DOT-HS-805 641

IHTSA-80-28

SATISFACTION OF THE AUTOMOTIVE FLEET FUEL DEMAND AND ITS IMPACT ON THE OIL REFINING INDUSTRY

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DECEMBER 1980 FINAL REPORT

DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION Office of Research and Development Washington, DC 20590

HE 18.5 .A34 no. DOT-TSC-NHTSA-80-28

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1. Report No. - DOT-HS-805 641	2. Government Acces	sion No.	3. Recipient's Catalog	3 No.
4. Title and Subtitle			5. Report Date	
Satisfaction of the Autom	otive Fleet Fu	el	December 198	80
Demand and Its Impact on	the Oil Refinin	ng	6. Performing Organia	the second s
Industry				
7. Author(s)		_	8. Performing Organiz	ation Report No.
M. A. Moore			DOT-TSC-NHTSA-	80-28
			10, Work Unit No.	
9. Performing Organization Name and Address SRI International (former	ly Stanford Re	search	HS159/R1405	
Institute)*	i) ocaniora ne	Scarch	11. Contract or Grant	No.
333 Ravenswood Avenue			DOT-TSC-106	4
Menlo Park, California 9	4025	ŀ	13. Type of Report ar	ad Period Coursed
12. Sponsoring Agency Name and Address				
U.S. DOT/NHTSA		Ļ	Final repor	
Office of Research and Deve	lopment		14. Sponsoring Agency	/ Code
Washington DC 20590	-			
15. Supplementary Notes U.S.	Department of 7	Fransportation		
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17. Key Words (Suggested by Author(s))		18. Distribution Statement		
Motor fuel, refining, diesel	L,	Document is av	ailable to the	public
fuel desulfurization		through the Na		
		tion Service,	Springfield, V	'irginia
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19. Security Classif. (of this report)	20. Security Classif. (c	of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassifi	ed	221	

*For sale by the National Technical Information Service, Springfield, Virginia 22151



PREFACE

This report presents the results of developing a mathematical model of the U.S. oil refining industry and applying this model in case studies of dieselization and automotive fuel desulfurization. This work was performed for the U.S. Department of Transportation, Transportation Systems Center, under Contract Number DOT-TSC-1064 during the 1975-1977 time period. It, therefore, predates and does not include any consideration of the possible implications of the current synfuels program.

The author wishes to acknowledge the contributions of Mr. Jerry Horton and Mr. Norman Rosenberg of the Transportation Systems Center and of Mr. K. Ushiba and Ms. Meera Rao of SRI.

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ABBREVIATIONS AND SYMBOLS

Ъ	barrel
b/d	barrels per day
BERC	Bartlesville Energy Research Center
BuMine s	U.S. Bureau of Mines
cd	calendar day
D/G	diesel-to-gasoline ratio
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPRI	Electric Power Research Institute
ERDA	U.S. Energy Research and Development Administration (now DOE)
FCC	fluidized catalytic cracking
FOB	free on board
FOE	fuel oil equivalent
gal	gallons
HDS	hydrodesulfurization
LP	linear programming
LPG	liquefied petroleum gas
М	10^3 ; 1,000; one thousand
MM	10 ⁶ ; 1,000,000; one million
min	minute
MON	motor octane number
PAD	Petroleum Administration for Defense
%	percent
ppm	parts per million
RIM	Refining Industry Model (SRI)
RON	research octane number
sd	stream day
TSC	Transportation Systems Center (DOT)
VFR	vehicle-fuel-refinery
VGO	vacuum gas oil
vol%	volume-percent
wppm	parts per million by weight

1 EXECUTIVE SUMMARY

A number of actions proposed to improve the fuel economy and reduce air-polluting emissions of the automotive fleet will involve changes in the quality or quantity of the fuel being used. Such changes, in turn, will affect the refining industry, because automotive fuels are predominantly refined petroleum products.

To assess the extent of the potential impacts in terms of cost and energy efficiency, a mathematical (linear programming--LP) model was developed to simulate the U.S. refining industry. This model covers refining and bulk product distribution for each of the five Petroleum Administration for Defense (PAD) districts. The refinery sector simulation in the industry model was developed through the use of the detailed SRI refinery and petrochemical LP model.

Two series of case studies were performed with the Refining Industry Model (RIM):

- An assessment of the impact of increased penetration of the diesel-powered vehicle into the automotive market (dieselization study)
- (2) An assessment of the impact of a mandated reduction of sulfur content of both gasoline and diesel fuel (desulfurization study).

Both studies were performed within the framework of a 1995 scenario characterized by extensive petroleum conservation. Estimates of 1995 demand for gasoline and diesel fuel were provided by the U.S. Department of Transportation, Transportation Systems Center (DOT/TSC). Estimates of demand for other refined products were adapted from a concurrent SRI study for the Electric Power Research Institute (EPRI). The resulting 1995 scenario should be viewed as a plausible basis for analysis rather than as a forecast resulting from this project.

In this scenario, the total demand for gasoline plus diesel fuel, 7.3 million barrels per day (b/d), is about 78 percent of the 1978 total of about 9.4 million b/d. Six cases, as defined in Table 1-1, were analyzed. Quantitative results for these cases are summarized in Tables 1-2 through 1-4. The cost analyses shown in the summary tables have been updated to 1979 dollars from the 1974 values used in the original work. The W. L. Nelson construction and operating cost indices, published periodically in the <u>Oil and Gas Journal</u>, were used to adjust the refining costs to 1979 values.

Table l-l

CASES STUDIED

Case No.	Description
Case l	RIM validation with 1974 industry data
Case 2	1995 base case for dieselization study
Case 3	1995 scenario with 15 percent diesel penetra- tion of the automotive fuel market
Case 4	1995 scenario with 30 percent diesel penetra- tion of the automotive fuel market
Case 5	Case 4 with desulfurization of all gasoline to 100 ppm (by weight) sulfur content
Case 6	Case 5 with addition of diesel fuel desulfur- ization to 200 ppm (by weight) sulfur content

Table 1-2

1995 DEMAND SCENARIO FOR STUDY CASES

Case	U.S. Demand (10 ⁶ b/cd [*])	Percent of Total
1995 base case		
Gasoline Jet fuel Diesel Distillate fuel oil Residual fuel oil	5.4 2.3 1.8 2.0 <u>1.3</u>	42 18 14 16 10
Total major fuel products	12.8	100
Case 315% diesel penetration		
Gasoline Diesel	4.7 <u>2.5</u> 7.2	
Case 430% diesel penetration		
Gasoline Diesel	4.0 <u>3.2</u> 7.2	

* Barrels per calendar day.

DIESEL PENETRATION STUDY RESULTS

	1974		1995		
	Case 1	Case 2	Case 3	Case 4	
Diesel penetration, %	~ ~	Base	15	30	
Diesel/gasoline ratio	0.17/1	0.32/1	0.53/1	0.80/1	
Diesel production, % refinery output	8.7	14.2	20.5	27.0	
Gasoline production, % refinery output	50.7	43.8	38.9	33.8	
Cost differential, \$/b (gasoline + diesel)*	Base	-0.92	-0.78	+0.075	
New investment, 10 ⁶ \$*		72.4	131	1,967	
Energy consumption, % of domestic products (FOE)	6.31	6.25	6.17	7.30	

Cost figures in this table are adjusted for inflation from the 1974 dollars shown in the body of the report to 1979 dollars using the W. L. Nelson inflation indices. The factors used are 1.50 for operating costs and 1.33 for investment.

Table 1-4

FUELS DESULFURIZATION STUDY RESULTS, 1995

	Case 4	<u>Case 5</u>	<u>Case 6</u>
Diesel Penetration, %		30	
Gasoline desulfurization, % (100 ppm S)	0.0	100	100
Diesel desulfurization, % (200 ppm S)	0.0	0.0	100
Incremental cost, c/gal desulfurized gasoline	Base	3.0	3.0
Incremental cost, c/gal desulfurized diesel		Base	4.5
Incremental investment, 10^9 \$*			
For gasoline desulfurization For diesel desulfurization	Base	2.7 Base	4.8
Incremental energy consumption, % of domestic product (FOE basis)			
For gasoline desulfurization For diesel desulfurization		1.1	0.4

Cost figures in this table are adjusted for inflation from the 1974 dollars shown in the body of the report to 1979 dollars using the W. L. Nelson inflation indices. The factors used are 1.50 for operating costs and 1.33 for investment. The major conclusions of the dieselization study are summarized as follows.

- If the demand for diesel fuel increases while demand for other distillate fuel oils is maintained at the projected level, a shortage of middle distillate products (jet fuel, diesel, and No. 2 fuel oil) tends to occur when gasoline production equals demand. Conversely, if crude oil runs are increased to meet demand for middle distillates, excess gasoline is produced.
- For the 15 percent diesel penetration case, the incremental cost of refining gasoline plus diesel increased by 0.3 cent per gallon (14 cents per barrel) as the volumetric production ratio of diesel-to-gasoline increased from the 1995 base case (Case 2) ratio of 0.3/1 to a ratio of 0.5/1. At a diesel/ gasoline ratio of 0.8/1, the refining cost rises sharply as new hydrocracking capacity is required, reaching about 2.0 cents per gallon of diesel plus gasoline more than the cost for the 0.5/1 ratio case.
- Refining energy consumption reaches a minimum value of 6.17 percent of domestic product output (fuel oil equivalent basis) at the 0.5/l diesel/gasoline ratio, a decrease of 0.08 percentage points below the 1995 base case.

Two fuels desulfurization cases were examined with the RIM:

- Desulfurization to 100 ppm sulfur of all gasoline produced in the 30 percent diesel penetration case (Case 5).
- (2) Desulfurization to 200 ppm sulfur of all diesel produced in the 30 percent diesel penetration case, as well as desulfurization of gasoline to 100 ppm sulfur (Case 6).

The RIM indicates that desulfurization of all gasoline to 100 ppm sulfur will cost about 3.0 cents per gallon and requires a refining industry investment in new facilities of about \$2.7 billion. Refinery energy consumption for this case increases to 8.4 percent of domestic refinery output, 1.1 percent more than consumption for Case 4.

The addition of diesel desulfurization to 200 ppm sulfur adds about 4.5 cents per gallon to the cost of diesel fuel and increases energy consumption by 0.4 percent of total domestic refined products over Case 5 consumption. The incremental investment for diesel desulfurization is \$4.8 billion.

The cost estimates for both cases assume that new hydrodesulfurization (HDS) facilities will be required. Thus, the costs may be reduced to the extent that existing HDS facilities are operable by 1995 and are technologically adequate for meeting the severe requirements. The industry model will facilitate the future examination of these parameters and will permit the analysis of numerous variations from the cases presented in this report.

2 INTRODUCTION

2.1 Overview and Scope

The interactions of the U.S. transportation system and the oil refining industry are extensive. Nearly half of U.S. refinery output by volume is motor gasoline, and substantial quantities of automotive diesel fuel, jet fuel, and bunker fuel are also produced. Virtually all of the energy consumed in U.S. transportation is currently derived from petroleum products. A few exceptions exist, such as electric transit systems, and some potential exists for replacement of petroleum-based fuels with alcohols or other substances that may be derived from nonpetroleum sources. However, for the next 10 to 20 years, petroleum fuels for transportation are unlikely to be extensively displaced by nonpetroleum alternatives. Thus, the petroleum refining industry is expected to continue to play a critical role in supplying the basic energy requirements of the U.S. transportation system.

Concern for environmental quality and energy conservation in recent years has focused on the automobile as a major source of air pollutants and as an inefficient fuel user. A number of changes in the automobile intended to lessen its detrimental effects on the environment and to increase its energy-efficiency are in various stages of implementation. Some changes alleviate one problem only at the expense of exacerbating the other; one example is the requirement for unleaded gasoline to reduce ambient lead concentrations, which increases the amount of crude oil required to produce a gallon of gasoline. Other potential changes in the automobile or in the required quality of automotive fuel could have equally profound effects on the oil refining industry. Two such changes addressed in this study are increased use of automotive diesel fuel and reduction of the allowable sulfur content of automotive fuels.

To provide a sound basis for assessing the effects on the oil refining industry of such changes, the objectives of this project are twofold.

- (1) Develop a mathematical modeling system of the U.S. petroleum refining industry, consisting of:
 - (a) A detailed refinery model
 - (b) A refining industry model.
- (2) Use the models to analyze the impact on the refining industry of the following hypothetical changes in the fuel requirements for the 1995 automotive fleet:

- (a) Two levels of displacement of gasoline by diesel fuel:15 and 30 percent of automotive fleet fuel requirements
- (b) Reduction of the sulfur content of gasoline and diesel fuel to 100 ppm and 200 ppm by weight, respectively, in the context of a 30 percent diesel penetration of the automotive fuel market.

2.2 General Approach

The steps required in the case study method used in this work are summarized below. These topics are discussed in greater depth in the appropriate sections of the report.

- Define the specific hypothetical issues to be studied (i.e., increased diesel penetration of the automotive fuel market and desulfurization of automotive fuels). These definitions provide a basis for defining specific cases to be studied and indicate the types of information required. They also provide guidelines for making a number of decisions related to the type of model required, as discussed in the next step.
- Select a type of model that can adequately simulate the system under study, and construct the model. In this case, the petroleum refining industry was judged to be adequately simulated by LP techniques. This implies that the important characteristics of the U.S. petroleum refining industry may be mathematically described by linear equations. As constructed for this study, the RIM represents the domestic refining industry aggregated geographically by PAD districts.
- Validation of the RIM is the next logical step. This was performed by operating the model with data on historical industry capacity and product demands to match refinery output and product imports.
- The validated RIM is then modified with case-specific technological options and hypothetical product requirements and exercised to determine optimal industry operations.
- Finally, the case study results are interpreted by applying knowledge of industry practice, economics, and technology. An important aspect of this interpretation is the identification of possible consequences, both economic and noneconomic, for each type of refinery.

3 MODEL DESCRIPTION AND DEVELOPMENT

3.1 Refinery Model

3.1.1 Petroleum Refining Overview

The key element in the petroleum refining industry is, of course, the refinery. The term refinery is used generically to describe any process plant that converts crude oil and other hydrocarbon feedstocks into the various petroleum products. Ideally, these products should be produced in the volumes and qualities required by the market, but the indigenous fractions of crude oil do not, in general, match either the quantities or qualities of the products in demand. Thus, the combination of process units called a refinery is required.

Over the years the petroleum refining industry has evolved the process technology to produce marketable volumes of products meeting various specifications from crude oils of varying quality. Although no two refineries in the United States are identical, there is considerable uniformity in the types of refining processes used.

As shown in the flow chart of a typical refinery depicted in Figure 3.1.1-1, catalytic reforming is the major process used to increase the octane number of low-octane naphthas. Catalytic cracking is the major process used to convert heavy distillate oils to gasoline. The light olefins--propylene and butylene--that are by-products of catalytic cracking are generally reacted with isobutane in a process called alkylation to produce a high-quality gasoline blend stock. Hydrocracking, a process commercialized in the 1960s, is used in many refineries to supplement catalytic cracking in the production of additional gasoline and jet fuel.

Residual oil processing in U.S. refineries has been directed primarily at converting much of this residual fraction to lighter, more valuable products. Thermal cracking processes ranging in severity from visbreaking to coking are the major processes in general refinery use for residual reduction, although solvent deasphalting is used in some cases. As the prices of low-sulfur residual fuel oil have moved closer to prices of distillates and gasoline, considerable interest has developed in residual HDS technology, and the first installations that use this type of process have recently started operating. In refineries that process high-sulfur (sour) crudes, hydroprocessing is extensively applied for sulfur removal from both naphtha and distillate streams.

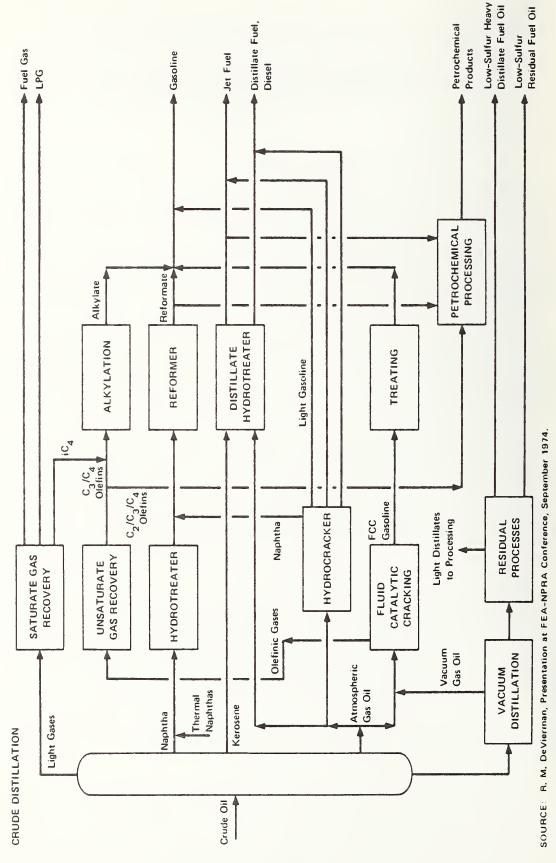


FIGURE 3.1.1-1 TYPICAL REFINERY PROCESS FLOW

3.1.2 Description of Refinery Model

This subsection briefly describes the LP refinery model used to develop the refinery sectors of the RIM. A more detailed description of the refinery model is included as Appendix A to allow interested readers to judge the level of detail considered in this work.

The LP refinery model used in this study is a generalized model that may be constrained and calibrated to simulate a specific existing refinery or used to simulate typical refineries in assessments of refining industry economics. A block flow diagram of the model is shown in Figure 3.1.2-1. The model is comprehensive in process coverage, including virtually all modern commercial petroleum refining processes, and in coverage of specifications for blending fuel products. It is capable of handling multiple crude oils and other hydrocarbon feedstocks. In addition, the model includes the process options for the production of basic olefin and aromatic petrochemicals. The investment, operating cost, product blending quality, and yield factors are modeled in sufficient detail to permit budgeting and scheduling of existing refinery operations, planning of new facilities, and determination of feedstock values and product pricing.

In specific mathematical terms, the model consists of a number of simultaneous linear equations and inequalities in the form of a matrix. The specific size of the matrix may vary with the problem being assessed and is thus influenced by such factors as the number of crude oils under study, the number of process options allowed, and the number of products or grades of products under study. The version used for the major part of this work covers four crude oils and a typical set of products; it requires 476 equations with 1,169 variables.

The specific processes included in the model are considered to be representative of the types most prevalent in the industry. Each process is represented in the LP model as an entity defined in terms of an investment, utility requirements, catalyst cost, feedstock requirements, yield streams as generally produced in the industry, and the blending qualities of each of these streams that pertain to the appropriate product options. If the operating severity of a process may vary in practice, the model has multiple sets of yields, utility, and feedstock requirements corresponding to the various severity levels. Each severity implies a set of process variables--temperature, pressure, space velocity, recycle ratio, and the like--that is not explicitly stated in the refinery model.

The refinery processes in which variation in operating severity is most critical are catalytic reforming and fluidized catalytic cracking (FCC). Multiple severity options are included in the proposed refinery for both of these processes. The catalytic reformer has five severities, ranging from 91 to 103 research octane number (RON). FCC conversion^{*}

In general practice, FCC conversion means the volume percent of feedstock cracked to 430°F and lighter material.

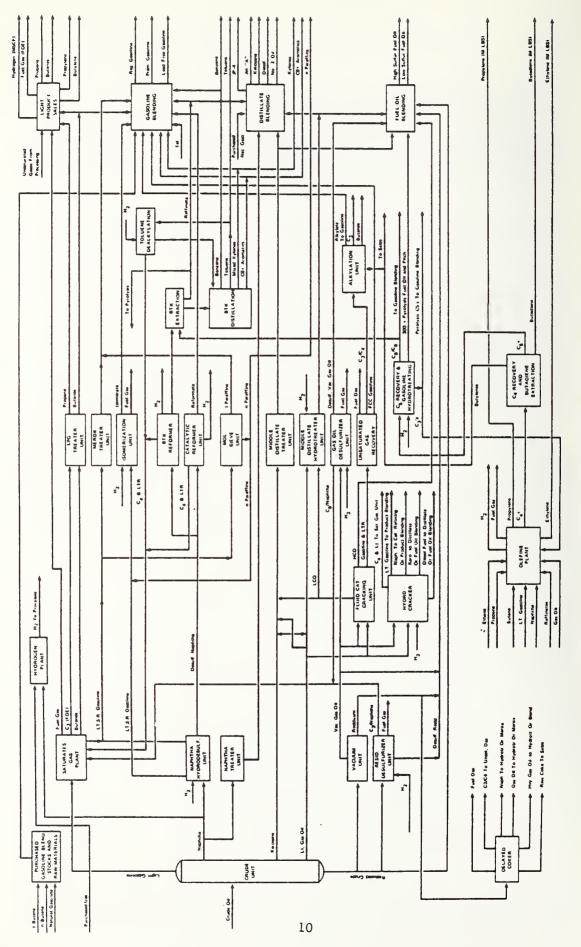


FIGURE 3.1.2-1 REFINING AND PETROCHEMICAL LP MODEL

varies from 60 to 90 percent. In addition, the hydrocracking process has options for maximum gasoline, turbofuel, and diesel operations.

3.2 Refining Industry Model

3.2.1 The Oil Refining Industry -- Overview

On 1 January 1979, the U.S. oil refining industry consisted of 289 operating refineries of various sizes distributed unevenly throughout the country. Table 3.2.1-1 shows that the largest number of refineries and the greatest share of capacity are situated in PAD District III, which includes the Gulf Coast states. A significant portion of the PAD III refinery output is transported to East Coast markets by coastal tankers and product pipelines.

Table 3.2.1-1

Percent Number of Capacity of U.S. <u>Refineri</u>es^{*} (10³ b/d) PAD Capacity 1977 Region District 1974 1977 1974 1974 1977 East Coast Τ 28 28 1,678 1,732 11 11.2 4,030 Midwest ΤT 68 69 4,145 28 26.1 6,132 6,837 Gulf Coast III 83 96 41 43.1 Rocky Mountain IV 29 29 547 546 4 3.4 2,432 West Coast V 2,550 51 51 16 16.1 259 14,819 15,862 100 100.0 Total 273

REFINING INDUSTRY GEOGRAPHICAL DISTRIBUTION

Reported as operating.

Average

Source: Bureau of Mines, Petroleum Refineries, U.S. Department of the Interior (1 January 1974, and 1 January 1977).

The distribution of refineries by size is also a significant parameter in a study of the industry. Significant economies of scale are realized in petroleum refining, and the larger plants are generally more flexible in adjusting to changes in the feedstock qualities and product demand. On the other hand, some of the small refiners efficiently serve market

57.2

58.1

areas outside of the economic marketing areas of the large refiners. As shown in Table 3.2.1-2, the 42 percent of U.S. refineries with capacities less than 20,000 b/d produce 5 percent of U.S. petroleum products. On the other hand, about 60 percent of U.S. refining capacity exists in plants with capacities greater than 100,000 b/d, though such size plants account for only 18 percent of U.S. refineries.

Table 3.2.1-2

Class	Num of Pl	مل	Percent of Plants			Capacity (103 b/d)		nt of city
<u>(10³ b/d)</u>	1974	<u>1977</u>	<u>1974</u>	<u>1977</u>	1974	1977	1974	1977
0-20	109	112	42	42	805	860	5	5
20-50	65	62	25	23	2,249	2,113	15	13
50 - 100	40	45	15	17	3,002	3,269	21	19
100-200	30	31	12	11	4,149	4,352	28	26
200+	_15	19	6	7	4,614	6,156	31	37
Total	259	269	100	100	14,819	16,750	100	100

REFINING INDUSTRY PLANT SIZE DISTRIBUTION

 \star Refineries operating on 1 January of given year.

Source: "Annual Refining Surveys," <u>Oil and Gas Journal</u> (1 April 1974 and 28 March 1977)

Comparison of the 1974 and 1977 data in this table indicates that the number of refineries in each size class has changed little. However, the continuing trend to larger refineries is evident; about 80 percent of the 2 million b/d increase in capacity has come from refineries in the 200,000 b/d class. This suggests that refiners are generally expanding by adding capacity at existing sites rather than by building new refineries in other areas.

A third characteristic that has a significant impact on the flexibility of the industry in adjusting to changes in product mix or product quality is the application of "downstream" processes. As shown in Table 3.2.1-3, the major processes downstream of the primary crude distillation are the vacuum distillation of the residual stream from the primary crude unit, FCC, catalytic reforming, and the various applications of hydroprocessing. Because several of these processes are used in sequence, the percentages do not add up to 100 percent.

Table 3.2.1-3

	Process Capacity as Percent of Crude Oil Capacity			
Process		<u>1977</u>		
Atmospheric distillation	100.0	100.0		
Vacuum distillation	35.6	36.7		
FCC	30.2	29.2		
Catalytic reforming	22.4	21.7		
Alkylation	5.6	5.2		
Hydrocracking	5.7	5.4		
Hydroprocessing	38.5	43.6		
Coking	6.7	7.6		
Lube production	1.4	1.4		
Asphalt production	4.4	4.7		

REFINING INDUSTRY PROCESS APPLICATION

Source: "Annual Refining Surveys," Oil and Gas Journal (1 April 1974 and 28 March 1977)

3.2.2 <u>Refining Industry Model--Objectives, Scope, and</u> <u>Conceptual Design</u>

The basic objective of the industry model is to assess the effects on the oil refining industry of potential changes in the automotive fleet. The model is intended to permit assessment of:

- The ability of the industry to produce fuel products in amounts or qualities different from those currently produced
- The capital and energy requirements for such changes
- Effects of such changes on various sectors of the industry by geographic and refinery size classification
- The effects of supplies of supplemental feedstocks such as natural gas liquids.

The model covers the entire U.S. refining industry and is aggregated by PAD district. (Product transportation modes include major product pipelines and marine transportation.) Aggregation by PAD districts was selected for consistency with the data base developed by Bureau of Mines (BuMines)^{*} on refinery yields and crude oil and product movements.

LP was selected for this modeling effort for several reasons. From a theoretical standpoint, most of the quantifiable characteristics of the petroleum refining industry may be adequately expressed as linear quantities. Product output, capacity limitations, and product distribution are essentially material balance equations, which are inherently linear. Investment, though it is nonlinear for a single refinery, tends to approach linearity when it is calculated for an industry of several hundred refineries. Refinery operating costs that are not investmentrelated are generally linear, insofar as small process units can be designed with the same utility and catalyst requirements per barrel of capacity as larger units.

LP modeling has a number of advantages.

- The structure of an LP model is relatively simple, compared with that of heuristic, dynamic, stochastic, or other types of models
- LP modeling is widely used in the oil refining industry, and thus the advantages and limitations of the model are generally known
- Elaborate LP systems have been developed, and these are accessible to the public through several computer service vendors. The Control Data Corporation Apex III system was used in this work. The availability of an existing system for performing the mathematical procedure obviates the need for a considerable amount of programming needed to use other modeling techniques.

This discussion is not intended to be a comprehensive comparison of the advantages and disadvantages of LP with those of other modeling techniques. Such a comprehensive comparison is beyond the scope of the project. More detailed discussions of mathematical modeling as applied to the oil refining industry may be found in numerous sources.¹⁻³

The objective function selected for optimization in the case studies is that of minimizing industry costs of products delivered to hypothetical bulk terminals in each of the PAD districts. This quantity was judged to be an acceptable indicator of the effects of a given change on the industry.

The generally good agreement of the RIM results with industry data shown in the validation work appears to support the use of cost minimization to reflect industry behavior. However, it may be of interest in further studies to examine other quantities for optimization. Energy used in refining and capital for new facilities are monitored in the model and could be selected for optimization.

Now available from Department of Energy (DOE), Energy Information Administration (EIA).

Structurally, the model comprises a refining submatrix (Table 3.2.2-1) and a distribution submatrix (Figure 3.2.2-1) for each PAD district. The refining submatrix is defined by equations that sum each product, feedstock, and resource used, and variables that represent each mode of refinery operation and the total of each product. As shown, the singledistrict refining industry matrix includes large and small refineries . L. with sweet and sour crude operations, each of which has base conversion, low conversion, and high conversion operating modes. In our analysis of PAD district III refineries, an intermediate size class was observed that differed in process configuration from the average configurations for small and large refineries. A medium capacity refinery mode was added to District III to account for this. Each of the refining modes in the model is derived from an optimal solution of the detailed Refinery Model described in Section 3.1. This approach assures that the yields and costs will accurately reflect the refinery process technology used.

New refining facilities that did not exist in 1974 are modeled as incremental refining modes. These incremental modes include the parameter of investment in addition to the operating cost parameters of the existing refinery modes. The existing incremental refinery modes are case-specific, as in the case of additional hydrotreating or hydrocracking for diesel fuel production and hydrotreating for gasoline and diesel desulfurization. Twenty-two types of refinery products are represented in the model, including aromatic chemicals.

The possible need for additional refining and pipeline capacity is allowed for in the aggregate total for a given facility in a given district, and the appropriate investment is included. The distribution submatrix in each district is defined by a second set of equations, one for each product and cost item. The variables in these equations are (1) the total production of a given product within the district; (2) the product volumes transferred in and out of the district; and (3) the consumption within the district. The submatrices for the various districts are linked by the transfer of the various products from one district to another. Two transportation modes--marine and pipeline--are available to all applicable product movements between the PAD districts and the foreign sector. Transfers that are physically improbable, such as marine transport from or to the Rocky Mountain district (PAD IV), have been excluded from the model.

The major user input data are the delivered product requirements in each PAD district, in thousands of barrels (42 gallons) per calendar day (b/cd). Output of the RIM consists of the Apex system listing of row and column values, plus a FORTRAN report providing tabular analyses of the optimal inter-PAD product movements, refining capacity utilization, utility and energy requirements, labor, operating costs, and investment.

