PDVSA

10.0 ECONOMIC ANALYSIS

PDVSA

CONTENTS

10.1 OVERALL METHODOLOGY

The objective of this section was to perform economic analyses for various technology options in order to recommend "short term" and "long term" strategies for the development of GTL projects in Venezuela. The following information was gathered for all the technologies under consideration to perform the economic analyses:

- Total Installed Cost
- Product profile
- Feed and Product Prices
- Operating Cost

The following technology options were considered for evaluation:

- Exxon
- Shell
- Sasol
- Syntroleum
- Rentech (POx, Rentech's F-T)
- PDVSA/Intevep (ATR, Intevep's F-T)

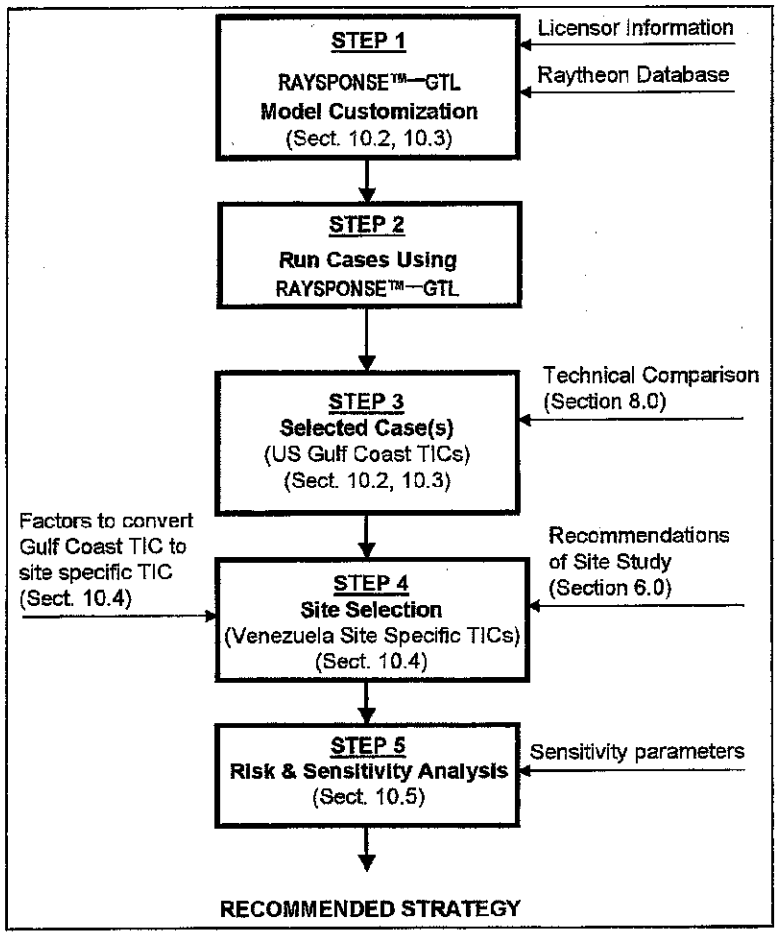
Of the above, only Sasol and Syntroleum provided the required information for the entire GTL plant. Exxon and Shell did not participate in the study. Rentech and PDVSA/Intevep provided information pertaining to their Fischer-Tropsch technology only. The following steps are imperative before proceeding with the economic analyses:

- Adjust the Total Installed Costs (TICs) for Sasol and Syntroleum cases so that they are on a comparable basis with other licensors.
- Develop TICs for Rentech and Intevep cases utilizing the information provided by the respective licensors for the Fisher-Tropsch synthesis unit.

Raytheon's proprietary software model, **RAYSPONSE™—GTL**, was used to accomplish these tasks. Reference should be made to Section 9.0 of this report for a description of this model.

Figure 10-1 is a schematic of the methodology used to perform economic analysis.

Fig. 10-1 **Economic Analysis Methodology**



Step 1:

The **RAYSPONSE™—GTL** model was customized by adding project-specific information such as licensor-provided yields, utility requirements, capital costs, feed/product/utility prices. Raytheon's database was used to fill-in the information not provided by licensors.

Step 2:

The **RAYSPONSE™—GTL** model was run for various technology options keeping the investment costs on a Gulf Coast basis. The results of all the options analyzed are summarized and analyzed.

Step 3:

Based on technology (Section 8.0) and economic evaluations, one or more technologies were selected.

Step 4:

TIC conversion factors were developed for the three potential sites namely, Jose, Anaco and Guiria. Based on the results of the site study (Section 6.0) and site specific parameters, additional **RAYSPONSE™—GTL** runs were made to select a suitable site.

Step 5:

At the completion of step 4, licensor(s) and location of the GTL plants were selected for the "short term" and "long term" projects. The selected cases were then used to perform risk and sensitivity analysis.

10.2 "SHORT TERM" CASES

10.2.1 General

As agreed with PDVSA, a Natural Gas feed rate of 150 MMSCFD has been used as the basis for the economic evaluation of the "short term" cases. **RAYSPONSE™—GTL** runs were performed for Sasol, Syntroleum, Rentech and PDVSA/Intevep cases. Since Exxon and Shell declined to participate in the study, published information has been used to perform the economic evaluation for these two cases using a spreadsheet model. Table 10.1 summarizes the results of economic analyses for the cases.

The preliminary economic analyses performed in this section are suitable for the purpose of comparing alternate routes and are based on the following parameters:

- West Texas Intermediate : $20 per BBL (Real terms).
- Diesel Premium : Based on Venezuela and World Conditions:
  7 $/BBL "Short Term" - Venezuela market.
  4 $/BBL "Long Term" - World market.
- Investment Cost Basis : US Gulf Coast.
- Investment Schedule : Three years:
  Year 1 - 10% TIC.
  Year 2 - 50% TIC.
  Year 3 - 40% TIC.
- Project Life : 20 Years.
- Depreciation : 10 Years, Straight Line.
- Net Present Value (NPV) : Based on a 10% Discount Factor.
- Investment Tax Credit : None

A more detailed economic analysis, considering additional parameters for the selected cases is presented in Section 10.5.

10.2.2 Exxon

Exxon have indicated via a communication to Raytheon that no reliable investment cost data are available in the published literature. However, to perform a rough analysis, Raytheon estimated the TIC for Exxon technology based on an article by Morgan Stanley Dean Witter. This article estimated an investment cost of about 24,000 $/BBL for a 50,000 BBL/D plant. Based on this, Raytheon estimated that a 10,000 to 15,000 BBL/D GTL plant would cost approximately 29,000 $/BBL. This increase in cost for the smaller scale plant is due to the fact that significant economy of scale is lost.

Using a liquid yield of 17,000 BPD (See Section 8.2.1.1.4), Raytheon estimated an internal rate of return of 12.9 % for the Exxon technology based GTL plant, on a US Gulf Coast cost basis.

10.2.3 Shell

Since Shell did not participate in this study, Raytheon used information from published sources to perform an economic analysis. A Morgan Stanley Dean Witter article estimated an investment cost of about 26,000 $/BBL for a 50,000 BBL/D plant. Raytheon estimated that smaller size plant, considered for the "short term", would cost about 30,000 $/BBL. This in combination with an estimated liquid yield of 17,300 BPD (See Section 8.3.7) resulted in an estimated internal rate of return of 12.5 %.

