10.4 SITE SELECTION ECONOMICS

The U.S. Gulf Coast (USGC) investment costs for the selected "short term" and "long term" technology cases need to be converted into Venezuelan site-specific investment costs. The available infrastructure, gas prices and other factors will significantly influence the project economics. The conversion factors developed will be used to select a suitable site for both "short term" and "long term" projects.

10.4.1 TIC Site Conversion Factor

Raytheon has experience and in-house data to develop cost estimates for large projects in Venezuela. The following bases and methodology were developed by Raytheon, and agreed to by PDVSA, for converting USGC investment cost (4th Quarter, 1999) to Jose, Güiria and Anaco.

Conversion Plant Model

Actual plant costs of similar complexity and type of equipment were used to break the capital costs down into enough detail to make adjustments to elements that affect the TIC of a plant in different locations. These elements are listed below:

- Split between process equipment and bulk materials purchased in country, or imported.
- Development of an "All-in" craft rate to include indirect costs.
- Generic craft productivity multiplier for Venezuela.
- Site craft productivity multipliers for each site.
- Inland freight.
- Ocean freight.
- Import duties
- Local, municipal taxes.

- Engineering split local in country versus offshore.
- Engineering productivity multiplier.
- Engineering rates, local versus offshore.
- Design criteria that affect costs.
- Cost adders specific to the plant site.

Basis and Methodology

Process Equipment – Based on the type of equipment in a GTL plant, Raytheon's in-house data, and discussions with PDVSA, it was assumed that 25% of the costs arose from domestic purchases and 75% from offshore purchases. Based on Raytheon's extensive experience on recent Venezuelan projects, 10% was added to the locally purchased items, indicating it would be more costly than USGC pricing. This was applicable to each site.

Bulk Materials – The costs were split 50% locally purchased and 50% imported, based on in-house data and discussions with PDVSA. 10% was added to the locally purchased items, indicating it would be more costly than USGC pricing. This was applicable to each site.

Craft Labor Rates – An "All-in" craft labor rate was provided for each of the (3) locations by PDVSA. This agreed with Raytheon's in-house data.

- Jose = $20.50 per hour.
- Anaco= $24.60 per hour.
- Güiria = $30.80 per hour

Craft Productivity – A multiplier of 2.5 x USGC was used and adjusted for each location as agreed during discussions with PDVSA as follows:

- Jose = 1.00 X 2.50 = 2.50
- Anaco= 1.10 X 2.50 = 2.75
- Güiria = 1.20 X 2.50 = 3.00

Inland Freight – 3% was used for all sites except Anaco, where 3.5% was used due to its inland location and old, bad roads to the plant.

Ocean Freight – 10% was applied to all imported material costs.

Import duties – 10% was applied to all imported material costs.

Local/Municipal Taxes - 2% was applied to the TIC.

VAT – Value Added Taxes were excluded. It was agreed with PDVSA that this was difficult to calculate due to variable exclusions and potential government concessions not known at this time.

Detailed Engineering – A 60% local and 40% offshore split was agreed to with PDVSA for the model. Local productivity was adjusted by a multiplier of 2.50 x USGC with an "All-in" wage rate of $45.00 per hour. An "All-in" offshore engineering rate of $90.00 per hour was used.

Note: Regardless of the split, the cost is nearly equivalent to USGC when productivity and wage rates are taken into consideration.

Adjustments to the overall multipliers – An adjustment to the civil and structural accounts were made due to the soils and seismic zones that affect the plant design quantities and cost. Seismic zones of 6 (Jose), 7 (Güiria) and 5 (Anaco) were used for each site, adjusted for soil data.

- The Jose soils report indicates spread footings.
- The Anaco soils report indicates wider use of deep foundations and piling for most moderate to heavy load structures. A 30% adder (to USGC) for the civil and structural accounts was allowed following discussions with Raytheon's engineering group.
- Güiria soils report indicates heavy terracing, which would then allow most structures to be supported on shallow foundations, with deep foundations or piling only for very heavy structures. A 30% adder (to USGC) for the civil and structural accounts was allowed following discussions with Raytheon's engineering group.

Site Specific Multipliers – Based on the information stated above, the following multipliers were developed.

- Jose = 1.20 x USGC
- Anaco = 1.32 x USGC
- Güiria A = 1.47 x USGC (No LNG plant at Güiria)
- Güiria B = 1.33 x USGC (LNG plant already constructed)

The licensing fee was kept constant for all the sites. A factor of 1.2 was applied to the catalyst & chemicals cost for all the sites when compared to the USGC cost.

Adders to estimate – Costs for the following are direct adders to the estimate and are not part of the conversion Multipliers listed above.

- The Anaco site appears to require:
  - Approximately 70 miles of road upgrades ($2,030,000).
  - Deep water well ($500,000).
  - The existing San Joaquin Extraction Plant is fed from two on-site 20 MW gas turbine generators, supplemented by a 69 kV feeder from the Mapire substation near Anaco. The estimate allows for a 5-mile transmission line to feed the Anaco plant, along with new switchgear to provide start-up power ($400,000).
- The Güiria site appears to require:
  - Deep water well ($500,000).
  - Presently, there is a limited supply of electric power in the area. It is assumed that the two planned plants (TAP and LNG) will bring in enough power to provide startup power for the GTL plant. An allowance of $500,000 has been included for a transmission line and switchgear to provide this startup power to the plant.

PDVSA

Güiria Site "B" – Alternate Multiplier and Cost adders

The Guiria plant has potential savings from the TAP and LNG projects. There is the opportunity for site synergy regarding craft labor supply, craft skills, camps and water, if the TAP and LNG plants are built prior to the GTL plant. In this case "B", the costs reflect this potential synergy.

PDVSA

CONVERSION MODEL - USGC TO VENEZUELA

	USGC Site		Jose Site			Anaco Site			Guiria Site - A			Guiria Site - B		
	USGC Basis	1999 USGC $	Venezuelan Basis	Mat'l Factor	Jose Venz $	Venez Basis	Mat's Factor	Jose Venz $	Venez Basis	Mat's Factor	Jose Venz $	Venez Basis	Mat's Factor	Jose Venz $
Process Equipment		$18,259,345			$18,715,829			$18,715,829			$18,715,829			$18,715,829
- Local	100%	$18,259,345	25%	1.10	$5,021,320	25%	1.10	$5,021,320	25%	1.10	$5,021,320	25%	1.10	$5,021,320
- Imported	0%	$0	75%	1.00	$13,694,509	75%	1.00	$13,694,509	75%	1.00	$13,694,509	75%	1.0	$13,694,509
Bulk Material		$20,326,046			$21,342,348			$21,342,348			$21,342,348			$21,342,348
- Local	100%	$20,326,046	50%	1.10	$11,179,325	50%	1.10	$11,179,325	50%	1.10	$11,179,325	50%	1.10	$11,179,325
- Imported	0%	$0	50%	1.00	$10,163,023	50%	1.00	$10,163,023	50%	1.00	$10,163,023	50%	1.00	$10,163,023
Craft Labor		$22,828,224			$29,248,663			$38,608,235			$52,733,199			$40,363,154
- Hours	570,706		1,426,764			1,569,440			1,712,117			1,640,779		
- "All-In" S/C Rate	$40.00		$20.60			$24.60			$30.80			$24.60		
- Craft Productivity	1.00		2.50			2.75			3.00			2.68		
- Site Specific Multiplier	1.00		1.00			1.10			1.20			1.15		
Construction Indirects	In Rate	$0	In Rate		In Rate	In Rate		In Rate	In Rate		In Rate	In Rate		In Rate
Inland Freight	3.0%	$1,157,662	3.0%		$1,201,745	3.5%		$1,402,036	3.0%		$1,201,745	3.0%		$1,201,745
Ocean Freight		$0			$2,385,753			$2,385,753			$2,385,753			$2,385,753
- Local	0%		0%			0%			0%			0%		
- Imported	0%		10%			10%			10%			10%		
Import Duties		$0			$2,385,753			$2,385,753			$2,385,753			$2,385,753
- Local	0%		0%			0%			0%			0%		
- Imported	0%		10%			10%			10%			10%		
Local/Provincial Taxes	2.00%	$1,740,000	2.00%		$2,000,000	2.00%		$2,260,000	2.00%		$2,000,000	2.00%		$2,000,000
VAT (Eclided)	0.00%	$0	0.00%		$0	0.00%		$0	0.00%		$0	0.00%		$0
Engineering														
Local:	100%	$22,244,798	60%			60%			60%			60%		
- Manhours	247,164		370,747		$16,683,599	370,747		$16,683,599	370,747		$16,683,599	370,747		$16,683,599
- "All-In" Rate	$90		$45			$45			$45			$45		
- Productivity	1.00		2.50			2.50			2.50			2.50		
Imported	0%		40%			40%			40%			40%		
- Manhours	-	$0	98,866		$8,897,919	98,866		$8,897,919	98,866		$8,897,919	98,866		$8,897,919
- "All-In" Rate	$45		$90			$90			$90			$90		
- Productivity	2.50		1.00			1.00			1.00			1.00		
Profit/Fee	0.00%	$0	0.00%		$0	0.00%		$0	0.00%		$0	0.00%		$0
Contingency	0.00%	$0	0.00%		$0	0.00%		$0	0.00%		$0	0.00%		$0
		$86,555,975			$102,862,000			$112,681,000			$126,346,000			$113,976,000
Adjustment to Multiplier			ADD:			ADD:			ADD:			ADD:		
- Earthquake Zone:	Zone 0		Zone 6			Zone 6			Zone 7			Zone 7		
- Civil/Structure Design	0%	$0	15%	Civil/Str	$800,000	30%	Civil/Str	$1,601,000	20%	Civil/Str	$1,067,000	20%	Civil/Str	$1,067,000
Total =		$86,555,975	Total =		$103,662,000	Total =		$114,282,000	Total =		$127,413,000	Total =		$115,043,000
USGC to Venezuela Site Specific Multipliers →			USGC Multiplier x		1.20	USGC Multiplier x		1.32	USGC Multiplier x		1.47	USGC Multiplier x		1.33
									Note: Assumes no existing Plant			Note: Assumes existing Plant		
Adders to Estimate:														
- Road Prepares/Widening				0 Miles	N/A		70 Miles	$2,030,000		0 Miles	N/A		0 Miles	N/A
- Bridges				Allow	N/A		Ea	N/A		Ea	N/A		Ea	N/A
- 500' deep water well (Allow)				LOT	N/A		LOT	$500,000		LOT	$500,000		LOT	N/A
- Major Electrical (Pole line/Switchgear)				LOT	N/A		LOT	$400,000		LOT	$500,000		LOT	$500,000
- Utility Pipe				LF	N/A		LF	N/A		LF	N/A		LF	N/A
Total Adders to Estimate:			Total =		$0	Total =		$2,930,000	Total =		$1,000,000	Total =		$500,000

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10.4.2 "Short Term" Case

PDVSA pre-selected three sites namely, Jose, Güiria and Anaco for consideration. Based on the site study (See Section 6.0), Jose was the only site selected for the "short term" project.