Conversion in the general sense used in the industry describes the "cracking" of heavy crude oil fractions to lighter stocks, as by FCC, hydrocracking, and coking.

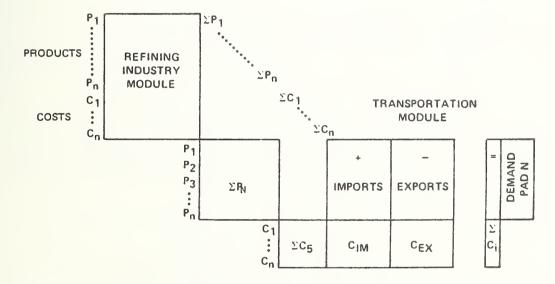
Table 3.2.2-1

TYPICAL REFINERY MODES IN THE REFINING INDUSTRY MODEL FOR PAD DISTRICT II REFINERY DATA INPUT

	20 CALHC*	20 CALLC	20 CASBA	20 CASHC	20 CASLC	20 CBLBA	20 CBLLC	20 CBLHC
Input								
Sweet crude Sour crude Californía crude Alaskan crude	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
Natural gasoline	-1.85	-1.85	-2.14	-2.14	-2.01	-1.85	-1.85	-1.85
Isobutane	-1.33	-1.33	-1.48	-1.48	-1.39	-1.33	-1.33	-1.33
Normal butane	-1.33	-1.33	-1.48	-1,48	-1.13	-1.33	-1.33	-1.33
Total	-104.51	-104.51	-105.10	-105.10	-104.53	-104.51	-104.51	-104.50
Output								
C3 LPG	2.44	2.44	1.97	2.30	1.85	2.44	2.44	2.44
C ₄ LPG	0.54	0.54	0.49	0.59	0.46	0.54	0.44	0.54
Naphtha	0.88	0.88				1.08	0.88	0.88
Regular gasoline	20.78	19.45	19.31	14.91	13.01	25.39	21.56	27.07
Premium gasoline	16.07	16.07	12.20	4.97	4.34	16.07	16.07	16.07
Low-lead gasoline	9.01	7.20	8.37	14.91	13.01	11.04	7.20	13.24
Lead-free gasoline	13.31	9.54	7.27	14.91	13.01	9.54	9.54	12.40
JP-4 jet fuel	1.34	1.09	1.27	1.27	1.20	1.34	1.09	1.09
Jet A jet fuel	5.36	4.37	4.01	4.01	0.94	4.59	4.37	4.59
Diesel	7.75	18.75	11.00	10.00	23.96	6.32	15.51	5.69
No. 2 fuel oil	15.61	15.61	22.19	20.69	17.99	15.61	15.61	11,48
High-sulfur No. 6	1.78	2.24	3.89	3.54	3.65	2.24	2.24	1.78
Low-sulfur No. 6	2.73	2.24	3.89	3.54	3.65	2.24	2.24	1.78
Lube stocks	1.22	1.22				1.22	1.22	1.22
Asphalt and road oil	3.01	3.01	7.65	7.65	5.72	3.01	3.01	3.01
Coke (low-sulfur) Coke (high-sulfur) Coke (California crude)	0.63	0.61				0.94	0.87	0.94
Benzene						0.14	0.14	0.14
Toluene						0.10	0.10	0.10
Mixed xylenes						0.19	0.19	0.07
Míscellaneous products	2.72	1.40	1.37	1.51	1.29	1.40	1.40	1.40
Total	105.18	106.66	104.88	104.80	104.08	105.43	106.12	105.93
Operating cost factors								
Purchased electric power	398.00	379.00	262.90	270.00	267.72	447.00	424.00	465.00
Total fuel required	5.86	5.62	4.70	4.88	4.62	5.85	5.85	6.09
Refinery energy consumption	6.59	6.33	5.20	5.39	5.12	6.69	6.64	6.97
Labor	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Operating costs	16.04	14.01	11.27	12.00	9.38	16.40	14.90	18.57

* Refinery nomenclature code is as follows:

- 20 PAD district II
- CA Low-sulfur crude
- CB High-sulfur crude
- L Large refinery, >50,000 BPCD
- S Small refinery, <50,000 BPCD
- BA Base operating mode
- LC Low conversion mode
- HC High conversion mode.





A complete equation listing of the RIM is presented in Appendix B, along with the naming conventions used. An example of the procedure for operating the RIM is provided in the validation work described briefly in the following section and in greater detail in Appendix C.

3.2.3 <u>Validation of Refining Industry Model (RIM) for 1974</u> Industry Operation

In principle, the procedure for validating the RIM is straightforward; it consists of matching the output of the constrained model with actual industry data for a given base period. The RIM is exercised with the product demands, refining capacities, and prices presented in Appendix C to obtain an optimal solution. This gives values by PAD district for crude oil and other feedstocks used, refinery output, inter-PAD district product transfers by pipeline or marine modes, and products exported or imported. The corresponding actual industry values are reported in Appendix D.

A comparison of the total U.S. refinery input and output of major products of the RIM with BuMines data is summarized in Table 3.2.3-1. In general, the RIM has a tendency to minimize imported products by processing additional crude oil. This tendency may be explained by the relative price structure of domestic crudes versus that of imported products. Domestic crude oil prices are, on the average, lower by several dollars per barrel than international crude prices. This difference is largely the result of the regulation of domestic prices and volume allocations by the federal government. The order of magnitude of the resulting crude oil price differentials has ranged from \$4 to \$5.50/b, as indicated in the following tabulation.

	Average Crude Oil Refiner Acquisition Cost ⁴ (dollars per barrel)							
	1974	1975	1976	1977	1978			
Foreign	12.52	13.93	13.48	14.53	14.57			
Domestic	7.18	8.39	8.84	9.55	<u>10.61</u>			
Difference	5.34	5.54	4.64	4.98	3.96			

The imported product prices used in this study reflect the higher foreign crude oil prices plus the product import fee of \$0.63/b. In addition, some of the product volumes reported in the import statistics come from U.S.-owned refineries in U.S. possessions in the Caribbean, such as the Amerada-Hess refinery on St. Croix. Because essentially all of the crude oil processed by these refineries is foreign, these refiners benefit from

Table 3.2.3-1

VALIDATION OF REFINING INDUSTRY MODEL--TOTAL U.S. REFINERY INPUT/OUTPUT, 1974 (Thousands of Barrels per Calendar Day)

				Percent
	RIM	BuMines	RIM-BuMines	Difference From (BuMines base)
Inputs				
Crude oil	12,530	12,133	397	+3.2
Natural gas liquids	512	746	-234	-31.4
Total input	13,042	12,879	163	1.3
Products				
Liquefied refinery gas	277	320	-43	-13.4
Naphtha	198	262	-64	-24.4
Gasoline (includes Avgas)	6,582	6,401	181	2.8
Naphtha-type jet fuel	181	195	-14	-7.2
Jet fuel (includes kerosene)	947	796	151	19.0
Distillate fuel oil	2,911	2,668	243	9.1
Residual fuel oil	1,063	1,070	-7	-0.6
Lubes and waxes	216	213	3	1.4
Asphalt and road oil	424	469	-45	-9.6
Petroleum coke (10 ³ b, FOE)	200	339	-139	-41
Imported products (net)				
Gasoline	0	201	-201	-100
Jet A/kerosene	0	138	-138	-100
Distillate fuel oil	51	278	-227	-82
Residual fuel oil	1,472	1,558	-86	-5.5

^{*}Fuel oil equivalent barrels.

the DOE entitlements program. This program allows these refiners to charge lower prices than other foreign refiners charge, which could explain why volumes of imports are larger than the optimal amount indicated by the RIM.

The RIM/BuMines refining input/output comparison by PAD district is shown in Appendix C. Note that the demand limits were set only for the major fuel products--gasoline, Jet-A, diesel, No. 2 fuel oil, and No. 6 fuel oil. The minor products are produced in proportion to the crude processed, at average 1974 yields.

Similar comparisons of RIM/BuMines data for inter-PAD transfers for gasoline, Jet-A, distillate fuels, and residual fuels are given in Appendix C. The RIM estimates of product movements from PAD III to PAD I and PAD II are generally in accordance with the reported statistics. A complete set of RIM output tables for the 1974 validation case is also included in Appendix C.

The DOE entitlements program is a scheme of intercompany transfer payments designed to alleviate crude oil pricing inequities resulting from price ceilings previously imposed under the Emergency Petroleum Allocation Act of 1973. A layman's explanation of these programs is presented in the DOE's "Monthly Energy Review" for January 1977.

4 CASE STUDIES

The application of the RIM to the quantitative evaluation of the effects on the refining industry of diesel penetration of the automotive fleet and reduction of the sulfur content of automotive fuels is described in this section. The general scenario (base case) used for the studies and the detailed analyses is described first.

4.1 Base 1995 Scenario

The development of a scenario for an industry as complex as the petroleum refining and distribution industry requires consideration of a large number of variables, which can be outlined as follows:

- (1) Product demand by product and region
- (2) Petroleum supply
 - Domestic crude--high- and low-sulfur
 - Alaskan crude
 - Foreign crude--high- and low-sulfur
 - California crude
- (3) Facilities
 - New domestic capacity compared with product imports
 - Modifications for diesel production, desulfurization
 - Transportation--pipeline, marine
 - Construction cost inflation
 - Site considerations for new capacity
- (4) Prices (domestic product prices are not required for cost minimizing objective)
 - Crude oil
 - Product imports
- (5) Federal, state, and local regulations
- (6) Technology for diesel production and sulfur removal.

4.1.1 Product Demand

The estimates used for the first of these factors--demand for major petroleum products by product and by region--are presented in Table 4.1.1-1. The gasoline and diesel demand forecasts were supplied by DOT/TSC.⁵ These projections were reasonably consistent with those developed by SRI in a recent study⁶ sponsored by EPRI for a high-conservation, low-demand growth case (see Appendix E). The projections for demand for fuel products other than gasoline and diesel fuel were, therefore, derived from the study for EPRI performed with the SRI National Energy Model. In brief, this model is a dynamic programming model that determines equilibrium prices for energy products needed to meet estimated energy demands for primary consumption such as vehicle miles traveled, space heating, and so on. The scope of the model covers the entire energy industry, from the primary energy resources through a network of conversion, refining, transportation, and transmission facilities.

A separate model is used to develop estimates of the primary energy demands over time by sector and region, and to determine price elasticities of demand. See the SRI report⁶ on the EPRI study for detailed descriptions of these models. The basic assumptions used for the energy forecasts and the SRI energy model demand projections for the low-demand case are presented in Appendix E for the transportation, industrial, residential/commercial, and electric power sectors.

4.1.2 Petroleum Supply

The RIM includes four types of crude oil:

- Low-sulfur, as typified by a South Louisiana crude
- High-sulfur, as typified by a West Texas sour crude
- California, a blend of Wilmington and West Texas sour
- Alaskan North Slope.

For the high- and low-sulfur crudes, the RIM does not distinguish between domestic and foreign sources. The implicit assumption is that refiners will selectively buy foreign crudes similar to the domestic crudes represented in the model.

The upper limits of crude availability in the RIM apply primarily to the low-sulfur crudes, as shown in Table 4.1.2-1. Alaskan crude is limited to the expected maximum of 2 million b/d. Total crude oil throughput is controlled by the refining capacity limits discussed in the following subsection.

Table 4.1.1-1

MAJOR PETROLEUM PRODUCTS^{*}--DEMAND SCENARIO (Millions of Barrels per Calendar Day)

						Total United States
	<u>L</u>					United States
1995 base case						
Gasoline Avgas and military (est.)	1.85 0.02	1.92 0.02	0.645 0.020	0.170 0.005	0.790 <u>0.020</u>	5.375 0.085
Total gasoline	1.87	1.94	0.665	0.175	0.810	5.460
Jet fuel (Jet A) Kerosene fuel oil	0.773 <u>0.070</u>	0.386 <u>0.050</u>	0.242 <u>0.040</u>	0.048 <u>0.003</u>	0.628 <u>0.008</u>	2.080 0.171
Total kerosene-type fuel	0.843	0.436	0.282	0.051	0.636	2.251
Diesel, No. 1 Diesel, No. 2 Distillate fuel Residual fuel	0.605 0.870 0.784	0.608		0.055 0.091 0.044		1.760 1.991 1.307
199515 percent diesel penetration						
Gasoline Diesel, No. 1 Diesel, No. 2 Total diesel	1.610 0.250 <u>0.605</u> 0.855	0.260 <u>0.630</u>		0.155 0.020 <u>0.055</u> 0.075	0.110	4.735 0.725 <u>1.760</u> 2.485
199530 percent diesel penetration						
Gasoline Diesel, No. 1 Diesel, No. 2 Total diesel	1.370 0.500 <u>0.605</u> 1.105	0.520 <u>0.630</u>	0.495 0.170 <u>0.210</u> 0.380	0.045	0.595 0.215 <u>0.260</u> 0.475	4.010 1.450 <u>1.760</u> 3.210

Demands for other coproducts were not fixed for this study.

The RIM could not meet this demand if production of other middle distillates was held constant and imports were limited; therefore, requirements in the final cases were relaxed to 60 percent of values shown.

Table 4.1.2-1

	Maxima (10 ³ b/cd)						
PAD District	Low-Sulfur	High-Sulfur	California Blend	Alaskan			
I	690	NL [*]					
II	1,920	NL					
III	3,132	NL.		NL			
IV	240	NL					
V	680	NL	NL	2,000			
Total	6,662						

PETROLEUM SUPPLY LIMITS IN REFINING INDUSTRY MODEL CASE STUDIES

NL means not explicitly limited.

4.1.3 Facilities

4.1.3.1 <u>Refining</u>. The value for the upper limit on domestic refining capacity is based on the 1977 level of about 16 million b/d. These limits are presented in Table 4.1.3.1-1. New capacity is allowed for large refineries at an average investment level of \$4,000 per daily barrel and for small refineries at \$6,000 per daily barrel. These expansion options have been added to the aggregate total for each district to allow flexibility in the selection of any of the available refining modes. The issue of additional domestic refining capacity may be of limited significance in this study, because the conservation demand scenario requires little expansion beyond current capacity if U.S.-owned Caribbean capacity is included.

4.1.3.2 <u>Transportation</u>. Transportation capacity limits and costs used in the study cases are presented in Table 4.1.3.2-1. Major product pipeline capacities are modeled with an option to expand at investment costs appropriate for the estimated sizes of required lines and distances. In making these estimates, it is assumed for this study that no major changes from the 1974 base pattern will occur.

Installation of new refining and pipeline capacity is allowed to occur at the optimal locations determined by the model. Marine transportation of products, where feasible, has unrestricted capacity.

Table 4.1.3.1-1

REFINING CAPACITY LIMITS, 1995 BASE CASE (Thousands of Barrels per Calendar Day*)

		PAD	Distric	ب		United States
Limits	I	II	I III II	IV	Λ	Total
Lower	1,337	2,425	1,337 2,425 4,226 410 1,912	410	1,912	10,310
lpper †	1,693	3,937	1,693 3,937 6,497 518	518	2,422	12,645
Model usage	1,647	3,801	1,647 3,801 4,226	469	1,912	12,055
‡ 1976 reported runs [‡]	1,590	3,610	5,733	443	2,078	13,453
1976 reported capacity	1,466	4,172	5,827	561	2,588	15,561

"Crude oil throughput.

Expansion allowed at investment cost of \$4,000 per daily barrel for large refineries, \$6,000 per daily barrel for small refineries.

* Source: Bureau of Mines, Mineral Industry Surveys, Crude Petroleum, Petroleum Products, and Natural Gas Liquids (March 1977).

Source: Federal Energy Administration, Trends in Refinery Capacity and Utilization (June 1976).

	<u>\$/b</u>	1.00	2.50 e"
	\$/b 10 ⁶ b/cd	0 65 	<pre>1.20 1.50 2.5 pipeline movements for 1974, multiplied by 1.25, as reported in U.S. <u>Mineral Industry Surveys, Petroleum Statement</u> (February 1975) :osts in \$/b derived from various issues of "Platt's Oil Price Service"</pre>
		0.58 0.60	report uary 1 Oil Pr
STS	IV 10 ⁶ b/cd	0 40 	1.25, as ment (Febr "Platt's
AND COS	strict \$/b	0.60	ied by <u>State</u> uues of
COSTS AND COSTS	To PAD District III 10 ⁶ b/cd \$/b	0 100 15 0	4, multipl <u>Petroleum</u> arious iss
	4/\$	0.30 0.50 0.38	1.50 or 197 from vi
	II 10 ⁶ b/cd	200 30 0	1.20 1.50 1.50 ipeline movements for 1974, multiplied by 1.25, as reported i <u>Mineral Industry Surveys, Petroleum Statement</u> (February 1975) sts in \$/b derived from various issues of "Platt's Oil Price
	<u>ځ/ه</u>	0.27 0.42	1.20 line m $\frac{\text{eral I}}{\text{in } \frac{5}{2}}$
	I 10 ⁶ b/cd	 80 2,000 0 0	ed on pipe Mines, <u>Min</u> tive costs
	From PAD District Pipeline	I II III IV Warine (cost only)	Sources: Limits based on Bureau of Mines, Representative c daily

Table 4.1.3.2-1

TRANSPORTATION CAPACITY LIMITS AND COSTS

26

4.1.4 Prices of Crude Oil and Imported Products

For the current studies, the RIM is being operated on the assumption that the objective is to meet projected regional product demands at minimum total cost. Because crude oil transportation facilities are not currently included in the model, estimated crude oil transportation costs are included in the total cost of crude in each region. Imported products are assumed to come from a Caribbean supply source at prices FOB refinery plus shipping cost. These prices are summarized in Appendix C.

The set of price and cost parameters used in the 1974 case has produced a reasonable simulation of actual 1974 refining and product transportation patterns. Therefore, the study cases are defined in terms of constant 1974 dollars.

4.1.5 Federal, State, and Local Regulations

The RIM is currently structured to take into account regulations related to transportation fuels--fuel efficiency and vehicle sulfur emissions. Variations in regulations concerning the quality or use of residual fuels are beyond the scope of this study. However, the refinery model could readily be modified to develop additional refining options to conform with such regulations.

4.1.6 <u>Technology for Diesel Production and Sulfur Removal</u> from Gasoline and Diesel

The technology applied in this study for diesel production and desulfurization is commercially mature; however, the extension of the diesel desulfurization to very low levels has not been practiced commercially. The estimates of the costs of this operation are thus less certain than those for the other processes. The specific processes used for additional diesel production and for desulfurization (hydrocracking and HDS) are discussed in greater detail in later subsections.

4.2 <u>Impact of Increased Diesel to Gasoline Production Ratio</u> on the Refining Industry

4.2.1 Overview

The superior fuel efficiency of the diesel engine over the conventional spark-ignited gasoline engine has created widespread interest in diesel engines as a means of improving the fuel economy of the nation's automotive fleet. The possibility of significant penetration of the diesel into the automotive market raises questions of fuel supply and effects on the refining industry. This study addresses these impacts in terms of product mix, refining and transportation costs, energy consequences, and potential new investment required.

4.2.2 Summary and Conclusions

The effects of increased diesel-to-gasoline ratios have been studied over the range of 0.17/1 to 0.8/1. The major results are summarized in Table 4.2.2-1. Detailed model output is presented in Appendix C for Case 1. Summary output for Cases 2, 3, and 4 of the dieselization study are presented at the end of this section.

The major conclusions drawn from the output of the RIM runs for the study cases are as follows.

- Given the conservation-oriented scenario selected for this study, a significant increase in diesel fuel consumption when production of other middle distillate products is held constant will tend to produce a shortage of domestic output of middle distillates. Even at the 1995 base case (Case 2) ratio of 0.3/1 diesel to gasoline, imports of No. 2 fuel oil will reach the maximum allowed for this study. At 15 percent diesel penetration (Case 3, 0.5/1 diesel-to-gasoline ratio), No. 2 fuel imports remain at the maximum, and jet fuel imports of 174,000 b/cd are required. At the maximum diesel penetration of 30 percent (Case 4, 0.8/1 diesel-to-gasoline ratio), the maximum allowed import volumes of 400,000 b/cd each of No. 2 fuel oil and jet fuel are reached. The required volumes of diesel fuel are provided by increased hydrocracking, although options exist in the RIM for refining No. 2 fuel oils to diesel fuel by hydrotreating or the use of a cetane-improving additive.
- At the 0.3/1 ratio (Case 2), the model indicates that about half of existing hydrocracking capacity (907,000 b/d as of 1 January 1977⁷) would be shifted to diesel production from gasoline. Refining industry investment for Case 3 is \$90 million, compared with \$54 million for the 1995 base case (Case 2). Case 3 uses all of the existing hydrocracking capacity. At the Case 4 diesel penetration of 30 percent (0.8/1 diesel-to-gasoline ratio), the need for new hydrocracking capacity raises the required investment sharply to \$1.5 billion.
- Refinery energy consumption for Cases 2 and 3 decreases from the 1974 industry operation by about 0.06 percent and 0.14 percent, respectively. The Case 4 requirement for new hydrocracking capacity increases the refining energy consumption to 7.3 percent of domestic refinery output, or 1.13 percent more than the minimum for Case 3.
- The refining industry cost savings over Case 1 are greatest for Case 2, \$0.61/b of domestic production of gasoline plus diesel. The cost saving is less for Case 3, \$0.52/b of gasoline plus diesel. At 30 percent diesel penetration, the cost for Case 4 is \$0.05/b greater than the 1974 cost.

	Case 11974	Case 21995	Case 31995	Case 41995
Percent diesel penetration $\overset{*}{}$	1	Base	15	30
Diesel production, 10 ³ b/cd (%) [†]	1,127(8.7)	1,767(14.2)	2,492(20.5)	3,211(27.0)
Gasoline production, 10 ³ b/cd	6,582(50.7)	5,460(43.8)	4,734(38.9)	4,010(33.8)
Diesel/gasoline ratio	0.17/1	0.32/1	0.53/1	0.80/1
Imported products, 10 ³ b/cd				
Jet A, 10 ³ b/cd No. 2 Fuel Oil. 10 ³ b/cd	51	400 [‡]	174 400‡	400 [‡]
No. 6 Fuel Oil, 10 ³ b/cd	1,971	273	338	433
Domestic Crude runs, 10 ³ b/cd	13,042	12,539	12,284	12,083
Cost differentials, $\frac{1}{2}$ b gasoline + diesel ⁸	Base	-0.61	-0.52	+0.05
New investment, 10 ⁶ \$	0 1	54.4	98.8	1,479
Energy consumption, percent of domestic products (FOE hasis)	15 9	6 25 6	6 17	7 30
recent reduction from base	Base	-0.06	-0.14	+0.99
Substitution of light diesel for motor gasoline, as forecast by DUT/TSC.	as torecast by	DUT/TSC.		

^TTotal production, thousands of barrels per calendar day, estimate for 1974 based on U.S. Bureau of Mines, Mineral Industry Surveys, Fuel Oil Sales (1975). Values in parentheses are percent of domestic refinery output.

* Maximum allowed in study cases.

Computed from RIM objective function for total U.S. fuels refining industry; includes 20 percent beforetax simple return on new investment; constant 1974 dollar values for costs, including crude oil and imported products.

Table 4.2.2-1

- Case 4 approaches the lower limit of gasoline production if naphtha is used only for gasoline blending, as it now is. This is a limit of the model. Under an option for alternative uses for naphtha (e.g., as a petrochemical feedstock or in turbine fuel), the industry could show a preference for running additional crude to reduce the imports of middle distillates and selling the excess naphtha at a potential premium price.
- The proportion of crude oil used for petroleum products other than the major fuel products is assumed to be the same in 1995 as it was in 1974. This assumption is not intended to be a prediction. The use of refining facilities specifically for production of petrochemicals and other nonfuel products could add significantly to the crude oil requirements indicated in the cases shown in this study.

4.2.3 Discussion and Analysis

The effect of increasing the diesel-to-gasoline ratios in U.S. refining and distribution industries depends on several critical factors:

- Demands for other refined coproducts
- The extent of the change
- Refining facilities and process technology available
- Crude oil availability
- Product import policy.

Diesel fuel is one of the several fuels called middle distillates that have distillation temperatures in the range of about 400 to 650°F. No. 2 heating oil has virtually the same boiling range as No. 2 diesel, and kerosene (No. 1 heating oil) and commercial jet fuel (Jet-A) are similar to No. 1 diesel fuel. In many instances, the products sold as fuel oils will also meet diesel specifications.

In the current demand pattern, these distillate products are, as the name implies, produced from crude oil primarily by the distillation process; hydrotreating is required only for the stocks derived from sour crudes. In general, the volume demands for these products are in balance with the corresponding yield fractions of the crude oil processed, as implied in the previous statement. However, the United States, with its emphasis on gasoline production, is an exception to the pure "straightrun" distillate content of these products. Some cracked distillate byproducts of the FCC and coking processes are blended into No. 2 fuel oil. The cracked stocks tend to have a high content of aromatic components, which results in low cetane^{*} quality, and they are therefore not suitable

Cetane number is a measure of the quality of combustion in the diesel engine, analogous to the octane rating for gasoline.

stocks for diesel fuel unless hydrotreated. Hydrocracking, used primarily in the United States for gasoline production, may be operated at lower severity to produce excellent diesel or jet fuel blend stocks. The cost of this process is substantially greater than that of FCC.

The effect on cost of changing the diesel-to-gasoline ratio may be analyzed as a function of the extent of change. When demand figures for Jet A and No. 2 heating oil are "protected" (i.e., held constant), the first increment of additional diesel fuel is the volume of distillate oil in the crude that exceeds distillate demand. In the United States, this material is generally fed to the FCC unit for conversion to gasoline; it could be made available for diesel blending at the expense of reducing the production of gasoline. The next increment of diesel production is made by operating existing hydrocracking at reduced severity; again, the result is a reduction in gasoline production. This approach is carried further by adding new hydrocracking capacity to process vacuum gas oil (650-1000°F) feed currently being cracked in FCC units for gasoline production. The FCC units are also operated at low severity, and the distillate product is hydrotreated to improve cetane ratings.

The quantitative effects of these changes on an industry-wide basis for several diesel-to-gasoline ratios were studied with the RIM. Results were summarized in the preceding section. The RIM output for the diesel study cases is summarized in Table 4.2.3-1, and the RIM summary output for each of the dieselization cases is shown in Tables 4.2.3-2 through 4.2.3-10. Changing the proportions of gasoline and diesel fuel produced should have little effect on the distribution and marketing sectors through 1995 because both products are compatible with existing facilities.

Production of U.S. cars requiring premium gasoline (98-100 RON) virtually ceased in 1971.⁸ At the historical scrapping rate for cars of about 10 percent per year, virtually all of the pre-1971 models will no longer be in use by 1995. If production of higher compression-ratio engines is not resumed, the need for three gasoline grades will not exist in 1995. Thus, the retail system that now provides three grades of gasoline can be adapted to provide two grades of gasoline and one grade of diesel. Our projections assume that leaded gasoline will be phased out entirely by 1995.

4.2.4 Review of Prior Studies

Several other studies of possible changes in gasoline-to-distillate ratio have been published. All have used a refinery LP model to evaluate "typical" refinery cases for various levels of diesel penetration, but they have been based on different scenarios, which, predictably, yield different absolute values for the effects of diesel penetration on the refining industry. For comparison with this study, it is particularly significant to note that these studies do not explicitly quantify the effects of the substantial regional differences in relative distillate product demands, crude oil qualities, and product imports.

DIESELIZATION CASE DATA SUMMARY

	Case 11974 Validation Case	Case 21995 Base	Case 31955, 15 Percent Diesel Penetration	Case 41995, 30 Percent Diesel Penetration
Refining industry cost * (10 ³ \$/d)	149,026	135, 145	135, 817	139, 913
Total refinery input [†] (10 ³ b/cd)	13,042	12,539	12, 284	12,083
Domestic refinery production, 10 ³ b/cd (vol%) ^{\$}				
Gasoline JP-4 Jet-A Diesel No. 2 fuel oil No. 6 fuel oil Other	6,582 (50.7) 181 (1.4) 947 (7.3) 1,127 (8.7) 1,784 (13.7) 1,063 (8.2) 1,301 (10.0)	5,460 (43.8) 165 (1.3) 1,350 (10.8 1,767 (14.2) 1,591 (12.8) 1,001 (8.0) 1,141 (9.1)	4,734 (38.9) 166 (1.4) 1,176 (9.6) 2,492 (20.5) 1,591 (13.1) 936 (7.7) 1,083 (8.9)	4,010 (33.8) 171 (1.4) 950 (8.0) 3,211 (27.0) 1,591 (13.4) 841 (7.1) 1,106 (9.3)
Total production	12,985 (100.0)	12,475 (100.0)	12,179 (100.0)	11,280 (100.0)
Imported products				
Jet fuel (Jet A) No. 2 fuel oil No. 6 fuel oil Total imports	51 <u>1,471</u> 1,522	400 273 674	174 400 <u>338</u> \$12	400 400 <u>433</u> 1,233
Total domestic demand	14, 507	13, 149	13,090	13,113
Energy consumed by domestic refining (10 ³ b/cd, FOE)	820	780	751	867
Incremental investment (10 ⁶ \$, 1974) Facilities for diesel (10 ³ b/cd)		54.4	90.8	1,479
Existing hydrocracker conversion New hydrocracking		486	811	856 325

* Includes feedstock costs, imported product costs, refinery operating costs, and capital recovery costs for new facilities (in 1974 dollars).

[†]Crude oil and natural gas liquids.

^{*}Volume percentage values given in parentheses refer to total production output, including the contribution of natural gas liquids. These values are, therefore, not comparable to BuMines/ Mineral Industry Surveys yields expressed as percentage of crude input.

