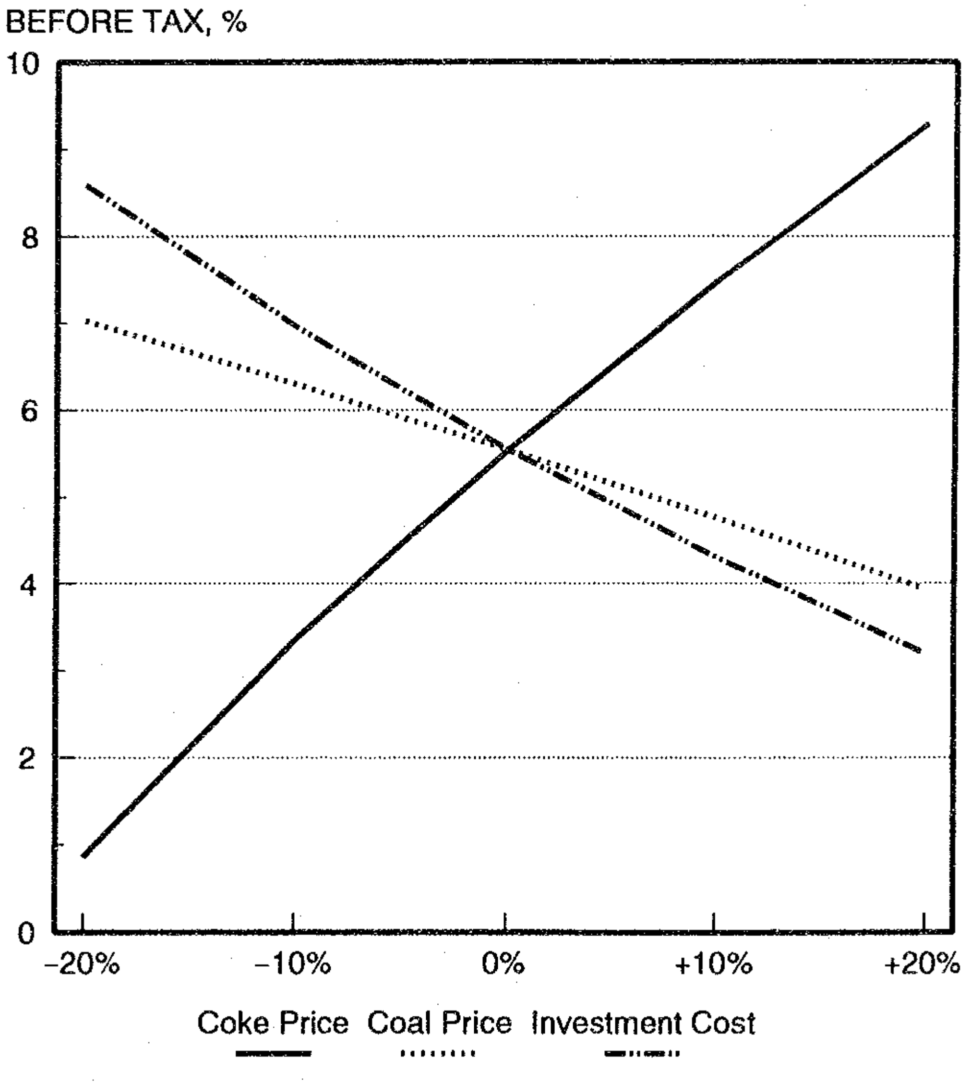
	Coal Blend No.	1	2	3	4	5	6	7
Blending Ratio of Coal(%)	FNO (Venezuela)	12	9	8	6	5	5	5
	LAS (Venezuela)	69	54	46	39	31	27	27
	Boyaca (Colombia)	9	7	6	5	4	3	3
	Pinnacle (U.S.)	4	12	16	20	24	25	
	Blue Creek (U.S.)	6	18	24	30	36	40	40
	Saraji (Australia)							25
Properties of Coal Charge	Ash (%, d.)	5.1	5.6	5.9	6.2	6.5	6.6	7.9
	Volatile Matter (%, d.)	33.1	30.6	29.4	28.2	26.9	26.4	26.9
	Total Sulfur (%, d.)	0.68	0.71	0.72	0.74	0.75	0.76	0.71
	Total Dilation (%)	175	172	170	169	167	168	173
	Max. Fluidity (log DDPM)	3.52	3.27	3.15	3.03	2.90	2.88	3.15
	SI	3.77	4.19	4.40	4.60	4.82	4.84	4.81
	CBI	1.58	1.81	1.93	2.04	2.16	2.16	1.64
	°CSR	49	50	51	51	52	52	59
Coke Quality	Ash (%, d.)	8.2	8.4	8.5	8.7	8.8	8.9	10.4
	Total Sulfur (%, d.)	0.60	0.62	0.63	0.65	0.66	0.66	0.63
	TI25	60	61	62	63	63	63	64
	CSR	56	57	58	58	58	59	62
Coke Production (ten thousand tons)		37	48	57	69	88	101	101

Table-7 COMPARISON SUMMARY ON COKE PLANT PROJECT

	Case		Base Case	Alt. Case
	Coke production	(tons/year)	1,000,000	1,000,000
	Coke yield	(%)	75.06	74.30
	Coal blending ratio			
	– Domestic coal	(%)	32.00	80.00
	– Imported coal (Boyaca)	(%)	3.00	20.00
	– Imported coal (U.S.A)	(%)	65.00	–
	B.F. coke sales volume for export	(tons/year)	850,000	850,000
1)	Capital Investment Cost	(million dollars)	661.76	656.62
2)	Financing Plan	(million dollars)		
	Equity	(30%)	198.53	196.99
	Long–term loans	(70%)	463.23	459.63
	Total		661.76	656.62
3)	Major Assumptions for Plant Operation			
	Sales prices for export	(FOB)		
	– B.F. cokes	($/ton)	120.0	120.0
	– Coke breeze	($/ton)	40.0	40.0
	Coal for coke making	(CIF, Dry base)		
	– Domestic coals	($/ton)	26.37	26.37
	– Imported coals (Boyaca)	($/ton)	43.96	43.96
	– Imported coals (U.S.A)	($/ton)	65.93	65.93
	Operating staff		700	700
	Service life on depreciation		20	20
	Interest rate on loan	(%)	5.0	5.0
	Repayment period		20	20
4)	Results of Financial/Economic Analysis			
	Financial internal rate of return(FIRR)	(before tax, %)	▲1.37	5.54
		(after tax, %)	▲1.37	4.95
	Debt service ratio	(DSR)		
	– 1st year of operation		0.42	0.87
	– 2nd year of operation		0.52	1.20
	– 3rd year of operation		0.53	1.26
	Average production cost	(per B.F. cokes, $/tons)		
	– Cost not including depreciation and interest		89.23	54.01
	– Cost including depreciation and interest		153.63	106.56
	Sensitivity analysis on FIRR	(before tax, %)		
	– Sales price including Breeze	(up 20%)	3.82	9.29
	– Coal prices	(down 20%)	2.20	7.03
	– Investment cost	(down 20%)	1.24	8.59
	Economic internal rate of return	(EIRR, %)	▲0.58	6.27
	Foreign currency earnings	(million, dollars)		
	– Whole project life		211.57	1,149.35

Note: Exchange rate: $1 = 115 yen = 95Bs
Pricing lebel: US$ in terms of fixed price in 1993
Project life: 23 years including 3 years of construction

Fig-1 **SENSITIVITY ANALYSIS OF FIRR ON INVESTMENT FOR COKE PLAN PROJECT, VENEZUELA (ALTERNATIVE)**



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