It is expected that the site selection economics will be independent of the technologies selected for the GTL plant. Raytheon has opted to use Sasol's data to convert to Jose location using **RAYSPONSE™—GTL** model. The following is a summary of preliminary economic results for the selected "short term" case on a USGC and Jose basis:

Description	No Lube USGC - TIC	No Lube Jose	Lube Jose
TIC, MM $ - Gulf Coast	395	466	**516**
IRR, %	14.5	12.3	**16.5 ***

* Here it should be noted that the 16.5 % IRR estimated is based on lube production from the first year and other simplified economic parameters. The IRR reported in Section 10.5 would somewhat decrease for the proposed strategy cases.

As expected, TIC increased for the Jose location when compared to the US Gulf Coast TIC. Correspondingly, the IRR decreased to 12.3%. As summarized in the Marketing Study, initially there is no demand for lube base oils. However, the market demand increases with time. In order to evaluate the impact of lube production on the project economics, another case was run. An additional investment of $ 50 MM was estimated to add a Hydroisomerization unit and the required utilities and offsites for this case. However, the IRR increased to 16.5%, clearly indicating the benefit of lube production on the project economics. VHVI Lube Production in the "short term" case needs a strategic decision by PDVSA, even though the market analysis indicates no demand due to the current situation of high consumption of monograde lubes in Venezuela and South America.

The estimated IRR for the Jose site did not take credit for any benefits from possible synergies.

10.4.3 "Long Term" Case

PDVSA pre-selected Jose, Anaco and Güiria to be considered for the "long term" GTL project. In this section we develop and compare the economics of building a "long term" GTL project in each of the three sites in order to recommend a single site to build the GTL plant.

The TIC site conversion factors developed in Section 10.4.1 were input into the **RAYSPONSE™—GTL** model. The model was run to determine the project economics for each of the three sites. The results are summarized in Table 10.3.

Jose

As expected, the TIC of the GTL plant increased ($ 1,309 MM) when compared to that estimated on the USGC basis ($ 1,095 MM). An IRR of 18.2% was estimated for this case.

The estimated IRR for the Jose site did not take credit for any benefits resulting from possible synergies. A list of potential synergies for the Jose site is provided in Section 6.0.

Anaco

The main advantage of Anaco, when compared to Jose, is its lower natural gas price (0.5 $/MMBTU compared to $0.6/MMBTU at Jose). PDVSA indicated that Anaco could also sell nitrogen, produced as a byproduct in the air separation plant, for reinjection use. In the Jose area, with numerous new and potential projects, the nitrogen could be sold as well. For the purpose of comparison, the value of nitrogen is not added for both Jose and Anaco cases.

Anaco has three major disadvantages when compared to Jose:

- Due to its inland location, additional freight cost will be incurred to bring equipment to the location.
- Lack of means for product disposition (such as pipeline or waterways, etc.). Requires additional TIC.

- Lack of make-up water. Additional air coolers would be required to minimize water usage. This would increase the plot space required and the TIC.

Production of syncrude in Anaco was considered, but discarded, due to high estimated pour point of the syncrude. A full GTL plant case was run using the **RAYSPONSE™—GTL** model based on the feed and product prices estimated for Anaco (Section 7.0). A TIC allowance of $ 50 MM was added to account for the above mentioned disadvantages. Raytheon estimated a TIC of $ 1,458 MM and an IRR of 17.0% for this case. This represents an increase in TIC of about $150 MM and a decrease in IRR of about 1.2%.

Güiria

Guiria has many disadvantages when compared to Jose and Anaco:

- Lack of infrastructure.
- Higher natural gas price ($ 1.0/MMBTU).

The following two cases were run for the Güiria location:

Güiria A: The proposed LNG plant was not built before the GTL project begins.

Güiria B: The LNG plant was built, and hence these two projects are vertically integrated, benefiting the GTL project.

The investment required for the Güiria-A case is very high ($ 1,583 MM) and the IRR is very low (12 to 14 %) when compared to the Jose case. The Güiria-B case, due to vertical integration with the LNG project, has significantly lower TIC ($ 1,442 MM) when compared to the Güiria-A case. However, the IRR is 4 to 5% less when compared to that estimated for the Jose case. This is mainly due to the higher natural gas price at this location.

Recommendation

It is found that the "long term" project would be economically feasible in all three locations. However, locating the GTL plant at Jose has economic advantages over the other two sites as clearly shown in the economic analyses summarized

in Table 10-3. IRR will improve more significantly at the Jose site, due to wider synergy possibilities than at Anaco and Güiria. Due to this reason, it is **recommended that the "long term" GTL plant be situated in Jose.** If for any reason, Jose is ruled out as the possible site, consideration should be given to Anaco as the alternate site for the "long term" GTL plant. In all cases a full GTL plant with lube production is recommended.

Table 10-4 summarizes the economic analyses for the recommended "long term" base case.

Table 10-3

Site Selection - "Long Term" Case (With Lube)

DESCRIPTION	Jose	Anaco [2]		Güiria - A [3]		Güiria - B [4]		USGC
		Case 1	Case 2	No LNG Plant		LNG Plant Built		
Natural Gas $/MMBTU	0.6	0.5	0.9	1.0	0.8	1.0	0.8	0.6
Total Installed Cost [1] MM$	1,309	1,458	1,458	1,583	1,583	1,442	1,442	1,095
Gross Revenue MM$	367	379	312	295	329	295	329	367
Projected IRR [4] %	18.2	17.0	14.2	12.4	13.8	13.6	15.1	21.3
Total Liquid Yield BBL/Day	50,900	50,900	50,900	50,900	50,900	50,900	50,900	50,900
TIC in $/BBL	25,700	28,640	28,640	31,100	31,100	28,330	28,330	21,510

[1] Total Installed Cost includes initial charge of catalyst and license fee.

[2] Assumes minimization of make-up water requirement. An allowance of 50 MM$ is included in the TIC to account for:

- Additional Air Coolers.
- Product pipelines or shipping.

[3] If the proposed LNG plant is not built before the GTL plant, additional TIC is expected due to the lack of infrastructure.

[4] If the GTL plant is vertically integrated with the proposed LNG plant, TIC of the GTL plant is expected to decrease. This is because infrastructure would be in place before the construction of the GTL plant.

Table 10-4

"Long Term" Base Case

Description	Sasol	PDVSA/Intevep	HYBRID [1]
Location	**Jose**	**Jose**	**Jose**
Total Installed Cost, MM$	1,309	1,255	**1,291**
Gross Revenue [2], MM$	367	385	**367**
Projected IRR, %	18.2	19.7	**18.5**

[1] The "Long Term" case will have three Fischer-Tropsch reactor trains. Since the economics of Sasol and PDVSA/Intevep cases are nearly the same (within the accuracy of the study), a hybrid GTL plant consisting of two trains of Sasol F-T reactors and one train of PDVSA/Intevep F-T reactor is considered as the base case.

[2] Gross Revenue of the hybrid GTL plant is kept same as that of the Sasol.

10.5 RISK AND SENSITIVITY ANALYSIS

10.5.1 Methodology

The recommended cases are analyzed in detail to determine the impact of certain key variables on the profitability of the project. To determine how these variables affect the project, a pro-forma economics spreadsheet is modeled for each case. The analysis performed contemplates two components: risk and sensitivity.

Risk analysis is useful to quantify the probability of a certain outcome when all the input variables are varying. To evaluate this Palisade's @Risk software was used, and each variable is modeled with a probability distribution that reflects the historical variation for that parameter.

Sensitivity analysis allows measuring the impact that one variable has on the profitability (IRR) while all other parameters remain constant.

Each case will be analyzed using these methods.

Basis for Pro-Forma Economics

Tax Credit

The Venezuelan government has allowed for a 10% tax credit or exoneration on the total investment cost of the project. The credit is calculated over the investment minus depreciation of the first year in operation. The credit must be used to offset net income tax from the first three years of operation. Sensitivity analysis was performed both with and without taking a tax credit.

Depreciation

Depreciation is calculated as straight line over 10 years with no salvage value.

Project Life

The project was analyzed over a 20-year operation period, with no terminal value for continued operations.

Discount Rates

Three discount rates were used to estimate the Net Present Value of the investments. The selected discount rates were 8%, 10% and 15%.

Financing

The project is evaluated on 100% equity based financing.

Site Location

The estimated total investment cost is based on the Venezuelan site selected for each case. Scaling factors used for conversion of TIC to the Venezuelan basis is discussed earlier in section 10.4.1.

Key Variables and Probability Distributions

Crude Oil Price

All prices of conventional refinery products are directly linked with the price of crude oil. Due to the volatility in crude prices, it is difficult to predict the future prices of the GTL diesel and naphtha. The project feasibility is directly impacted by crude oil prices, and it is important to evaluate the associated risks to the project. The crude oil prices were modeled using a triangular distribution function that is bounded between a minimum price of $15 per barrel and a maximum of $25 per barrel.