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SECTION A. 25

PEFINING INDUSIRY MUDEL - 1995, 8ASE

REFINEPT INPUL/OUTPUT SUMMARY P. A. D. DISTGICT

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INPUT		• • • • • • • • • • • • • • • • • • •	0 0 0 0 0 0 0	- 0 0 0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0		0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0
SWEET CRUDE	690.0	1376.2	2454.0	240°0	478°D	5239.2 539.2			5238 • 2 5238 • 2
SUUK LAUVE CALIF CRUDE	.1 + 1 6 6	0.0242	100111	0 * 6 7 7	1434.0	1434.0			100000
ALASKAN CRUDE Matheal Casoline	16.5	74.3	165.7	2622	26.8	249.4			249.4
NATURAL BAJULINE Normal Butane	6.0	52.6	42.7	3.5	26.3	135.0			135.0
ISOBUTANE	1.9	. •v.	29.6	1.5	14 . 3	6°66			6°66
TOTAL INPUT	1675.3		4403.9	500.0	1979.4	12539.3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		12539.3
OUTPUT									
C3 LPG	51.7	85°1	26.9	5.0	27.6	196.2			196.2
C4 LPG	14.3	15.9		• 2	6 • 1	36.4			36.4
NAP HTHA	1.8	21.3	37.2		24.9	65°l			1.00
REGULAR GASOLIME						, (
PREFIUN GASULINE Low Lead Gasoline									
LEAD FREE GASOLINE	729.1	1922.0	1823.0	196.5	766.5	5460.0			. 5460.0
JP-4 JET FUEL	9.1	43.9	54.9	13.7	42.8	165.7	1.5		166.5
JET A JET FUEL	353°C	316.5	266.2	30.0	382.0	1350.0			1350.0
016 SEL	8° 3	476.3	815°H	136.9	247.0	1767.3			1767.3
NO. 2 FUEL OIL	163.0	620°9	731.8	48.9	6 • 4	1501.0	4 C O • O		1991.0
HI SULFUR NO. 6	81°C	107.9	116.3	15.0	184.2	506.4	130.6		631.0
LO SULFUR NO. 6	69°6	107.9	116.3	15.0	194.2	695°O	142.6		637.0
LUBE STOCKS	4 C • B	÷.	6 • 4 A	1.1	19.6	175.6			175.6
ASPHALT AND ROAD OIL	63.9	178.3	13.3	6 • 6 2	00.5	40104			5°105
COKE (LO SULFUR)	1.9		9°1	1.1	1 • 3	13.3			. • • • • • • • • • • • • • • • • • • •
CUKE (HE SULFUK)	17 + 4	21°0	10.01	[•]		1 ° 1 5			1 • • • • • • • • • • • • • • • • • • •
CURE ILAL LRUVEJ					0 • n †				
	1.3	5 n 9 n	1.54		101	2002			37.7
MIXED XYLENES	• •	C ° 7	25.6		3.7	34.6			34 • 6
HISC. PRODUCTS	12.9	52 · B	22.3		2.4	4.59			94
TOTAL OUTPUT	1769.2	4012.7	4256.4	492.2	2004.0	12475.1	÷74.0	0 0 0 0 0 0 0	13144.1
, OUTPUT/INPUT, PCT	192.9	100.4	96.7	98°5	5.101	99°5			104.9

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REFINING INDUSTRY MODEL - 1995, BASE

SECTION 8. 11

PRODUCT CONSUMPTION SUMMARY

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C3 LPG	51.7	85.1	26.9	5.0	27.6	196.2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0	196.2
C4 LPG	14.3	15.9		• 2	6.1	36.4			36.4
NAPHTHA NAPHTHA N	1.8	21.3	37.2		24.9	85.1			L.c.
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1870.0	1940.0	665.0	175.0	010.0	5460.0			5460.0
JP-4 JET FUEL	4 2 ° B	31.5	30.0	6. 8	49.5	166.5			164.5
JET A JET FUEL	506.0	262.0	170.0	30.0	382.0	1350.0			1350.0
DIE SEL	605.0	630.0	219.0	62.3	260.0	1767.3			1767.3
ND. 2 FUEL DIL	870.0	60A.U	242.0	91.0	180.0	0.1991			1991.0
MI SULFUR NO. 6	392.0	65.3	65.0	15.0	100.0	637.0			637.0
LO SULFUR NO. 6	392.0	65.0	65.0	15.0	100.0	637.0			637.0
LUBE STOCKS	4 C . 6	29.6	6.45	1.1	19.6	175.5			175.6
ASPHALT AND ROAD DIL	63.9	170.3	73.3	25.5	66.8	407.9			401 ° 4
COKE (LO SULFUR)	1.9		9.1	1.1	1.3	13.3			13.3
COKE (HI SULFUR)	4.3	21.0	10.6	1.3		37.3			37.3
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	1.3	3.4	13.7		1.7	20.2			20.2
TOL UENE	۰.	2.3	22.3		4.2	32.7			32.7
MIXED XYLENES		7 . 2	25.6		3.7	34.6			34.6
MISC. PRODUCTS	12.9	52°B	22.3		2.4	40°4			9 Û . 4
- 101AL	4972.2	4015.8	1781.5	429.3	2050.3	13149.1	0 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8		13149.1

SECTION C. 4

D. U. T. TRANSPORTATION SYSTEMS CENTER Refining industry mudel - 1995, base

UTILITY SUMMARY

PETROLEUM ADFINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	6	7	5	U • S •
ELEC. PWR (1000KWH/D)	6056.5	13906.1	16615.7	1443.6	9448.3	47464.2
FUEL REQD. (1000FDE8/D)	76.6	204.1	243.7	23 • 3	113.1	660 . 6
ENERGY CUNS. (1000FDEB/D	94.6	232.6	291.7	28 • 0	133.1	179.9
LABOR (NO. EMPLOYEES)	8235.0	19006.1	21130.0	2343。8	9560°D	67274 . 8
UPER COSTS (M\$/D)	136.1	491.6	296°8	30•6	149°3	1194.5
INVESTMENTS (MM\$)	12.0	4 ° 5	30.2	3.7	4 • L	54.4

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Q. U. T. TRANSPORTATION SYSTEMS CENTER

SECTION A. 25

REFINING INDUSTRY MUDEL - 1995, 15 PCT DIESEL

REFINERY INPUT/UUTPUT SUMMARY

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	1	2	æ	\$	5	U•5.	THPORT	EXPORT	10141
. Indui	0 0 0 0 0 0 0 0 0 0 0 0		5 0 0 0 0 1 0 0 1			0 0 0 0 1 0 1 0		9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	9 9 9 9 9 9 9 9
	0.044	0 6171	7.6515	0 076	170 0	5042.0			0000
	0 4 4 4 U	0.5444	1126.4	2 2 2 2 2		1.7244			1 2644
		0.0343	L • D > 7 T	C C C C C C	1434.0	1626.0			70 7271
AL AT TRUCE						0.000			
MATURAL GASDIIME	13.4	75.1	106.6	26.2	26.8	248.0			244.0
NOP MAL AUTANE	9.0	5.62	37.0	8.6	24.7	126.6			126.6
		53.2	23.5	1.9	14.3	6.46			6 • 5 6
TOTAL INPUT	1360.3	+010+2	4425.4	500.6	1977.8	12283.6		5 6 6 8 8 8 8 8 8 8 8 8 8	12293.6
OUTPUT									
C3 LPG	39.3	19.4	27.2	4.7	22.9	173.5			173.5
C4 LPG	9.8	7.9		• 2	1.7	19.4			19.4
NAP HTHA	1.8	6.15	42.2		25.2	90.6			90.6
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE	546 0	1204 7	1428.4	1 4 4	461 0	A 725 A			4735.0
LEAD FREE GASOLINE			10001						
JP-4 JET FUEL	8.3	4 * * *	57.4	13.7	42.8	166.5			166.5
JET A JET FUEL	231.0	262.0	271.0	30.0	3 H 2 . D	1175.0	174.C		1350.0
01E SEL	139.6	7 + 4 - 7	1034.2	141.3	432.4	2492.2			2492.2
ND. 2 FUEL DIL	173.1	652.4	1.017	49.0	6 • 4	1591.0	4.0.0		1991.0
HI SULFUR ND. 6	66.9	169.3	120.6	15.0	180.9	494.7	142.3		637.0
LO SULFUR NO. 6	57.5	169.3	120.6	15.0	139.2	441.6	195.4		637.0
LUBE STOCKS	1.76	29.6	85.4	1.1	17.3	170.5			170.5
ASPHALT AND ROAD DIL	51.3	181.1	6.07	25.5	56.2	3 8 4 . 5			344.5
COKE (LO SULFUR)	1.9		11.6	6.	1.1	15.5			15.5
COKE (HI SULFUR)	2.9	21.0	6°9	1.3		32.0			32.0
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	6.	3 ° 4	13.6		1.7	19.9			19.9
TOL UENE	ф	2.3	25.4		4 • 2	32.5			32.5
MIXED AYLENES	۳	1.1	27.6		3.7	36.5			36.5
MISC. PRODUCTS	10.4	53.3	33.0		2.4	96.1			96.1
TOTAL OUTPUT	1361.8	4030.6	4282.7	441.9	191.7	12178.7	911.7		13050.3
OUTPUT/INPUT, PCT	101.6	100.3	96.8	96.2	1.00.1	1.00			106.6

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REFINING INDUSTRY MODEL - 1995, 15 PCT DIESEL

SECTION 8. 11

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	1	2	£	5	S	U • S •	EXPORTS	EXP TOT	TOTAL
i		19.4	27.2		22.9	173.5		8	173.5
	9°6	7.8		• 2	1.7	19.4			19.4
	1.8	21.3	42.2		25.2	90.6			40.6
REGULAR GASOLINE Premium Gasoline									
DL INF	0.0641	1680.0	580.0	155.0	200.0	4735.0	1	ſ	
JI INE									
	9.2.6	C • 7 F	30.0	0.0	C*A+5	100.7			100.5
	506.0	262.0	170.0	30.0	382 .0	1359.7			1350.0
	855.0	0.098	295.0	82.2	370.0	2492.2			2492.2
	870.0	668.0	242.0	91.0	180.0	1991.0			1991.0
6	392.0	65 ° 0	65 ° 0	15.0	100.0	637.0			637.0
Ŷ	392.6	65°0	65°G	15.0	106.0	037.0			637.0
	37.1	29.6	85.4	1.1	17.3	170.5			173.5
DAD OIL	51,3	101.1	70.3	25°5	56.2	384.5			384.5
(N)	1.9		11.6	6.	1.1	15.5			1:.5
JR)	2.9	21.0	6 • 8	1.3		32.0			32 • O
()					10.6	10.6			10.6
	6.	3.4	13.8		1.7	19.9			19.61
	• 0	2.3	25.4		4.2	32.5			32.5
	ç •	4.7	27.6		3.7	36.5			3°; 8
MISC. PRODUCTS	-	53+3	30°0		2 . 4	96.1			96.1
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D. D. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 15 PCT DIESEL

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SECTION C.

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	5 1 1 1 1 1 1			IJ. S.
ELEC. PWR (1000KWH/D)	4781.4	13996.9	16091.7	1420.7	9448•3	45739.1
FUEL REQ0. (1000FDE8/D)	59.8	192.8	236.5	22 • 9	103.3	615.5
ENERGY CONS. (1COOFDEB/D	75 • 5	234.5	283.7	27 • 6	130.2	751.4
LABOR (NO. EMPLOYEES)	6685.O	19190.2	21291.8	2343.8	9560.0	59073.7
OPER COSTS (M\$/D)	93 . 8	364 • 6	269•5	36•6	79.6	944.1
INVESTMENTS (MMS)	12 • J	26°3	30.5	3 . 7	16.6	9 ° V 6

D. U. T. IMANSPORTATION SYSTEMS CENTER

SEC 110N A. 25

REFINING INDUSTRY MUDEL - 1995, 30 PCT. DIÉSEL

61 5 5 240.0 478.0 545 220.0 478.0 545 23.1 1434.0 143 23.1 1434.0 143 23.1 16.3 127 24.0 1070.4 127 13.7 26.3 127 14.3 26.3 127 15.0 1970.4 127 16.3 1070.4 127 13.7 26.3 127 16.3 1070.4 127 16.3 1070.4 127 16.4 1070.4 127 16.5 1070.6 171 16.5 184.2 123 15.0 184.2 123 16.1 10.6 137 15.1 10.6 137 16.6 184.2 123 16.1 10.6 113 16.1 10.6 113 10.6 10.6 113 10.6 10.6 113 10.6 10.6 113 10.6 10.6 113 10.6 10.6 113 10.6 10.6 113 10.6 10.6 113					1	TPUT SUMMAR	۲۲ ۲			
I 2 3 4 5 DE 647.0 1920.0 3132.0 240.0 478.0 647.0 DE 647.0 11270.0 3132.0 240.0 478.0 647.0 DE 647.0 1920.0 3132.0 240.0 478.0 647.0 DE 647.0 11270.0 3122.0 240.0 674.0 143 DE 647.0 1360.3 3180.1 500.07 494.9 1079.4 1279 ASOLINE 39.3 3180.1 500.07 494.9 107.0 24.0 17.9 ASOLINE 39.3 3180.1 500.07 49.9 24.0 17.9 24.0 17.9 ASOLINE 39.3 31.0 11.0 31.0 11.0 17.9 12.9 12.9 ASOLINE 560.0 1250.0 1276.0 1276.0 12.9 24.0 10.9 ASOLINE 560.0 160.1 10.0 10.0 10.0 <th1< th=""><th></th><th></th><th>i e</th><th>A. D.</th><th>) (</th><th></th><th></th><th></th><th></th><th></th></th1<>			i e	A. D.) (
DF 690:0 1127.0 3132.0 240.0 470.0 670.0 DF 647.0 11270 3132.0 240.0 470.0 470.0 143 RUDE 647.0 11270 3132.0 3132.0 240.0 470.0 470.0 470.0 143 RUDE 130.3 3186.1 5300.7 494.9 1979.4 1208 ASOLINE 39.3 53.8 32.2 5.0 497.9 1979.4 1208 ASOLINE 39.3 53.8 32.2 5.0 497.9 1979.4 1208 ASOLINE 39.3 53.2 497.9 32.2 5.0 497.9 24.2 ASOLINE 39.3 32.2 5.0 32.2 5.0 32.2 5.0 32.2 ASOLINE 546.9 127.9 32.2 5.0 32.2 5.0 32.2 5.0 32.2 5.0 32.2 5.0 32.2 32.2 5.0 32.2 5.0 32.2 </th <th></th> <th></th> <th>2</th> <th>1</th> <th></th> <th>Ş</th> <th>U+S+</th> <th>140041</th> <th>EXPORT</th> <th>TOTAL</th>			2	1		Ş	U+S+	140041	EXPORT	TOTAL
DE NUCE 697.0 6477.0 1127.0 1127.0 3132.0 1724.1 240.0 228.8 479.0 1934.0 ANDLE RUDE 13.4 8.0 58.2 41.5 124.1 30.3 22.7 30.3 240.0 50.8 479.0 144.3 ANDLINE 13.4 8.0 58.2 41.5 124.1 30.3 22.7 30.3 24.0 50.8 479.0 50.3 I.INDUT 1360.3 3188.1 5000.7 499.9 144.3 24.7 24.9 24.7 24.9 ANDLINE 30.3 3188.1 5000.7 499.9 24.2 24.9 24.2 24.9 24.2 24.9 ASOLINE 54.0 125.2 5.0 25.2 1470.6 13.7 25.2 24.2 24.9			- 9 9 9 9 9 9 9 9 9 9					-		
CRUDE 647.0 1127.0 1724.1 220.8 1434.0 1 AN CRUDE 1.0 41.5 43.7 2.1 1434.0 1 AN CRUDE 1.0 41.5 43.7 2.1 2.4 2.4 AN CRUDE 1.0 41.5 30.8 124.1 2.0 14.3 TANE 1.0 41.5 30.4 1.5 40.9 1979.4 12 TOTAL INPUT 1360.3 3180.1 5060.7 49.9 147.3 26.3	SWEET CRUDE	696.0	1920.0	0.2515	240.0	478.0	6450°0			6460.0
AN CRUE AN CRUE AN CRUE AN CRUE A L 6450LIME B 0 0 01746 1.0 0 110 TAKE D 017ME 1.0 0 110 1.0 0 110 1.0 0 1250.3 1.0 011 1.0 0 1250.3 1.0 011 1.0 01 1.0 01 1.0 01 1.0 01 1.0 01 1.0 01 1.0 01 1.0 0 1.0 0 1	SOUR CRUDE	647.0	1127.0	1724.1	228.8	1434.0	3726.8 1434.0			3726.8
AL GASOLIME 13.4 58.2 124.1 22.7 26.8 L MAE 1.9 41.5 30.0 7.1 1.1 2.1 1.4 2.1 TAME 1.9 41.5 30.0 7 49.4 1.1 2.1.3 2.0.3 TOTAL INPUT 1360.3 3180.1 500.0 41.5 500.7 494.9 1979.4 12 Mat 59.3 3180.1 59.0 32.2 5.0 24.2 24.3 Mat 63011ME 596.9 12.8 32.2 5.0 24.2 24.3 Mat 63011ME 596.9 12.8 31.3 13.7 24.2 24.9 Mat 63011ME 596.9 1259.3 147.0 558.0 24.2 AR 63011ME 596.9 1259.3 147.6 137.9 24.2 24.9 AR 63011ME 596.9 1259.3 147.6 157.0 167.0 558.0 127.9 AR	ALASKAN CRUDE									
Leutame 0.0 41.5 30.8 2.1 1.9 1.0 1	NATURAL GASOLINE		58.2	124.1	22.7	26.8	245.1			245.1
TOTAL INPUT 1360.3 3188.1 5360.7 494.9 1979.4 12 G 39.3 63.8 32.2 5.0 24.2 G 39.3 63.8 32.2 5.0 24.2 G 39.3 63.8 32.2 5.0 24.9 G 34.3 1.3 7 24.2 24.9 A GASOLINE 546.9 1259.3 1476.0 558.0 MA <gasoline< td=""> 546.9 1259.3 1478.6 167.0 598.0 JET FUEL 711.9 111.9 13.7 42.8 JET FUEL 711.9 13.7 42.8 64.4 JET FUEL 235.4 104.2 13.6 44.5 64.4 JET FUEL 235.4 114.9 735.6 10.6 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5 144.5</gasoline<>	NORMAL BUTANE Isobutane	8 • 0 1 • 9	41°5 41.5	43.7 36.8	1.3 2.1	20.3	120.4			120.8
6 39.3 63.8 32.2 5.0 24.2 6 550.11ME 98 550.0 24.2 7 98 550.1 24.9 24.9 7 98 550.1 21.3 499 24.9 7 98 550.1 24.9 24.9 24.9 7 93 1478.8 167.0 558.0 7 93 34.3 71.9 13.7 42.8 9.1 71.9 146.7 317.9 382.0 9.1 71.9 146.7 317.9 382.0 9.1 71.9 146.7 317.9 382.0 9.1 146.7 317.9 167.0 596.0 9.1 146.7 317.9 167.0 194.2 9.1 146.7 317.9 167.0 194.2 9.1 146.7 117.9 13.7 42.8 161.01 237.5 162.6 166.9 164.5 17.0 137.0 509.4 162.2 194.5 17.0 101.0 114.3 10.2 10.6 17.0 114.7 23.7 162.2 10.1 11.1 21.9 10.2		1	188	5060.7	. + 6	1979.4	2083			12083.4
39.3 63.61 5.2 5.0 24.2 9.6 5.2 5.0 24.2 6450LINE 5.6.9 21.3 49.9 24.2 6450LINE 5.6.9 1259.3 1476.8 167.0 556.0 6450LINE 546.9 1259.3 1476.8 167.0 556.0 6450LINE 546.9 1259.3 1476.8 167.0 556.0 6450LINE 546.9 1259.3 1476.8 167.0 556.0 6450LINE 545.9 1259.3 1476.8 167.0 556.0 6450LINE 545.9 1259.3 171.9 13.7 42.0 6450LINE 545.9 1259.3 171.9 13.7 42.0 6450LINE 545.9 155.0 166.3 499.0 362.0 71.9 166.3 166.2 150.0 184.2 71.0 57.5 57.5 155.0 166.3 194.2 8 10.6 13.7 166.3 10.6 10.6 8 10.6 116.3 10.3 10.3 10.3 8 10.6 11.0 10.3 10.3 10.6 8 10.6 11.6 13.9 1	UTPUT									
9.8 5.2 49.9 -2 1.7 1.8 21.3 49.9 -2 24.9 1.8 21.3 1478.8 167.0 558.0 9.3 34.3 17.9 167.0 558.0 9.3 34.3 17.9 167.0 558.0 9.3 34.3 17.9 167.0 558.0 9.3 71.4 146.7 17.9 13.7 71.4 146.7 71.9 13.7 528.0 71.4 146.7 150.7 167.3 10.0 235.4 804.2 150.6 196.0 194.2 235.4 804.2 150.6 194.6 104.2 235.4 804.2 150.6 194.6 104.2 235.5 10.3 10.3 10.4 104.2 10.9 10.3 10.3 10.6 1.1 10.4 10.4 10.3 10.3 2.4 10.4 10.4 10.3 495.7 196.1 2.4 10.4 10.3 495.3 495.7	C3 LPG	39.3	63.8	32.2	5.0	24.2	164.5			364.5
1.8 21.3 49.9 24.9 24.9 INE 546.9 1259.3 1478.8 167.0 558.0 9.3 34.3 71.9 13.7 42.8 9.3 34.3 71.9 13.7 42.8 71.4 148.7 71.9 13.7 42.8 71.4 148.7 71.9 13.7 42.8 71.4 148.7 793.6 44.5 6.4 71.4 148.7 793.6 44.5 6.4 235.4 804.2 793.6 44.5 6.4 235.5 804.2 793.6 166.3 499.0 235.5 166.6 146.3 166.3 199.6 235.5 57.5 162.8 15.0 199.6 37.1 2.9 9.8 10.3 1.3 2 9.8 10.3 1.3 1.3 0.1 1.1 25.5 28.4 3.7 10.4 42.5 28.4 3.7 3.7 2.9 9.8 1.3 495.7 10.7 10.4 42.5 28.4 3.7 3.7 2.9 9.4 10.3 495.7 1969.1 10.4	C4 LPG	9°8	5.2		• 2	1.7	16.8			16.8
File 5+6.9 1259.3 1470.6 556.0 File 5+6.9 1259.3 1470.6 167.0 556.0 9.3 34.3 71.9 13.7 42.8 71.4 146.7 317.9 13.7 42.8 71.4 146.7 317.9 13.7 42.8 71.4 146.7 317.9 13.7 42.8 71.4 146.7 156.5 166.3 499.0 235.4 804.2 156.5 166.3 499.0 237.9 509.4 793.6 162.8 156.0 237.5 57.5 156.2 166.3 196.0 37.1 120.6 114.3 25.5 10.1 10.9 12.0 10.3 1.0 1.3 2.9 9.8 10.3 1.0 1.0 2.9 9.8 1.0 1.0 1.7 0.9 1.0 2.9 1.0 1.0 0.9 1.0 1.0 1.0 2.4 0.9 1.0 1.0 1.0 1.0 0.9 1.0 2.9 1.0 1.0 0.1 1.0 2.9 1.0 2.4 0.4 <	NAP HTHA	1.8	21.3	49°9		24.9	97.9			97.9
INE 546.9 1259.3 1478.8 167.0 558.0 71.4 143.7 71.9 13.7 42.8 71.4 143.7 71.9 13.7 42.8 71.4 143.7 71.9 13.7 42.8 71.4 143.7 317.9 30.0 382.0 71.4 143.7 150.7 30.0 382.0 71.4 143.5 150.6 166.3 499.0 237.0 509.4 749.6 146.2 166.4 237.0 509.4 749.6 166.0 196.0 37.15 29.4 10.3 1.1 1.3 239 9.8 10.3 1.1 1.3 1.9 1.0 1.4 1.3 1.1 2.9 9.8 1.1 1.3 1.0 2.9 9.8 1.0 1.3 1.0 1.7 2.9 9.8 1.1 1.3 1.3 1.1 2.9 9.8 1.0 1.1 1.3 2.4 2.9 5.4 <	REGULAR GASOLINE PREMIUM GASOLINE									
0 13.7 13.7 42.9 71.9 13.7 14.6 14.6 17.9 13.7 71.4 146.7 17.9 13.7 42.9 235.4 804.2 152.0 17.9 30.0 382.0 235.4 804.2 152.0 17.9 30.0 382.0 235.4 804.2 152.0 157.9 30.0 382.0 237.9 70.9 152.0 154.0 104.2 37.1 27.9 152.0 154.0 136.0 37.1 27.9 10.3 10.6 1.9 10 1.1 1.1 25.5 1.0 1.0 2.9 9.0 1.0 1.1 1.0 1.0 2.9 1.0 1.0 1.0 1.0 1.0 2.9 1.0 1.0 1.0 1.0 1.0 2.0 1.0 2.5 2.4 2.4 2.4 10 10.1 2.0 1.0 2.4 2.4 10 10.1 2.0 1.0 2.4 2.4 10 10.1 2.0 1.0 2.4 2.4 10 10.1 2.4 2.4 2.4	LOW LEAD GASOLINE	546.0	1 260 3	1470 0	167 0	55A.0	4010-0			4010.0
71.4 146.7 317.9 30.0 382.0 235.4 804.2 1565.7 166.3 499.0 382.0 237.0 509.4 78.5 156.6 156.6 44.5 66.4 237.0 509.4 78.5 156.6 156.6 166.3 499.0 382.0 57.0 509.4 78.5 156.6 156.0 156.6 166.4 499.0 499.0 57.0 57.6 166.3 166.0 150.0 136.0 136.0 166.4 37.1 27.9 166.3 162.2 114.3 25.5 1.1 19.6 1.9 1.0 1.0 1.0 1.0 1.0 1.0 1.1 2.9 9.8 1.0.3 25.5 1.1 1.1 1.7 3.7 2.0 1.1 2.5 5.4 2.4 3.7 3.7 3.7 2.6 1.1 2.5 5.4 3.7 3.7 3.7 3.7 3.7 10.6 13.1 3.465.7 1369.1 495.7 1369.4	LEAU THEE VAJULANE		2 2 2 2	71.0	5 - E E	A 2 . A	171.0			171.0
235.4 804.2 155.7 166.3 4990 237.0 509.4 793.6 166.3 4990 57.0 509.4 793.6 156.0 156.0 57.0 509.4 78.5 156.0 190.6 57.0 57.0 509.4 793.6 150.0 1364.2 57.1 27.5 166.3 499.6 199.6 37.1 21.2 16.2 114.3 25.5 199.6 10.9 1.0 1.0 1.0 1.0 1.0 1.0 2.9 9.8 10.3 1.0 1.1 1.3 1.1 1.3 2.9 9.9 1.0 1.0 1.0 1.0 1.0 1.1 1.3 2.9 1.0 1.0 1.0 1.0 1.1 2.2 3.7 2.4 2.0 1.0 1.0 1.0 1.0 2.4 2.4 2.4 1.0 1.0 2.2 2.3 3.7 3.7 2.4 2.4 1.0 2.0 2.44 2.4	JET & JET FUEL	4.17	5 · 1 - 1	917.9	30.0	382.0	01010	400.0		1350.0
2.37.0 509.4 793.6 44.5 6.4.5 15.0 194.5 6.89 78.5 162.8 15.0 194.5 194.5 57.1 57.9 162.0 15.0 194.5 37.1 51.3 120.6 114.3 194.6 37.1 51.3 120.6 114.3 194.6 37.1 10.4 16.6 114.3 25.5 10.4 10.0 1.4 10.3 10.5 10.4 10.4 2.9 9.8 10.3 10.5 1.4 10.4 2.9 9.8 10.3 1.6 1.4 1.4 2.9 9.8 1.0.4 2.5 1.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 10.4 4.2.5 2.8 2.4 2.4 2.4 2.4 10.1 113.1 19.1 196.7 119.2 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4	DIESEL	235.4	804 .2	1565.7	164.3	499.0	3217.7	k 9 1		3210.7
0 162.8 15.0 184.2 57.5 57.9 65.0 15.0 184.2 57.5 57.9 65.0 15.0 184.2 57.1 29.6 114.3 25.5 66.4 10 1.9 1.1 1.9 1.0 11 2.9 9.8 10.3 1.0 1.3 10 2.9 9.8 10.3 1.0 1.3 10 2.9 9.8 10.3 1.0 1.0 2.9 9.8 10.3 1.0 1.0 1.0 0.0 1.0 1.0 1.0 1.0 4.2 0.0 1.0 2.4 2.4 2.4 0.0 1.0 2.4 2.4 2.4 10.4 4.2 5.3 4.4 2.4 10.4 4.2 5.3 4.4 2.4 10.4 4.2 5.3 4.4 2.4 10.1 1301.0 4.4 4.4 5.4 10.1 101.6 1.0 4.4 5.4	NO. 2 FUEL OIL	237.0	509.4	743.6	44.5	6.4	1591.0	400.0		1991.0
0 157.5 57.9 65.0 15.0 136.0 37.1 27.9 162.2 1.1 196.0 1 1.9 7.9 10.3 15.0 136.0 1 1.9 7.9 10.3 15.0 136.0 1 2.9 9.8 10.3 1.0 1.3 1 2.9 1.0 13.9 1.0 1.0 1 .6 1.0 25.5 53.4 2.2 1 .6 1.1 25.5 53.4 1 .6 1.0 25.5 53.4 10.4 .6 1.0 2.4 2.4 10.4 .6 1.0 2.4 2.4 10.4 .6 .6 1.0 2.4 10.4 .6 .6 .6 2.4 10.4 .6 .6 .6 .7 10 .6 .6 .6 .7 10 .6 .6 .6 .7 10 .6 .7 .6 .7 10 .6 .7 .7 .7 10 .6 .7 .7 .7	HI SULFUR NO. 0	68.9	78.5	162.8	15.0	104.2	5r9.5	127.5		637.0
0 37.1 29.6 162.2 1.1 19.6 1 1.9 7.9 14.3 25.5 66.8 1 1.9 7.9 9.8 1.3 1.3 1 2.9 9.8 10.3 1.3 1.3 1 2.9 9.8 10.3 1.3 1.3 1 2.9 9.8 10.3 1.3 1.3 1 .6 1.1 25.5 3.7 3.7 10.4 2.2 29.4 2.4 2.4 10.4 4.2.5 53.4 2.4 2.4 10.4 4.45.3 4.85.7 1969.5 11 101.6 100.3 95.7 98.1 54.5	LO SULFUR NO. 6	51.5	57.9	65°0	15.0	136.0	331.4	365.6		637.0
0 01L 51.3 120.6 114.3 25.5 64.6 1.9 7.9 0.8 11 1.3 2.9 9.8 10.3 1.3 10.6 1.9 7.9 0.3 1.3 10.6 1.0 2.2 2.5 5.5 5.4.6 1.0 2.9 1.0 1.0 1.0 5.2 1.0 1.0 1.1 2.2 2.2 5.4.8 1.1 2.2 2.4.8 3.7 1.1 10.4 4.2.5 5.3.4 1.1 131.6 3197.9 4455.3 1.1 101.6 100.3 95.7 101.6 100.3 95.7 98.1	LUBE STOCKS	37.1	24.6	162.2	1 • 1	19.6	1 89.6			189.6
1 1.9 7.9 8.8 1.01 1.3 1 2.9 9.8 10.3 1.3 10.6 2 9 1.6 13.9 10.5 1.7 0 0 1.1 25.5 2.8 1.1 0 5 2.2 2.8 1.1 2.4 1 2 2.2 2.8 3.7 2.4 1 2.4 42.5 53.4 2.4 2.4 10 412.5 445.3 465.7 11969.5 11 10 10 4100.3 45.7 98.1 54.5	ASPHALT AND ROAD OIL	51.3	120.6	114.3	25.5	66.0	379°A			378.6
1 2.9 9.8 10.3 1.3 10.6 0 9 1.6 13.9 1.7 1.7 0 9 1.6 13.9 1.7 1.7 0 6 1.2 5.5 5.4 2.2 10 2 2.2 53.6 53.4 2.4 10 4 2.2 63.4 2.4 2.4 10 4 2.5 63.4 485.7 1964.5 10 10 100.3 45.7 98.1 54.5	COKE (LU SULFUR)	1.9	7.9		1.1	1.3	21.0			0.15
1 0.01 13.9 13.9 13.9 10.6 1 7 1 25.5 53.5 53.5 10.4 2.2 2.2 28.8 3.7 10.4 42.5 63.4 495.7 1969.5 11 3197.9 495.5 495.7 98.1 101.6 100.3 95.7 98.1 57.5	COKE (HI SULFUR)	2 ° 9	9°6		1.3		24.4			24.4
9 1.6 13.9 1.7 .6 1.1 25.5 3.7 .6 1.1 25.5 3.7 10.4 4.2.5 53.4 3.7 11.1 3197.9 4945.3 465.7 1969.5 11.1 101.6 103.3 95.7 98.1 54.5	COKE (CAL CRUDE)					10.6	10.6			10.6
.6 1.1 25.5 4.2 .5 2.2 29.8 3.7 10.4 42.5 53.4 2.4 10.4 42.5 53.4 1.4 11.1 3197.9 4945.3 485.7 1969.5 101.6 103.3 95.7 98.1 54.5			1.6	13.9		1.7	18.1			16.1
.5 2.2 29.8 3.7 10.4 42.5 63.4 2.4 1 10.4 42.5 63.4 2.4 1 11.1 3197.9 4945.3 485.7 1969.5 11.3 101.6 103.3 95.7 98.1 54.55			1.1	25.5		4.2	9.15			31.4
10.4 42.5 63.4 2.4 110	MIXED XYLENES	ч. •	2.2	28.8		3.7	35.2			35.2
UF 1331.6 3197.9 4945.3 485.7 1969.5 11390 101.6 103.3 95.7 98.1 55.5 98		1	42.5				118.7			1.8.7
101.¢ 103.3 95.7 98.1 54.5 98		~	3197.9	345.			11390.2	1233.1		13113.3
	DUTPUT/INPUT, PCT	101.6	100.3	95.7	98.1	6°56	æ			108.5
			J F F	P P	# }					