10.2.4 Sasol

Sasol considered the GTL plant as a black box and provided product profile, total investment cost, operating cost and utilities requirement. Sasol also provided the following approximate investment cost breakdown for various blocks that make up the GTL plant.

Description	% of TIC
Syngas	30
F-T Synthesis	15
Product Work-Up	10
Other Process Units	10
Utilities	15
Offsites	20

Reference should be made to Section 8.2.1.3.4 for a summary of information provided by Sasol for this project. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
ATR	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	Shultz-Flory Distribution + Sasol's Overall Yield	**RAYSPONSE™**	Sasol's TIC + Cost Breakdown
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

RAYSPONSE™—GTL program has all the processing steps required to model GTL plants based on various technologies. In the model, all the required processing steps were kept open, and the others closed out. In addition, Shultz-Flory distribution was used to estimate the product distribution from the Fischer-Tropsch unit. The "alpha" value in the Shultz-Flory distribution was used as a tuning parameter to estimate the F-T unit product distribution that matches the Sasol data. The overall yield was tuned using a "yield factor" to match the total liquid yields estimated by Sasol. The **RAYSPONSE™—GTL** model generated:

- The investment cost for the overall plant and each of the units.
- A block flow diagram (BFD) with key stream flows (See Figure 10.2).
- Utilities summary.

The **RAYSPONSE™—GTL** model estimated a TIC of 389 MM$. This is in close agreement with the TIC provided by Sasol (395 MM$). An internal rate of return of 14.5 % was estimated for this case based on the TIC of 395 MM$. This particular run benchmarked **RAYSPONSE™—GTL** model and ensures comparison of all the technologies on the same basis for the "short term" cases.

10.2.5 Syntroleum

Like Sasol, Syntroleum also considered the GTL plant as a black box and provided product profile, total investment cost, operating cost and utilities requirement. Reference should be made to Section 8.2.1.4.4 for a summary of

information provided by Syntroleum for this project. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
ATR - air based	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	Shultz-Flory Distribution + Syntroleum's Overall Yield	**RAYSPONSE™**	**RAYSPONSE™**
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

Raytheon performed a simulation of ATR with air feed and natural gas to determine the capacity and yield of Syntroleum's ATR. The gas flowrate through the unit was, as expected, significantly higher than that for an oxygen based ATR. The estimated syngas flowrate was used to develop the investment cost of Syntroleum's ATR. Syntroleum claim that its high activity F-T catalyst allows once through F-T reactor design. The expected increase in F-T reactor size due to the presence of large amounts of nitrogen in the feed would be offset by the decrease in its size due to the once through nature (no recycle) of the process.

Shultz-Flory distribution was used to estimate the product distribution from the Fischer-Tropsch unit. The "alpha" value in the Shultz-Flory distribution was used as a tuning parameter to estimate the F-T unit product distribution that matches the data provided by Syntroleum. The overall yield was tuned using a "yield factor" to match the total liquid yields estimated by Syntroleum. **RAYSPONSE™—GTL** model generated:

- Investment cost for overall plant and each of the units.
- A block flow diagram (BFD) with key stream flows (See Figure 10.3).
- Utilities summary.

The **RAYSPONSE™—GTL** model estimated a TIC of $ 455 MM. The estimated TIC is more than that provided by Syntroleum. The primary reason for this increase is the common basis used to estimate the investment cost for offsite and utility systems.

An internal rate of return (IRR) of 11.2 % was estimated for this case. In Raytheon's assessment, export power was an integral part of a Syntroleum GTL plant. Due to this, credit was taken for export of 50 MW power in addition to the liquid products in the IRR calculation. The IRR is significantly lower due to lower liquid yields and low value for the exported power when compared to other technology routes.

10.2.6 Rentech

Rentech provided information only for the Fischer-Tropsch synthesis section and assumed a POx unit for synthesis gas production. It was necessary to develop a TIC for the whole GTL plant in order to perform an economic analysis. The conventional methods employed to develop TIC for this situation would involve numerous time consuming steps. The **RAYSPONSE™—GTL** model, due to the modeling techniques and database, was effective in significantly reducing the time required to develop the TIC for this case. Further, this allowed comparison of various technologies cases on the same basis.

Reference should be made to Section 8.2.3.1.4 for a summary of information provided by Rentech for this project. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
POx	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	Rentech	Rentech	Rentech
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

All the information provided by Rentech for the F-T synthesis section was added to the **RAYSPONSE™-GTL** model. POx unit was used for syngas production. The **RAYSPONSE™-GTL** model was run to generate all the required information to perform the economic analysis. Figure 10.4 is the BFD generated by Raytheon for a GTL plant based on Rentech's F-T technology.

It was estimated that the GTL plant would cost about $ 468 MM. The following are the key reasons for the higher investment cost of the GTL plant when compared to that based on Sasol technology:

- POx requires additional oxygen. Requires 2-train oxygen plant for this NG feed capacity.
- Multiple F-T reactors are required. The maximum single train capacity of Rentech's F-T reactor is 3000 – 3500 BPD.

The estimated IRR of 13.9 % is within 1 % of the Sasol case inspite of the significantly higher TIC. This is due to the increased liquid product yield when compared to that of the Sasol technology.

10.2.7 PDVSA/Intevep

Intevep provided information only for the Fischer-Tropsch synthesis section. As in the case of Rentech, it was essential to develop the TIC for the whole GTL plant in order to perform an economic analysis. The **RAYSPONSE™—GTL** model was used for this purpose.

Reference should be made to Section 8.2.3.2.4 for a summary of information provided by PDVSA/Intevep for this project. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
ATR	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	PDVSA/Intevep	PDVSA/Intevep	PDVSA/Intevep
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

All the information provided by PDVSA/Intevep for the F-T synthesis section was added to the **RAYSPONSE™—GTL** model. An ATR unit was used for syngas production. The **RAYSPONSE™—GTL** model was run to generate all the required information to perform the economic analysis. Figure 10.5 is the BFD generated by Raytheon for the GTL plant based on the PDVSA/Intevep F-T technology.

It was estimated that the GTL plant would cost about $ 373 MM. This case has the lowest cost GTL plant when compared with all the other technology providers due to the low cost of the F-T unit. However, TIC's required for both PDVSA/Intevep and Sasol are about the same, since the difference seen is well within the accuracy of the estimate. Also, it should be noted that, due to the early stage of technology development, the F-T unit cost is considered soft and may increase as the process develops further.

The estimated IRR of 16.6 % is higher than that estimated for all the other technology options. The primary reason for this is that the estimated product distribution indicates approximately 2,500 BPD lower naphtha and a corresponding increase in kerosene and diesel range material. Diesel being valued higher than naphtha, the revenue of the PDVSA/Intevep case is improved appreciably, resulting in an increased IRR.

10.2.8 Recommended Technology

An overall ranking of all the licensors based on technical and economical parameters is provided in Section 8.3.8.

"Short Term" Project

Group A: Sasol, Shell

Group B: Exxon

Group C: Rentech, Syntroleum

PDVSA/Intevep is not included in the above list since its technology is still in the bench scale and is not expected to be ready for commercialization for the "short term" project.

The Sasol case will be used in Section 10.4.3 to select a suitable site for recommendation, since complete and reliable information is not available for Shell's GTL technology.