Feed Natural Gas Cost

The prices of the feed natural gas to the GTL plant vary with location and time. The price was modeled using a Beta distribution.

Premium on GTL Diesel

The premium price for GTL diesel over conventional diesel averages $7 per barrel for the "short term" and is $4 for the "long term" case. This premium was obtained by calculating the amount of current production cutter stock and heating oil that can be upgraded to road diesel by blending with GTL diesel. This premium will vary between $5 - $9 per barrel for the "short term" (Venezuela case) and $0 - $7 per barrel for the "long term" case. A bounded triangular

distribution was used to model this factor for the short-term case, and a Beta distribution was used for the "long term" project.

Total Installed Cost

The investment costs obtained are estimated and are good for comparison of technologies on the same basis. When used to evaluate the feasibility of a project a TIC variation range is determined to perform risk analysis. The range used for the sensitivity and risk analysis for the TIC for each case is -15%, +20%. This range was estimated from the licensors confidence in their estimate, plus the confidence that Raytheon has in the site specific factors developed. This range is modeled using a Beta distribution.

Operating Cost

The range used for the sensitivity and risk analysis for the operating cost for each case is -10%, +10%. This range is modeled using a Beta distribution.

10.5.2 "Short Term" Case

For the "short term" case, Raytheon recommend two technology licensors be considered. Both Shell and Sasol technologies provide for optimal internal rate of returns and are technically mature to meet a "short term" schedule for a GTL plant. Little information was available for the Shell technology, so Raytheon has selected the Sasol case as the "short term" case on which to perform sensitivity analyses. This case contemplates the following technologies: Sasol's F-T reactor technology, Haldor Topsoe AutoThermal Reforming, and Chevron technology for the product work-up section ("Sasol Case"). These companies have an agreement to pursue GTL projects together (See Chapter 8, Technology Evaluation). Sasol has made it clear that their technology is available for licensing for diesel and naphtha production only. No specialty products (lube oils, waxes, etc.) can be produced under the current scope of the license. The Marketing Study performed for Venezuela reveals that by the year 2010, there will be a demand for Very High Viscosity Lubes. Adding a Hydroisomerization unit to produce lubes, when that market is realized, has a strong positive impact on the rate of return for the GTL plant.

The following table summarizes the differences in IRR between the GTL plant, with and without lube oil production, for the Jose site.

"Short Term" Case: Sasol	Without Lube Oil Production	With Lube Oil Production*
Internal Rate of Return	12.01%	14.05%
Total Installed Cost ($MM)	472	522

* When added to the facility after five years.

The sensitivity analysis performed for the "short term" case includes additional capital expenditure for lube oil production five years after start-up of the GTL facility. This case is not currently possible due to Sasol's requirement that no lubes be produced if their license is acquired, but the increase in return on investment is high enough to merit negotiations with them to include lube production in the scope of their license.

10.5.2.1 Risk Analysis

The parameters that were allowed to vary for the "short term" case and the ranges, between which these values could change, are summarized in Table 10-4.

Table 10-4

Parameter	Units	Base Value	Min. Value	Max. Value	Probability Distribution	Frequency
Crude Oil Prices	$/bbl	20	15	25	Triangular bounded	Year to Year
Feed Natural Gas Cost	$/MMBTU	.6	.5	.9	Beta bounded	One Time
Premium for GTL Diesel	$/bbl	7	5	9	Triangular bounded	One Time
Total Invest. Cost	MM$	487	414	584	Beta bounded	One Time
Operating Cost	MM$	29.5	26.5	32.4	Beta bounded	One Time

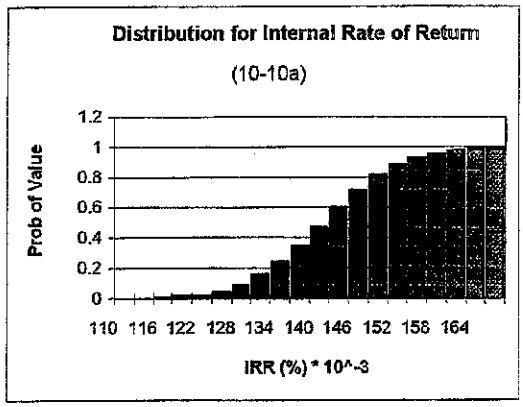
The resulting internal rate of return and net present values are summarized in

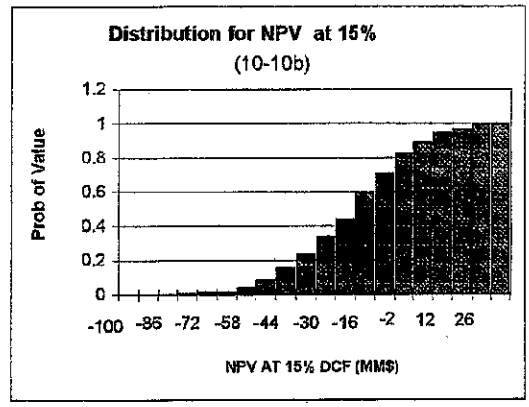
Table 10-5. Figures 10-10a-d represent the cumulative probability distribution for each parameter.

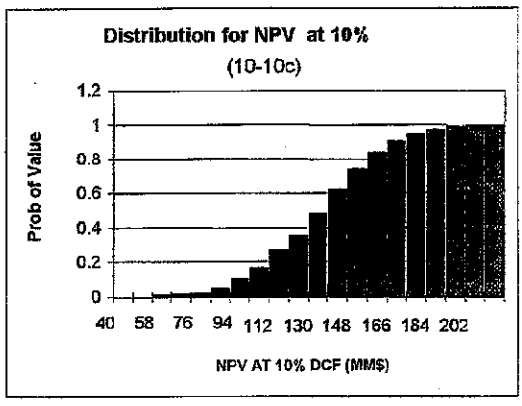
Table 10-5

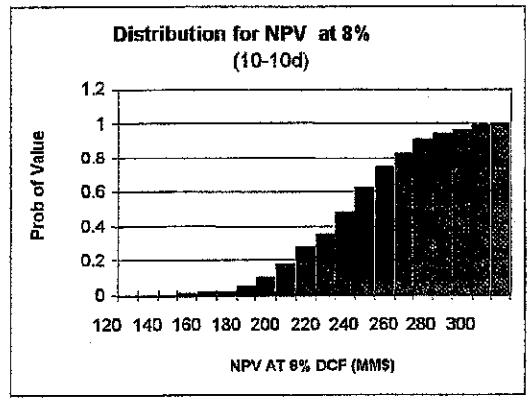
Parameter	Mean	Minimum Value	Maximum Value	Standard Deviation	Probability of Parameter
Internal Rate of Return (%)	14.05	11.4	16.7	0.01	>12.9% IRR >= 90%
Net Present Value @ 8% (MM $)	230	131	318	31	>188 NPV >= 90%
Net Present Value @ 10% (MM $)	130	48	206	27	> 93 NPV >= 90%
Net Present Value @ 15% (MM $)	-21	-88	35	21	>0 NPV <=1%

Fig. 10-10a-d





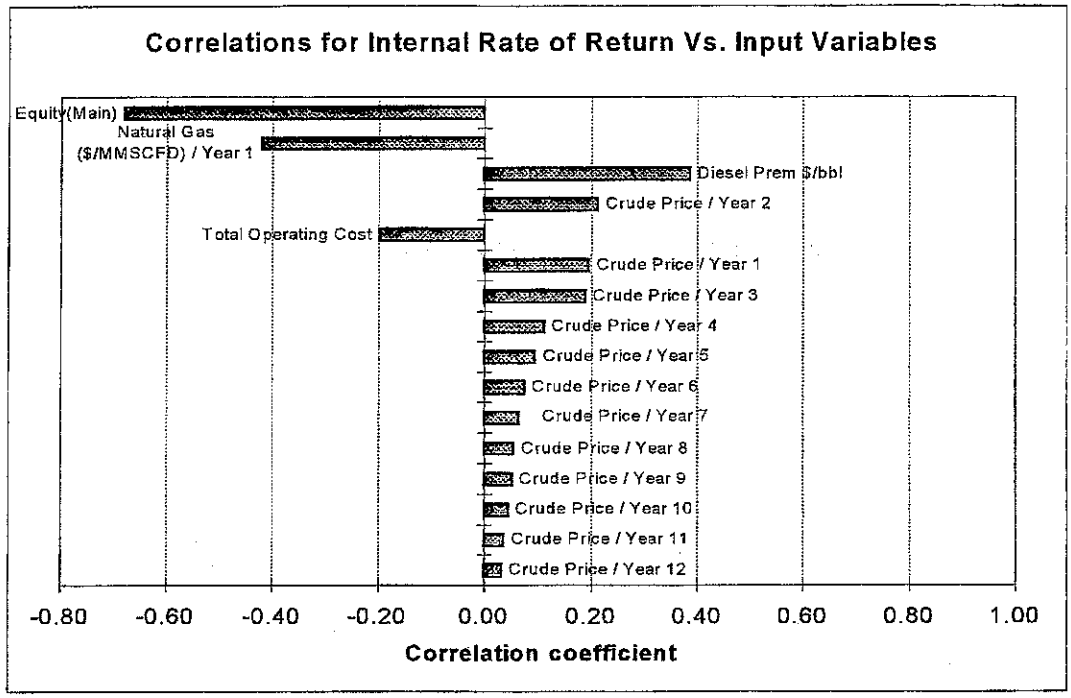




The results in Table 10-5 and figures 10-10a-d show that there is a 90 % probability this project would make more than 12.9% IRR.

Figure 10-11 describes the correlation between the input variables and the IRR. The variables are ranked in order of importance to the project profitability with the topmost variable having the biggest effect on IRR.

Fig. 10.11



The factor that has the strongest effect on the project profitability is the total investment cost (TIC). GTL plants are capital intensive, and since the pro-forma economics performed on the project assumes 100% equity based financing, variations in the TIC have a significant effect on the IRR.

The price of natural gas was found to be the second most important parameter that affects the viability of the project. The price of natural gas was allowed to vary once, at the beginning of the project.