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D. U. T. IRANSPORTATION SYSTEMS CENTER

SECTION 8. 11

REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL

			PR ODUC 1	PRODUCT CONSUMPTION	ON SUMMARY				
			P. A. D. DISTRICT	RICT	6 0 6 8 6 8 6 8 8 8 8 8 8 8 8 8 8 8 8 8	0			
	1	2	۲ ۵	*	5	U • S •	FXPORTS	EXP 101	TOTAL
C3 LPG	39.3		32.2	5 0	24.2	164.5	0 8 8 8 8 8 8 8 8	8 9 9 9 8 8 8 9 9	164.5
C4 LPG	9.9	5 . 2		• 2	1.7	16.9			16.0
NAPHIHA NAPHIHA	1.8	21.3	49.4		24.9	97.9			9.14
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1370.0	1420.0	995.0	130.0	0.000	0.0104			4010.0
JP-4 JET FUEL	42.8	31.5	36.0	11.3	49°5	0.171			171.0
JET A JET FUEL	504.0	262.0	170.0	30.0	C.SHE	0.0361			1356.0
DIESEL	1105.0	1150.0	360.0	100.7	475.0	3217.7			321J.7
NO. 2 FUEL DIL	676.0	608.0	242.0	91.0	140.0	1991.0			1991.0
HI SULFUR ND. 6	392.0	65.3	65°3	15.0	106.0	637.0			637.0
LO SULFUR NO. 6	392.0	65.0	65°0	15.0	100.0	637.0			637.0
LUBE STOCKS	37.1	24.6	162.2	1.1	19.0	149.6			189.6
ASPHALT AND ROAD DIL	51.3	120.6	114.3	25.5	66.8	379.6			374.6
COKE ILO SULFUR)	1.9	7.9	8 e H	1.1	1.3	21.0			21.0
COKE (HI SULFUR)	2.9	8°6	10.3	1.3		24.44			24.4
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	6°	1.6	13.9		1.7	18.1			16.1
TOL UENE	• 0	1.1	25.5		4 • 2	31.4			91.4
MIXED XYLENES	. 5	2.2	28°8		3.7	35.2			35.2
MISC. PRODUCTS	16.4	42.5	63.4		2.4	119.7			119.7
TOTAL	4834.1	3907.0	1962.5	427.2	2142.5	13113.3	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5		13113.3

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REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL

3

SECTION C.

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

		2	E	4	5	U • S •
ELEC. PWR (1000KWH/D)	4781.4	12825.9	24725.5	1485.0	12940.4	56758.1
FUEL REQD. (1300FDEB/D)	59 ° b	152.7	252.1	23 • 2	166.2	594°0
ENERGY CONS. (1000FDEB/D	68°9	197.3	396.4	26.0	178.7	967.2
LABOR (NO. EMPLOYEES)	6685 ° 0	15270.9	24451.2	2343。8	9644.2	5 R 3 9 5 • 0
OPER COSTS (M\$/D)	93 ° 8	262.2	331.5	25.4	75.5	788.4
INVESTMENTS (MM\$)	12.0	199.1	847.1	3.7	416.8	1478.7

41

The studies reviewed in the following discussion are the major ones that were available to the author when this report was written. The omission of a study implies no value judgment about their quality or validity. Comparisons of cost and energy savings estimates for various studies are presented in Table 4.2.4-1.

A 1974 Exxon study⁹ for EPA indicates a maximum saving of about \$0.50/b of automotive fuel (diesel plus gasoline) at a 1/l ratio of diesel to gasoline. This is compared with a base case of a 1/10 diesel-togasoline ratio. The corresponding process energy savings is about 2 percent of the total process energy consumption. This study was based on a new, 100,000 barrels per stream day (b/sd) refinery that would come onstream between 1990 and 2000. Thus, much of the cost saving is attributable to the smaller investment required for a refinery specifically designed to produce the 1/l ratio of diesel to gasoline. This differs from SRI's model, which recognizes no investment credit for idle facilities. Investment and operating costs are in 1973 dollars.

A 1976 study released by Bonner and Moore Associates, Inc.,¹⁰ also based on a refinery LP model, is somewhat more comprehensive in its coverage of multiple demand scenarios derived from an earlier SRI report.¹¹ The comparable diesel scenario from this study provides cases covering a range of diesel/gasoline ratios from 0.1/1 to 1.2/1. The consumer cost effects for these cases result from changes in costs of refining, marketing, and distribution. Distribution costs are based on the assumption that three grades of gasoline will continue to be marketed until 1990, so that additional facilities will be required for diesel marketing. This study indicates a maximum net saving of \$2.34/b (\$0.056/gallon) of gasoline plus diesel in 1990 dollars^{*} at a gasoline/diesel ratio of about 0.7/1. The maximum refinery and distribution energy saving of about 1.1 percent below the baseline case occurs at the 1.2/1 ratio.

The approach of optimizing the vehicle-fuel-refinery (VFR) system was analyzed in a study by Wilson and Tierney of Texaco.¹² This study also used a single refinery LP model. A base case representing the U.S. refining industry in 1972 included process capacities typical of the industry configuration for that year. Parametric cases were developed in which only production of highway transportation fuels was allowed to vary, with other products held stable at base case volumes. These cases were:

- An all unleaded 91 RON gasoline case with base case diesel production
- A maximum diesel case
- Two maximum broadcut fuel (100-650°F) cases with base case diesel volume.

Escalated from the 1975 base year at the various rates given in Reference 11.

COMPARISON OF DIESELIZATION STUDIES

	Q + 11 21.	Range of Diesel/Gasoline (D/G) Ratios	Maximum Cost Saving (corresponding D/G volume ratio) \$/b	Saving ng D/G io)	Maxi Ene P Domes	Maximum Refinery Energy Saving, Percent of Domestic Products (FOE)	ery g, icts	Industry Investment Energy 10 ⁶	Industry Incremental Investment at Maximum Energy Saving, 10 ⁶ 1974 \$ \$/h/A
	arad	Studied	D + G	D/G	Base	Saving	D/G	Total	D + G
	SRI/DOT	0.17-0.80	0.61	0.32	6.31	0.14	0.53	90.8	19 5
	Kant et al. ^y	0.11-2.7	0.52	1.0	9.1	1 9	92 0) - 1 -) - 1 -
43	Bonner and Moore ¹⁰	0.11-1.20	2.34	0.69	с и Г			: () () ()	10.1
			$(1.57)^{\dagger}$	•	T ° O	1°1	1.2	120	102.7
	Shearer and Wagner ¹³	0-00-0	None‡		15.4	1.4	0.46	*	41.0
	* Single refinery effect, not extrapolated to H.S. industru	ct, not extrapolate	d to ILS, indus	1					

trapolated to U.S. industry.

[†]Deflated to 1974 costs at 3 percent per year. [‡]This study¹³ indicated cost increases for D/G ratios higher than the base case.

For the maximum diesel case, the diesel/gasoline ratio was about 0.36/1, compared with 0.18/1 in the base case. The refinery fuel requirement decreased from 8.6 percent of crude in the base case to 7.2 percent in the maximum diesel case. Cost data were not presented. Only existing process unit capacities were considered, and it is not clear whether the option of hydrocracking for maximum distillate production was permitted.

A study by Shearer and Wagner¹³ of Amoco showed that raw material and variable operating costs increased for all cases of increased diesel/ gasoline ratios. In this study, based on a single refinery model with Arabian light crude, the increase in feedstock cost more than offset the reduction in refinery fuel requirement. The base refinery configuration did not include hydrocracking and did not produce residual fuel oil.

As shown in Table 4.2.4-1, the cost and energy savings estimates developed in these studies vary considerably. The major difference between the SRI study and the others is that SRI applied an industry-wide model, whereas the others used single refinery models. In particular, the SRI model's flexibility in balancing regional product demands with imported products and interregional transfers leads to more moderate estimates of changes required in the domestic refinery sectors. The effect of this feature is particularly evident in SRI's lower estimates of energy savings for dieselization. The numerous other differences in scenarios also undoubtedly contribute to the differences in results of various studies. The major source of these variations is probably differences in the product mixes (see Table 4.2.4-2) used in the studies. The projected demand for jet fuel is especially critical because the major components of this product are also the major components of automotive diesel fuel.

Beyond this general discussion, a detailed quantitative reconciliation of the study results is probably not feasible. The differences among the studies may be considered useful as a measure of the range of uncertainty in quantifying effects of dieselization on the refinery industry. The maximum refinery energy saving found in any study is only about 2 percent,⁹ and that saving was calculated for a new refinery optimally designed to handle a product mix different from today's demand pattern. Existing U.S. refining capacity, supplemented by U.S.-owned Caribbean refineries, may be sufficient to obviate the need for any substantial amount of new U.S. refining capacity. Thus, the economics of new refineries are probably not a realistic reflection of the industry-wide impact of changes in the product mix.

4.2.5 Technology for Increasing Diesel Availability

As discussed in the preceding section, a number of steps may be taken in a refinery to increase diesel fuel production at the expense of reductions in output of other products. The effects of reductions in light gas oil feed to FCC units and reduced conversion severity of FCC units are implicitly accounted for in the low-conversion refinery modes in the RIM.

	SRI ^{11*}	Kant et al.11 [†]	Bonner and Moore ^{10‡}	Stearer and Wagner ¹³ §
Domestic products (volume percent of refinery output)				
Liquid propane gas	**	3.2	**	
	43.8	57.0	33.03	40.1
Jet fuel	12.1	9.2	18.42	9.8
Diesel	14.2	5.6	8.92	18.3
Heating oil	12.8	17.9	14.28	16.9
Residual	8.0	7.2	12.69	÷ ÷
Other	9,1	-	12.66	14.9
	100.0	100.0	100.00	100.0
Imported products (volume percent of corresponding refinery product)				
Jet fuel	0°0	8	1	
Heating oil	25.0	:	8	
Residual	27.3	4	54.4	
All products (volume percent of total domestic demand)				
Domestic	94.9	:	93.5	;
Imported	5.1	8	6.5	8
	100,0		100.0	
* Case 2, 1995 base domestic refinery		§ Case of maximum energy	ergy savings.	
	л т т т	LPG included in "Other" product category.)ther" product	category.
HOW THET OLI CASE.	d l l	¹¹ Produced coke instead of residual fuel oil.	cead of residu	al fuel oil.
Baseline scenario for 1995.				

PRODUCT DISTRIBUTION Table 4.2.4-2

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The following discussion describes explicit incremental options in the RIM for increased diesel production.

Any significant increase in the proportion of diesel fuel produced is likely to require the use of refinery streams that are deficient in cetane quality. Cetane quality improves as the aliphatics content of the blend stocks increases and the aromatics content decreases. Therefore, increasing the hydrogen content of the stock (e.g., by hydrotreating or hydrocracking) improves cetane quality. Additives such as amyl or hexyl nitrates also increase cetane quality.

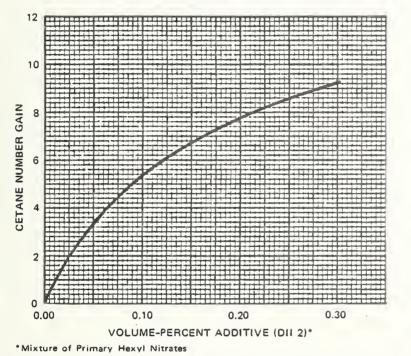
4.2.5.1 Additives for Cetane Improvement. Amyl and hexyl nitrates produce cetane number improvement, as shown in Figure 4.2.5.1-1. The cost of a four-point cetane index improvement resulting from additives is about 0.22 cents/gallon of diesel fuel, based on a recent price of 45 cents per pound in tank-car quantities.¹⁴ According to the response curve in Figure 4.2.5.1-1, this quality increase corresponds to an additive requirement of 0.06 volume-percent.

This level of cetane improvement was selected for inclusion in the RIM for the sake of consistency with the hydrotreating option described in the following section. If this option for incremental production of diesel fuel at the expense of No. 2 fuel oil were to be studied in depth, several levels of cetane improvement could be developed from the response curve and cost data.

However, a basic problem exists in assessing cetane improvement methods in evaluations of incremental diesel production. The volume of marginal cetane quality blend stocks that could be added to the national diesel pool by upgrading is not explicitly known. Production of FCC light cycle oil and light coker gas oil may be estimated from published capacity data for the two relevant cracking processes, but such estimates were not made for this study because the chosen scenarios indicated that No. 2 fuel oil would be in short supply.

Surveys of the qualities of No. 1 and No. 2 fuel oils produced in the United States are published annually by the DOE (formerly ERDA) Bartlesville Energy Research Center (BERC).¹⁵ The available quantities corresponding to the reported sample qualities are noted only by classes of volumes produced. It is thus only possible to estimate roughly the extent of cetane improvement required and the corresponding volume of incremental diesel fuel produced.

Note also that the average cetane values reported in the annual survey of diesel fuel quality by BERC¹⁶ exceed the American Society of Testing and Materials (ASTM) minimum of 40 by 5-10 points. This study has not established whether the apparent excess cetane quality is the result of the need to meet specifications required for market competition, or is simply characteristic of the distillate stocks of the crude oils currently processed in U.S. refineries. Some indication supporting the latter



SOURCE: Ethyl Corporation, "Diesel Fuel Additives," Brochure PCD417872 (Undated)

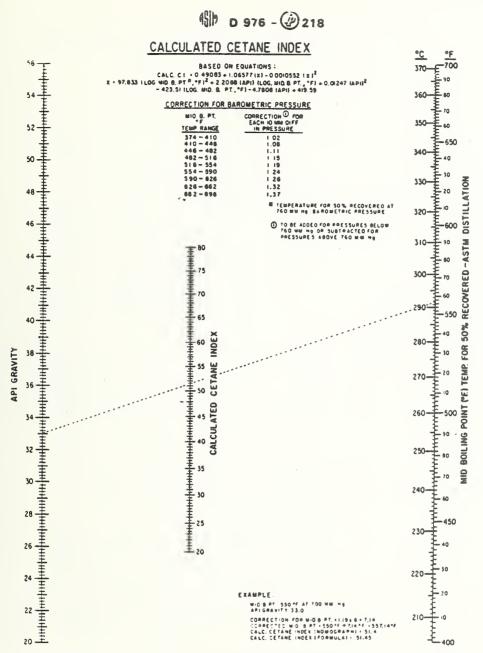
FIGURE 4.2.5.1-1 CETANE IMPROVEMENT BY ADDITIVE

explanation is obtained by calculating the average cetane index of No. 1 and No. 2 heating oils from data reported in the annual BERC fuel oil survey. Using the ASTM D-613 correlation of cetane index versus API gravity and mid-boiling point (Figure 4.2.5.1-2), the sample averages are well above 40 cetane index. This suggests a general availability of excess cetane quality in the U.S. refining industry distillate pool at current levels of diesel production.

4.2.5.2 Hydrotreating for Cetane Improvement. The traditional commercial application of distillate hydrotreating has been in sulfur removal required to meet SO2 emission regulations. In this application, some degree of aromatic ring saturation occurs, and this saturation improves the cetane quality of diesel blend stocks. In the refinery model, an allowance of a four-point cetane number improvement is provided for hydrotreated kerosene stocks and a two-point improvement is provided for light gas oils. More severe hydrotreating with catalysts designed for aromatic ring saturation could provide a considerably greater cetane improvement than the four point improvement allowed in the Refinery Model, but published data on this particular type of operation are scarce, probably because of the previously discussed traditional lack of incentive for applying such severe hydroprocessing. However, an analogy may be drawn to hydrotreating for jet fuel smoke point improvement, which is practiced to a limited extent in the refining industry.¹⁷ Using the increase in gravity (°API) as a measure of aromaticity reduction, several examples given in this reference show a 2-4°API increase between feed and product. Applying this to the D976 correlation presented in Figure 4.2.5.2-1 at a constant mid-boiling point of, say 440°F, 36°API, the calculated cetane index increases from 39 to 47 for a 4°API increase in gravity.

The economics of this process as represented in the RIM as an option for incremental diesel production were adopted from the distillate hydrotreating data in the Refinery Model, as summarized in Table 4.2.5.2-1. The problem of estimating the limits of potential application are the same as those discussed for the additive option.

4.2.5.3 <u>Hydrocracking for Diesel</u>. Of the three options developed for the production of incremental diesel fuel, only hydrocracking produces diesel fuel at the sacrifice of gasoline production. The rationale is that heavy gas oil feedstocks currently being cracked in FCC units for gasoline production may alternatively be charged to hydrocracking for production of high-quality diesel fuel. It should be noted that the FCC process may be operated at low cracking severity to produce a lower gasoline-tocracked-distillate ratio. However, the cetane quality of the cracked distillate is poor, so this stock is usually blended into the No. 2 fuel oil pool. As mentioned previously, severe hydrotreating may be used to upgrade cracked distillates to diesel or even jet fuel quality, but this option has little commercial application with the traditional product mix. If extensive diesel penetration occurs, this approach will probably be explored by the refining industry.



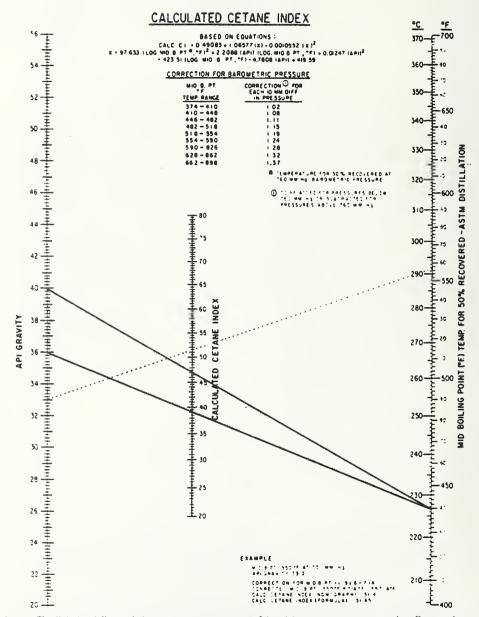
NOTE—The Calculated Cetane Index equation represents a useful tool for *estimating* cetane number. Due to inherent limitations in its application, Index values may not be a valid substitute for ASTM Cetane Numbers as determined in a test engine.



By publication of this standard no position is taken with respect to the validity of any patent rights in connection therewith, and the American Society for Testing and Materials does not undertake to insure anyone utilizing the standard against liability for infringement of any Letters Patent nor assume any such liability.

SOURCE: 1974 Annual Book of ASTM Standards, Petroleum Products and Lubricants (I), Part 23 (1974).

FIGURE 4.2.5.1-2 CALCULATED CETANE INDEX



No()—The Calculated Cetane Index equation represents a useful tool for *estimating* cetane number. Due to inherent limitations in its application. Index values may not be a valid substitute for ASTM Cetane Numbers as determined in a test engine.

FIG. 1 Nomograph for Calculated Cetane Index (ECS-1 Meter Basis-Method D 613).

By publication of this standard no position is taken with respect to the validity of any patent rights in connection therewith, and the American Society for Testing and Materials does not undertake to insure anyone utilizing the standard against liability for infringement of any Lettery Patent nor assume any such liability.

SOURCE: 1974 Annual Book of ASTM Standards, Petroleum Products and Lubricants (I), Part 23 (1974).

FIGURE 4.2.5.2-1 CETANE INDEX IMPROVEMENT THROUGH HYDROTREATING

Table 4.2.5.2-1

ECONOMICS OF INCREMENTAL HYDROTREATING FOR UPGRADING HEATING OIL STOCKS TO DIESEL QUALITY

Yields (barrels)	
No. 2 fuel	-1.0
Diesel	+1.0
Refinery fuel (FOE b)	-0.022
Electric power (kWh/b of incremental diesel)	0.008
Labor (No./10 ³ b/d)	0.50
Operating cost (\$/b diesel)	0.0125
Total energy (FOE b/b of diesel)	0.025
Investment (10 ³ \$/b/d)	0.510

Hydrocracking is a versatile, if relatively costly, process for converting heavy gas oils to lighter products ranging from diesel fuel to gasoline and even lighter fuels. Most of the hydrocracking capacity now installed is intended to operate in the maximum gasoline mode, but may be used to produce additional jet fuel or diesel, as the particular refiner's market requires.

To quantify the incremental effects of using hydrocracking to produce diesel at the expense of gasoline produced by FCC, the Refinery Model was run in (1) a high gasoline demand mode with limited hydrocracking capacity available, and (2) in a high diesel demand mode with unlimited hydrocracking capacity available. The differences in yields and costs between these two operations represent the incremental effects used in the RIM. Table 4.2.5.3-1 summarizes the two refinery model runs described. As shown in this table, the yield and cost differences are normalized on a quantity per barrel of gasoline reduction for inclusion in the RIM. The investment requirement for this operation is based on requirements for incremental capacity only; no credit is allowed for unused process capacity.

The units per barrel of gasoline values are the coefficients used in the RIM, as shown in Table 4.2.5.3-1, with the exception of gasoline. The 1.0 value for gasoline is based on a reduction weighted to reduce production of leaded premium and regular grades in greater proportion than low-lead and unleaded grades, as is consistent with existing trends.

A separate set of hydrocracking options is included in the RIM to represent the conversion of existing gasoline hydrocracking capacity to the maximum diesel mode. The upper limits of these options are set at 1.3 times the existing capacity to allow for the potential of higher

INCREMENTAL HYDROCRACKING FOR DIESEL PRODUCTION

	<u>High Gasoline</u>	<u>High Diesel</u>	Difference	Difference per Barrel of Gasoline
Yields, volume percent of crude				
C3 LPG	0.83	0.83		
C _A LPG	0.25	0.25		
Naphtha	0.88	0.88	••	
BTX	2.85	2.85		
Gasoline	44.01	32.69	-11.32	-1.0
JP-4	1.80	1.80	••	
Kerosene	1.40	1.40	••	
Jet-A	4.70	4.70		
Diesel	17.40	31.38	+13.98	+1.235
No. 2 fuel	12.00	12.00		
No. 6 fuel	9.89	5.60	-4.29	-0.379
Lubes	2.00	2.00	••	
Asphalt	1.40	1.40		
Coke	0.29	0.29		*
Refinery fuel	5.67	6.38	0.89	0.0786
Utilities				
Electricity $[(kWh \times 10^3)/d]$	337.95	713.38	375.43	33.16
Operating cost (10 ³ \$/d)	3.78	3.36	-0.432	-0.0382
Labor (no. people/103 b/d)				0.8
Energy consumption (FOE b/b gasoline)				0.520
				Investment
				106 1973 \$
Incremental facilities (10^3 b/d)				
Vacuum still	37.5	40	2.5	0.22
Gas recovery	3.0	4.4	1.4	0.46
Gasoline reformer	16.0	18.5	2.5	1.6
Distillate merox	1.4	4.2	2.8	0.12
Hydrogen plant		0.88	0.88	7.04
Isomerization unit	0.25	1.23	0.98	0.43
Hydrocracking	0.90	19.5	18.6	16.6
Electrical distribution (MW)	12.66	29.7	17.02	1.6
Steam (10 ³ lb/hr)	141	164	23	0.23
Cooling water (gal/min)	24.0	35.8	11.8	0.33
				28.63
				20.05

Notes: Correction for inflation: $$28.6 \times 10^6 \times 1.54^{\dagger} = 43.0×10^{6} .

Investment per barrel of gasoline reduction: $43.0/11.32 = 53.8 \times 10^3$ b/day.

* Included with No. 6 fuel reduction.

[†]Based on Nelson Inflation Index, published periodically in <u>Oil and Gas Journal</u>.

throughput at the lower severity required for diesel operation. A nominal investment of \$100/b/d is allowed for minor process modification. The yield and utility differentials used in this option are based on the values for the gasoline and diesel options in the refinery model.

4.3 <u>Impact of Transportation Fuel Desulfurization on the</u> <u>Refining Industry</u>

4.3.1 Overview

The primary impetus for further reduction of sulfur in gasoline is the finding that the catalytic converters applied to 1975 and later model cars for reduction of undesirable exhaust emissions convert sulfur to sulfuric acid and sulfate particles. Catalyst systems now used in the catalytic converters require an essentially lead-free gasoline. Coincidentally, the major refinery processes used to provide the octane quality previously provided by tetraethyl lead produce blend stocks with a very low sulfur content. This has resulted in current lead-free gasoline sulfur levels of about 300 ppm. Although other approaches to the automobile emission reduction problem could be used, this study analyzes only the effects of reducing the sulfur in gasoline to 100 ppm.

Further sulfur removal from distillate (diesel) fuels is related to concern for sulfur emissions because the diesel exhaust inherently contains low concentrations of hydrocarbons and CO without converters. Control of NO_x emissions is a complex issue that is excluded from this study.

4.3.2 Summary and Conclusions

For gasoline desulfurization, it is assumed for this study that all gasoline produced in 1995 will be lead-free, and that the predominant process used for gasoline desulfurization will be HDS of light straight-run stocks and FCC feedstock. These assumptions are supported by the studies cited in Section 4.3.3. The costs and investments in this study are based on the total cost of desulfurizing all gasoline produced to 100 parts per million by weight (wppm) sulfur and all the diesel production to 200 wppm sulfur, using presently known commercial catalytic HDS technology.

The base case for the desulfurization studies is Case 4, the 30 percent diesel penetration case. Table 4.3.2-1 summarizes the RIM results for Case 5. The reduction of the sulfur content of 4,010 b/cd of gasoline production to 100 wppm costs \$0.834/b, or about 2 cents/gallon of gasoline produced. The facilities investment required is about \$2 billion, and the energy increase in refining is indicated to be 1.1 percent above the base, or 7.3 percent of total domestic refinery output.