FIGURE 10.2: GTL BLOCK FLOW DIAGRAM - SASOL/CHEVRON, SHORT TERM CASE

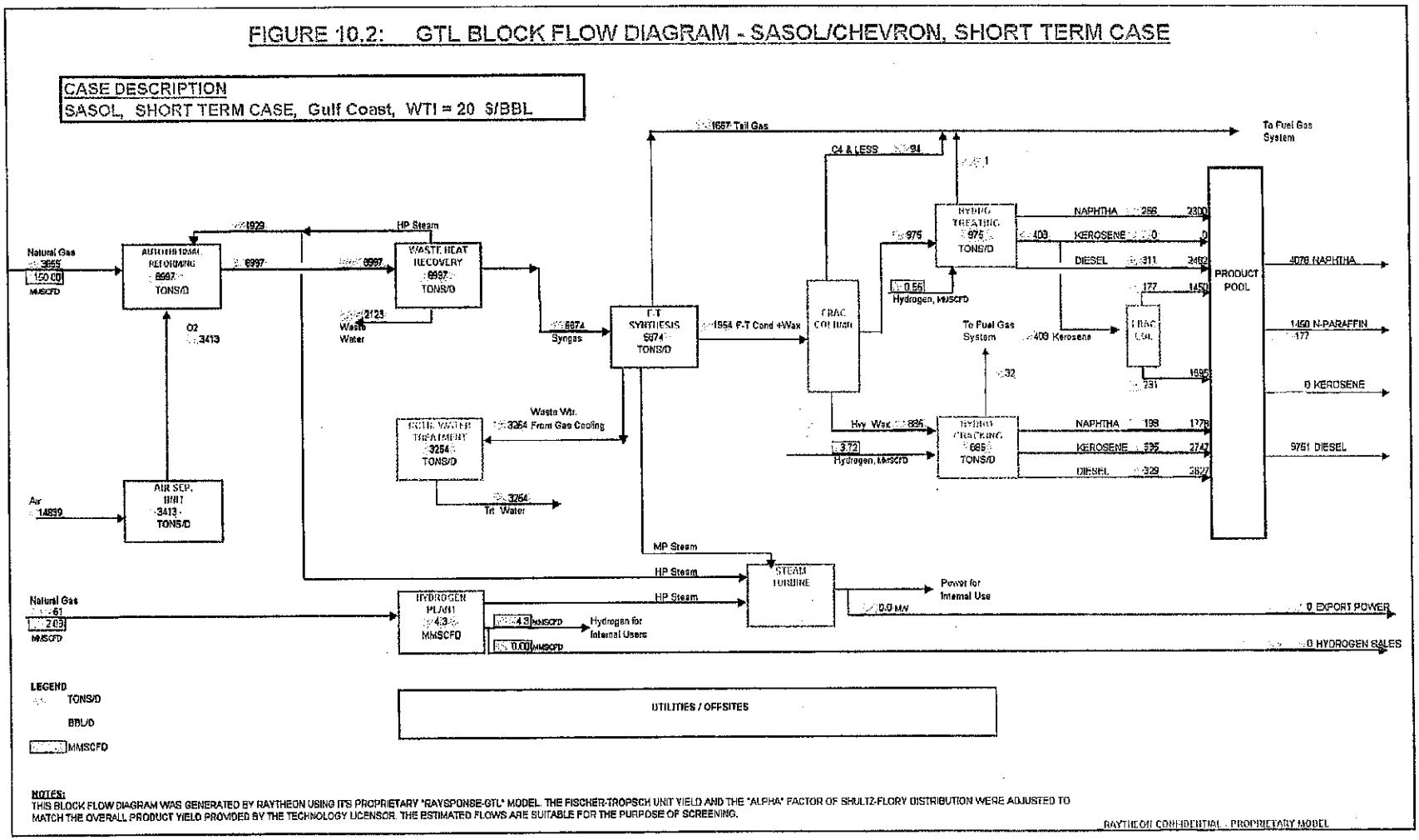


FIGURE 10.3: GTL BLOCK FLOW DIAGRAM - SYNTROLEUM, SHORT TERM CASE

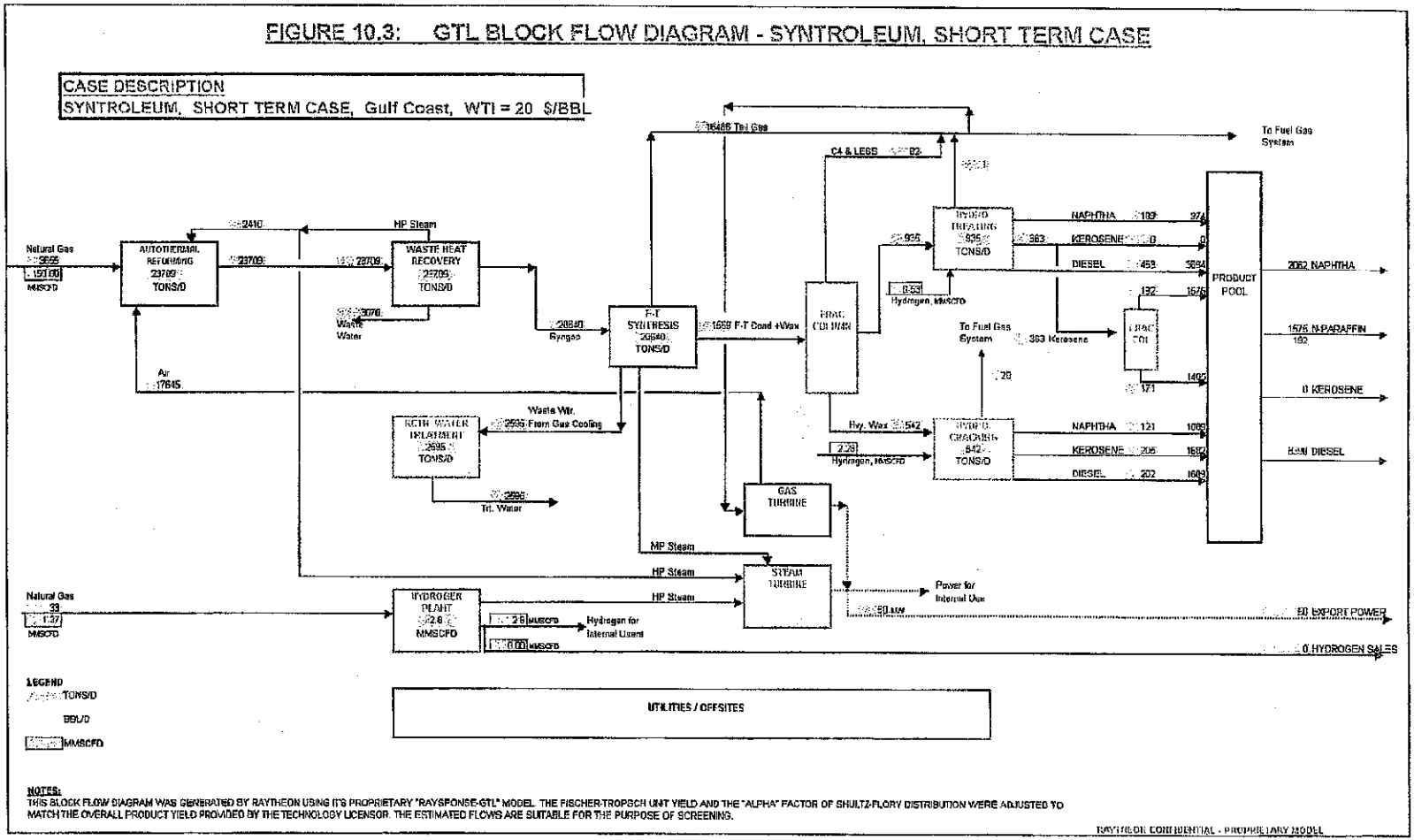


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FIGURE 10.4: GTL BLOCK FLOW DIAGRAM - RENTECH, SHORT TERM CASE

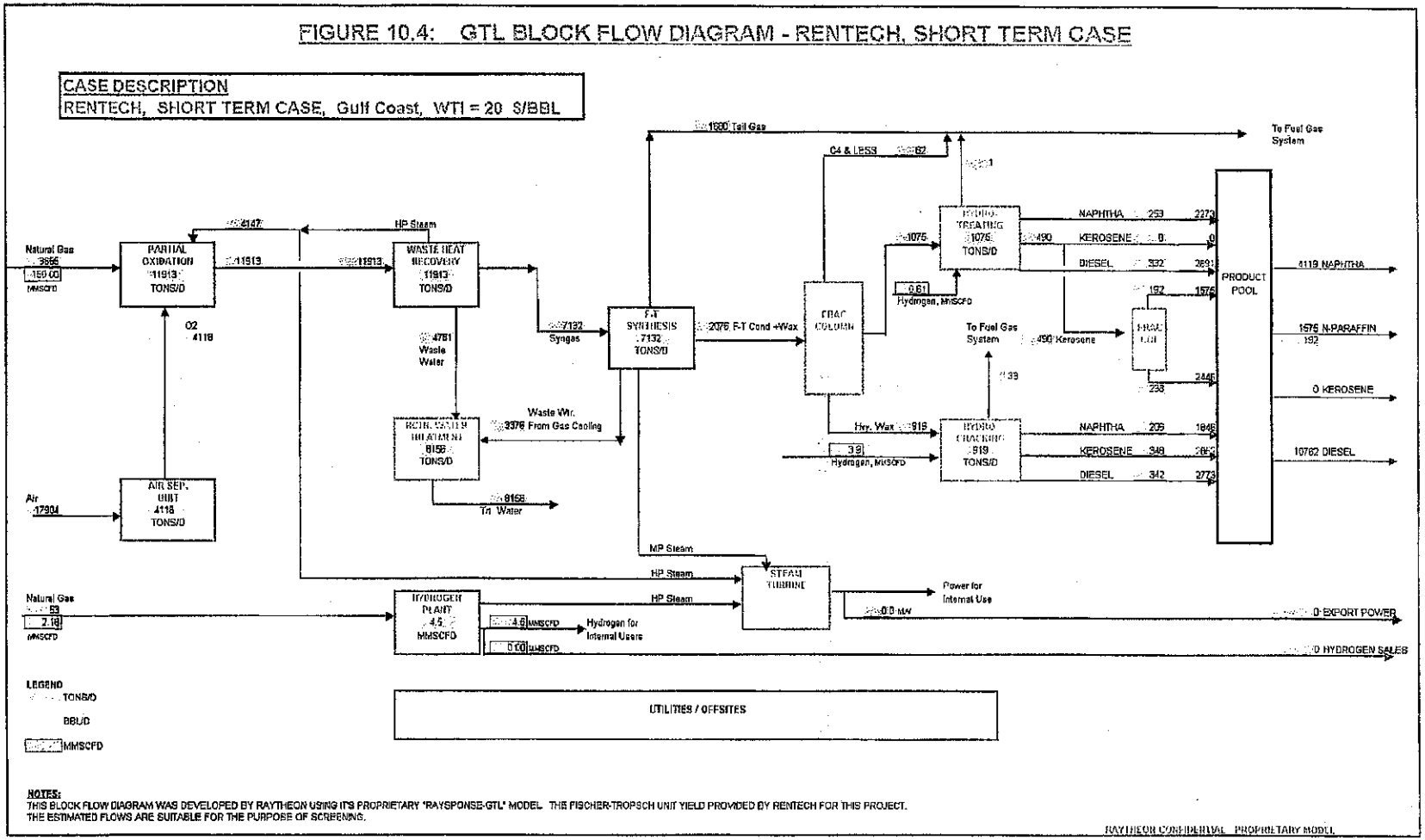

FIGURE 10.5: GTL BLOCK FLOW DIAGRAM - PDVSA/INTEVEP, SHORT TERM CASE

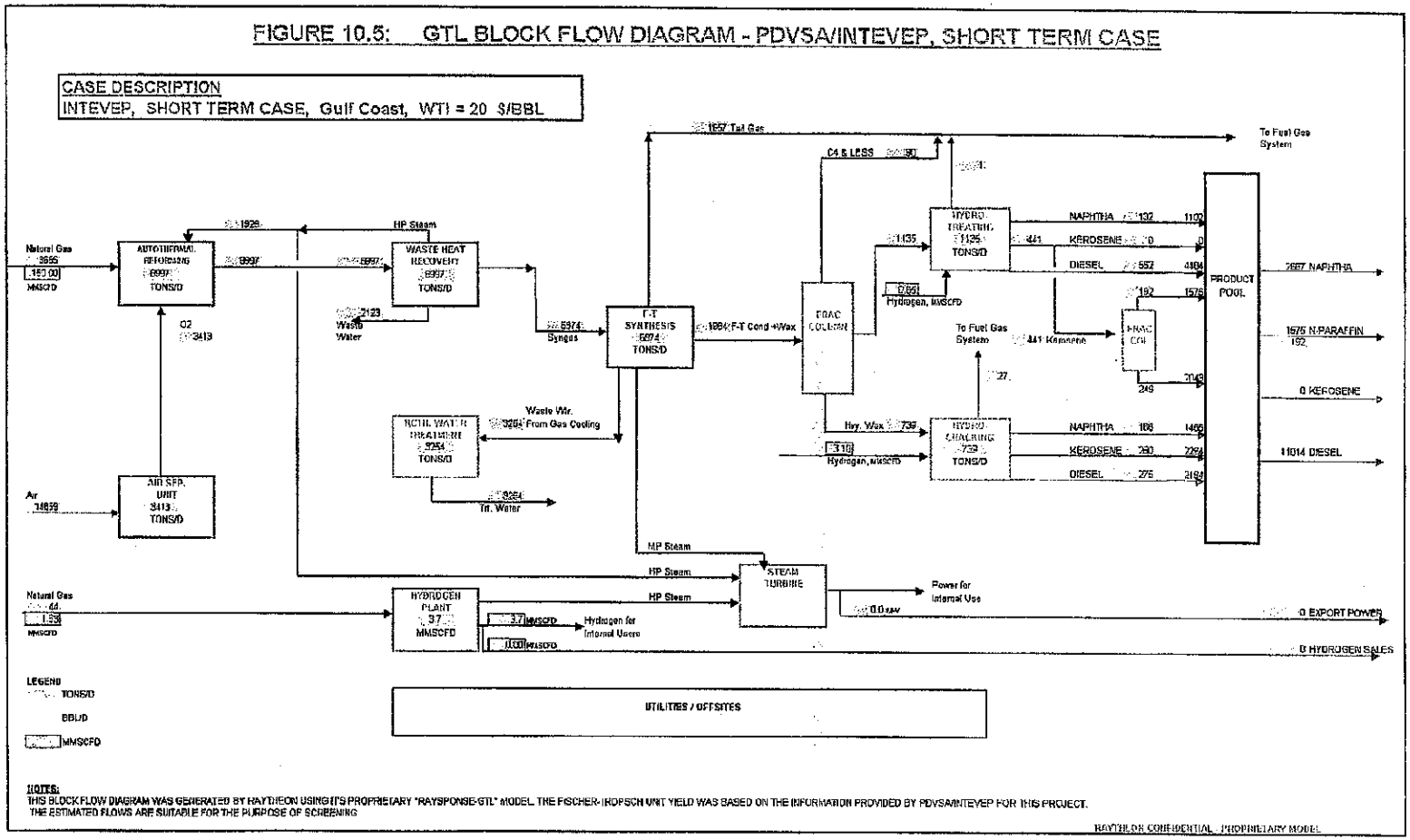

Table 10-1

Economic Analysis Summary - "Short Term" Case

Description	Exxon	Shell	Sasol [3]	Syntroleum [3]	Rentech [5]	Intevep [5]
Total Installed Cost [1], MM$			**395**	455	468	373
Gross Revenue, MM$			**86.2**	77.5 [4]	97.8	94.1
Projected IRR, %	12.9	12.5	**14.5**	11.2	13.9	16.6
NPV @ 10% DF [6], MM$	85	75	**108**	33	110	156
Total Liquid Yield, BBL/Day			**15300**	12,000	16,450	15,300
TIC in $/BBL	29,000	30,000 [2]	**25,800**	37,920	28,450	24,380

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

[2] Exxon and Shell declined to participate in the study. The figures provided here were estimated based on an article by Morgan Stanley Dean Witter dated September 9, 1997. This article provided the cost for larger size GTL plant. Based on the $/BBL difference between "long term" and "short term" cases as estimated by Raytheon, Exxon and Shell $/BBL for the "short term" cases were increased to 29,000 $/BBL and 30,000 $/BBL respectively.

[3] TIC provided by Sasol is 395 MM$ and that provided by Syntroleum is 351 MM$. The estimated TIC for the Sasol case was 389 MM$. However, for the calculation of IRR, TIC provided by Sasol (395 MM$) has been used.

[4] Revenue for Syntroleum includes sale of 150 MW export power.

[5] Rentech and Intevep only provided Fischer-Tropsch Unit TIC. All other unit investment costs were estimated by **RAYSPONSE™**.

[6] NPV (Net Present Value) was calculated using a Discount Factor of 10%.

10.3 "LONG TERM" CASES

10.3.1 General

A Natural Gas feed rate of 500 MMSCFD was used as the basis for the economic evaluation of the "long term" cases. The production constraints used were based on the recommendation of the Marketing Survey (Section 7.0).