The premium that can be realized for the GTL diesel is the third factor that affects the project. Diesel is the major product from a GTL plant, and the premium ranges between 20% and 45% of the average price of conventional diesel. It is important to note that the model assumes that the diesel premium remains constant for the entire project life. This means that a $1 change in the premium affects the entire project cash flow, and the premium is not modeled to vary independently each year.

The GTL product prices were allowed to vary from year to year. This was achieved by correlating the crude price to the GTL product prices (except N-Parrafin and Lube) and allowing the crude price to vary every year of the project. Since the first full year of production is the second year of the project (first year assumed to have only 75 % onstream factor), crude price in that year was the fourth most important parameter.

The operating cost was determined to be only the fifth most important factor.

10.5.2.2 Sensitivity Analysis

The following sensitivity cases were studied for the "short term" project. All the sensitivity studies were performed for plant TIC based on a Venezuelan basis.

- Case 1: Base case with 10% tax credit.
- Case 2: Base case + lube production with 10% tax credit.

Note: The base case mentioned here is the Sasol "short term" case with no lube production.

For all these cases, the effects of the following variables on project IRR were studied

a. Total Installed Cost (MM $).

From the Risk analysis, it was concluded that the Total Installed Cost (TIC) had the most significant effect on the project IRR. Figure 10-12 shows the sensitivity of the project IRR to the TIC of the project for the above mentioned cases. The sensitivity was performed for TIC values ranging from -15 to + 20 % of the base TIC.

b. Operating Cost (MM$)

Based on the risk analysis performed, it was determined that operating cost is a significant variable for the project IRR. Figure 10-13 indicates the sensitivity of IRR to the operating cost for the "short term" case. The operating cost was varied from –10 % to + 10 % of the base case.

c. Diesel Premium ($/bbl).

According to the Risk analysis the diesel premium was the third most important variable for the project IRR. Figure 10-14 shows the changes in IRR vs. the diesel premium price. The diesel price has an important effect on the economic feasibility of the project, as it is the product with the highest yield from the GTL plant.

d. West Texas Intermediate Crude Price ($/bbl).

As indicated in the marketing study, all the GTL product prices have been correlated to the West Texas Intermediate crude price. Therefore, the WTI crude price is an important parameter in the IRR sensitivity study. The WTI price was varied from $15/bbl to $25/bbl. Figure 10-15 shows the sensitivity of the project IRR to the WTI crude price.

e. Natural Gas Feed Price ($/MMBTU).

The natural gas feed cost represents about 20 percent of the product cost. Natural gas feed price ranked second in the risk analysis study, and hence very important for the profitability of the project. The natural gas feed cost was varied from $0.5/MMBTU to $0.9/MMBTU. Figure 10-16 shows the variation between the IRR and the Natural Gas Feed Price.

Fig. 10-12

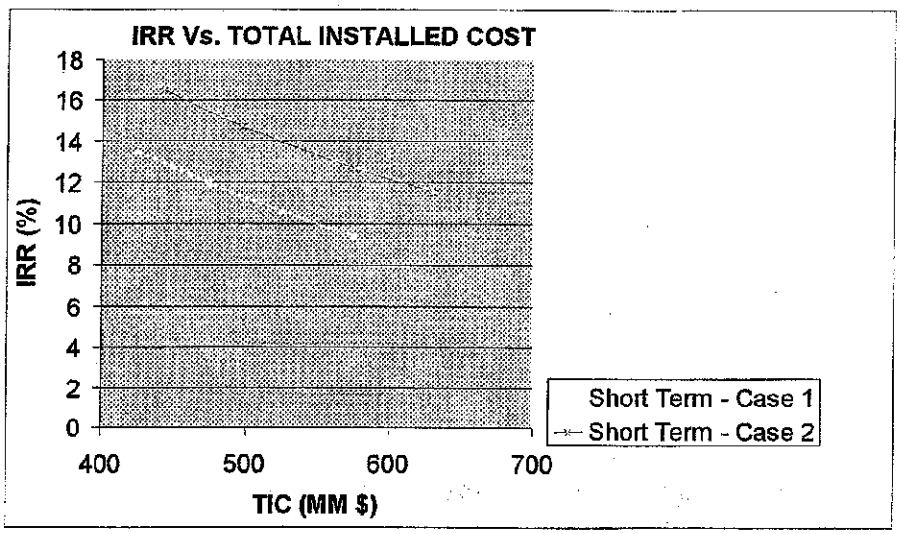


Fig. 10-13

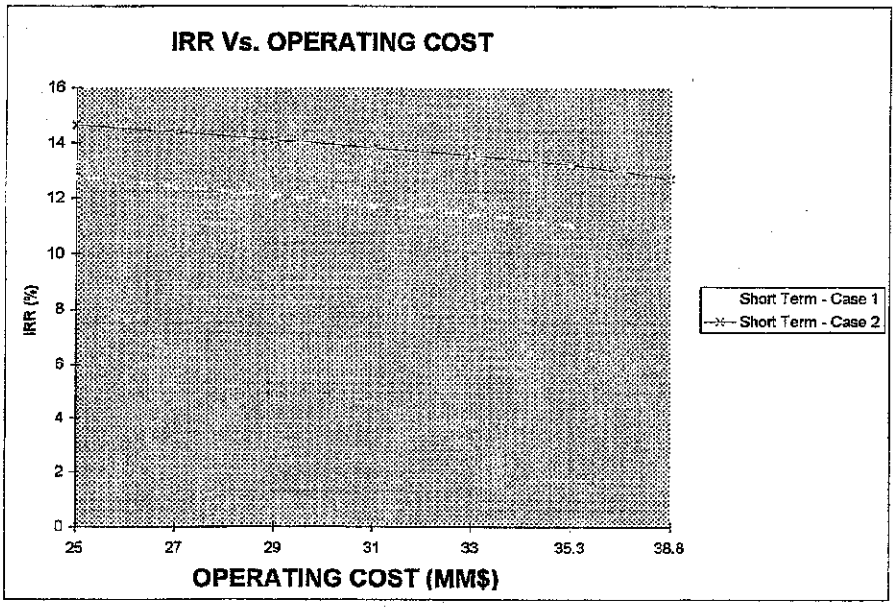


Fig. 10-14

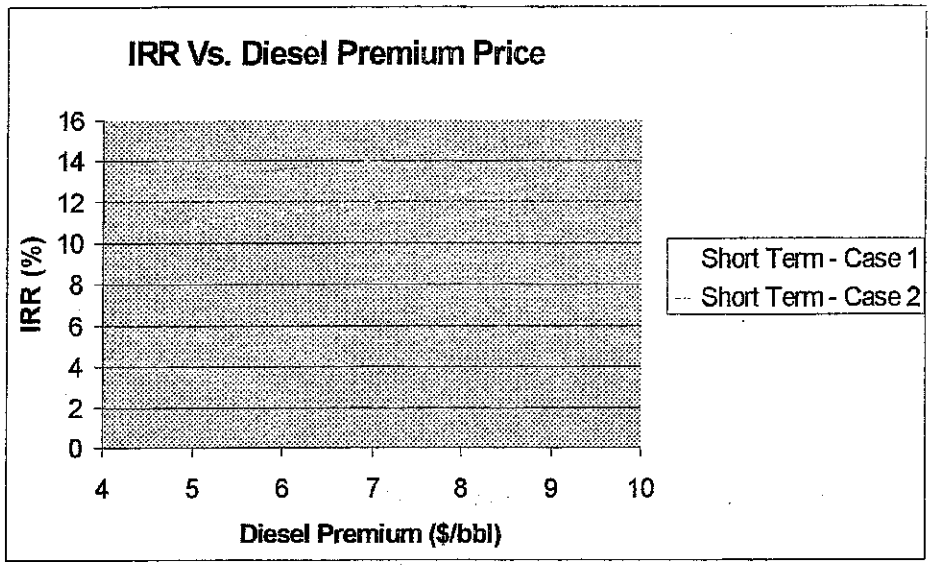


Fig. 10-15

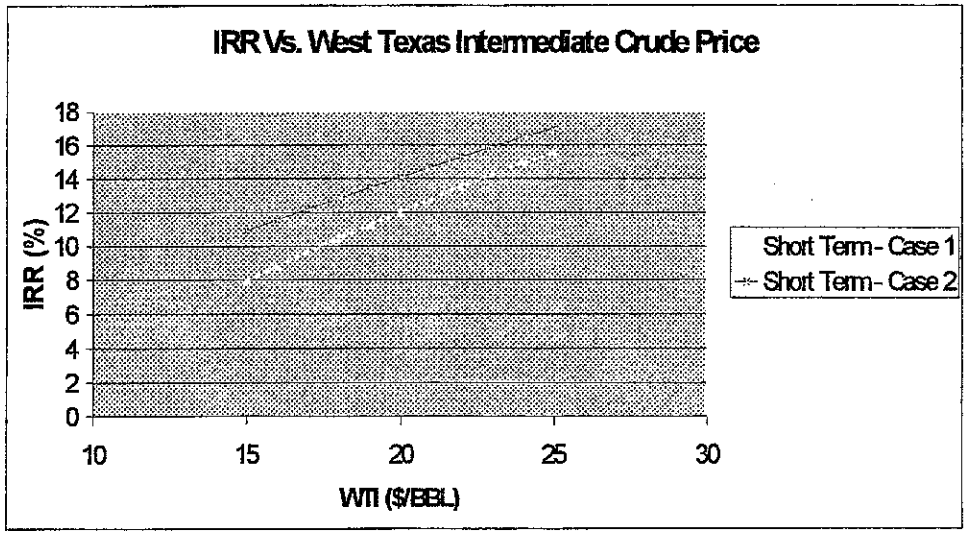
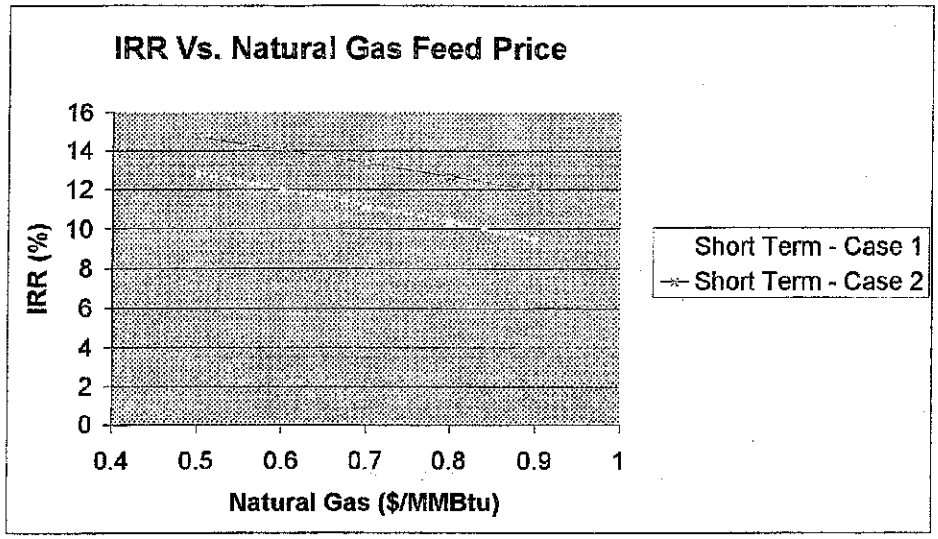