FUELS DESULFURIZATION SUMMARY

	<u>Case 4</u>	<u>Case 5</u>	<u>Case 6</u>
Percent diesel penetration	30	30	30
* Percent of gasoline desulfurized	Base	100	100
Percent of diesel desulfurized [†]	Base	Base	100
Incremental cost, \$/b desulfurized product	Base	0.834 [‡]	1.018
Incremental cost, \$/b desulfurized product		Base	0.18
Incremental investment, $10^6 \**	Base	1,940	5,580
Incremental investment, 10 ⁶ \$	<i>~</i> ~	Base	3,640
Energy consumption (FOE basis), percent			
of domestic production	7.3	8.4	8.8
Incremental	Base	1.1	1.5
Incremental	* *	Base	0.4

*From Case 4 sulfur level (about 300 wppm) to an average of 100 wppm. *From Case 4 sulfur level (600-1,700 wppm) to an average of 200 wppm. *\$/b gasoline.

§/b gasoline plus diesel.

Investment based on constant 1974 dollars.

Reducing the sulfur content of the Case 4 production of 3,210 b/cd of diesel fuel to 200 wppm adds about \$0.18/b of gasoline plus diesel output. Applied to diesel only, the incremental cost above Case 5 is \$1.22/b, or about 3 cents/gallon of diesel. The increase in energy consumption for diesel desulfurization over Case 5 is 0.4 percent of total domestic refined products.

For both the gasoline and diesel desulfurization cases, the costs shown represent the maximum cost case, which assumes that all new facilities will be required by 1995. To the extent that existing facilities for desulfurization will be operable and technologically adequate by 1995, the costs presented may be higher than actual costs. Estimates of the potential for adapting existing facilities is beyond the scope of this study, as is estimation of the effects of potential new developments in technology.

4.3.3 Discussion and Analysis

Reduction of sulfur in leaded gasoline to current levels has long been practiced to minimize the unfavorable effect of sulfur on octane improvement by tetraethyl-lead.¹⁸ Lead-free gasoline has a higher concentration of very low-sulfur, high-octane components than leaded gasoline. The major gasoline components that are not already desulfurized for refinery process requirements are the light straight-run (C_5 -175°F) stocks, coker gasoline, and FCC gasoline, an important component for improving octane rating and increasing volume. Because we expect only lead-free gasoline to be produced by 1995, this analysis of the major technological options for further sulfur reduction focuses on these blend stocks. Naphtha for catalytic reformer feed is currently desulfurized to a level of 1-2 wppm to protect the reformer catalyst.

FCC gasoline desulfurization does, however, present several technological options for consideration. These are summarized briefly here and discussed in detail in Section 4.3.5.

- (1) The full range of FCC gasoline may be desulfurized using existing commercial processes, with a potential loss of octane quality resulting from the concommitant saturation of olefins. The octane loss may be a minimal problem if the recently announced "Selective Ultrafining" process¹⁹ developed by Amoco proves to be commercially feasible.
- (2) The FCC feed may be desulfurized to provide low-sulfur gasoline and low-sulfur fuel oil blend stocks with the additional benefits of improved FCC yields and reduced FCC sulfur emissions.
- (3) As proposed in a recent study by Bonner and Moore, Inc.,²⁰ for BERC, the FCC gasoline octane loss problem in HDS may be ameliorated by prior fractionation of the FCC gasoline into a light fraction containing most of the olefins and little sulfur and applying HDS to the heavier fraction containing more sulfur and less olefins.

The process economics selected for inclusion in the RIM for this study are based on a 1974 study by Pullman-Kellogg²¹ sponsored by EPA. This study concluded that FCC feed HDS plus light naphtha HDS were economically preferable to the alternatives mentioned.

Analyzing the possibility of reducing the sulfur content of diesel fuel from the current averages of 600-1,000 wppm to about 200 wppm presented a problem of data availability. Because specific data on this operation could not be developed within the time frame allowed for this phase of the study, the economics used in the RIM for this operation were assumed to be similar to those for vacuum gas oil desulfurization (VGO) for 95 percent desulfurization. This assumption may overstate the cost of HDS of diesel fuel to 200 wppm, but perhaps our cost estimates represent a maximum-cost case. The availability of hydrogen for fuels HDS is another issue that requires further investigation. Our analyses of both gasoline and diesel sulfur removal assumed that the incremental HDS facilities would be supplied with hydrogen available from existing refinery sources, primarily the catalytic reformers. Because the actual situation may be characterized by reduced gasoline consumption, and thus perhaps by less gasoline reforming and greater HDS hydrogen requirements, the hydrogen balance requires further analysis.

The RIM output for the study cases is summarized in Table 4.3.3-1. Detailed results by PAD district are presented in Tables 4.3.3-2 through 4.3.3-7 for Cases 5 and 6.

4.3.4 Review of Previous Studies

The Bonner and Moore, Inc., study²⁰ provides a detailed analysis and critique of prior assessments of gasoline desulfurization costs. The comparison summary from Volume II of that study is presented in Table 4.3.4-1, with the SRI results added, adjusted to first-quarter 1976 dollars with the same factors indicated in the table for mid-1974. As shown in Table 4.3.4-1, the cost values derived from the RIM are at least within the range of the reported values that could be explained by the widely varying scenarios used in the different estimates. A detailed reconciliation of these figures with those of one or more of the other studies cited is beyond the scope of this study.

4.3.5 Gasoline Desulfurization Technologies

Two basic refining approaches can be used to achieve the required gasoline sulfur reductions. One is to desulfurize individual gasoline blending stocks. The other is to desulfurize feedstocks for process units such as the cat cracker that produce gasoline blending stocks. Specific operations belonging to these two different approaches are listed below. All of these operations are commercially feasible, and some are already practiced.

(1) Option 1: Desulfurize Gasoline Blending Stocks

- (a) Hydrotreat cat gasoline.
- (b) Hydrotreat straight-run gasoline.
- (c) Hydrotreat coker gasoline.
- (d) Hydrocrack coker gasoline.
- (e) Cat crack straight-run gasoline, coker gasoline, or cat gasoline.
- (f) Merox-extract sulfur compounds in gasoline.

FUELS DESULFURIZATION CASE DATA

	Case 4 (1995) 30% Diesel Penetration	se 4 (1995) 30% Diesel Penetration	Case 5 Case 5 with G Desulfu	Case 5 (1995) Case 4 with Gasoline Desulfurizstion	Case 6 Gaso and D Desulfui	Case 6 (1995) Gasoline and Diesel Desulfurization
Refining industry cost, [*] 10 ³ \$/dsy	139,913		143,157		147,185	
Total refinery input, T 10 ³ b/cd	12,083		12,090		12,090	
Domestic refinery production, 10 ³ b/cd (vol%)						
Gssoline	4,010	(33.8)	4,010	(6.66)	4,010	(33.9)
JP-4	171	(1.4)	172	(1.4)	172	(1.4)
Jet-A	950	(8.0)	950	(8.0)	950	(8.0)
Diesel	3,211	(27.0)	3,210	(27.2)	3,210	(27.2)
No. 2 fuel	1,591	(13.4)	1,591	(13.5)	1,591	(13.5)
No. 6 fuel	841	(1.1)	786	(9.9)	786	(9.9)
Other	1,106	(9,3)	1,100	(6,9)	1,100	(6, 3)
Total production	11,880	(0.001)	11,819	(100.0)	11,819	(100,0)
Imported products						
Jet fuel (jet A) [†]	400		400		400	
No. 2 fuel [*]	400		400		400	
No. 6 fuel	433		488		488	
Total imports	1,233		1,288		1,288	
Total domestic demand	13,113		13,107		13,107	
Energy consumed by domestic refining, 10 ³ b/cdFOE	867		066		1,035	
Incremental investment, 10^6 \$, 1974	Base		1,941		5,581	
Fscilities for desulfurization, 10 ³ b/cd feed						
Light naphtha HDS	1		385		385	
FCC feed HDS	;		3,031		3,031	
Diesel HDS	:				1,670	
*						
Includes feedstock costs, imported product costs, refinery operations costs, and capital recovery costs for new facilities (1974 Anilare)	finery of	erations	costs, a	nd capital	recovery	/ COSES

 $^\dagger {\rm Crude}$ oil snd natural gas liquids. $^\dagger {\rm Imports}$ of Jet A snd No. 2 as shown are at maximum value allowed.

D. U. I. IHANSPORTATION SYSTEMS CENTER

SECTION A. 25

PEFINING INDUSTRY MUDEL - 1995, 3U PCT. DIEJLL #/(ASC. DESU F.--CASE 5

Refluert Input/OUFPUT SUMMARY

		• •	. A. 0. DISTAICT	I A L C T					
	1	~	m	÷	3	° 5 ° N	IMPORT	1404 X 3	TOTAL
INPUT									
SWEET CRUDE	690°0	1920.0	3132.0	240.0	478.0	6460.3			6460.5
SOUR CRUDE	647.0	1292.1	1231.4	228.8		3699.3			3694 . 3
CALIF CRUDE					1434.0	1434.0			1434.0
MATURAL GASDINE Matural Gasdine	13.4	61.7	118.5	22.7	26.8	0-642			0.625
NOR HAL BUTANE	8.8	45.6	4 4 4 7	1.6	27.1	127.7			127.7
I SO BUT ANE	Ð • 41	52.5	46.0	3• 3	18.2	125.7			125.7
. TOTAL INPUT	1364.9	3371.9	4872.5	496.3	1984.1	12089.8	0 0 0 0 0 0 0 0		12089.8
OUTPUT									
	5 0 5	1 27	3.0.6	4	6 76	1 2 2 1			1 1 1 1
	8.9				1.7	17.6			17.4
NAPHIMA	1.8	21.3	46.1	;	24.9	0.40			0.46
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE				147 0		0.010			4010.0
LEAU FREE GAJULINE 10-4 iet fiifi	040°.	34.45	7 07 CT	101.01	0 ° 0 C C	4010°			3 1 2 1
JET A JET FIJEL	0.00	3.721	2022	0.05	C . C M C	0.411	0-007		1350.0
DIESEL	222.3	914.6	1347.8	166.3	0.995	3210-0			3210.0
NO. 2 FUEL DIL	225.5	547.1	771.1	43.7	3.6	0.194.	466.0		0.1911
HI SULFUR NO. 6	68.9	9.49	149.2	15.0	184.2	502.3	134.7		637.C
LO SULFUR NO. 6	5.76	6°6	65.0	15.0	136.6	2 9 3 . 4	3:3.6		637.0
LUBE STOCKS	1.76	29.6	46.B	1.1	19.6	144.2			104.2
ASPHALT AND ROAD DIL	51.3	133.2	100.1	25.5	66.8	377.0			377.0
COKE (LO SULFUR)	1.9	6.9	8.6	1.1	1.3	19.9			19.9
COKE (HI SULFUR)	2.9	11.2	9.2	1.3		24.6			24.6
COKE (CAL CRUDE)					10.6	10.4			10.6
BENZEME	6.	9 · 1	13.9		1.7	19.3			16.3
	•	1.2	25.4		4 • 2	31.5			31.5
MIXEU XYLENES	¢.	2 • 2	21.9		3.7	34.5			1 1 .
MISC. PRODUCTS	10.4	44.7	64.9		2.4	122.4			122.4
TUTAL OUTPUT	1379.1	3337.6	4653.9	484.9	1906.7	11419.2	1218.3		13107.5
OUTPUT/INPUT,PCT	101.0	0.94	45.5	97.7	1.94	c 7 . A			100.4

D. U. T. FRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY NJDEL - 1395, 30 PCT. DIESEL. #/6450. DTS' F.--CASE 5

SECTION 8. 11

PRODUCT CONSUMPTION SUMPARY

1

		2	•	*	5	N• S•	EXPOPTS	EXP 101	LJIAL
C3 LPG	34.3	07.1	30.6	5.0	24.2	166.1	0 0 0 0 0 0 0 0	9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	166.1
C4 LPG	9°6	5 • B		•2	1.7	17.4			17.4
NAP HIHA	1.8	21.3	40.1		24.9	0.45			0.45
REGULAR GASOLINE PREMIUM GASOLINE									
LUW LEAU GASULINE LEAD FREE GASOLINE	0.0761	1420.0	495.0	130.0	595°0	4010.0			4010.0
JP-4 JET FUEL	4 2 ° F	31.5	36.1	12.0	49.5	171.8			171.6
ET A JET FUEL	506.0	262.0	170.0	30.0	342.0	1350.0			1350.0
OIE SEL	1105.0	1150.0	360.0	100.0	475.0	3219.9			321U ° O
0. 2 FUEL DIL	970.0	6V3.0	242.0	91.0	180.0	1991.0			1991.0
I SULFUR NO. 6	392.0	0°49	65.V	15.0	100.0	637.0			637.0
O SULFUR NO. 6	392.0	65 . Ú	65.0	15.0	100.0	627.9			£37.C
UBE STJCKS	37.1	29.6	96.6	1.1	19.6	194.2			184.2
SPHALT AND ROAD OIL	51.3	133.2	101.1	25.5	66.0	377.3			377.0
OKE (LO SULFUR)	1.9	6.9	0°9	1.1	1.3	19.9			19.91
COKE (HI SULSER)	2.9	11.2	3°5	L.3		24.6			24.6
COKE (CAL CRUDE)					10.6	10.6			10.6
BEN ZENE	• 9	1 • H	13.9		1.7	19.3			1e.3
TOL UENE	• 0	1.2	25.4		4.2	3:•5			31.5
IXED XVLENES	ۍ ۲	2.5	27.9		3.7	34.5			34.5
IISC. PRODUCTS	10.4	44.7	64°3		2.4	122.4			122.4
TOTAL		30.24.0	1476.7		2562.5	12107.5	0 0 0 0 0 0 0 0 0	0	12107 5

			0 0 0 0 0 0	1000		
	PETROLEUM	EUM ADMINSTR	ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)	EFENSE DIST	RICTS (PAD)	
	1	2	3			U • S •
ELEC. PWR (1000KWH/D)	5355•6	18559.7	24871.6	1660.4	13526.2	63973.7
FUEL RE40. (1000F0E8/D)	68 • 6	180.4	272.1	25 • 9	115.1	662.1
ENERGY CONS. (1000FDEB/D	78.7	296.2	403.1	29.0	188.7	989.7
LABOR (NO. EMPLOYEES)	1.6107	16924.8	24374.1	2444 • C	0*6266	50735.1
OPER COSTS (M\$/D)	101.0	293.6	357.5	27.5	82•A	862.4
INVESTMENTS (MMS)	230.8	1135.6	1339.2	70.5	640•0	3420.0

D. D. T. TRANSPORTATION SYSTEMS CENTER

REFINING IMDUSTRY MODEL - 1995, 30 PCT. DIESEL, W/GASO. DESU F.--CASE.

UTILITY SUMMARY

SECTION C. 4

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				GNINI JOH	ISOUM THISOUNT ONLY IS	JULI			
		rikk faller och and en statementer med stateme	REF		2U	řCASE 6	C1		
	-	i	• A. D. DISTHICT	k1CT					
	-	~	- e i	3	5	U.S.	-	EXPORT	
			0 0 1 0 0		1 0 0 0 0	0 0 1 0 1 0 0 0 0		0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	8 0 0 8 8
Sweft CRUNE	0.063	1920.0	0.3FTE	0°072	478.0	6460.0			0*09*9
SOUR CRUDE	647.0	1292.1	1531.4	228.6		544°3			5.494.3
CALIF CRUDE					1434.0	1434.0			1434.0
ALASKAN CRUDE Matheal casoline	A 51	41.7	2.011	1 66	9 40	0 676			0 6 4 6
NOPMAL BUTANE	- G G.	45.0		1.6	27.1	127.7			127.7
	5.8	25.5		3.3	18.2	125.7			125.7
TOTAL INPUT	1364.9	9371.4	4872.5	496.3	1984.1	12089.8			12089.8
01JTPUT								-	
C3 [b6	14°.4	67.1	30.6	2°0	24.2	166.1			166.1
C4 LPG	9°8	5.8		۰ <i>د</i> ر	1.7	17.4			17.4
NAPHTHA	1.A	21.3	46.1		24.9	94.0			94.0
REGULAR GASOLINF									
FREWIUM GASULINE									
TEATERFE GACHINE	546.9	N.1221	1516.3	187.0	KKA B		And a state of the		2010-0
JP-4 JET FUEL	B . 3	36.4	70.6	13.7	42.8	171.8			171.8
JET A JET FUFL	5.66	137.5	307.3	30 . 0	342.0	450.0	400°0		1350.0
DIFSEL	£:222	974.6	1347.H	166.3	0.99.4	1210.0			0°012E
NO. 2 FUEL OIL	225.5	547.1	771.1	43.7	3.6	1541°0	0.004		1991.0
HI SULFUR NO. 6	6A.9	6.49	149.2	15.0	184.2	502.3	134.1		637.0
TO SULFUP NO. 6		6.6	65 ° U	15:0	136.1	243.4	353.6		637.0
LUHE STOCKS	37.1	29.65	46.4	1.1	19.6	144.2			184.2
ASPHALT AND ROAD OIL	6.12	2.661	100.1	2°24	66°8	377.0			0.116
	•	5 ° C	80.0	1.1	1.5	6.61			× • • •
	F	2*11	7*6	L • 1		0 • • · ·			
DENZENE- (LAL UNUVE)	0								2 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 -
	•								
I ULUENE MIYEO YYI ENEC	<i>C</i> u	2°1	4 ° C V		* P * 1	ر الا ۲			C•15
MIATU ATLINES			5°12		1.5	5+ ° 1			
	11.4	1 . 44	P . 40		5.4	122.4			122.4
TOTAL OUTPUT	5	3337.6	4650.9	444	1966.7	11419.2			13107.5

Table 4.3.3-5

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Table 4.3.3-6

D. U. T. THANSPOHTATION SYSTEMS CENTER

SECTION P. 11

PEFINING INDUSTAY MODEL

1

		a.	A. D. DISTUICT	ніст					
	-	2	٤	4	s	1)+5+	ExPORTS	FAP T01	TOTAL
			30.6	2.0	24.2	1.166.1			166.I
C4 1 PG	т 0	л. г		2.	1.7	17.4			17.4
NAPHTHA	1 н	21.3	46.1		24.9	44.0			94.0
PEGULAR GASOL INF	×× -								
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	0.07ET	0.0541	0.564	130.0	295°D	10100			0.0104
JP-4 JFT FUFL	2.24	31.5	36.1	12.0	44°5	171.4	,		171.6
JET A JFT FUFL	504.0	262.0	170.0	30.0	342.0	1.350.0			1350.0
TESE.	1145.0	1150.0	140-0	100.0	475.0	121456			3210.0
10. 2 FUFL OTL	H70.0	60H.0	242.0	0.10	140.0	0.1421			1991.0
HI SULFUR NO. 6	U° ChE	65.0	65.0	15.0	100.0	637.0			637.0
O SULFUP NO. 6	.0°26E				100:001	0.153			0:159
UHF STOCKS	1°16	79°62	96.A	1 • 1	19.6	144.2			184.2
ASPHALT AND ROAD OIL	51.3	133.2	100.1	25.5	66.A	377.0			377.0
רמאד ונא בטנ בטאז	6.1	P.4	н. н. н.	1.1		<u></u>			6.61
CONF (H] SULFUR)	ۍ <i>د</i>	11.2	9°5	٤.1		24°6			24.6
COKE (CAL CHIDE)					10.6	10.6			10.5
RENTENE	b •	н.1	6*E1		·				E.H[
TOLIENE	÷.	1.2	25.4		4°5	31.5			31.5
MIXFD XYLFNES	ۍ •	2.5	27.9		3.7	34 .5			34.5
MISCSTOURDER		- t.4.7	6* 79		2.4	122.4			122.4
TOTAL									

U.S. 73988.9 687.7 681.6 62661.1 1034.7 7060.1 PETHOLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD) S 8.56 15083.3 10278.5 119.1 195.7 1205.9 PEFINING INDUSTRY MODEL P. O. T. THANSPORTATION SYSTEMS CENTER UTTLTTY SUMMANY -- CASE 6 27.2 28.5 2179.1 4 2543.7 E. IE 259.1 8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 29076.9 282.9 25182.8 365.5 422.0 2467.6 Table 4.3.3-7 2 21600.3 188.2 17504.6 244.5 303.9 7. 4455 E.4403 70.4 81.8 7146.5 102.3 4H2.9 REFY ENERGY CONSUMPTION PURCH ELECTRIC POWER TOTAL FUEL REQUIRED OPFRATING COSTS INVESTMENTS 4 SECTION C. LAHOR

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Table 4.3.4-1

COMPARISON OF DESULFURIZATION COST

د

Study	Investment (millions of first-quarter 1976 \$)*	Increased Gasoline Cost, ¢/gal (first-quarter 1976)	Average Gasoline Sulfur Level (Wppm)	Percent of Total Gssoline Desulfurized	Net Energy Requirement, 10 ³ FOE b/cd
SRI/DOT: total United States	3,270	2.32	100	100	123 [†]
Bonner and Moore/ERDA, United States including California					
Primary study	455 580	0.23 0.30	100 50	60 60	23 26
Total desulfurization	975 1,181	0.37 0.50	100 50	100	36 52
Restricted Cat gasoline splitting (United States excluding California only)	2,963	1,01	74	100	94.1
NPRA Burvey	4,460		100 50 [‡]	100	100-200 [†]
Pullman Kellogg/EPA study	2,520	1.98 to 0.83 ⁹	80	100	82
ADL/EPA	780 1,440 2,880 4,430	0.49 1.23 0.86 1.81	100 50 50	60 60 100	18 68 42 160
Batteile/API study	4,450 15,580 4,570 15,930		100 30 30	4 6 8 6 8 6	82 287 292
Texaco EPA testimony	8,440 to 12,060 9,650 to 13,270	4.86 to 6.00 5.46 to 6.80	100** 50**	100	180 211

* * All of the cost data have been converted to first-quarter 1976 dollars using the following inflation factora: 1974 dollars, 1.21; January 1974 dollars, 1.24; mid-1974 dollars, 1.17; 1975 dollars, 1.11.

This is the additional energy consumed by the additional facilities, as opposed to the net energy requirement, which includea a credit for increased product yields.

* Respondents questioned the feasibility of this.

 $^{8}_{\rm The}$ incressed cost increases with decreasing refinery size.

** Texaco referred to the 100 and 50 wppm sulfur level as <u>specifications</u>, not as the average sulfur level of production referred to in the rest of the data.

Source: Reference 20 SRI International

- (2) Option 2: Desulfurize Process Feedstocks
 - (a) Desulfurize regular cat-cracking feed.
 - (b) Desulfurize, demetallize, and saturate asphaltenes in residual oil for cat cracking.
 - (c) Desulfurize, demetallize, and saturate asphaltenes in whole crude oil.

Note that Options 1(a) through 1(c) are not the same as the naphtha pretreatment used in connection with reforming. Although the process schemes for both are the same, the extent of sulfur removal differs: The reformer pretreatment reduces sulfur levels to 1-2 wppm, whereas gasoline hydrotreating reduces it typically to 80-200 wppm.

Gasoline hydrotreating is already in commercial use, and its application has been growing rapidly in the past several years. According to the annual refining capacity survey conducted by <u>Oil and Gas Journal</u>, naphtha desulfurization capacity, in which desulfurization of gasoline stocks is the principal operation, was about 710,000 b/d in January of 1977, but in 1972, it was only 148,000 b/d.

One drawback of hydrotreating is the potential for loss of octane numbers resulting from saturation (hydrogenation) of high-octane components in the feed, such as olefins and aromatics. Such losses are particularly likely with light, cat-cracked gasoline. Therefore, the refiner may be required to increase the reforming capacity to make up the octane losses.

Option 1(d) refers to the use of hydrocracking for desulfurization. Although the process is normally used to convert gas oils into light boiling products, it can be used for desulfurizing high-sulfur gasoline stocks, such as coker naphtha. However, hydrocracking is much more expensive than hydrotreating, and use of hydrocracking solely for gasoline desulfurization is not generally cost-effective. Refiners may choose to use it only when they have excess capacity.

The cat cracker can be used to desulfurize gasoline stock because about 50 percent of feed sulfur is converted to hydrogen sulfide by cracking reactions. Some volume losses due to cracking are unavoidable, but these are partially compensated for by the probable increase in octane rating in the desulfurized gasoline and the ability to use light gases from cracking in alkylation for the production of premium gasoline.

Option 1(f), Merox Treatment, is widely practiced today. The process is basically a deodorizing scheme; the odor-causing sulfur compounds in gasoline, called mercaptans, are extracted or converted into odorless compounds by Merox Treatment. Active mercaptans are extracted by the Merox solution, whereas less active mercaptans are catalytically dimerized to disulfides and remain in the gasoline. Because nonmercaptan sulfur compounds, which account for a large fraction of the total sulfur in gasoline, are unaffected in Merox Treatment, the process is not a primary desulfurization process. Unlike the schemes in Option 1, which feature desulfurization of individual gasoline stocks, Option 2 features desulfurization of catcracker feedstocks. When feedstocks are pretreated, cracked gasoline will be low in sulfur and can be blended directly into low-sulfur gasoline pool. Pretreatment processes are already used commercially, and according to the <u>Oil and Gas Journal</u> annual survey, current cat-cracker feed pretreatment capacity is about 530,000 b/d (in 1972, it was about 300,000 b/d). Desulfurization of feedstocks will not only eliminate the need for downstream desulfurization of cat gasoline, but will also improve cat cracker operation by increasing gasoline yield, decreasing sulfur content of cycle oil and slurry oil, decreasing catalyst consumption, decreasing sulfur emissions, and so on.

5 GENERAL CONCLUSIONS

If consumption of diesel fuel increases, as a proportion of gasoline, it appears that the existing refining industry can achieve roughly a threefold increase in the diesel/gasoline production ratio while reducing costs and improving energy efficiency. Our results, like those of other studies of this issue, suggest that the elimination of gasoline production is not cost- or energy-effective. Desulfurization of gasoline and diesel fuels to very low sulfur contents would require major capital outlays by the refining industry. However, the cost of desulfurization per unit of product is only a few cents per gallon.

Given the conservation premises of this study, the crude oil runs required to meet the projected 1995 requirements for the major fuel products could be less than current levels if demand for other petroleumderived products (e.g., petrochemicals) is reduced as demand for the major fuel products declines. Because reductions in demand for petrochemicals do not appear likely, significant petrochemical production facilities will presumably be integrated with existing refining capacity.

The sharp reduction in residual fuel requirements and the short supply of middle distillates indicated by this scenario could lead to changes in the current residual fuel emphasis in the product mix of the Caribbean export refineries. Like fuel desulfurization, this change would require major capital outlays, but it would probably add only a few cents per gallon to product costs.

6 RECOMMENDATIONS

In a sense, the use of the word "conclusions" in previous sections of this report is not precisely appropriate. The results reported here are based on a complex set of inputs. Although these inputs are mathematically explicit in the model, they reflect numerous assumptions, approximations, and omissions of indirect factors that could alter the outcomes reported. The assumptions, approximations, and indirect factors that could significantly affect the reported results are outlined in the following paragraphs.

- (1) The conservation scenario may reflect realistic possibilities in the transportation sector, but be overly optimistic in estimating the potential for conservation of other petroleum products. Hence, future studies should consider the effects of higher demand levels for other fuel products.
- (2) Similarly, the petrochemical industry, the natural gas liquids industry, and the fuel products portion of the petroleum refining industry may become even more closely integrated in the future. A more explicit treatment of this possibility should be included in future work.
- (3) Demand levels for the major fuel products were forecast separately and input to the model as explicit requirements. It is possible, with an optimizing model, to structure demand as a function of primary requirements, such as vehicle miles of travel, and use the model to determine the optimal product mix where alternatives exist. Future work should explore this option.
- (4) Synthetic fuels and fuels without octane or cetane requirements were not included in this study. By the end of the century, both of these kinds of fuel could become significant sources of energy for the transportation sector. Further study should observe these technological possibilities, especially in post-2000 scenarios.

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Appendix A

DESCRIPTION OF REFINERY MODEL

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Appendix A

DESCRIPTION OF REFINERY MODEL

A.1 General Product and Process Specifications

This appendix provides additional description of the refinery model first mentioned in Section 3.1. A flow sheet of the model is provided in Figure A-1, and a schematic representation of a generalized LP system is presented in Figure A-2. General specifications for products and processes are shown in Tables A-1 through A-4. More specific processes are detailed in later subsections.

A.2 Crude Fractionation

Before distillation, crude oil is treated in a desalter to remove brine and solids that are usually present in the form of a suspension or an emulsion. The desalted crude is then heated to 650-670°F and charged to the distillation column for separation into light ends, naphthas, kerosene, gas oil, and topped crude. Distillation occurs at near atmospheric pressure (4-10 psig), and hence the unit is frequently referred to as an atmospheric unit. The model specifications for the process are outlined in Table A-5.

A.3 Hydrotreater

Catalytic hydrogen treating, often called hydrotreating, is used to remove sulfur compounds, nitrogen compounds, and other undesirable impurities in petroleum fractions. The process is extremely flexible in dealing with many types of feedstocks and achieving widely varying product qualities. By far the greatest application is in hydrotreatment of reformer feedstocks. Also, applications for desulfurization of middle distillates and heavy fuel oil fractions, improvement of lube oil oxidation stability, and jet fuel smoke point improvement are widespread. Yields for the process are given in Tables A-6, and hydrogen consulption is given in Table A-7.

A.4 Catalytic Reforming

Catalytic reforming is a continuous process to upgrade low-octane naphthas to high-octane premium blending stock for gasoline. The process is also used for the production of aromatics for use in petrochemicals. The model inputs for the gasoline reformer are shown in Table A-8; and those for the aromatics reformer are shown in Table A-9.