RAYSPONSE™ runs were performed for Sasol, Syntroleum, Rentech and PDVSA/Intevep cases for two different scenarios; one without and one with lube production.

Since Exxon and Shell declined to participate in the study, published information has been used to perform the economic evaluation for these two cases using a spreadsheet model. Table 10.2 summarizes the results of economic analyses for these cases. Like "short term" cases, the economic analyses performed here are preliminary and a more detailed analysis for the recommended case is provided in Section 10.5.3.

10.3.2 Exxon

Raytheon estimated the TIC for Exxon technology based on an article by Morgan Stanley Dean Witter. This article estimated an investment cost of about 24,000 $/BBL for a 50,000 BBL/D plant. Based on this, Raytheon estimated the TIC of the "long term" GTL plant and performed the economic analysis.

Using a liquid yield of 56,700 BPD (refer to Section 8.2.1.1.4), Raytheon estimated an internal rate of return of 14.3 % for the Exxon technology based GTL plant, on a US Gulf Coast cost basis.

The marketing study performed by Raytheon recommended the production of 3,000 BPD of (140) XHVI lube base oil. This would be achieved by adding a hydroisomerization unit to process the lube cut from the hydrocracking unit. The estimated IRR of 18.2 %, clearly favors lube production. For this case, Raytheon used an average investment of about 25,000 $/BBL of total liquid product.

10.3.3 Shell

A Morgan Stanley Dean Witter article estimated an investment cost of about 26,000 $/BBL for a 50,000 BBL/D GTL plant based on Shell technology. This information, in combination with an estimated liquid yield of 57,800 BPD (Section 8.3.7), resulted in an internal rate of return of 13.2 % for the project. As expected, addition of lube production improved the IRR to 16.9 %. For this case, Raytheon estimated an average investment of about 27,000 $/BBL of total liquid product.

10.3.4 Sasol