Fig. 10-16



10.5.2.3 "Short Term" Case Conclusions

The risk and sensitivity analysis performed for the "short term" case, and within the ranges of variation modeled, produce the following conclusions:

- There is a 90% chance of having an internal rate of return (IRR) of at least 12.9%.
- The project IRR is influenced strongly by the total investment cost and the diesel premium.
- The crude prices have an impact on the project IRR, but it is not as strong as the first two parameters.

The project is impacted the least by the cost of natural gas.

10.5.3 "Long Term" Case

This case contemplates the increased throughput and returns due to economies of scale. At the start-up of this larger GTL plant, there will be a market for Very High Viscosity Lubes in Venezuela, so it is strongly recommended as a product. Due to the increased throughput, three F-T reactor trains are required to process the natural gas. Raytheon recommends a "hybrid" technology license as the best option for the "long term" case. The "hybrid" case is the consequence of installing two Sasol F-T reactors and one Intevep reactor. The Intevep technology considered has potential, and due to the "long term" nature of the project, further refinement and development of the technology is possible. The "long term" GTL project considered could be where the first commercial scale plant is proven as a viable technology.

This case contemplates the following technologies: Sasol's F-T reactor technology for two reactors and Intevep's technology for one, Haldor Topsoe AutoThermal Reforming, and Chevron technology for the product work-up section ("Sasol Case"). Sasol has made it clear that their technology is available for licensing for diesel and naphtha production only. No specialty products (lube oils, waxes, etc.) can be produced under the current scope of the license. The Marketing Study performed for Venezuela reveals, that by 2010, there will be a demand for Very High Viscosity Lubes. Adding a Hydroisomerization unit to produce lubes has a strong positive impact on the rate of return for the GTL plant. This case is not currently possible due to Sasol's requirement that no lubes be produced if their license is acquired, but the increase in return on investment is high enough to merit negotiations with them to include lube production in the scope of their license.

The following table summarizes the differences in IRR between the GTL plant with and without lube oil production:

"Long Term" Case: Sasol	Without Lube Oil Production	With Lube Oil Production
Internal Rate of Return	14.5%	18.4%
Total Installed Cost ($MM)	1221	1291

The sensitivity analysis performed for the "long term" case includes additional capital expenditure for the lube oil production facility. This case is not currently possible due to Sasol's requirement that no lubes be produced if their license is acquired, but the increase in return on investment is high enough to merit negotiations with them to include lube production in the scope of their license.

10.5.3.1 Risk Analysis

The parameters that were allowed to vary for the "long term" case and the ranges, between which these values could change, are summarized in Table 10-6.

Table 10-6

Parameter	Units	Base Value	Min. Value	Max. Value	Probability Distribution	Frequency
Crude Oil Prices	$/bbl	20	15	25	Triangular bounded	Year to Year
Feed Natural Gas Cost	$/MMBTU	.6	.5	.9	Beta bounded	One Time
Premium for GTL Diesel	$/bbl	4	0	7	Beta bounded	One Time
Total Invest. Cost	MM$	1291	1097	1549	Beta bounded	One Time
Operating Cost (*)	MM$	72.5	65.3	79.8	Beta bounded	One Time

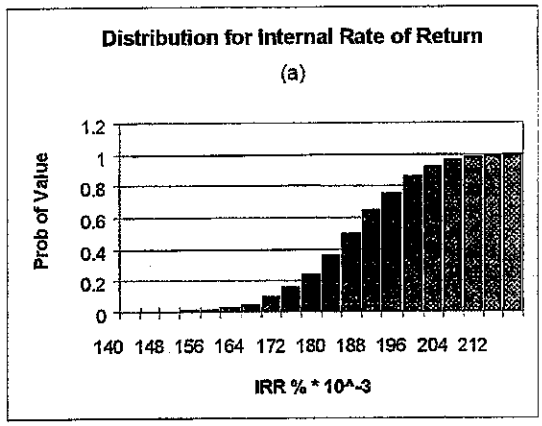
(*) Excludes Feed Costs.

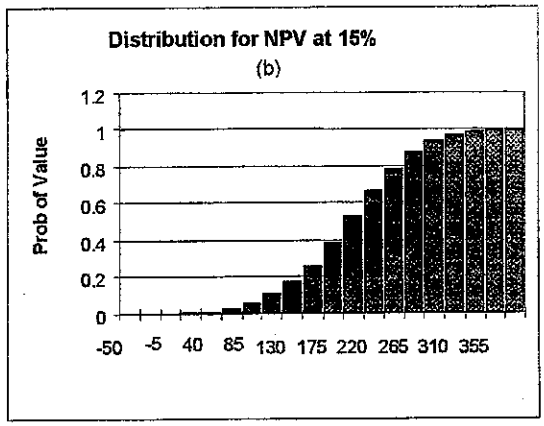
The resulting internal rate of return and net present values are summarized in Table 10-7. Figures 10-17a-d represent the cumulative probability distribution for each parameter.

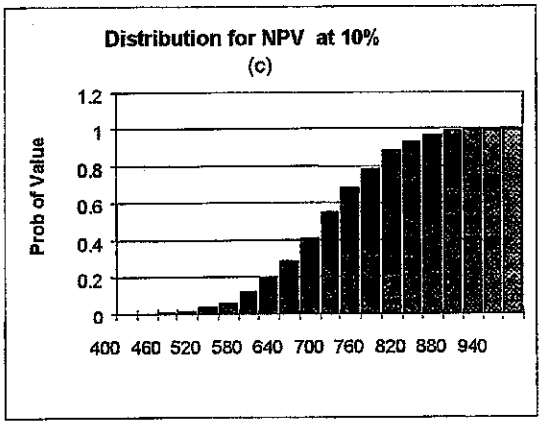
Table 10-7

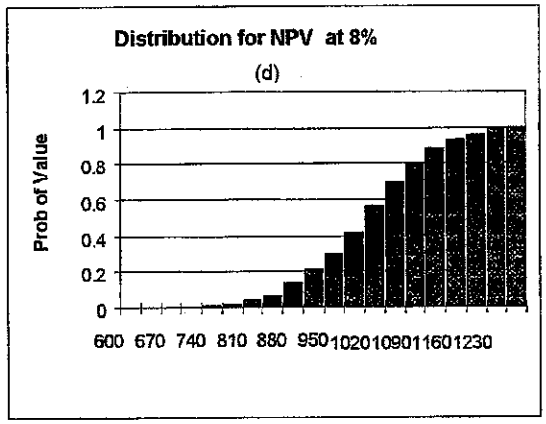
Parameter	Mean	Minimum Value	Maximum Value	Standard Deviation	Probability of Parameter
Internal Rate of Return (%)	18.4	14.6	21.8	0.01	>16.8% IRR >= 90%
Net Present Value @ 8% (MM $)	1003	667	1298	105	>868 NPV >= 90%
Net Present Value @ 10% (MM $)	688	403	940	89	>573 NPV >= 90%
Net Present Value @ 15% (MM $)	192	-26	373	64	>107 NPV >=90%

Fig. 10-17a-d





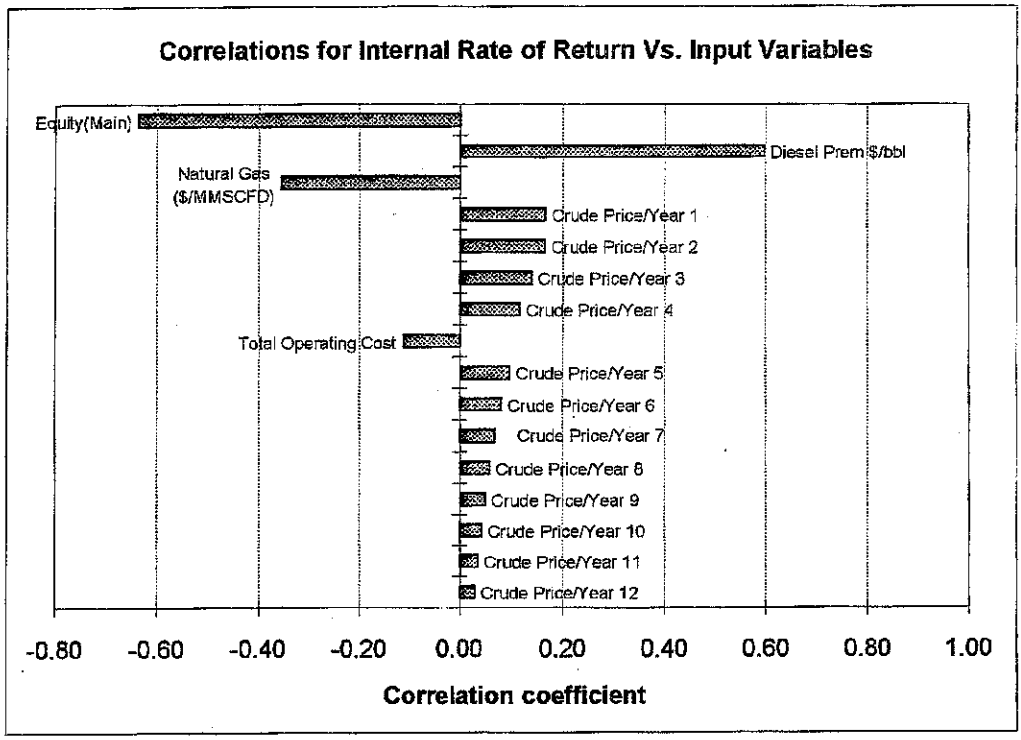




The results in Table 10-6 and figures 10-17a-d show that there is a high probability that the IRR for this project will be more than 16.8%.