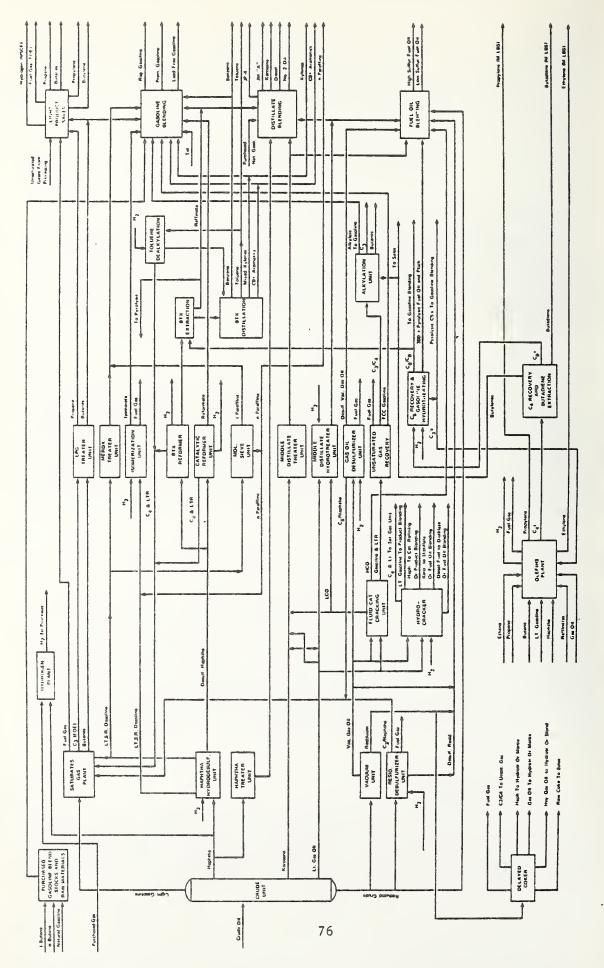


FIGURE A-1 REFINING AND PETROCHEMICAL LP MODEL

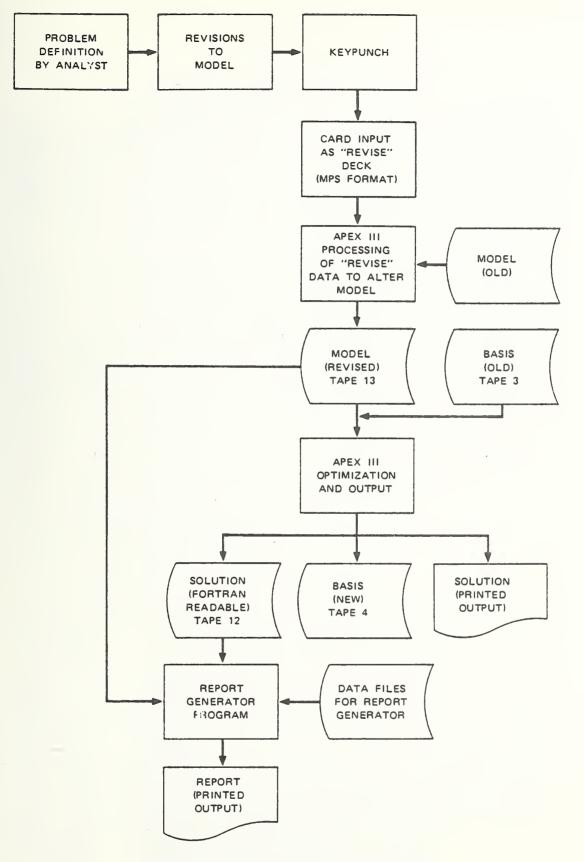


FIGURE A-2 LINEAR PROGRAMMING SYSTEM

CRUDE OIL YIELDS AND PROPERTIES

CRUDE NAME: ______ Delta - Ostrica ______ FIELD, LOCATION __Plaquemine, La.

	TOTAL	CRUDE, N	APHTHAS		LLATES			
9.	Total	Light	Light	Medlum	Medium	Heavy		Light Ga
CUT NAME	Crude	Gasoline		Naphtha	Nanhtha	Nanhtha_	Kerosene	011
TBP Cut Points, "F		C5/160	_C5/175	160/295	175/295	295/375	375/530	530/650
Vield, LVS	100.00	3.6	4.6	9.8	8.8	7.5	19.1	15.1
Yield, Wt.\$	100.00	2.72	3.59	8.53	7.66	6,91	18.53	15.24
Gravity, "API	33,6	86.9	80.3	58.2	58.1	47.6	38.7	32.1
Density, Lbs/8bl	299.8	226.6	233.6	260.9	261.1	276.3	290.8	302.5
Specific Gravity	0.8571	0.6479	0.6682	0.7459	0.7464	0.7901	0.8314	0.8649
Characterization Factor, UOP K		12.93	12.64	11.83	11.87	11.72	11.66	11.75
Sulfur Content, Wt.\$	0.356	0.001	0.002	0.011	0.012	0.027	0.061	0.171
RVP, psia	3.5	10.3	9.5	2.2	2.1	0.9	0.1	
RVP Index		162.0	150.0	28.3	26.9	10.5	0.9	
Research Octane, Clear		72.0	70.8					I
+0.5 gm Pb/gal		78.7	78.6					
+1.0 gm Pb/gal		83.7	82.7		I	1		T I
+2.0 gm Pb/gal		68.2	37.3		1	1	1	1
+3.17 gm Pb/gal		91.1	90.2		1	1		
Motor Octane, Clear		-9.2	68.8		1	1		
+0.5 gm Pb/gal		76.9	76.7		1		1	1
+1.0 gm Pb/gal		31.5	1 8C.8				1	1
+2.0 gm Pb/gai		57.0	36.0		1	1		
+3.17 gm Pb/gal		91.1	90.0			1	1	
Total Parattins, LVS		100.0	38.7	33.0	43.4	41.2	1	1
Total Naphthenes, LVS		2.2	3.8	46.4	47.1	43.8	1	
Total Aromatics, LV\$		0.0	2.5	9.7	9.5	1.15.0	22.0	
Freeze Point, "F			1	-105.0	-105.0	-89.0	-43.0	1
Freeze Point Index				16.0	16.0	25.0	105.0	
Pour Point, °F	-40.0		†	10.0	10.00	1	-60.0	0.0
Pour Point Index						1	53.0	360.0
Smoke Point, mm						21.7	13.6	1 20010
Aniline Point, *F						130.0	145.0	164.0
Diesel Number						1 1000	1-2-0	1 10-10
Cetane Number			<u> </u>					
Cetane Index							47.5	55.0
Viscosity, cs ê 122°F				0.75	0.77	1.03	1.75	4.1
, cs € 210°F					and all	- Laine	1.12	- 4.
Viscosity Index @ 122°F				79.0	75.0	70.0	50.0	48.0
Nitrogen Content, Wt.\$			<u> </u>	- / dail	19-19-	/0-0	50.0	40.0
Nickel Content, wt.			ł				+	
Vanadium Content, ppm wt.							+	+
ASTM Distillation Temp., °F. IBP	_			179	:91	1 100	1 100	617
ASIM JISTILIATION Lemp., 'r, IOP 105		49	91 109		204	309	408	567
		113	109	192 208	216	325	439	559
30% 50%			the second s		229	332	459	601
70%			130	220	229	337	474	614
		136		234	261	351	498	634
90% FP			171					656
		173	228	232	290	362	529	
VABP, °F		128	142	227	235	335	452	590
	1		1				1	

	RESID	UES		
	Tcoped	Vacuum	Vacuum	1
CUT NAME	Crude	Cas Cil	Bottoms	
TBP Cut Point, °F	650+	650/1050		1
Yield, LV\$	43.5	33.2	10.3	
Yield, Wt.\$	47.17	35.25	11.32	1
Gravity, "API	20.7	24.0	11.1	I.
Density, Lbs/81	.325.1	318.3	347.1	1
Specific Gravity	0.9795	0.9100	0.9923	
UOP K		11.90		1
VABP, °F		B11.C		
Sulfur Content, Wt.S	2.669	0.533	1.070	
Pour Point, °F	85_0	_75.0	100.0	 Τ
Viscosi⁺y, cs @ 122°F	420.0	120.0	70.000	
, cs @ 210°F				 I
Viscosi v Index @ 122°F	20.5	.25.0	5.0	1
Nitrogen Content, Wt.\$	0_139_	0.063	0.364	
Nickel Content, ppm Wt. Vanadium Content, ppm Wt.	4.05	0.08	15.80	1
	3.01	0.11	11.60	1
Aniline Point, °F		192_0		
Aromatics, Wt.\$				 1
Conradson Carbon, Wt.\$	4.34	0.80	14-80	
Asphaltenes, Wt.\$	1_0	0.053	3.8	1
Refrac. Index @ _ 57 °C		1.4894		
				1
				 1
				 +
				 1

LIGHT	1 Sin C	rude
HYDROCARBONS	hT.	Vol.
Methane	0.0	0.0
Ethane	0.04	0.1
Propane	0.16	0.3
Isobutane	0.20	0.3
n-Butane	0.48	0.7
Isopentane		0.8
n-Pentane		0.7
Cyclopentane		0.02
sohexanes		0.48
n-Hexane		0.39
Methylcyclopentane		0.39
Benzene		0.19
Cyclohexane		0.42
Isoheptanes		1.30
Normal Heptane		0.27
C7 Cyclopentanes		1.02
Methylcyclohexane		0.55
Toluene		0.34
Isooctanes		1.43
Normal Octane		0.29
Cg Cyclopentanes	hanne	0.69
C8 Cyclohexanes		0.37
Ethylbenzene		0.07
Paraxylene	++	0.09
Metaxylene		0.14
Orthoxylene		0.12
Cg Paraffins		
Cg Naphthenes		
Cg Aromatics		

REFINERY PRODUCTS AND FEEDSTOCKS

Products

C3 LPG C₄ LPG Propylene Propane Butylenes Isobutane Normal butane Benzene Toluene Mixed xylenes C_{0} aromatics Régular gasoline Premium gasoline Low-lead gasoline Lead-free gasoline Naphtha-type jet fuel (JP-4) Kerosene Kerosene-type jet fuel (Jet A) Diesel fuel No. 2 heating oil High-sulfur fuel oil Low-sulfur fuel oil Ethylene Butadiene Coke (low-sulfur) Coke (high-sulfur)

Feedstocks

Louisiana sweet crude West Texas sour crude California heavy crude Alaskan North Slope crude Normal butane Isobutane Natural gasoline Ethane Propane

REFINERY MODEL PRODUCT SPECIFICATIONS

Gasoline Specification

	Density	Sulfur	RVP	TEL	Va	porizati (vol%)	on		
	<u>(1b/b)</u>	<u>(wt%)</u>	Index	(G/gal)	130°F	235°F	<u>356°F</u>	R ON*	MON
Regular									
Minimum			87.5	**	10	50	90	94	86
Maximum	265	0.1	166.0	3.17	••	70			
Premium									
Minimum			87.5		10	50	90	100	92
Maximum	265	0.1	166.0	3.17		70			
Low lead									
Minimum	••		87.5		10	50	90	92	84
Max imum	26 5	0.1	166.0	0.5		70			
Lead-free									
Minimum	••		87.5	0	10	50	90	91	83
Maximum	265	0.1	166.0	0		70		••	

Jet Fuel and Kerosene Specifications

	Density	R VP	Sul fur	Aromatics	Smoke			Vapori: (vo)			
	(15/5)	Index	(wt%)	(vo1%)	Point	290°F	350°F	<u>370° F</u>	400° F	<u>450°F</u>	470°F
JP-4											
Minimum	262.5	25.5				20		50			90
Maximum	280.3	40.1		25.0					••		
Kerosene											
Minimum	271.1				20						
Maximum	290.2		0.3	25		••	10		50		
Jet A											
Minimum		••			25				10	50	
Maximum	288.5		0.3	20							

Distillates and Fuel Oil Specifications

	Density (1b/b)	Sulfur (wt%)	Pour Point Index	Cetane Index	Visc <u>Index</u>		zation 1%) 590°F
Diesel Minimum Maximum	297.2	0.5	410	50 		 90	90
No. 2 Minimum Maximum	306.4	0.5	615	40		 90	••
No. 6 (low sulfur) Minimum Maximum	350	1.0	••	••	19.1		
No. 6 (high sulfur) Minimum Maximum	350	3.0			19.1		

	Density (1b/b)	RVP (psia)
C3 LPG Minimum Maximum	104.4	215.0
C4 LPG Minimum Maximum	104.4	 85.0
Refy F.G. Minimum Maximum	104.4	

LPG Specifications

*Clear (lead-free) octane numbers.

PROCESS UNITS IN REFINERY LP MODEL

Process	Туре
Crude (atmospheric fractionation)	Conventional distillation
Saturates gas recovery plant	Fractionating absorber with debutanizer and depropanizer
Vacuum tower	Conventional vacuum distillation
Fluid catalytic cracker	Riser cracking, zeolite catalyst
Catalytic reformer gasoline manufacture	Cyclic regeneration, bimetallic catalyst
Catalytic reformer arómatics manufacture	Cyclic regeneration, bimetallic catalyst
Aromatics extraction	Sulfolane
Aromatics recovery Benzene tower Toluene tower Xylene tower	Distillation and clay treat
Toluene dealkylation	Noncatalytic hydrodealkylation
Treating and sweetening LPG Gasoline Naphtha Kerosene Diesel	Merox
Hydrodesulfurization Naphtha (catalytic reformer feed preparation) Kerosene Distillate Vacuum gas oil Residuum hydrodesulfurization	Fixed bed CoMo catalyst
Hydrocrackinggas oil	2 stage, fixed bed
Alkylation Propylene Butylene	HF Acid catalyst
N-paraffin separation	Molecular sieve
C ₅ /C ₆ isomerization	Fixed bed catalytic
Unsaturated gas recovery	Same as Satgas plant
Hydrogen manufacturesteam reforming Fuel gas Refinery fuel gas Naphtha -	High temperature fixed bed
Olefins manufacture	Pyrolysis, cryogenic recovery
Butadiene extraction	Extraction distillation
Pyrolysis naphtha hydrotreater	2-stage catalytic
Delayed coking	

FRACTIONATION OF LOUISIANA CRUDE (Barrels per Barrel of Feed)

	Atmospheric	Vacuum	
Operating Mode	Distillation	Distillation	Gas Recovery
(m. 1 - (h / 1)	1 000		
Crude (b/d)	-1.000		
Products (b/d)			
Ethane (FOE)	0.00046		
Propane	0.0030		
I-Butane	0.0030		-1.000 (feed)
N-Butane	0.0070		
C5/160 LSR	0.0360		
Naphtha 160/295	0.0980		
Heavy naphtha	0.0750		
Kerosene	0.1910		•
Light gas oil	0.1510		
Topped crude	0.4350	-1.000 (feed)	
Vacuum gas oil		0.7632	
Vacuum bottoms		0.2368	
I-Butane			1.000

Table A-6

CATALYTIC HYDROTREATER YIELDS (Barrels per Barrel of Feed)

		Atmospheric	Light Cycle		
		Gas Oil	Gas Oil		Atmospheric
Feedstock	Kerosene	(AGO)	(LCGO)	VGO	Residual
Hydrogen (FOE)	-0.0056	-0.0076	-0.0094	-0.0198	-0.0208
Hydrogen sulfide (FOE)	0.0002	0.0006	0.0021	0.00363	0.0075
Methane (FOE)	0.00004	0.00008	0.00008	0.0025	0.0031
Ethane (FOE)	0.00005	0.00009	0.00009	0.0027	0.0027
Propane	0.0001	0.0003	0.0003	0.0069	0.0072
Isobutane	0.0001	0.0001	0.0001	0.0014	0.0020
Normal butane	0.0	0.0001	0.0001	0.0026	0.0032
C5/375 Hydrotreated (HT)					
Naphtha				0.0091	0.0346
375/650 Hydrotreated (HT)					
Distillate				0.0085	0.1131
Desulfurized kerosene	1.0010				
Desulfurized AGO		1.0000			
Desulfurized LCGO		1.0000	1,000		
Desulfurized VGO			1.000	0.980	
Desulfurized veo Desulfurized residual				0.900	0.8542
Desulturized residual					0.0342
Unit Liquid Volume (LV) loss					
(gain)	0.00411	0.00633	0.0066	0.0025	-0.0073

HYDROGEN CONSUMPTION IN NAPHTHA HYDROTREATING FOR CATALYTIC REFORMER FEED (FOE Barrels of H₂ per Barrel of Feed)

Hydrogen Consumption

Light naphtha	0.0028
Medium naphtha	0.0038
Heavy naphtha	0.0038
Full-range naphtha	0.0038
Cat-cracked naphtha	0.0154
Coker naphtha	0.0154

Table A-8

GASOLINE REFORMER YIELDS^{*} (Barrels per Barrel of Feed)

	Yields	
Severity, RON clear	94 93	3
Hydrogen (FOE) Hydrogen lost to fuel Methane Ethane Propane Isobutane Normal butane 94 RON reformate 93 RON reformate (heavy naphtha)	0.0115 0 0.0049 0 0.0073 0 0.0191 0 0.0090 0 0.0120 0 0.8880	.0359 .0090 .0074 .0130 .0304 .0123 .0158
Unit LV loss (gain)	0.0023 -0	.0109
	Severity Range <u>RON Clear</u>	Corresponding Gasoline Yield Range (b/b of feed)
Full-range and medium naphtha feeds Heavy naphtha feeds	91-103 91-103	0.908-0.783 0.903-0.769

^{*} Base yields shown are adjusted for N + 2A difference from base.

AROMATICS REFORMER YIELDS (Barrels per Barrel of Feed)

Naphtha (160/295°F)	-1
Hydrogen (FOE)	0.0472
Hydrogen to fuel	0.0118
Hydrogen sulfide (FOE)	0.0003
Methane (FOE)	0.0190
Ethane (FOE)	0.0332
Propane	0.0776
Isobutane	0.0277
Normal Butane	0.0381
CS/160 reformate	0.1064
Raffinate	0.1299
Benzene	0.0717
Toluene	0.1734
Mixed Xylenes	0.1584
C9+ aromatics	0.1060
Unit LV loss (gain)	-0.00043
Naphtha HDU feed	-1
Extraction unit feed	-0.6394
BTX distillation feed	-0.5095

A.5 Fluid Catalytic Cracker

Fluid catalytic cracking unit, otherwise called FCC or cat cracker, is one of the major processing units in U.S. refineries, with a combined total capacity of more than 4,600,000 b/d. The unit is basically a gasoline producer. By employing a fluidized catalyst system, heavy petroleum fractions are converted into gasoline or lighter products. Unlike the hydrocracker, FCC conversion does not require hydrogen and a high-pressure reactor system. FCC model inputs are shown in Table A-10.

A.6 Hydrocracking

Hydrocracking is an efficient, low-temperature catalytic method of converting refractory middle-boiling or residual material to high-octane gasoline, reformer charge stock, jet fuel, and high-grade fuel oil. Unlike reforming, in which hydrogen is produced at the expense of a yield loss, hydrocracking consumes a large amount of hydrogen but results in a liquid yield increase of as much as 25 percent over the feed.

FCC YIELDS (Barrels per Barrel of Fuel)

	Light Gas Oil Base [*] Yield	Heavy Gas Oil Base [*] Yield
Atmospheric gas oil	-1	
Vacuum gas oil		-1
Hydrogen (FOE)	0.0009	0.0010
Hydrogen sulfide (FOE)	0.0004	0.0009
Methane (FOE)	0.0038	0.0047
Ethylene (FOE)	0.0033	0.0039
Ethane (FOE)	0.0033	0.0039
Propylene	0.0521	0.0577
Propane	0.0185	0.0206
Butylenes	0.0603	0.0661
Isobutane	0.0588	0.0634
Normal butane	0.0163	0.0177
C5/150 CC Naphtha	0.1651	0.1771
150/300 CC Naphtha	0.2477	0.2657
300/430 CC Naphtha	0.1376	0.1476
Light cycle oil	0.2462	0.2453
Slurry oil	0.0538	0.0547
CC Coke (10 ³ 1b)	0.01154	0.0120
Unit LV loss (gain)	-0.0681	-0.1303

Base yields at 70 percent conversion are corrected for Δ conversion in 60 to 90 percent range, feed density, and feed nitrogen content.

Reactions involved in hydrocracking are cracking, hydrogenation, cyclization, and isomerization. The product gasoline cut is rich in saturated cyclic components (naphthenes) and can be reformed to a premium grade blending stock. The model inputs for maximum gasoline inputs are shown in Table A-11; those for distillate production are shown in Table A-12.

A.7 Alkylation

High-octane gasoline stock called alkylate is produced in the alkylation reaction between olefins, usually propylene and butylene, and isobutane with sulfuric acid or hydrogen fluoride as catalyst. The total alkylation capacity in the United States is 868,5000 b/d. Of this, about 60 percent is produced in the plants that use sulfuric acid, and the

HYDROCRACKER--MAXIMUM GASOLINE OPERATION (Barrels per Barrel of Feed)

-1	
	-1
-0.0922	-0.1251
0.0128	0.0128
0.0023	0.0027
0.0067	0.0068
0.0364	0.0370
0.0965	0.0920
0.0504	0.0480
0.3483	0.3340
0.7086	0.7911
-0.1704	-0.2013
	-0.0922 0.0128 0.0006 0.0023 0.0067 0.0364 0.0965 0.0504 0.3483 0.7086

Table A-12

HYDROCRACKER--DISTILLATE PRODUCTION (Barrels per Barrel of Feed)

	Jet Fuel or Kerosene Operation	Diesel or No. 2 Fuel Oil Operation
Vacuum gas oil	-1	-1
Hydrogen (FOE)	-0.0996	-0.0846
Hydrogen losses (FOE)	0.0128	0.0102
Hydrogen sulfide (FOE)	0.0020	0.0020
Methane (FOE)	0.0024	0.0021
Ethane (FOE)	0.0059	0.0051
Propane	0.0260	0.0161
Isobutane	0.0479	0.0302
Normal butane	0.0270	0.0261
C5/180 Hydrocrackate	0.1955	0.0873
180/300 Hydrocrackate	0.3438	
180/345 Hydrocrackate		0.2625
300/550 Hydrocrackate	0.5932	•
345/650 Hydrocrackate		0.7564
Unit LV gain (loss)	-0.1569	-0.1134

remainder in plants that use hydrogen fluoride. Alkylates are highly branched paraffins having clear research octane rating of 93 to 97. Model inputs for alkylation are shown in Table A-13.

Table A-13

ALKYLATION UNIT (Barrels per Barrel of Feed)

	Propylene <u>Alkylation</u>	Butylene Alkylation
Propylene	-0.5682	
Butylenes		-0.5650
Isobutane	-0.7743	-0.6497
C ₃ Alkylate	1.00	
C ₄ Alkylate		1.0
Unit LV loss (gain)	0.3425	0.2147

A.8 Isomerization and Molecular Sieve Isoparaffin Separation

An isomerization unit is used to convert normal paraffins into isoparaffins for octane upgrading. This is a catalytic reaction carried out in a hydrogen atmosphere. The feed is heated with recycle hydrogen and charged to reactors loaded with solid catalyst. Reaction conditions are generally at temperatures of 250° to 350°F and pressures between 250 and 400 psig. Chlorine on the catalyst promotes isomerization reactions. A small amount of chlorine in the form of decomposable chloride is continuously added to replace the depleted portion. The model inputs are shown in Tables A-14 and A-15.

Table A-14

ISOMERIZATION OPERATION (Barrels per Barrel of Feed)

C5/C6 feed (b/d) -1.00 H₂ consumption (FOE b/d) -0.0097 Products (b/d) Methane (FOE) 0.00095 Ethane (FOE) 0.00167 Propane (FOE) 0.01398 Isomerate 1.000

MOLECULAR SIEVE UNIT (N-PARAFFIN SEPARATION) (Barrels per Barrels of Feed)

C5/160 Light straight run	-1	
C5/175 Light straight run		-1
C5/C6 Normal paraffin	0.416	0.338
C5/C6 Isomerate	0.584	0.662

A.9 Hydrogen Plant

The hydrogen produced from the catalytic reforming operation is often sufficient to replace the hydrogen consumed by the usual naphtha and middistillate hydrotreating. A hydrogen plant becomes necessary when the refinery installs a major hydrogen-consuming unit, such as a hydrocracker or a fuel oil desulfurization unit.

Hydrogen can be produced from natural gas, naphtha, or heavier feedstocks. The heavier the feedstock, the higher the production costs. Model inputs are shown in Table A-16.

Table A-16

HYDROGEN PLANT YIELDS (Barrels per Barrel of Feed)

	Fuel Gas	<u>Naphtha</u>
Hydrogen (FOE)	1.0	1.0
Fuel gas (FOE)	-0.8747	
Naphtha (10 ³ 1b)		-0.299
Unit LV loss (gain)	-0.1253	-1

A.10 Delayed Coker

Delayed coking is used to convert the low-grade pitch materials such as vacuum column bottoms, FCC slurry oil, etc., into lighter liquids and raw coke. The delayed coking capacity in the United States is now about 43,400 short tons of raw coke per day, or about 900,000 b/d as liquid feed. Because a large percentage of sulfur in the feed ends up in coke, the process provides an efficient means of controlling the sulfur level in fuel oils. Raw coke, often called green coke, has numerous uses other than as fuel when it can meet certain specifications. For example, if the sulfur content is less than 1.5 percent, it is calcined and used as electrode in metallurgical applications (primary aluminum production and steel production). Model inputs are shown in Table A-17.

Table A-17

DELAYED COKER YIELDS (Barrels per Barrel of Feed)

. .

Vac Resid	-1
Hydrogen (FOE)	0.0023
H ₂ S (FOE)	0.0019
CH ₄ (FOE)	0.0360
C ₂ Ū (FOE)	0.0032
C_2S (FOE)	0.0242
Propylene	0.0152
Propane	0.0337
Butylene	0.0171
I-Butane	0.0073
N-Butane	0.0167
Coker gasoline	0.27
Light coker GO	0.28
Heavy coker GO	0.14
Raw coke $(b/10^3 1b)$	0.1123
Unit LV loss (gain)	0.1524

A.11 Hydrodealkylation

Dealkylation of alkylbenzene (toluene, ethylbenzene, etc.) is an important source of benzene because the demand for benzene as a petrochemical raw material often exceeds the amount recoverable from reformate, pyrolysis gasoline, or other hydrocarbon streams. Dealkylation reaction removes side chains of aromatics molecules and thus produces benzene and gaseous products. Model inputs are shown in Table A-18.

A.12 Gasoline Blending Properties

The gasoline blending properties specified for this model are shown in Table A-19.

A.13 Distillate Blending

The distillate blending properties assumed for this report are shown in Table A-20.