Sasol provided product profile, total investment cost, operating cost and utilities requirement for a GTL plant that feeds 465 MMSCFD of natural gas. This was the largest GTL plant that Sasol was willing to commit to at this time, based on three parallel trains of air separation, reformer and F-T unit. However, Sasol indicated that it might be possible to expand the three-train capacity to 500 MMSCFD natural gas for the "long term" project due to continuing developmental work by Sasol and their alliance partners in the technology area. In order to compare all the technologies at the same feed rate basis, Raytheon assumed that it would be possible, in future, to build a GTL plant that feeds 500 MMSCFD without exceeding the three train capacity limits. This is reasonable due to the fact that the additional per train capacity required for this assumption to be true is small (7.5 % more than current maximum) and is very likely possible before the start of the "long term" project (> year 2007). Information provided by Sasol for the 465 MMSCFD natural gas feed case was prorated for the 500 MMSCFD case.

A summary of information provided by Sasol for this case is included in Section 8.2.1.3.4. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
ATR	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	Shultz-Flory Distribution + Sasol's Overall Yield	**RAYSPONSE™**	Sasol's TIC + Cost Breakdown
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

RAYSPONSE™—GTL model was run for the "long term" case, using a natural gas feed rate of 500 MMSCFD. The "alpha" factor for Shultz-Flory distribution and the F-T "yield factor" were kept equal to those of the "short term" case. The **RAYSPONSE™-GTL** model generated:

- The investment cost for the overall plant and each of the units
- A block flow diagram (BFD) with key stream flows (Figure 10.6)
- Utilities summary

The **RAYSPONSE™—GTL** model estimated the following for this case:

Description	No Lube	Lube
TIC, MM $ - Gulf Coast	1039	**1095**
IRR, %	16.7	**21.3**

The TIC estimated for the "No Lube" case is consistent with the TIC of $ 972 MM provided by Sasol for the 465 MMSCFD case. This particular run benchmarked the **RAYSPONSE™—GTL** model and ensures comparison of all the technologies on the same basis for the "long term" cases.