Figure 10-18 describes the correlation between the input variables and the IRR. The variables are ranked in order of importance to the project profitability with the topmost variable having the biggest effect on IRR.

Fig. 10-18



The factor that has the strongest effect on the project profitability is the total investment cost (TIC). GTL plants are capital intensive, and since the pro-forma economics performed on the project assumes 100% equity based financing, variations in the TIC have a significant effect on the IRR.

The premium that can be realized for the GTL diesel is the next factor that affects the project. Diesel is the major product of a GTL plant, and the premium ranges between 0% and 30% of the average price of conventional diesel. It is important to note that the model assumes that the diesel premium remains constant for the entire project life. This means that a $1 change in the premium affects the entire project cash flow, and the premium is not modeled to vary independently each year.

The price of natural gas was found to be the third most important parameter that affects the viability of the project. The price of natural gas was allowed to vary once, at the beginning of the project.

Due to their importance, GTL product prices were allowed to vary from year to year. This was achieved by correlating the crude price to the GTL product prices (except N-Parrafin and Lube) and allowing the crude price to vary every year of the project. The crude prices of first through fourth year of the project follow the natural gas price in terms of importance.

The operating cost was determined to be only the eighth most important factor for the "long term" project (fifth most important for the "short term" project). The drop in importance when compared to the "short term" project is due to the decrease in operating cost (lower $/BBL of liquid product) as a result of larger size plant.

10.5.3.2 Sensitivity Analysis

The following sensitivity cases were studied for the "long term" project. All the sensitivity studies were performed for plant TIC based on a Venezuelan basis.

- Case 1: Base case with 10% tax credit.
- Case 2: Base case + lube production with 10% tax credit.

Note: The base case mentioned here is the Sasol/Intevep "long term" case with no lube production.

For all these cases, the effects of the following variables on project IRR were studied.

a. Total Installed Cost (MM $).

From the Risk analysis, it was concluded that the Total Installed Cost (TIC) had the most significant effect on the project IRR. Figure 10-19 shows the sensitivity of the project IRR to the TIC of the project for the above mentioned cases. The sensitivity was performed for TIC values ranging from -15 to + 20 % of the base TIC.

b. Operating Cost (MM$).

Based on the risk analysis performed, it was determined that operating cost is a significant variable for the project IRR. Figure 10-20 indicates the sensitivity of the IRR to the operating cost for the "long term" case. The operating cost was varied from –10 % to + 10 % of the base case.

c. Diesel Premium ($/bbl).

According to the risk analysis, the diesel premium was the second most important variable for the project IRR. Figure 10-21 shows the changes in IRR vs. the diesel premium price. The diesel premium was varied from $0/bbl to $7/bbl. The diesel price has an important effect on the economic feasibility of the project, as it is the product with the highest yield from the GTL plant. See 7.3.4 in the Marketing Study section for the rationale used to determine the diesel premium.

d. West Texas Intermediate Crude Price ($/bbl).

As indicated in the marketing study, all the GTL product prices have been correlated to the West Texas Intermediate crude price. Therefore, the WTI crude price is an important parameter in the IRR sensitivity study. The WTI price was varied from $15/bbl to $25/bbl. Figure 10-22 shows the sensitivity of the project IRR to the WTI crude price.

Fig 10-19

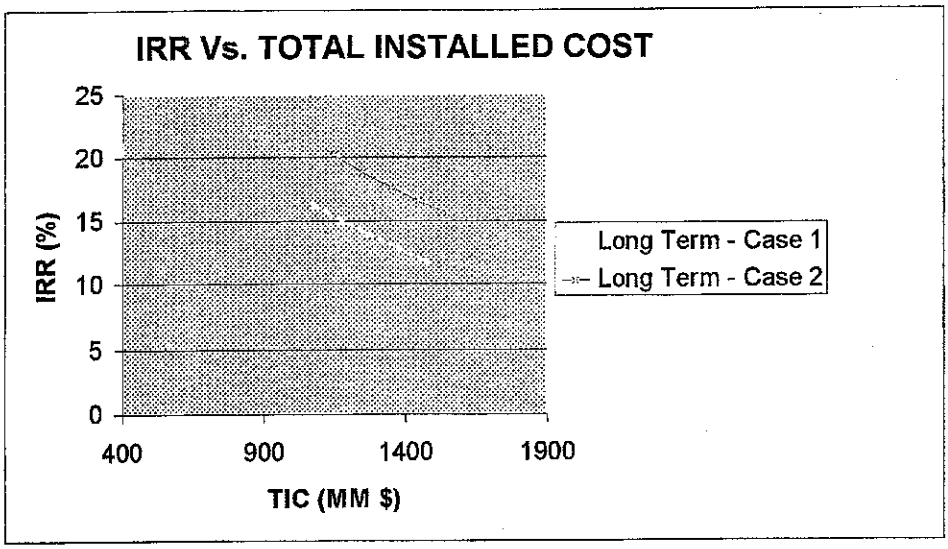


Fig 10-20

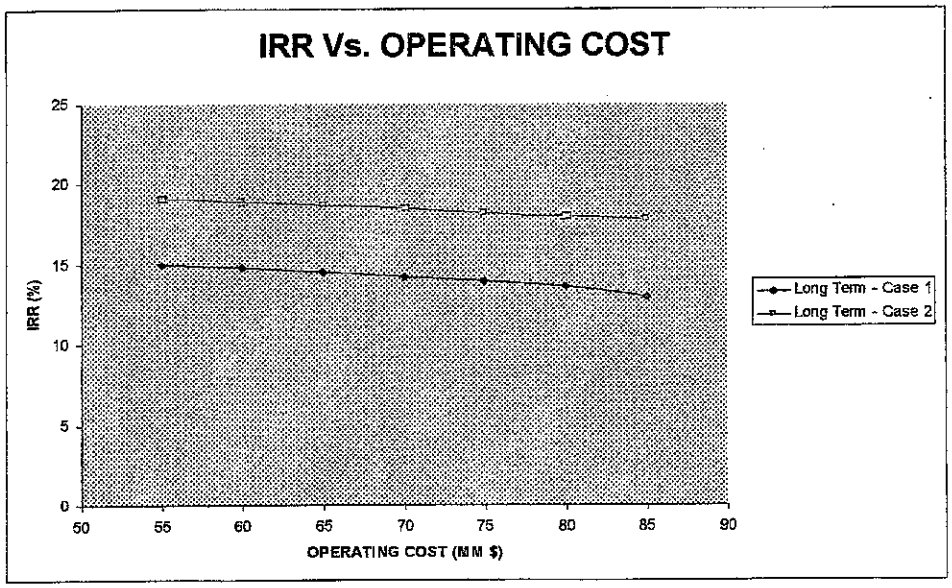


Fig. 10-21

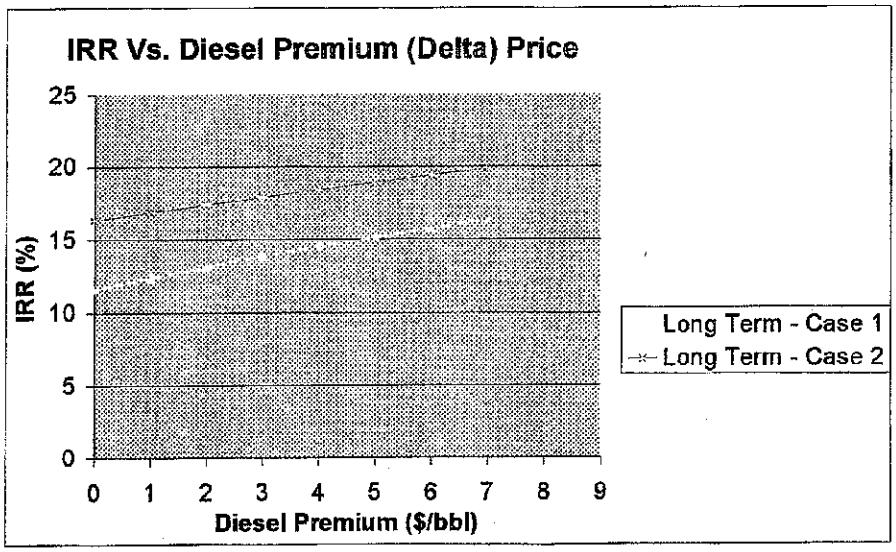
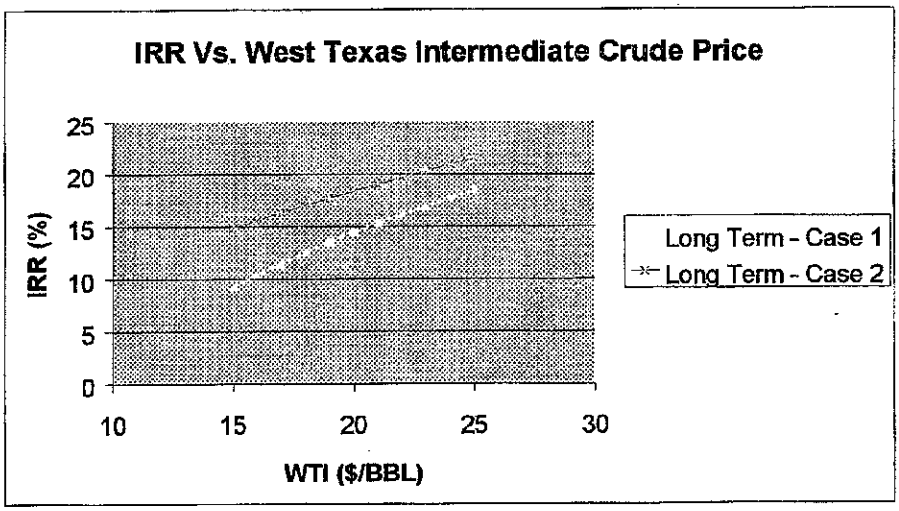