TOLUENE	DEAI	LKYLATI	DN (YIELDS
(Barrels	per	Barrel	of	Feed)

Operating mode	TDA
Feed (b/d)	
Toluene H ₂ consumption (FOE)	-1.00 -0.0753
Product (b/d)	
H ₂ (FOE) Methane (FOE) Ethane (FOE) Propane I-Butane N-Butane Benzene	0.0050 0.2072 0.0053 0.0072 0.0040 0.0019 0.800

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GASOLINE BLENDING PROPERTIES

		RESEARCH	OCTANE	NUMBERS	MOTOR OCTANE NUMBERS							
ANTIKNOCK LEVEL G PB/GAL	0.0	0.5	1.0	2.0	3.17	0.0	0.5	1.0	2.0	3.17		
	J	К	L	<u>M</u>	N	0	P		R	<u> </u>		
NATURAL GASOLINE	66.6	74.9	79.3	84.5	88.3	68.7	75.7	79.5	84.1	87.6		
ISOBUTANE	102.8	106.3	108.4	110.7	111.6	100.7	104.8	107.5	110.6	112.2		
NORMAL BUTANE	97.4	99.8	101.4	103.2	104.1	92.5	97.3	99.9	103.1	104.7		
LSR (C5/160) A	72.0	79.7	83.7	88.2	91.1	68.2	76.9	81.5	87.0	91.1		
LSR (C5/160) B	72.1	77.3	80.1	84.4	88.6	71.5	76.7	79.6	83.3	86.4		
LSR (C5/175) A	70.8	78.6	82.7	87.3	90.2	68.8	76.7	80.8	86.0	90.0		
LSR (C5/175) B	71.0	76.3	79.2	83.5	87.6	70.0	75.4	78.3	82.2	85.3		
PROPYLENE ALKYLATE	91.0	95.0	97.2	99.8	102.0	89.0	94.5	97.4	100.9	104.0		
BUTYLENE ALKYLATE	97.0	100.2	102.5	105.5	108.0	95.0	99.5	102.4	106.5	110.0		
C5/C6 ISOMERATE	83.4	89.1	92.2	95.8	98.2	80.2	87.9	91.8	96.3	99.3		
RAFFINATE	62.7	72.1	77.1	82.9	87.2	64.1	72.5	76.9	81.7	84.4		
C5/180 HYDROCRACKATE	81.0	86.4	- 89.2	92.6	95.0	78.4	85.2	88.8	92.9	95.7		
180/400 HYDROCRACKATE	52.0	60.4	64.9	70.3	74.0	52.7	61.7	66.5	72.2	76.1		
180/300 HYDROCRACKATE	56.0	65.3	70.3	76.0	80.0	56.4	65.3	70.1	75.7	79.5		
180/345 HYDROCRACKATE	54.0	62.8	67.6	73.1	77.0	54.5	63.5	68.3	73.9	77.8		
C5/150 CC NAPHTHA	94.4	97.3	99.0	101.1	103.0	83.6	87.1	89.1	91.4	93.1		
150/300 CC NAPHTHA	91.6	94.1	95.5	97.2	98.4	75.7	79.3	81.3	83.7	85.5		
300/430 CC NAPHTHA	86.0	88.9	90.5	92.4	93.8	77.4	80.0	81.4	83.2	84.5		
COKER GASO C5-400 (A)	60.0	64.0	67.0	76.0	83.0	51.0	55.0	62.0	68.0	72.0		
COKER GASO C5-400 (B)	60.0	64.0	67.0	76.0	83.0	51.0	55.0	62.0	68.0	72.0		
C5/160 REFORMATE	86.4	91.7	94.6	97.7	99.4	82.9	89.7	92.9	96.9	100.0		
BENZENE	108.8	111.9	113.8	115.9	116.9	93.3	97.3	99.5	102.5	104.8		
TOLUENE	114.1	115.9	117.1	118.8	120.4	99.0	102.8	105.4	108.2	109.3		
MIXED XYLENES	111.6	112.2	112.6	113.0	113.4	107.2	108.8	109.8	111.1	112.1		
C9+ AROMATICS	108.7	110.2	110.8	111.7	112.7	92.9	93.2	93.7	94.5	95.0		
PYROLYSIS C5 S	93.0	94.7	95.7	96.9	97.8	76.3	78.0	79.0	80.3	81.2		
PYROLYSIS GASOLINE	100.7	101.8	102.5	103.4	104.1	90.0	91.5	92.4	93.5	94.3		
PYROLYSIS RAFFINATE	62.7	72.1	77.1	82.9	87.2	64.1	72.5	76.9	81.7	84.4		
C5/375 VHT NAPHTHA	52.0	60.4	64.9	70.3	74.0	52.7	61.7	66.5	72.2	76.1		
C5/375 RHT NAPHTHA	52.0	60.4	64.9	70.3	74.0	52.7	61.7	66.5	72.2	76.1		
91 RON REFORMATE	91.0	94.2	96.0	98.1	99.6	81.9	85.4	87.3	98.6	91.3		
94 RON REFORMATE	94.0	96.6	98.1	99.8	101.3	83.9	87.1	88.9	91.1	92.7		
97 RON REFORMATE	97.0	98.9	100.0	101.7	103.0	85.9	88.9	90.6	92.6	94.1		
100 RON REFORMATE	100.0	101.5	102.5	103.7	104.7	87.8	90.6	92.2	94.1	95.5		
103 RON REFORMATE	103.0	104.1	104.8	105.6	106.3	89.8	92.4	93.8	95.5	96.8		
91 RON REFORMATE (HN)	91.1	93.1	94.3	95.7	96.7	84.0	86.2	87.4	89.0	90.1		
93 RON REFORMATE (HN)	93.1	94.9	96.0	97.3	98.2	85.8	87.8	89.0	90.4	91.4		
95 RON REFORMATE (HN)	94.9	96.6	97.5	98.7	99.5	87.6	89.4	90.4	91.7	92.6		
100 RON REFORMATE (HN)	100.0	100.9	101.5	102.2	102.8	91.6	92.8	93.4	94.3	94.9		
103 RON REFORMATE (HN	103.0	104.1	104.8	105.6	106.3	94.4	95.2	95.7	96.3	96.7		

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Table A-19 (Concluded)

		GASO.				ROX	TEL	DENSITY	SULFUR	RVP	RVP		_		TEDA	
	-	PO	-		GT	EAT NT	G /GAL Z	LBS/BBL	WT PCT B	PSIA C	INDEX D	130 E	158	235	356	365
	A	B	<u>C</u>	D	01	<u>M1</u>		A					<u> </u>	G	<u>_H</u> _	<u> </u>
NATURAL GASOLINE	1	1	1	1				230.6	0.017	13.9	231.0	56	76	95	100	100
ISOBUTANE	1	1	1	1				197.0	0.0	72.0	1450.0	100	100	100	100	100
NORMAL BUTANE	1	1	1	1				204.4	0.0	10.3	162.4	62	92	100	100	100
LSR (C5/160) A	1	1	1	1	1			226.6	0.001	52.0	1120.0	100	100	100	100	100
LSR (C5/160) B	1	1	1	1	1			226.9	0.042	9.6	149.8	50	80	100	100	100
LSR (C5/175) A	1	1	1	1	1			233.7	0.002	12.2	197.8	66	92	100	100	100
LSR (C5/175) B	1	1	1	1	1			236.1	0.050	11.2	178.8	50	80	100	100	100
PROPYLENE ALKYLATE	1	1	1	1				250.3	0.0	4.7	58.5	3	8	79	98	99
BUTYLENE ALKYLATE	1	1	1	1				248.4	0.0	4.9	66.4	2	6	88	99	100
C5/C6 ISOMERATE	1	1	1	1				228.5	0.001	14.2	236.6	72	100	100	100	100
RAFFINATE	1	1	1	1				251.0	0.001	4.2	58.5	0	7	49	92	94
C5/180 HYDROCRACKATE	1	1	1	1	1			231.4	0.0005	13.0	213.0	50	90	100	100	100
180/400 HYDROCRACKATE		1				1		270.4	0.001	1.0	11.8	0	0	10	86	90
180/300 HYDROCRACKATE	1					1		261.3	0.001	1.4	17.1	0	0	27	100	100
180/345 HYDROCRACKATE	1					1		264.0	0.001	1.2	14.4	0	0	14	100	100
C5/150 CC NAPHTHA	1	1	1	1				226.8	0.01	18.9	330.9	85	95	100	100	100
150/300 CC NAPHTHA	1	1	1	1				263.8	0.025	3.9	53.8	0	8	72	100	100
FCC HVY NAPH	1	1	1	1				294.6	0.075	0.2	2.0	0	0	0	31	44
COKER GASO C5-400 (A)	1	1	1	1	1			263.0	0.27	4.0	55.0	0	ĩ	60	98	99
COKER GASO C5-400 (B)	1	1	1	1	1			263.0	0.60	4.0	55.0	0	1	60	98	99
C5/160 REFORMATE	1	1	1	1				232.7	0.0	13.0	213.0	62	91	100	100	100
BENZENE	1	1	1	1				309.3	0.0005	3.2	43.1	0	0	100	100	100
TOLUENE	1	1	1	1				303.8	0.0005	1.3	15.7	ŏ	ŏ	100	100	100
MIXED XYLENES	1	1	1	1				304.8	0.0005	0.4	4.2	ŏ	ŏ	0	100	100
C9+ AROMATICS	1	1	1	1				308.4	0.001	0.2	2.0	ŏ	ŏ	õ	30	75
PYROLYSIS C5 S	1	1	1	1				241.4	0.0	15.6	262.8	85	95	100	100	100
PYROLYSIS GASOLINE		-	•	•				291.0	0.009	2.0	25.5	0	2	62	98	99
PYROLYSIS RAFFINATE		1						251.8	0.0	4.7	66.4	ő	7	49	92	99
C5/375 VHT NAPHTHA		1				1		269.7	0.01	1.0	11.8	õ	2	23	97	99
C5/375 RHT NAPHTHA	1	1				i		269.7	0.01	1.0	11.8	0	2	23	97	99
91 RON REFORMATE	i	i	1	1		•		273.9	0.01	3.0	40.1	0	5	43	97	99
94 RON REFORMATE	i	1	î	i				276.0	0.0	3.2	43.1	0	6	43	92	94
97 RON REFORMATE	1	1	1	1				278.2	0.0	3.4	45.1	1	7	42	92	94
100 RON REFORMATE	1	1	ī	1				281.4	0.0	3.4	40.1	2	8	43	92	93 93
	1	1	1	1				285.8	0.0	3.9		-	-	-		
103 RON REFORMATE	1	1	1	1				286.6	0.0		53.8	3	10	43 7	92	93
91 RON REFORMATE (HN)	1	1	1	1						0.8	9.2	0	1		59	71
93 RON REFORMATE (HN)		1	1	1				287.6	0.0	1.0	11.8	0	2	8	58	70
95 RON REFORMATE (HN)	1			_				289.1	0.0	1.1	13.1	0	3	9	57	69
100 RON REFORMATE (HN)	1	1	1	1				281.4	0.0	1.3	15.7	1	4	12	49	61
103 RON REFORMATE (HN)	1	1	1	1				285.8	0.0	1.0	11.8	0	1	6	40	55

DISTILLATE BLENDING PROPERTIES

		Lv Pct				-		Smoke		
		Density Sulfur Rvp Lbs/bbl Wt Pct Ps:		Rvp	Aro-		Point	Pour		Point
	-		Psia	Index		-	Index	Deg F	Index	MM
	<u> </u>	B	<u> </u>	D	<u> </u>	F	G	<u> </u>	<u> </u>	
LSR (C5/160) A	226.6	0.001	10.3	162.4	0.0					
LSR (C5/175) A	233.6	0.002	9.6	149.8	2.5					
NAPHTHA (160/295) A	260.9	0.011	2.2	28.3	9.7	-105.0	16.0			
NAPHTHA (175/295) A	261.1	0.012	2.1	26.9	9.5	-105.0	16.0			
HEAVY NAPHTHA A	276.3	0.027	0.9	10.5	16.0	-88.0	25.0			21.7
KEROSENE A	290.8	0.061	0.1	0.9	22.0		105.0	-60.0	63.0	18.6
LT GAS OIL A	302.5	0.171		- • •				0.0	360.0	
REDUCED CRUDE A	325.1	0,669						85.0		
LRS (C5/160) B	226.9	0.042	12.2	197.8	0.0					
LRS (C5/175) B	236.1	0.050	11.2	178.8	2.7					
NAPHTHA (160/295) B	260.8	0.152	3.1	41.6	12.6	-105.0	16.0			
NAPHTHA (175/295) B	261.0	0.163	2.5	32.7	13.0	-105.0	16.0			
HEAVY NAPHTHA B	279.1	0.420	0.9	10.5	21.8	-93.0	21.5			27.4
KEROSENE B	289.3	0.832	0.1	0.9	25.0		126.0	-37.0	126.0	19.2
LT GAS OIL B	303.3	1.345	0.1	0.7	23.0	- 37.0	120.0	23.0	665.0	17.6
REDUCED CRUDE B	328.6	2.175						23.0	000.0	
VACUUM GAS OIL A	318.3	0.533						75.0		
VACUUM RESID A								100.0		
	347.1 319.5	1.070 1.774						92.0		
VACUUM GAS OIL B		3,000						92.0		
VACUUM RESID B	351.5		0.0	10.5	14.0		25 0			15 7
HVY NAPH A VIA KHT	276.3	0.003	0.9	10.5	16.0	-88.0	25.0	60.0	62.0	25.7
KEROSENE A VIA KHT	290.8	0.006	0.1	0.9	22.0		105.0	-60.0	63.0	22.6
HVY NAPH B VIA KHT	278.4	0.042	0.9	10.5	21.8	-93.0	21.5	27 0	126.0	31.4
KEROSENE B VIA KHT	287.7	0.083	0.1	0.9	25.0	-37.0		-37.0	126.0	23.2
FESULF FCC HVY NAPH	290.0	0.01	1.0	12.0	32.0	-98.0	19.0	-80,0	30.0	22.0
DESULF LGO (A)	298.8	0.017						0.0		
DESULF LGO (B) .	296.1	0.135						23.0	665.0	
DESULF LCGO (A) VIA GH	304.3	0.065						-23.0	190.0	
DESULF LCGO (B) VIA GH	302.4	0.19						-23.0	190.0	
C5/375 HT NAPHTHA	269.7	0.01	1.0	11.8	22.0					
375/650 HT DISTILLATE	295.5	0.02						-20.0	206.0	
DESULF VGO (B)	309.6	0.20						95.0	3800.0	
DESULF HCGO (A) VIA VH	314.9	0.11						35.0	900.0	
DESULF HCGO (B) VIA VH	311.0	0.38						35.0	900.0	
C5/375 HT NAPHTHA	269.7	0.01	1.0	11.8	22.0					
375/650 HT DISTILLATE	295.5	0.02						-20.0	206.0	
DESULFURIZED RESID B	324.6	0.30						60.0	1660.0	
RAFFINATE	251.0	0.001	4.2	58.5	8.5					
FCC HVY NAPH 300-430	294.6	0.075	0.20	2.0	40.0	-98.0	19.0	-80.0	30.0	18.0
LIGHT CYCLE OIL	337.9	1.615								
SLURRY OIL	382.2	2.77								
C5/180 HYDROCRACKATE	231.4	0.0005		213.0	0.0					
180/400 HYDROCRACKATE	270.5	0.001	1.0	11.8	8.0					
180/300 HYDROCRACKATE	261.3	0.001	14	17.1	5.0					
180/345 HYDROCRACKATE	264.0	0.001	: 2	14.4	5.0					
300/550 HYDROCRACKATE	284.5	0.004			8.0	-60.0	62.5	-60.0	62.5	30.0
345/650 HYDROCRACKATE	289.1	0.01			10.0	-50.0	86.0	-50.0	86.0	
COKER GASO C5-400	263	0.26	10	160	13					
LCG0 400-650	308.0	0.65						-20.0	206.0	
HCGO 650-950 -	319.0	1.10						40.0	1000.0	
COKER GASO C5-400	263	0.6	10	160	13					
LCG0 400-650	308.0	1.89						-20.0	206.0	
HCGO 650-950	319.0	3.78						40.0	1000.0	
C5/160 REFORMATE	232.7	0.0	13.0	213.0	2.5					
PYROLYSIS FUEL OIL	315.0	0.1						-25.0	180.0	
PYROLYSIS PITCH	350.0	1.5								

Table A-20 (Concluded)

	Cetane Diesel at 122 F			2 F	LV Pct Evaporated at Temp T (Deg F)											
	Index	Index	CS	Index	290	350	370	400	450	470	540	590	625			
	<u>_K</u>	L	<u>M</u>	<u>N</u>	0	<u>P</u>	<u>_</u>	R	<u> </u>	T	<u> </u>	<u>v</u>	W			
LSR (C5/160) A					100	100	100	100	100	100	100	100	100			
LSR (C5/175) A					100	100	100	100	100	100	100	100	100			
NAPHTHA (160/295) A			0.75	79.0	100	100	100	100	100	100	100	100	100			
NAPHTHA (175/295) A			0.77	78.0	100	100	100	100	100	100	100	100	100			
HEAVY NAPHTHA A			1.08	70.0	0	90	100	100	100	100	100	100	100			
KEROSENE A	47.5	56.1	1.75	60.0	0	0	0	0	50	70	100	100	100			
LT GAS OIL A	55.0	52.6	4.1	48.0	0	0	0	0	0	0	0	30	80			
REDUCED CRUDE A			420.0	20.5	0	0	0	0	0	0	0	0	0			
LSR (C5/160) B			•		100	100	100	100	100	100	100	100	100			
LSR (C5/175) B					100	100	100	100	100	100	100	100	100			
NAPHTHA (160/295) B					100	100	100	100	100	100	100	100	100			
NAPHTHA (175/295) B					100	100	100	100	100	100	100	100	100			
HEAVY NAPHTHA B			0.95	73.0	0	90	100	100	100	100	100	100	100			
KEROSENE B	48.5	- 54.2	1.5	63.0	0	0	0	0	50	70	100	100	100			
LT GAS OIL B	53.5	49.5	3.7	49.5	0	0	0	0	0	0	0	30	80			
REDUCED CRUDE B			440.0	20.3	0	0	0	0	0	0	0	0	0			
VACUUM GAS OIL A			120.0	25.0	0	0	0	0	0	0	0	0	0			
VACUUM RESID A				6.0	0	0	0	0	0	0	0	0	0			
VACUUM GAS OIL B			100.0	25.9	0	0	0	0	0	0	0	0	0			
VACUUM RESID B				6.0	0	0	0	0	0	0	0	0	0			
HVY NAPH A VIA KHT		54.3	1.08	70.0	0	90	100	100	100	100	100	100	100			
KEROSENE A VIA KHT	47.5	56.1	1.75	60.0	0	0	0	0	50	70	100	100	100			
HVY NAPH B VIA KHT	(0 f	<i>c</i> / 0	0.95	73.0	0	90	100	100	100	100	100	100	100			
KEROSENE B VIA KHT	48.5 33	54.2	1.5	63.0	0	0 30	0 49	0 88	50 100	70 100	100 100	100 100	100 100			
DESULF FCC HVY NAPH LT GAS OIL A VIA GHT	55.0	52.6	4.1	48.0	0	0	47	0	100	100	100	30	80			
LT GAS OIL A VIA GHT	53.5	49.5	3.7	49.5	0	0	0	0	0	0	0	30	80			
LCGO (DESULFURIZED)		47.5	1.8	60.0	ŏ	ŏ	ő	ő	o	ŏ	ŏ	0	0			
LCGO (DESULFURIZED)			1.8	60.0	ő	ŏ	0-	ŏ	ŏ	ŏ	ŏ	ŏ	ŏ			
C5/375 HT NAPHTHA					60	95	100	100	100	100	100	100	100			
375/650 HT DISTILLATE	48.5	46.2	1.5	63.0	0	0	0	0	10	25	85	100	100			
VGO B VIA HT			26.0	32.9	0	0	0	0	0	0	0	0	0			
HCGO (DESULFURIZED)			100.0	26.0	0	0	0	0	0	0	0	0	0			
HCGO (DESULFURIZED)			100.0	26.0	0	0	0	0	0	0	0	0	0			
C5/375 HT NAPHTHA					60	95	100	100	100	100	100	100	100			
375/650 HT DISTILLATE	48.5	46.2	1.5	63.0	0	0	0	0	10	25	85	100	100			
DESULFURIZED RESID B			150.0	24.2	0	0	0	0	0	0	0	0	0			
RAFFINATE					74	100	100	100	100	100	100	100	100			
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LIGHT CYCLE OIL			3.0	52.0	0	0	0	0	0	7	62	90	100			
SLURRY OIL			50.0	29.3	0	0	0	0	0	0	0	0	0			
C5/180 HYDROCRACKATE					100	100	100	100	100	100	100	100	100			
180/400 HYDROCRACKATE					50	84	91	100	100	100	100	100	100			
180/300 HYDROCRACKATE					97	100	100	100	100	100	100	100	100			
180/345 HYDROCRACKATE	50.0			(1.0	70	100	100	100	100	100	100	100	100			
300/550 HYDROCRACKATE 345/650 HYDROCRACKATE	50.0	61.6	1.5	63.0	0	16	33	48	67	74	96	100	100			
COKER GASO C5-400	56.0	63.5	2.1	57.0	0 50	2 75	6 90	12 100	28	36 100	66 100	85 100	100 100			
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COKER GASO C5-400			200.0	20.0	50	75	90	100	100	100		. 100	100			
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NCGO 650-950			100.0	26.0	ŏ	ŏ	ŏ	0	õ	0	0	0	0			
C5/160 REFORMATE					100	100	100	100	100	100	100	100	100			
PYROLYSIS FUEL OIL	25.5	30.0	6.5	42.6	0	8	12	22	40	50	74	89	97			
PYROLYSIS PITCH				5.0	0	0	0	0	0	0	0	0	0			

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Appendix B

REFINING INDUSTRY MODEL

Appendix B

REFINING INDUSTRY MODEL

This appendix is a supplement to Section 3.2.2. Included are:

- A brief description of the model
- A list of tables generated by the FORTRAN report program
- The naming conventions for the equations and variables
- A complete listing of the refining industry model (RIM) by equation order.

B.1 Model Description

The RIM is a linear programming (LP) mathematical representation of the refining and bulk transportation sectors of the U.S. petroleum industry. The geographic aggregation of the model is by the five Petroleum Administration for Defense (PAD) districts and one foreign sector. The refining industry in each district is represented by a large and a small refinery type, each having three operating modes (base, low, and high conversion) on each of two basic crude oil types (high- and low-sulfur). Additional crude oils included are the heavy, high-sulfur crude used for District V (West Coast) refining, and Alaskan North Slope crude for PAD districts III and V. Twenty-two types of refinery products are included.

The model is coded in the Mathematical Programming System (MPS) format, which is compatible with many LP mathematical systems. The associated report generating program is written in FORTRAN and is, in part, specific to the Control Data 6000 series computer and to the APEX III LP system.

A step-by-step description of the technique for application of the RIM is included in Appendix C, which describes model validation.

For an optimal solution of the model, the results are reported in the following sets of output tables:

- (1) Analysis of production and movements between districts and foreign sector for each product
- (2) Refinery capacity utilization by refinery types (high-sulfur, low-sulfur, West Coast), refinery size classes, and PAD districts

- (3) Analysis of production and movements of all products from other districts and foreign sector for each district
- (4) Utility summary by type and district
- (5) Utility consumption by refinery types, sizes, and PAD districts for each utility
- (6) Investment summary by refinery types, sizes, and districts for future investment options to be added.

B.2 Refining Industry Model Naming Conventions

B.2.1 Equations

(1) Refining section

XXYYYZ

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XX = PAD District No. (extra digit for future subdistrict)
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YYY = Product Code (see Table B-1)
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- Z = P for production
 - D for distribution
 - R for utility requirement

Example:

105CAP = PAD 1 production of diesel

Others:

ØJBF = Overall objective function

 $XX \phi BJ =$ Subobjective function in District XX

XXLRG = Sum large refinery capacity in District XX

XXSML = Ditto small refinery

(2) Transportation section

.

XXPCAPYY = Pipeline capacity from PADXX to YY XXMCAPYY = Ditto marine capacity XXPCOST = Sums DIST XX pipeline cost based on total volume XXMCOST = Ditto marine.

Table B-1

INDUSTRY MODEL NOMENCLATURE CODE

The Refineries	
L	Large refinery
М	Medium refinery
S	Small refinery
The Crudes	·
CA	Sweet crude
CB	Sour crude
CC	California crude
CD	Alaskan crude
The Cases	,
BA	Base conv
HC	High conv
LC	Low conv
MD ·	Max dist
The Products	
C3P	C3 LPG
C4P	C4 LPG
NAP	Naphtha
4AA	Regular gasoline
4BA	Premium gasoline
4CA	Low-lead gasoline
4DA	Lead-free gasoline
5AA 5BB	JP-4 jet fuel
5BB 5CA	Jet A jet fuel
5CB	Diesel (No. 1) No. 2 fuel oil
5CC	Diesel (No. 2)
5DA	High sulfur No. 6
5DB	Low sulfur No. 6
VGO	Vacuum gas oil
VRD	Vac residue
CKA	Coke (low sulfur)
CKB	Coke (high sulfur)
CKC	Coke (California crude)
CKD	Coke (Alaskan crude)
1A6	Benzene
1A7	Toluene
1A8	Mixed xylenes
1A9	C_9 + aromatics
NC4	Normal butanes
IC4	Isobutanes
NGF	Natural gasoline
MIS	Miscellaneous products
KWH	Purchased electric power
BTU	Net fuel required
LAB	Labor
OPC	Operating costs
INV	Investments

B.2.2 Variable Names

```
(1) Products
    XXYYYZ
      XX = PAD District
     YYY = Product code
       Z = Disposition code: blank = sum of DISTXX production
           C = Dist XX demand
(2) Crudes
    XXCYIN = Sum of crude of type N to Dist XX
        XX = PAD District
         Y = A Sweet crude
             B Sour crude
             C California heavy crude
             D Alaskan North Slope crude
    Other inputs
    XXYYYY = Sum of input YYYY to Dist XX
      YYYY = NGFN = Nat gasoline
             TNC4 = n-Butane
             TIC4 = i-Butane
(3) Refinery types
    XXCYZZZ
        XX = Dist. No.
         Y = A Sweet crude
              B Sour crude
             C California heavy crude
             D Alaskan North Slope crude
       ZZZ = LBA = Large, Base
             LLC = Large, Low Conversion
             LHC = Large, High Conversion
              S - - = Ditto for small refinery
             M-- = Ditto for medium refinery
    XXTLRG = Total large refinery capacity in district XX
    XXTSML = Ditto small refinery
```

(4) Incremental refinery processes XXDLHCY = Hydrocracking XX = District No. DLHC = Diesel Hydrocracking Y = 1, Shift existing HC capacity from maximum gasoline operation to maximum distillate operation Y = 2, New HC capacity for distillate production XXDLHTI = Hydrotreating No. 2 to diesel fuel cetane specification XXDSHTY = Hydrodesulfurization of motor fuel Y = A, HDS light gasoline and FCC feed for 100 ppm S, maximum Y = C, HDS diesel fuel to 200 ppm S, maximum XXZPREM = Option to shift premium gasoline to unleaded with credit for TEL saved XX5CXX = Option to shift marginal No. 2 fuel oil to No. 1 diesel pool by use of cetane-improving additive XX5BBX = Option to blend incremental Jet A fuel out of No. 1 diesel and No. 2 fuel oil Inter-PAD transfers, by product (5)XXYYYZZK XX = PAD Dist source of product YYY = Product codeZZ = PAD Dist destination of product K = P = pipelineM = marineTotal transfers, by transport mode (6) XXTPIPYY = TOTAL volume of product moved from Dist XX to Dist YY by pipeline XXTMARYY = Ditto marine (7) Sub-cost function totals XXØBJT = Total cost of refining and transportation in District XX, M\$/CD

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	111	101	101	101 UP1	101	L 0 1 UP 1	101	H LOI UPI	1.31	0 101 012	101	101
	204 AAD Ch 2 AA Ch 2 AA KHS U2	2046A0 RHS LUI RHS UP1	2040A0 RHS LD: RHS UP:	2056AS0 RHS L(RHS U	205 A A O RHS LO RHS UP	205880 RAS LOI RAS UPI	205CA0 RHS LOI RHS UPI	205DLIM RHS LI RHS UI	205C80 RHS L]: RHS UP:	20V600 RHS L AHS U	2050A0 RHS LD1 RHS UP1	205080 RHS LU: RHS LP:

						-8.30000000 P 30N6FW -9.720000000 P 30BTU .300000000 X 30JPREM -1.000000000 P 30TNCST	-1.00000000 P 30CALBA 1.00000000 L 30TLR6	-1.00000000 P 30CBHBA	1.00000000 L 3015ML	-1.000000000 P 30CAMHC -1.00000000 P 30CASBA	-1.066060000 P 30CBMHC		025000000 P 30CAMC 025000000 P 30CBL9A 025000000 P 30CBL9A 028100000 P 30CALMC	.01080000 P 3008MBA 015300000 P 3008LHC
						-9.000000000 P 30CDIN 01000000 P 30KHH 958900000 P 30KHV -1.000000000 P 30FCST	-1.000000000 P 3008LHC -1.000000000 P 3000LBA	-1.000000000 P 30CAMHC 1.000000000 L 30THED	-1.00000000 P 30CASLC	-1.000000000 P 30CAMLC -1.000000000 P 30CALLC	-1.000000000 P 30CBMLC -1.000000000 P 30CBLHC		025303300 P 30CAMLC 025909000 P 30C8MHC 025900000 P 30CALBA 029300000 P 30CASBA	001520090 P 30CAMHC
1.006006030 P 20CKAC	1.JOC0000J0 P 20CKBC	1.00000000 P 201A6C	1.000000000 P 201A7C	1.000600000 P 201A6C	1.300000000 P 20MISC	-9.000000000 P 30CBIN -7.300000000 P 300PC -1.000000000 P 300PC	-1.000000000 P 30CBLLC -1.00000000 P 30CALLC	-1.000000000 P 30CAMLC -1.00000000 P 30C8MHC	-1.000000000 P 30CASHC	-1.000000000 P 30CAMBA -1.000000000 P 30CALHC -1.000000000 P 30CASLC	-1.000000000 P 30CBHBA -1.000000006 P 30CBHBA	-1.00000000 P 3000LBA	025000000 P 30CAMBA 025000000 P 30CBMLC 225000000 P 30CBMLC 314000000 P 30CDLBA]Alstudep P 35CAMBA]Isteesad P 36CALP4
-1.CUUJ003CG P 2CCKA	-1.CCUJOLOCO P 20CK8	-1.00030000 P 20146	-1.0000603000 P 241A7	-1.0000000 P 20148	-1.660300000 P 26AIS	-9.250000000 L 30CAIN -6.900006000 P 30INC4 066370000 P 30LAB 09200000 P 305CXX	-1.000000000 P 30C8L8A -1.000000000 P 30CALHC 1.000000000 P 30LR6N	-1.605000001 P 3008MLC -1.000300001 P 3008MLC	-1.60000000 P 3004584 1.00000600 P 305MLN	1.60000000 L 30CAIN -1.00000000 P 30CALBA -1.00000000 P 30CASHC	1.00000000 P 300616A -1.00000000 P 300816A	1.000000 P 30001N	1.40340404 P 30NGFN 025334004 P 3008MBA 0253304034 P 3006LLC 025304034 P 3006LLC 023440446 P 300ALC	Leventeran P 307804
20114 14 14 14 14 14 14 14	64 115 6.000000000000000000000000000000000000	EU 116 0.00000000 0.000000000	EQ 117 0.000003060 0.000600660	E0 118 0.0600000000	EQ 119 0.000000000 0.0000000	EQ 120 0.000000000 0.000000000	64 121 0.00000000000000000	EQ 122 C.000000066 O.C00000000	EQ 123 0.00000000 0.00000000	EQ 124 0.000000060 ú.JCJ06J3CJ	έα 125 υ. ύ ξυξουβάς C. 0000000 00	έα 126 α. σύρυσοπος ৫. συρτοστος	72 127 6.000013010 3.03100010	ей. 128 • • и 13 с • 13 с С
20CMAD RMS LUI RMS UPI	ZUCK40 RHS LJ: RHS UP:	ZUIA60 RHS LU: RHS UP:	* - 201470 RHS LJ3 RHS UP:	ZOLAND RMS LOS RMS UPS	ZONISD RMS LOI RMS UPI	ANS LUS	30LRG RHS LD: RHS UP:	304 ED RMS LU: RMS UP:	305 ML RHS LUI RHS UPI	3JCALD RHS LOS RHS UPS	30C81D RHS LU: RHS UP:	30C D L U R H S L U R H S U Z	BONGFD RHS LUI RHS LUI	30NC40 643 L31