10.3.5 Syntroleum

Similar to the "short term" case, Syntroleum also provided, product profile, total investment cost, operating cost and utility requirements for the "long term" case, considering the GTL plant as a black box. Reference should be made to Section 8.2.1.4.4 for a summary of information provided by Syntroleum for the "long term" case. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
ATR - Air based	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	Shultz-Flory Distribution + Syntroleum's Overall Yield	**RAYSPONSE™**	**RAYSPONSE™**
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

For the "long term" cases, Raytheon used yields and cost bases similar to those explained in the Syntroleum "short term" case section (Section 10.2.4), maintained the Shultz-Flory "alpha" value and "yield factor" estimated for the "short term" case and ran the **RAYSPONSE™—GTL** model. The model generated:

- Investment cost for the overall plant and each of the units
- A block flow diagram (BFD) with key stream flows (Figure 10.7)
- Utilities summary

The **RAYSPONSE™—GTL** model estimated the following for this case:

Description	No Lube	Lube
TIC, MM $ - Gulf Coast	1258	**1302**
IRR, %	10.7	**15.0**

The estimated TIC of $ 1,258MM is more than that provided by Syntroleum ($1,098 MM for no lube production). The primary reason for this increase is the common basis used to estimate the investment cost for offsite and utility systems.

In Raytheon's assessment, export power was an integral part of a Syntroleum GTL plant. Due to this, credit was taken for export of 150 MW power in addition to the liquid products in the IRR calculation. The IRR is significantly lower due to lower liquid yields and low value for the exported power when compared to other technology routes.

10.3.6 Rentech

Rentech provided information only for the Fischer-Tropsch synthesis section and suggested Raytheon assume a POx unit for synthesis gas production. Reference should be made to Section 8.2.3.1.4 for a summary of information provided by Rentech for this project.

The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
Pox	RAYSPONSE™	RAYSPONSE™	RAYSPONSE™
F-T Synthesis	Rentech	Rentech	Rentech
Product Work-up	RAYSPONSE™	RAYSPONSE™	RAYSPONSE™
All Others	RAYSPONSE™	RAYSPONSE™	RAYSPONSE™

As explained in the Rentech "short term" case section (10.2.6) TIC and other information for the whole GTL plant based on Rentech's F-T technology were developed by running the **RAYSPONSE™—GTL** model. Figure 10.8 is the BFD generated by Raytheon for a GTL plant based on Rentech's F-T technology.

The **RAYSPONSE™—GTL** model estimated the following for this case:

Description	No Lube	Lube
TIC, MM $ - Gulf Coast	1268	1324
IRR, %	15.4	19.4

The following are the key reasons for the higher investment cost when compared to that of Sasol technology:

- POx requires additional oxygen.
- Multiple F-T reactors are required. The maximum single train capacity of Rentech's F-T reactor is 3000 – 3500 BPD.

10.3.7 PDVSA/Intevep

PDVSA/Intevep provided information on yield and investment data for the Fischer-Tropsch synthesis section only for the "short term" case, and indicated that the "long term" case will consist of three trains of F-T units.

Reference should be made to Section 8.2.3.2.4 for a summary of information provided by PDVSA/Intevep for this project. The following is a summary of information sources for yield, utilities and investment cost used in the **RAYSPONSE™—GTL** model for this case:

Unit	Yield	Utilities	Investment
ATR	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
F-T Synthesis	PDVSA/Intevep	PDVSA/Intevep	PDVSA/Intevep
Product Work-up	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**
All Others	**RAYSPONSE™**	**RAYSPONSE™**	**RAYSPONSE™**

The methodology used to develop cost information was identical to that described in PDVSA/Intevep "short term" case section (10.2.7). The **RAYSPONSE™—GTL** model was run to generate all the required information to perform the economic analysis. Figure 10.9 is the BFD generated by Raytheon for the GTL plant based on the PDVSA/Intevep F-T technology.

The **RAYSPONSE™—GTL** model estimated the following for this case:

Description	No Lube	Lube
TIC, MM $ - Gulf Coast	997	**1050**
IRR, %	18.4	**23.0**

This case has the lowest cost GTL plant when compared with all the other technology providers due to the low cost of the F-T unit. However, TICs required for both PDVSA/Intevep and Sasol are about the same, since the difference seen is well within the accuracy of the estimate. Also it should be noted that due to the early stage of technology development, Intevep's F-T unit cost is considered soft and may increase as the process develops farther.

The estimated IRRs are higher than those estimated for all the other technology options. The primary reason for this is that the Intevep's yield data indicate lower naphtha and a corresponding increase in kerosene and diesel range material. Diesel being valued higher than naphtha, the revenue of the PDVSA/Intevep case is improved appreciably, resulting in an increased IRR.

10.3.8 Recommended Technology

A ranking of all the licensors based on technical and economical parameters is provided in Section 8.3.8.

	"Long Term" Project
Group A:	Exxon, Sasol
Group B:	Shell
Group C:	Rentech, Syntroleum

However, for the "long term" project, 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.

The Sasol case will be used in Section 10.4.3 to select a suitable site for recommendation, since complete and reliable information is not available for Exxon's GTL technology.