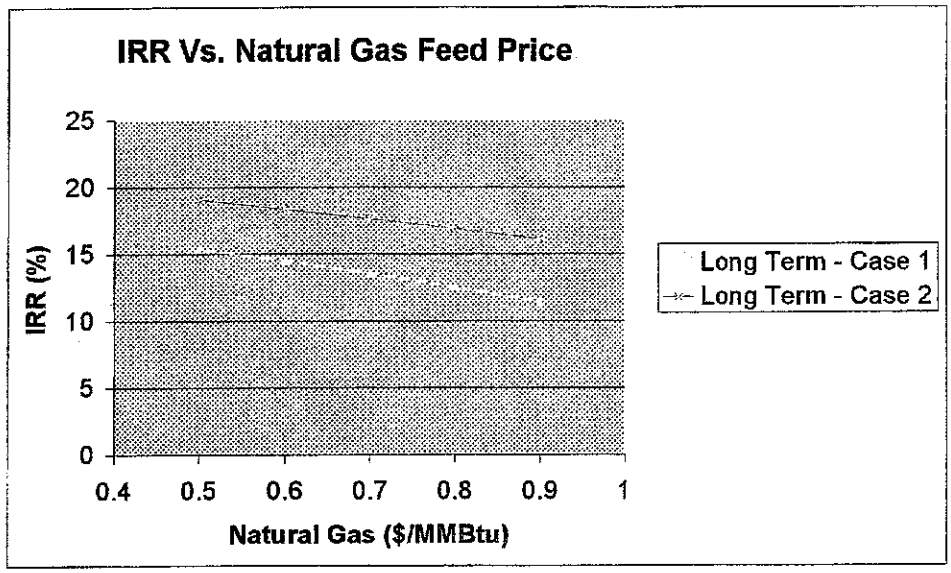
Fig. 10-22



e. Natural Gas Feed Price ($/MMBTU).

The natural gas feed cost represents about 20 percent of the product cost. The natural gas feed price ranked second in the risk analysis study. The natural gas feed cost was varied from $0.5/MMBTU to $0.9/MMBTU. Figure 10-23 shows the variation between the IRR and the Natural Gas Feed Price.

Fig. 10-23



10.5.3.3 "Long Term" Case Conclusions

The risk and sensitivity analyses performed for the "long term" case, and within the ranges of variation modeled, produce the following conclusions:

- There is a 90% chance of having an internal rate of return (IRR) of at least 16.8%.
- The project IRR is influenced strongly by the total investment cost, diesel premium, and natural gas price.

- The crude prices have an impact on the project IRR, but it is not as strong as the first two parameters.

The project is impacted the least by the cost of natural gas, however this cost has a stronger consequence for the "long term" case than for the "short term" one.

PDVSA

11.0 RECOMMENDED CASES

PDVSA

CONTENTS

11.1 GENERAL

The objective of this section is to summarize the recommended cases and strategy for the short and long term project. These recommendations are consistent with the project objective, results of site study, marketing analysis, technology evaluation and economic analyses.

"Short Term" Project:

150 million standard cubic feet per day (MMSCFD) of natural gas feed, with commissioning targeted no later than the year 2006.

"Long Term" Project:

500 million standard cubic feet per day (MMSCFD) of natural gas feed, with commissioning beyond the year 2007.

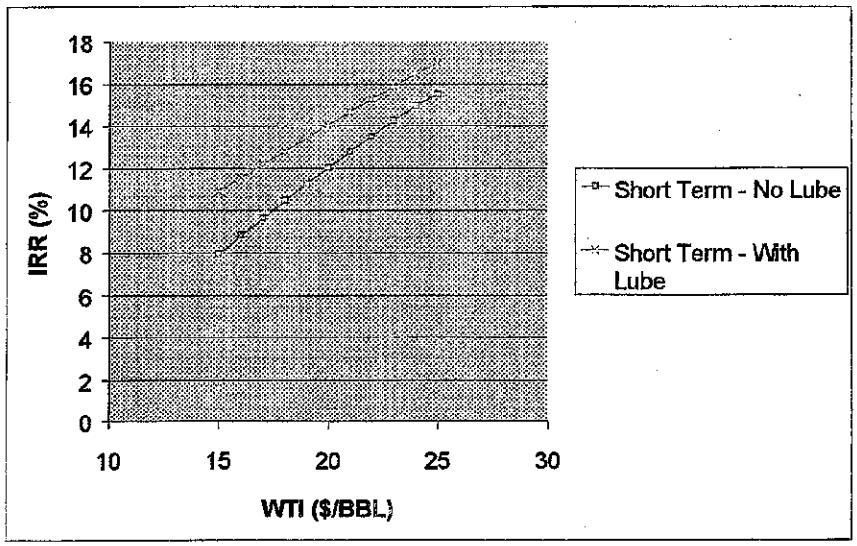
11.2 "SHORT TERM" PROJECT

The following is a summary of recommendations for the "short term" project:

- For the Jose location, the "short term" project, without lube production, requires a Total Installed Cost (TIC) of $ 472 MM and is estimated to yield an Internal Rate of Return (IRR) of about 12%.
- The "short term" project economics can be further improved by adding lube production capabilities after five years (2008 and above). This case requires a TIC of $ 522 MM dollars and is estimated to yield an IRR of about 14 %. Using risk analysis, It was estimated that there is a 90% probability that the project will yield an IRR of 12.9% or above.

- Synergy benefits with the existing and planned projects at Jose will enhance the project IRR further. A list of potential synergy options is provided in Section 6.0.
- The estimated IRR is based on the following parameters:
  - Natural Gas price of 0.6 $/MMBTU.
  - West Texas Intermediate (WTI) crude price of 20 $/BBL.
  - 7 $/BBL premium for GTL diesel.
  - 10% tax credit.
  - Project life of 20 years.
  - 10 years, straight-line depreciation.
- Figure 11-1 indicates the impact of the WTI price on the IRR of the project. As expected, the project IRR would increase with increase in WTI price.

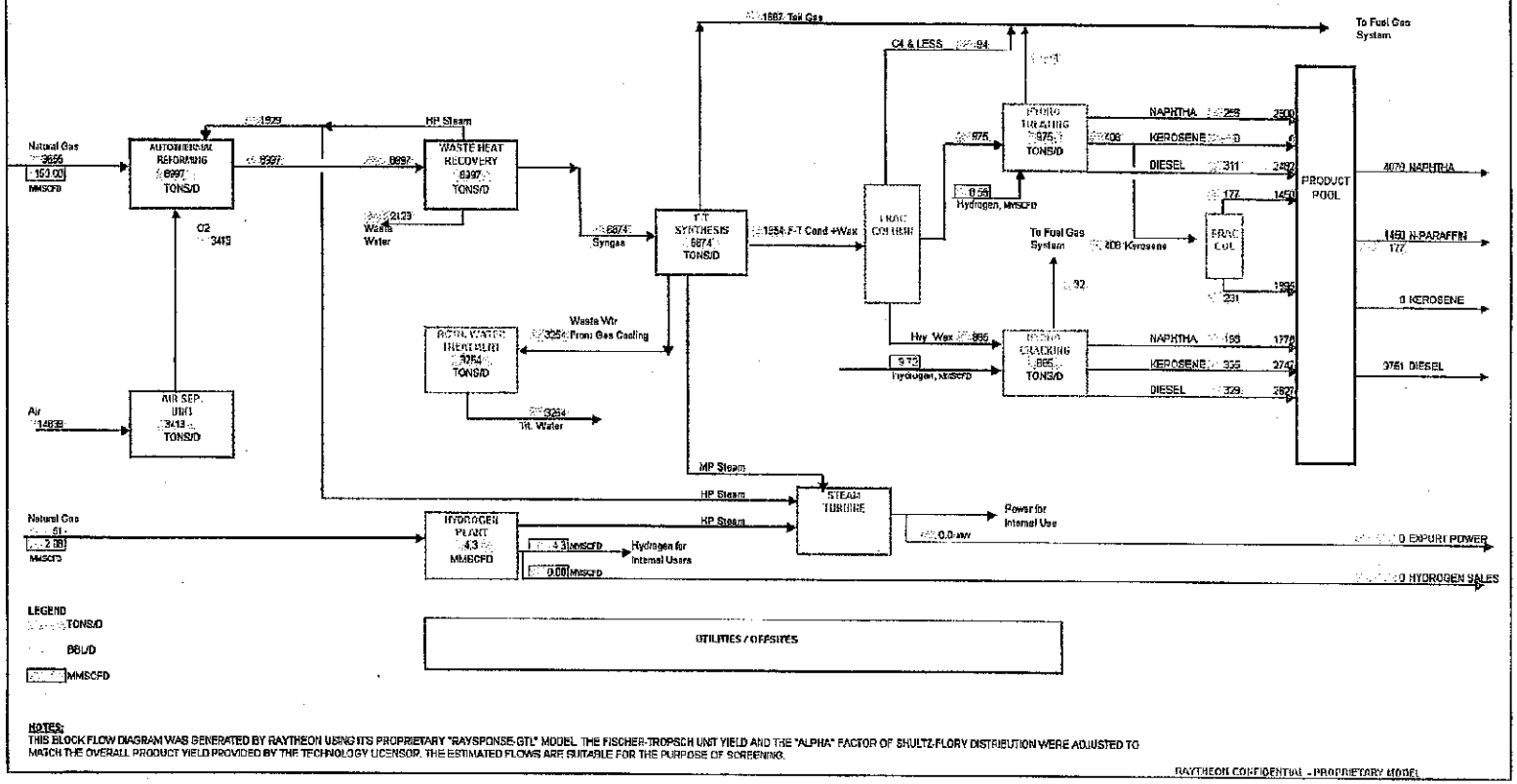
Fig. 11-1 **IRR Vs West Texas Intermediate Crude Price "Short Term" Case**