PDVSA

FIGURE 10.6: GTL BLOCK FLOW DIAGRAM - SASOL/CHEVRON, LONG TERM CASE

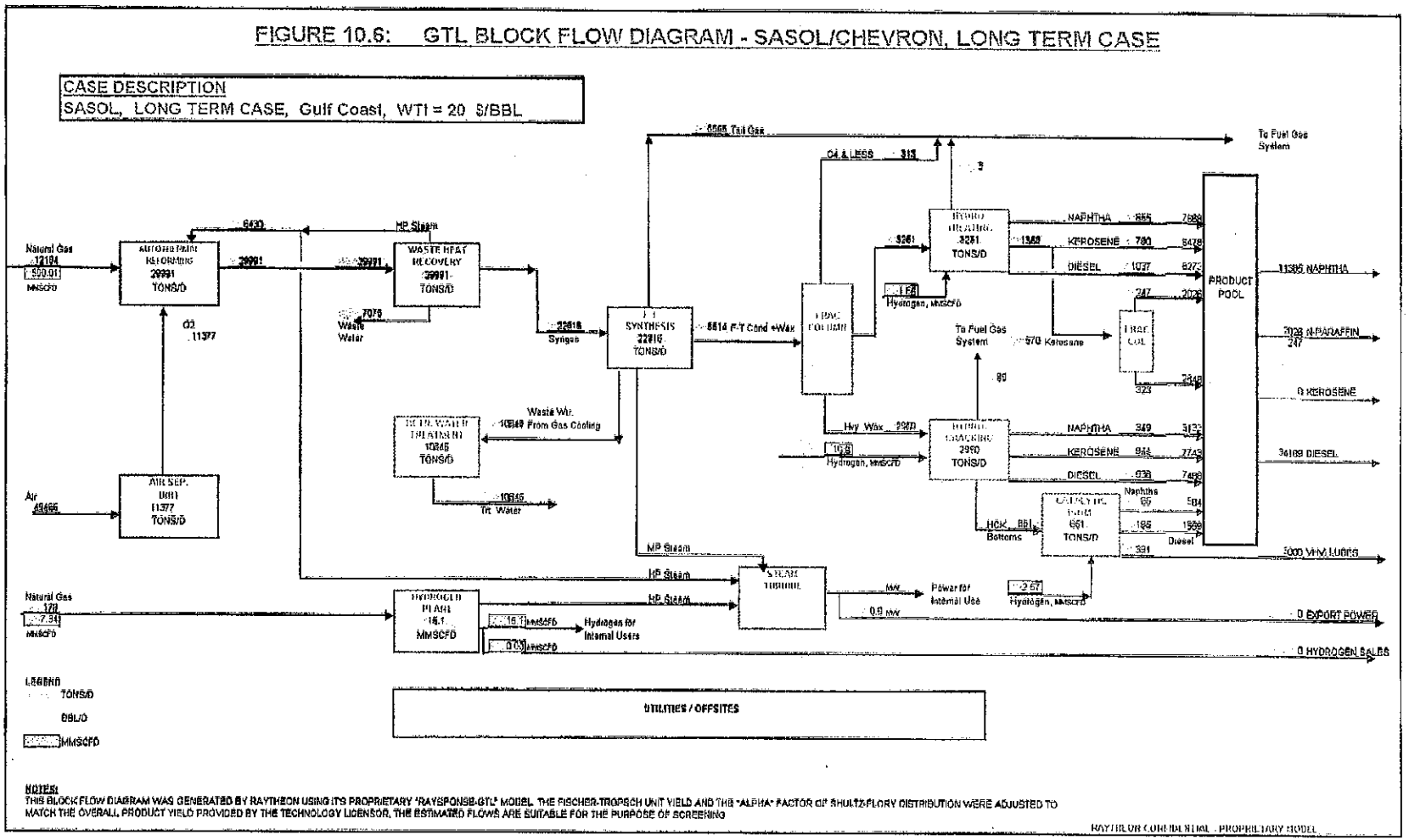

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FIGURE 10.7: GTL BLOCK FLOW DIAGRAM - SYNTROLEUM, LONG TERM CASE

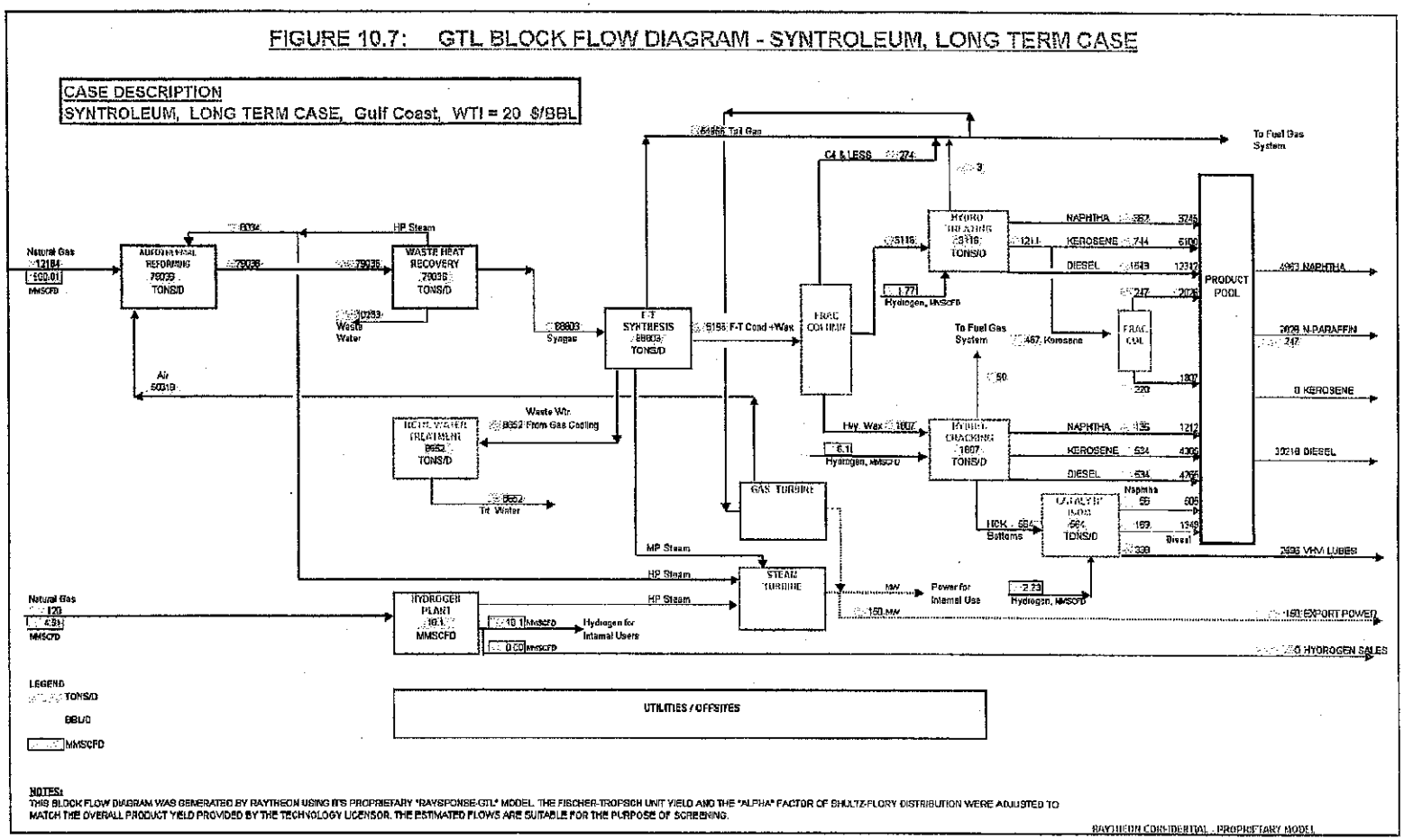

FIGURE 10.8: GTL BLOCK FLOW DIAGRAM - RENTECH, LONG TERM CASE

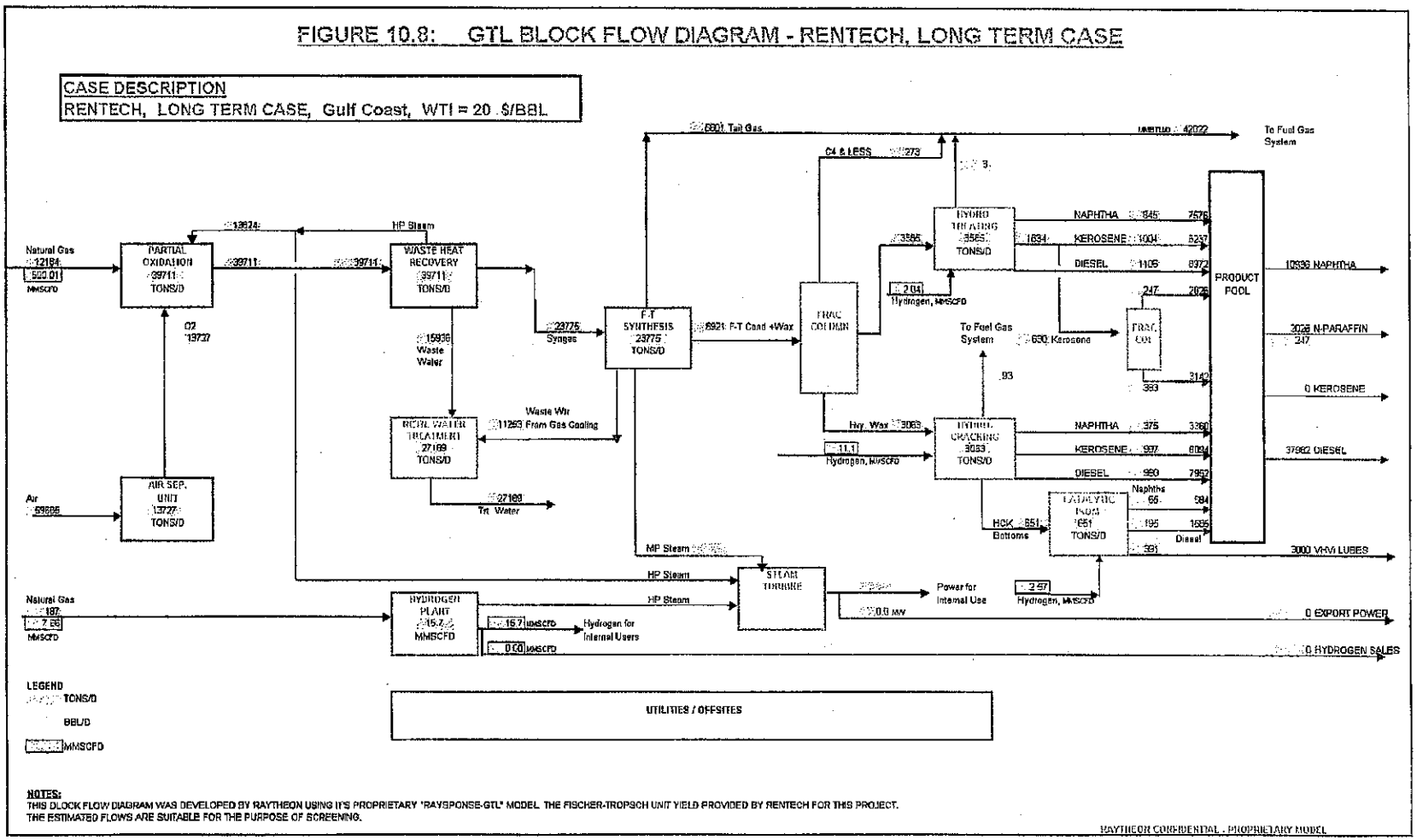

FIGURE 10.9: GTL BLOCK FLOW DIAGRAM, PDVSA/INTEVEP, LONG TERM CASE

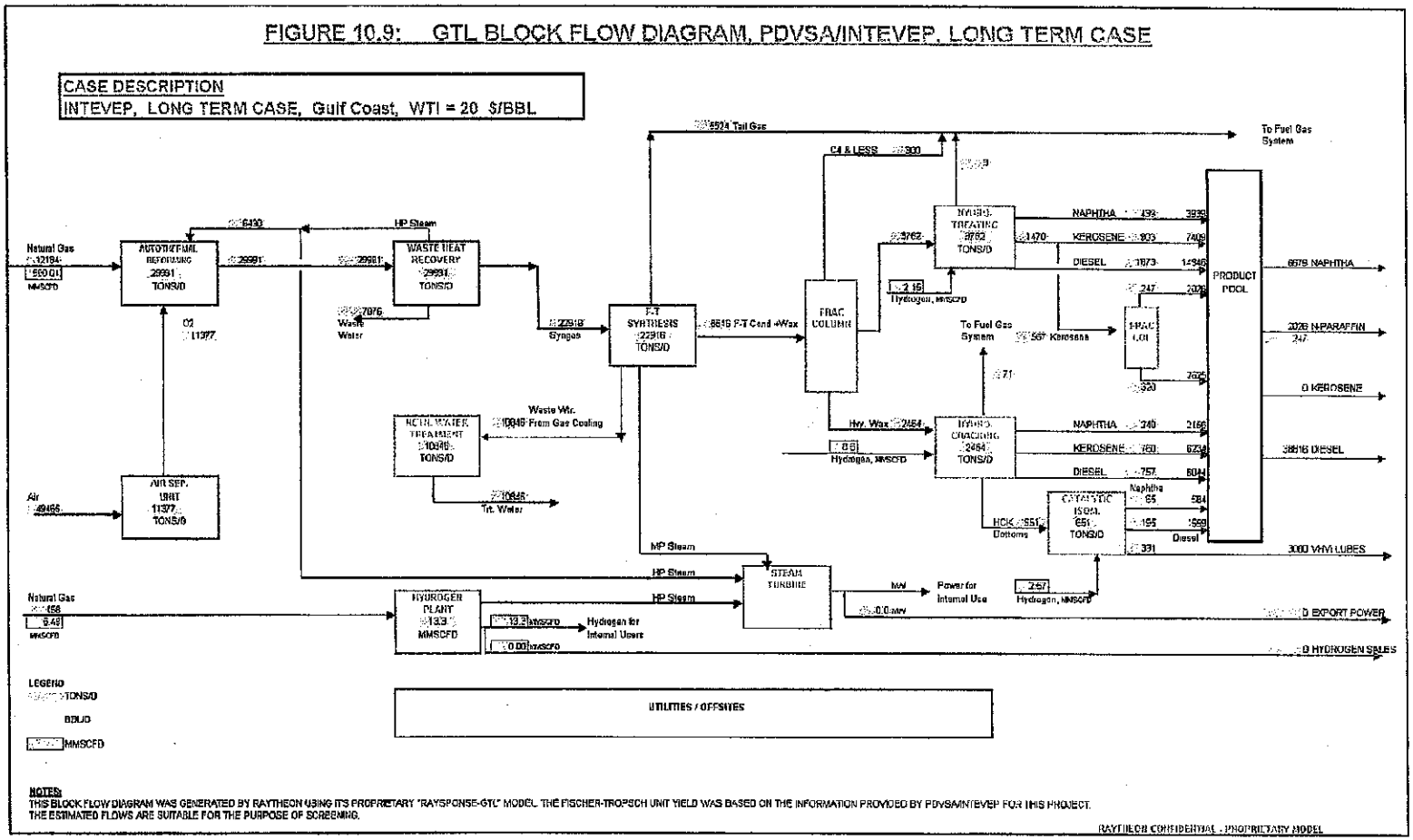

Table 10-2

Economic Analysis Summary - "Long Term" Case

Description	Exxon		Shell		Sasol [3]		Syntroleum [3]		Rentech [5]		Intevep [5]	
	No Lube	Lube	No Lube	Lube	No Lube	Lube	No Lube	Lube	No Lube	Lube	No Lube	Lube
Total Installed Cost, [1] MM$					1,039	1,095	1,258	1,302	1,268	1,324	997	1,050
Gross Revenue, MM$					264	367	205	294	295	398	282	385
Projected IRR, %	14.3	18.2	13.2	16.9	16.7	21.3	10.7	15.0	15.4	19.4	18.4	23.0
NPV @ 10% DF [6], MM$	361	755	293	686	442	839	52	400	426	823	547	946
Total Liquid Yield, BBL/Day					50,900	50,900	40,000	40,000	54,900	54,900	50,900	50,900
TIC in $/BBL	24,000 [2]	25,000	26,000 [2]	27,000	20,410	21,510	31,450	32,550	23,100	24,120	19,590	20,630

[1] Total Installed Cost includes initial charge of catalyst and license fee.
[2] Exxon and Shell declined to participate in the study. The figures provided here were estimated based on an article by Morgan Stanley Dean Witter dated September 9, 1997.
[3] TIC provided by Sasol is 972 MM$ for 465 MMSCFD NG Feed. The TIC provided by Syntroleum is 1098 MM$.
[4] Revenue for Syntroleum includes sale of 150 MW export power.
[5] Rentech and Intevep only provided Fischer-Tropsch Unit TIC. All other unit investment costs were estimated by **RAYSPONSE™**.
[6] NPV (Net Present Value) was calculated using a Discount Factor of 10%.