- Raytheon recommend that PDVSA only consider the technologies that have been proven on a commercial scale for the "short term" plant.
- Based on the market study, the plant should initially produce fuels and linear normal paraffins.
- It is recommended that (140) XHVI lube base oil be produced from the year 2008. This would be achieved by adding a Hydroisomerization/ Hydrofinishing unit and the required infrastructure, during the year 2006-2007.
- Figures 11-2 and 11-3 are block flow diagrams produced by Raytheon for the "short term" case. Figure 11-2 represents the scheme up to the year 2007 and Figure 11-3 depicts the scheme beyond the year 2007. The following is a summary of expected major products from this GTL plant:

PRODUCTS	TILL 2007	BEYOND 2007
Naphtha, BPD	4,080	3,140
N-Parrafins, MTD	177	177
Kerosene, BPD	0	0
Diesel, BPD	9,750	9,270
(140) XHVI Lube Base Oil, BPD	0	1,270

FIGURE 11.2: GTL BLOCK FLOW DIAGRAM - SHORT TERM CASE WITH OUT LUBE PRODUCTION

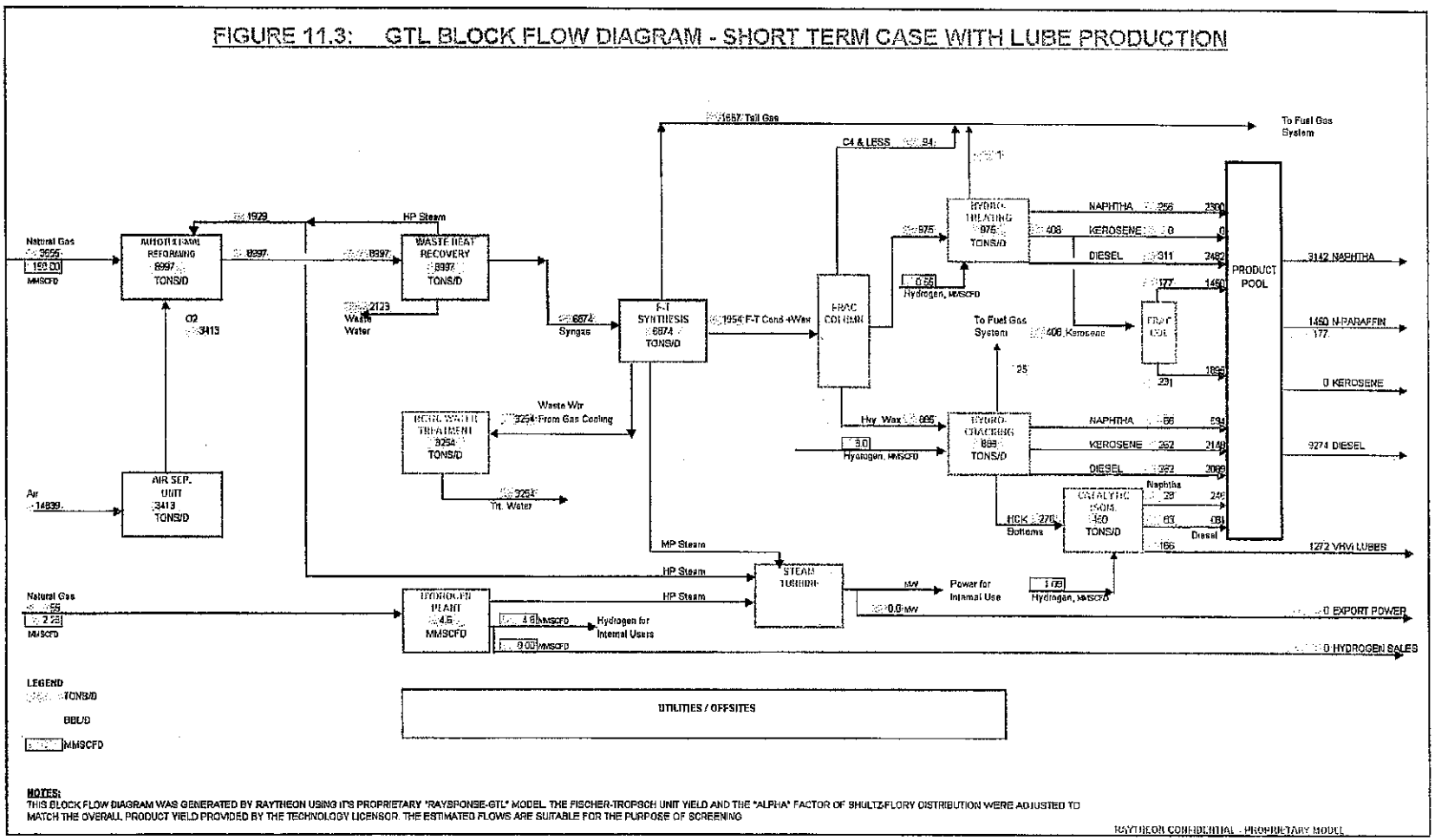


NOTES:
THIS BLOCK FLOW DIAGRAM WAS GENERATED BY RAYTHEON USING ITS PROPRIETARY "RAYSPONSE-GTL" MODEL. THE FISCHER-TROPSCH UNIT YIELD AND THE "ALPHA" FACTOR OF SHULTZ-FLORY DISTRIBUTION WERE ADJUSTED TO MATCH THE OVERALL PRODUCT YIELD PROVIDED BY THE TECHNOLOGY LICENSOR. THE ESTIMATED FLOWS ARE SUITABLE FOR THE PURPOSE OF SCREENING.

RAYTHEON CONFIDENTIAL - PROPRIETARY MODEL

PDVSA

FIGURE 11.3: GTL BLOCK FLOW DIAGRAM - SHORT TERM CASE WITH LUBE PRODUCTION



Raytheon
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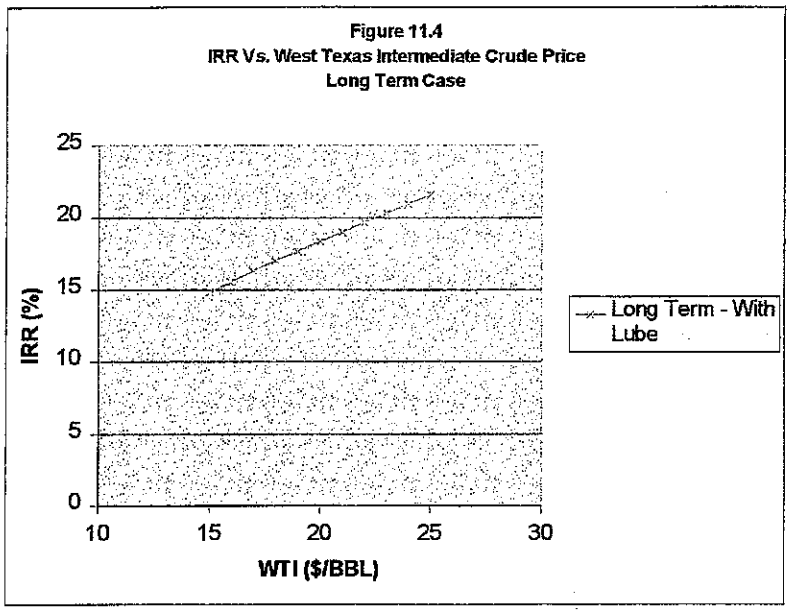
11.3 "LONG TERM" PROJECT

The following is a summary of recommendations for the "long term" project:

- The "long term" project was determined to be economically feasible, with a total installed cost of $ 1291 MM dollars and an estimated internal rate of return (IRR) of about 18.4%.. Using risk analysis, It was estimated that there is a 90% probability that the project will yield an IRR of 16.8% or above.
- The estimated IRR is based on the following parameters:
  - Natural Gas price of 0.6 $/MMBTU.
  - West Texas Intermediate (WTI) crude price of 20 $/BBL.
  - 4 $/BBL Premium for GTL diesel.
  - 10 % tax credit.
  - Project life of 20 years.
  - 10 years, straight-line depreciation.
- Figure 11-4 indicates the impact of the WTI price on the IRR of the project. As expected, the project IRR would increase with an increase in WTI price.
- Jose is the recommended site for this project. The estimated IRR will further improve if the potential synergy options listed in Section 6.0 are considered and benefits realized.
- Anaco is selected as the alternate site for the "long term" project. It was determined that production of syncrude at Anaco is not advantageous. It is recommended that the GTL plant configuration and product profile be similar to that recommended for the Jose site
- Raytheon recommend a re-evaluation of all the available technologies in a few years due to the rapidly evolving nature of GTL technologies and the emergence of new technologies in this field, such as PDVSA/Intevep's

DISOL. At the current state of the art, Sasol and Exxon technologies show greater overall advantages over other technologies.

Fig. 11-4 **IRR vs West Texas Intermediate Crude Price "Long Term" Case**



- Figures 11-5 is a block flow diagram produced by Raytheon for the "long term" case. The following is a summary of expected major products from this GTL plant:

PRODUCTS	FLOW
Naphtha, BPD	11,400
N-Parrafins, MTD	247
Kerosene, BPD	0
Diesel, BPD	34,200
(140) XHVI Lube Base Oil, BPD	3,000

FIGURE 11.5: GTL BLOCK FLOW DIAGRAM, LONG TERM CASE