007906000 P 30CANHC 010006000 P 30C8L8A 061100000 P 30CALHC 005100000 P 30CASHC	.008300000 P 30C8M8A .008300000 P 30C8LLC .008300000 P 30CALLC .010700000 P 30CALLC	.002500000 P 3008M8A .002500000 P 3008LLC .002500000 P 300ALC .00300000 P 300ALC	.008800000 P 30C8M8A .013200000 P 30C8LLC .008800000 P 30CALLC .0088000000 P 30CALLC	 159000000 P 30C8M8A 043000000 P 30CALLC 041000000 P 30CALLC 035400000 P 30CASLC 	 211900000 P 3008M8A 129000000 P 3008LLC 123000000 P 300ALLC 106300000 P 300ALC 	.055000000 P 30C8MBA .129000000 P 30CALLC .123000000 P 30CALLC .106300000 P 30CALLC	.061000000 P 30CBMBA .129000000 P 30CBLLC .123000000 P 30CALLC .106300000 P 30CALLC .106300000 P 30CASLC	1.600006000 P 3040A	 013000000 P 3008M8A 013000000 P 3008LLC 012900000 P 300ALLC 012900000 P 300ALLC 	.063000000 P 30C8M8A .063006000 P 30C8LLC .063006000 P 30CALLC
010000000 P 30CAMLC 010000000 P 30CBMHC 005200000 P 30CALBA 007500000 P 30CALBA	.008300000 P 30CAMHC .008300000 P 30C6L8A .006300000 P 30CALHC .010200000 P 30CASHC	.002500000 P 30CAMMC .002500000 P 30CALBA .002500000 P 30CALMC .002900000 P 30CASMC	.008900000 P 30CAMHC .008300000 P 30C8L8A .008800000 P 30CALHC .007900000 P 30CASHC	 .037200000 P 30CAMHC .159007000 P 30CBL8A .049200000 P 30CALHC .036900000 P 30CASHC -1.00000000 P 3048A 	 .111500000 P 30CAMHC .256700000 P 30CALBA .147500000 P 30CALHC .117000000 P 30CASHC -1.00030000 P 304AA 	 .111500000 P 30CAMHC .061000000 P 30CBL8A .147600000 P 30CALHC .117300000 P 30CASHC -1.000000000 P 304CA 	 .141500000 P 30CAMHC .061000000 P 30CBL8A .177300000 P 30CALHC .17330000 P 30CASHC -1.000303000 P 304DA 	1.000303000 P 304CA	.0139900000 P 30CAMMC .019900000 P 30CALBA .013300000 P 30CALMC .012490000 P 30CASMC	.0733700000 P 30CAMHC .063300303 P 30C6L8A .163300303 P 30CALHC
01(J000006 P 30(AMBA 01(000000 P 30(BMLC 016000006 P 30(BLLC 0064610000 P 30(DLBA 064610000 P 3000LBA	 • 008300000 P 30CAMLC • 3065300000 P 30C8MHC • 008300000 P 30CALBA • 016700000 P 30CASBA - 1.• 0000000000 P 30C3P 	 002500000 P 3UCAMLC 602500000 P 30CAMAC 003000000 P 30CALBA 003000000 P 30CASBA 1.000000000 P 30C4P 	.0068000000 P 30CAMLC .008800000 P 30C8MMC .008800000 P 30CALBA .308200000 P 30CALBA	 035300000 P 30CANLC 048700000 P 30C8MHC 159000000 P 30CALBA 098000000 P 30CASBA -40C0C0000 L 30DLMC2 	 .105000000 P 30CAMLC .146100000 P 30C8MHC .2111000000 P 30CALBA .150000000 P 30CASBA 300000000 L 300LMC2 	 .10500000 P 30CAMLC .1561000000 P 30CBMHC .0610000000 P 30CALBA .362000000 P 30CASBA 150000000 L 30DLMC2 	 .105006000 P 30CAMLC .176800000 P 30C8MHC .061000000 P 30CAL8A .0410C0000 P 30CAS8A .15(C00000 L 30DLHC2 	1.J0000000 P 304AA	.313406030 P 30CAMLC .013466000 P 3468MHC .31496045 0 P 30CALBA .312400000 P 30CASBA	•165u60000 P 30CAMLC •Jo3n6uuud P 3u6BMHC • 1715??)、 P **falfa
1	 OUGAUUOU P 30CAMBA UCUB30COUO P 30CBMLC OCB3CUOCO P 30CBLMC Uloj00000 P 30CDLBA Ulou0000 P 30CDLBA 	 CC25UGUU0 P 30CAMBA 002200000 P 30CBMLC 00250CG00 P 30CBLMC 010000000 P 30CDLBA 02350UCU1 L 30DLMC2 	«VOBBOCOVO P 3CCAMBA «L1320VUVO P 3VCBMLC «O06BGGGOG P 3VCBLMC «LC96UGGG P 30CDLBA «UC0VGUG P 30CDLBA	 	 16400000 P 30CAMBA 116906400 P 30CBMLC 161300660 P 30CBLMC 11400000 P 30CDLBA 30000000 P 30LMCI 	 C55000000 P 30C4M8A 116920000 P 30C8MLC 161300000 P 30C8LMC c6240000 P 30C6LBA -150000000 P 30DLMC1 	.037J0CJUO P 30CAMBA .1175U0003 P 30CBMLC .19950U033 P 30CBLMC .054L00U000 P 30CBLMC .054L00U000 P 30CULBA	1.00000000 P 3048A -1.0000100 P 3076AS	•019900000 P 30CAMBA •19900000 P 30CAMEC •13900000 P 30CALME •022400000 P 30CDL48 •1.000000 P 3000L48	 «C71)CCUUC F 30CAMBA «L033)?CUUC F 30CBMLC «L033)?CUUC F 30CBMLC «L134)
4 921 0.0 0.00000000000000000000000000000000	E 130 0.00000000 0.00000000	Eu 131 0.000000000 0.00000000	E 0 132 0.00000000 0.00000000	E0 133 0.00000000 0.00000000	E0 134 C.00000000 0.003000000	E 135 6.00300000 0.00000000	EU 136 0.00000000 0.00000000	640 137 1 0.00000000 -1 0.00000000	ຣັດ 138 ວູ⊷ດແບ້ງວິດອີດ ວູຍບັບບັດດີດວ່າ −1	+C 134
301 C4U RHS L-J4 RHS UP1	30C 3PP RhS LJ 1 RHS UP 1	30C 4PP RHS LOI RHS UPI	30NAPP Kms Lùi Rms UPi	304 BAP AHS LOS RHS UPS	304 AAP RHS LOI RHS UP:	304CAP RHS LOI RMS UPI	3040AP RHS LJ: RHS UP:	3056ASP RHS LUI RHS UPI	305 AAP RHS LU1 RHS UV1	309444 K F S L - 13 K F S C - 13

 065000000 P 30CBMBA 245900000 P 30CALLC 295500000 P 30CALLC 234200000 P 305CA 	•120000000 P 3068M8A •120000000 P 3068LLC •120000000 P 306ALLC •131100000 P 305ALC -1.000000000 P 305CXX	• U7100000 P 3068M8A • 020000000 F 3068LLC • 020000000 P 306ALLC -1.00000000 P 30V60	.028000000 P 30CBNBA .028000000 P 30CBLLC .028000000 P 30CALLC .049200000 P 30CALLC	.042000000 P 30CBMBA .028000000 P 30CBLLC .028000000 P 30CALLC .049200000 P 30CALLC	.022000000 P 30CBMBA .022000000 P 30CBLLC .0140000000 P 30CALLC .065600000 P 30CALLC	•003000000 P 30CALBA •003100000 P 30CASMC	.000000000 P 30CKBA -1.00000000 P 30CKB	•006100000 P 30C8M8A •002500000 P 30C8LLC •002400000 P 30CALLC	.006900000 P 30CBMBA .0058000000 P 30CBLLC .005700000 P 30CALLC	.008700000 P 3068M3A .007100000 P 3068LLC .005200000 P 306ALLC	.025700000 P 30C6M6A .014300000 P 30C458A
 11600000 P 30CAMHC 065000007 P 30CBLGA 098000000 P 30CALHC 109100000 P 30CASHC 1.000000000 P 30DLHTI 	•160070000 P 30CANHC •1533070000 P 30CALHC •180070000 P 30CALHC •202500000 P 30CASHC -1.000700000 P 30CASHC	.062000000 P 366AMHC .02000000 P 3068L8A .020100000 P 306ALHC .022100000 P 306ALHC	•043000000 P 30CAMHC •028000000 P 30CBLBA •028000000 P 30CALHC •047200000 P 30CASHC	-042300000 P 30CANHC -028000000 P 30CEL8A -028390000 P 30CEL8A -047200000 P 30CALHC -1.000000000 P 305D8	.014030000 P 30CANHC .022000000 P 30CALAC .014300000 P 30CALAC .063000000 P 30CASHC	.002300000 P 30CANHC .003209000 P 30CASBA	.002900000 P 30C048A	.005900000 P 30CANHC .002400000 P 30C8L8A .002400000 P 30C8L8A	.005700000 P 30CANHC .005700000 P 30C8L8A .005700000 P 30C8LHC	.005700000 P 305AMHC .006900000 P 3058LBA .005200000 P 305ALHC	.030100000 P 30CAMHC .021100000 P 30CALBA -1.7.1.1.010 P 30FIS
 259900000 P 30CAMLC 365500000 P 30CANMC 3980600000 P 30CALBA 109100000 P 30CALBA 974000000 L 30DLMC2 60600000 L 30DLMC2 	 188600000 P 30CAMLC 120000000 P 30C8MHC 180000000 P 30CAL8A 202500000 P 30CAS8A 005000000 P 300SMTA 	 026000000 P 30CAMLC 086760000 P 30CBMHC 026000000 P 30CALBA 027000000 P 30CASHC 	.028000000 P 30CAMLC .026000000 P 30CBMHC .028000000 P 30CALBA .070600000 P 30CASBA	.028000000 P 30CAMLC .048000000 P 30CBMHC .028000000 P 30CAL8A .070600000 P 30CAL8A .022000000 P 30CAS8A	.01400000 P 30CAMLC .022006000 P 30CBMHC .014600600 P 30CALBA .065600600 P 30CASBA	<pre> •002300000 P 30CAMLC •0047C00000 P 30CALLC -1.000000000 P 30CKA </pre>	.002900000 P 30C8MLC .036000000 P 30C8LHC	•005900000 P 30CAMLC •005905000 P 30CBMHC •002400000 P 30CALBA -1.0000505050 P 301A6	.006900000 P 30CAMLC .006900000 P 30CAMLC .005700000 P 30CALBA -1.006600000 P 301A7	.006706000 P 30CAMLC .108700000 P 30CAMLC .00526600 P 30CALBA -1.00000000 P 301AB	.021700000 P 30CAMLC .023400030 P 30CBL6A .11470.555 B 30CBL6A
 CGULLUUJ P BUCANBA 19850CCUU P BCCBMLC UESDODUUC P BUCBLMC UESDULUUD P BUCBLMC 2350LUUUD P BUCHCLB LEUUUUCC P BUCSCX 	 JUGOUUCCU P 30CAMBA J2000CGUU P 30CBMLC L54700000 P 30CBLMC C55200000 P 30C0LBA OU0000000 P 30DLMTL -400000000 P 305BMX 	.63.400000 P 30CAMBA .663000000 P 30CBMLU .620000000 P 30CBLHC .628160000 P 30CASBA	.64300000 P 30CAMBA .028060000 P 30CBMLC .026000600 P 30CBLHC .072860660 P 30C0LBA .100000000 P 3050A	.05200000 P 30CAMBA .04800000 P 30CBMLC .028000300 P 30CBLMC .U728000000 P 30CDLBA 455000000 P 300LMCL	.621400000 P 30CAMBA .622000000 P 30CBMLC .022000000 P 30CBLHC .626000000 P 30CDLBA -1.00000000 P 30VRD	•002300000 P 30CAMBA «094700000 P 30CALHC •003200000 P 30CASLC	.602900000 P 3008M8A .606460666 P 3008LLC	•0059006U3 P 3UCAMBA •00790000 P 300BMLC •6029060U P 300BLMC •001370000 P 300DLBA	 • 6 U & 9 C & M & A & A	 •UJ870UUG0 P 30CAMBA •U1340(500 P 30CBHLC •U52250500 P 30CBLHC •C03505000 P 30C0LBA 	
6.303063060	EQ. 141 0.0000000	EQ 142 0.000000000	EQ 143 0.00000000 0.0000000	EQ 144 0.0000000000	EQ 145 0.00000000 0.000000000	E0 140 0.000000000	EU 147 0.0003000000	60000000000000000000000000000000000000	6.000000000000000000000000000000000000	E4 150 6.000000000	EQ 151 0.000000000
305CAP RH5 LU1 RH5 UP1	305C8P RHS LO1 RHS UP1	30VGOP RHS LU: RHS UP:	3050AP RFS LU: RHS UP:	30508P RHS LO1 RHS LO1	304RDP RHS LU: RHS UP:	30CHAP RHS LOI RHS UP:	300 KBP RHS LU1 RHS UP1	BOLA6P RHS LD1 RHS UP.	301A7P RHS LO: RHS UP:	301A3P RMS LU: RMS UP:	30415P RMS 101 PHS UP1

30CBMBA 30CBLLC 30CALLC 30CALLC 30CASLC 300SMTC	30C8M8A 30C6LLC 30CALLC 30CALLC 30CASLC 30BTU	30CBMBA 30CBLLC 30CALLC 30CALLC 30CASLC 300SMTA	30C8M8A 30C8LLC 30CALLC 30CALLC 30CALLC 30LA8	30CBMBA 30CBLLC 30CALLC 30DLHC1 30DSHTC	300SHTA 30INV	20C3PU3M 30C3P01M 30C3P04P 50C3P03M 30C3PC3M	20C4P03N 30C4P01N 30C4P04P 50C4P03N 30C4P03N	20NAP03N 30NAP01N 30NAP04P 50NAP04P 30NAP03N 30NAPC	2048403M 3048401M 3048404P 5048404P 5048403M 3048403M	2048403M 3048401M 3048404P
3.370700000 P 4.156700000 P 3.805600000 P 2.483000000 P 3.12000000 P 3.12000000 P	.056660000 P .056190000 P .059050000 P .012890000 P	• 05700000 P • 06400000 P • 066150000 P • 066150000 P • 01800000 P	4 000000000 4 2 000000000 4 2 0000000000 4 3 00000000000 1 1 1	 138200000 P 093800000 P 118400000 P 038200000 P 00600000 P 	• 400000000 •	-1.000000000 P 1.000000000 P 1.000000000 P -1.000000000 P -1.000000000 P	-1.000000000000000000000000000000000000	-1.000000000 P 1.000000000 P 1.000000000 P 1.000000000 P 1.000000000 P	-1.000000000 P 1.000000000 P 1.000000000 P 1.00000000 P 1.00000000 P	-1.000000000 P 1.000000000 P 1.000000000 P
P 30CANHC P 30CALBA P 30CALHC P 30CALHC P 30CASHC P 30DSHTA	P 30CAMHC P 30CBLBA P 30CALHC P 30CALHC P 30CASHC P 30DSHTC	P 30CANHC P 30CBLBA P 30CALHC P 30CALHC P 30CANT1 P 300LHT1	P 30CAMHC P 30CBL8A P 30CALBA P 30CALHC P 30CASLC P 300SMTC	P 30CAMHC P 30CBLBA - 30CALHC P 30CALHC P 30CASLC P 30D5MTA	P 305MLN 1 305MLN	P 10C3P03P P 30C3P0FP P 30C3P02P P 40C3P03P P 40C3P03P	P 10C4PC3P P 30C4P0FP P 30C4P02P P 40C4P03P P 40C4P03P P F0C4P03P	P 10%AP03P P 30%AP05P P 30%AP02P P 46%AP03P P 46%AP03P	P 1648403P P 304840FP P 3048462P P 4648462P P 4648403P P 5048403P	F 104AAU3P P 304AAU5P P 304AA05P
3.215400000 4.334500000 3.903050000 2.435170000 1.05005000	0000080000 000010000 000010000 000000000	• 065010000 • 069320000 • 070446000 • 070446000 • 025000000	5.000300000 5.000300000 5.000300000 5.000300000 5.000300000 5.000300000	• 07500000 • 162100000 • 104200000 • 111700000 • 013000300	.510000000	-1.0000000000 1.000000000 1.0000000000 1.00000000	-1.000000000 1.0000000000 1.0000000000 -1.0000000000	00000000001 00000000001 00000000001 000000	000000000.1- 0000000000.1 0000000000.1- 0000000000	- 1.0003040000 - 1.0003040000 - 1.0003040000
30CAMLC 30CBMHC 30CBLBA 30CALBA 30CALBA 300LHT1	34CAMLC 30CBMHC 30CALBA 30CALBA 30CASBA 300SMTA	30CAMLC 30CBMMC 30CALBA 30CALBA 30CASBA 30DLMC2 30ENE	30CAMLC 30CAMLC 30CALBA 30CASHC 30CASHC	30CAMLC 30CBMMC 30CALBA 30CASHC 30DLMT1	300LHC2 30LRGN 30NPLP02	10C3PU3M 30C3PU3M 30C3PU2M 30C3PU2M 50C3PU5P FUC3P03M	1 6 6 4 P 6 3 M 3 6 6 4 P 6 5 M 3 6 6 4 P 0 5 M 3 0 6 4 P 6 5 P 7 0 6 4 P 6 3 M	1 C MAP C 3 M 3 O MAP C F M 3 O MAP C 2 M 3 O MAP C 2 M 7 O MAP C 3 M	1 C 4 B A O 3 M 3 O 4 B A U F M 3 O 4 B A U Z M 3 O 4 B A U Z M 7 C 4 B A U Z M	1048863M 3648465M 77447
3.16360000 P 3.412500000 P 3.432700000 P 2.4839700000 P 2.483000000 P	.056960000 P .057300000 P .060560000 P .042896000 P .01600000 P	.062910000 P .063700000 P .067785006 P .047560000 P 355006000 P -1.000060000 P	5 - 00000000 5 - 000000000 5 - 00000000 5 - 00000000 5 - 00000000 5 - 00000000 5 - 000000000 5 - 00000000 5 - 000000000 5 - 000000000 5 - 00000000 5 - 00000000 5 - 00000000 5 - 000000000 5 - 000000000 5 - 000000000 5 - 00000000 5 - 0000000 5 - 000000000 5 - 00000000 5 - 0000000000 5 - 000000000 5 - 00000000000000000000000000000000000	.09660000 P .108560000 P .138660000 P .11290000 P .012500000 P	.100000000 L 4.0000000000 P 1.700000000 P	-1.00000000 P 1.000000000 P 1.000000000 P 1.0000000000 P -1.000000000 P	-1.00000000 P 1.000000000 P 1.000000000 P 1.0000000000 P	-1.00000000 P 1.000000000 P 1.000000000 P 1.000000000 P -1.000000000 P	-1.300000000 P 1.300000000 P 1.30000000 P 1.30000000 P	-1.00000000 P 1.0000000 P
30C8H6A 30C8HLC 30C8LHC 30C0L8A 30C0L8A 30C0L6L 30KWH	30CAMBA 30CBMLC 30CBLHC 30CDLbA 30CDLbA	30CAMBA 30CAMBA 30CBLMC 30C0LBA 30OLHC1 300SHTC	30CANBA 30CUNLC 30CULLC 30CASBA 30CASBA 30DLHT1	30CAHBA 30CAHBA 30CBLHC 30CBLHC 30CASBA 30DLHC2 30DPC	300LHC1 3605HTC 30NPIP01	30C3P 2UC3P61P 30C3P61P 30C3P61P 50C3P05M	30049039 20049039 30049038 30049038	3JNAP 20NAPC3P 3UNAPU1P 3UNAPU1P 00NAP03P	30484 20484039 20484012 30484012 50484012	304AA 244AAU3P
a.2000000 a.299100000 4.599100000 6.439000000 7.439000000 1.0000000 1.0000000 1.0000000 1.0000000	. C > 6 + 40 + 00 P . C + 5 + 0 + 00 C P . 0 6 31 0 C - 00 J . C 7 2 2 + 1 + 0 C 9 C 7 2 2 + 1 + 0 C 9 	<pre>Pair Pair Pair Pair Pair Pair Pair Pair</pre>	5.000000000 5.00000000000000 5.000000000	<pre>.101300460 P .070566000 P .121306000 P .111760000 P .125706000 P .1.000000000 P</pre>	3.80000000 P 1.134000000 P 2.70000000 P		-1.60000404 P -1.60636030 P 1.0003060360 P 1.000500000 P -1.603060000 P			-1.((())() -1.((())() -1.
0. E0 0. C005CC05C 0. 003 103 056	EQ 153 0.00000000 0.0000000	Eq 154 6.00000000 u 0.00000000	E 0 155 0. JC0JJ0064 0. 00J000000	E0 156 0.00000000 0.00000000	E0 157 0.00000000 0.00000000	e 0 158 0.00003000 0.0000000	E 0 159 0.00000000 0.0000000	60 160 0.040400660 0.040400660	сч 161 0.320939066 С.366600065	ru 162 6.00000000
30KhHR RFS LUI RMS UPI	308 TUR R HS LU: R HS UP:	306 NËR RHS LQI KMS UPI	30LABR RHS LD: RHS UP:	300 PCR RHS LD: RHS UP:	30INVR RMS LDI RMS UPI	30C 3P0 RHS LD: RHS UP1	30C 4P0 RHS LD: RHS UP:	3CMAPD RHS LU: RHS UP:	304 8 AD 8 H S L J 8 8 H S U 8	304 AAD R HS LJI R HS LJI

03M 01A 049 0349 C	03M 04P 03M C	ų	03M 04P 03M C 3M	03M 04P 03M C 3M	0 3 M		103M 04P 03M 03M	OF M	OFH 03H	05M 03M		
2046A03M 3046A01M 3046A04P 5046A04P 5046A03M 3046AC	2040A03M 3040A01M 3040A04P 5040A03M 3040AC	304040	2054A03M 3054A03M 3054A03M 5054A03M 305AAC	2058803M 3058801M 3058804P 3058804P 5058804P 3058803M	205CA03M 305CA03M 305CA04P 505CA04P 305CA03F		2050803M 3050803M 3050804P 5050803M 3050803M	30V600FM 30V60C	3050A0FM 5050A03M	305080FM 5050803M		
-1.000000000 P 1.0000000000 P 1.0000000000 P 1.000000000 P	-1.00000000 P 1.000000000 P 1.000000000 P -1.000000000 P 1.000000000 P	-1.00000000		-1.000000000 P 1.000000000 P 1.0000000000 P 1.0000000000 P 1.0000000000 P	-1.000000000 P 1.000000000 P 1.000000000 P -1.000000000 P 1.000000000 P		-1.000000000000000000000000000000000000	1.00000000 P	1.000000000 P	1.000000000 P		
P 104CA03P P 304CA0FP P 304CA0FP P 404CA03P P 604CA03P	P 1040403P P 304040F P 3040402P P 4040403P P 404033P	P 304CAC	P 1054403P P 305440F P 305440F P 4054402P P 4054403P P 6054403P	P 1058803P P 305886FP P 3058802P P 4058803P P 4058803P	P 105CA03P P 305CA0FP P 305CA02P P 405CA03P P FU5CA03P		P 105C803P 9 305C805P P 305C862P P 405C803P P 405C803P	P 20V6003M P 30V6005M	P 2050A03M P 3050A05M	P 2050803M P 3050805M		
-1.000000000 1.000000000 -1.000000000 -1.0000000000	-1.0000000000 1.0000000000 1.0000000000 1.00000000	-1.0000000	-1.000000000 1.000000000 1.000000000 1.00000000	-1.00000000 1.000000000 1.000000000 -1.000000000	-1.00000000 1.00000000 1.00000000 -1.00000000 -1.00000000		-1.000300000 1.0003300000 -1.000300000 -1.000300000	-1.000000000	-1.000000000	-1-000000000		
1046A63M 3046A6FM 3046A62M 3046A62M 5046A62M 5046A63M	1040463M 304046FM 3040402M 3040402M 5040405P	3048AC	10544034 30544664 30544664 30544654 30544659 60544034	1058843M 3058845M 3058802M 3058802M 5058803M 6058803M	1056463M 3056405M 3056402M 3056405P 5056405P F056403M	305000	1050803M 3050805M 3050802M 3050803M 5050803M	10V6003M 30V6062M	1650463M 3050462H 3050462H	1050803M 3050802M 30508C	BUVROC	P 30CKAC
-1.00000000 P 1.0000000 P 1.00000000 P 1.00000000 P	-1.00000000 P 1.000000000 P 1.000000000 P 1.000000000 P -1.00000000 P	-1.30000000 P	-1.000000000000000000000000000000000000	-1.00000000 P 1.300000000 P 2.30000000 P 1.00000000 P	-1.30000000 P 1.000000000 P 1.0000000000 P 1.00000000000 P 1.00000000000 P	1.0000000 L	4 00000000°1- 4 00000000°1 - 1 000000000°1 - 1 000000000°1 -	-1.00000000 P	-1.000000000 P 1.000000000 L 1.00000000 L	-1.00000000 P 1.000000000 P 1.000000000 L	1.0000000	1 .000 66 00 50 P
P 364CA P 244CAu3P P 344CAu3P P 344CAu1P P 344CAu1P P 546CAU1P	P 3040A P 2340AL3P P 3040AL3P P 3040A01P P 3040A05M	P 304AAC X 3útgasc	P 305AA P 205AA03P P 305AA03P P 305AA01P P 305AA01P P 505A403P	P 30%48 P 20%8803P P 30%8801P P 30%8801P P 30%8801P P 50%4803P	P 305CA03P P 205CA03P P 305CA01P P 305CA03P P 505CA03P L 305CCC	L 305CAC	P 305C8 205C803P P 305C803P P 305C803P P 305C803P P 305C803P	P 30VGU P 30VGULM	F 3050A P 3050AL1M P F050Au3M	F 33508 P 30566L1M P FC566U3M	r JUVAC	r súcka
-1.00030000 -1.00030000 1.0000000 1.0000000 1.000000	-1.000000000 -1.00000000 1.00000000 -1.00000000	-1.60000000	-1.00000000 1.000000000 1.000000000 1.00000000	-1.00000000 1.00000000 1.00000000 1.00000000	-1.0000000 -1.00000000 1.00000000 1.0000000 1.0000000 -1.00000000 1.00000000	- • 75 00 000 00	-1.00000000 -1.00000000 1.00000000 1.00000000	-1.000000000 1.000000000	-1.000000000 1.000000000 -1.000000000	-1.0000000 1.0000000 -1.0000000	- 0.6000.00.1-	
20 100 100 100 0. 100 100 10 0. 000 000 00	E 4 1 54 0.0030033003 0.000003030	E0 1c5 0.060J000000 0.300309000	E 9 1 6 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	EQ 1000000000000000000000000000000000000	EQ 168 0.00000000 0.00000000	GE 149 0.000000000 +1NF	EQ 170 0.0000000000 0.00000000	 Eq 171 ο. υύουυσοις ο. οςοσοςοσος 	20 172 3.043633940 6.600063966	EQ 173 0.00000000 0.00000000	26 174 2.40510 3.902000310	119121000000000000000000000000000000000
304CA0 RHS LU RHS UP 1	3040AD RHS 1U1 RHS UV	3056A50 RH5 LU: RH5 UPE	305 AAD RHS LD1 RHS UP1	RHS LUI RHS LUI RHS UPI	305CAO RHS LOI RHS UPI		305CBO RhS LU: RhS UP:	30V 600 RHS LQ: RHS UP 4	305040 RHS LJI RHS UP 0	305030 KHS LJ RHS UP1	304600 RHS LUI RHS UPI	30CAAU RFS LUI RHS UPI

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a . (40000000 P	U P	9	404 AAF
.7581JJ000 P 46CBSHC 460JJ0000 7 46DLHCL	0947600000 P 400BSLC 0340500000 P 400ASLC -1.30000000 A 402PREM	 	.4 181 181 181 181	464 647 RHS LJI RHS UP 8
		-1.(((000000 P 40NAP	60 000 150 000000000000000000000000000000	40NAPP 6H3 L38 RHS UP1
-003100000 P 40CBSHC -035100000 L 400LMC2	• 303100000 P 40085LC • 003160000 P 400A5LC	 CUBIGUOD P 40CBSBA CUBIGCCOD P 40CASHC 	EC 189 C.006000000 0.00000000	40C 4PP RHS 101 RH3 121
.012800000 P 4008MC 027100000 L 400LMC2	.012800000 P 40CBSLC .0128600000 P 40CASLC	.(12800000 P 40CBSBA .(1200003 P 40CBSBA	EQ 166 0.003300660 0.00300000	40C3PP RMS LOI RMS UPI
005900000 P 4008LC 007300000 P 4008M1A	003460000 P 40CBSBA 003300000 P 40CASLC	1.00000000 P 40TIC4 000600000 P 40CASHC	Eu 187 3.303043060 0.04000060	401040 RMS 'LJ: RMS UP:
005903000 P 40C8SLC 001400000 P 40D5MTA	012600000 P 40CBSBA 009100006 P 40CASHC	1.60000000 P 40TNC4 C11006600 P 40CASBA	EQ 1 t6 0.000000000 0.000000000	40NC40 C 2HS L34 RHS UP8
037900000 P 40CBSLC 058400000 P 40CASLC	073000000 P 40CBSBA 073000000 P 40CASHC	1.600000000 P 4006FN 073000040 P 40CASBA	EQ 165 0.03J300626 0.300040030	40NGFD RHS LJ4 RHS UP4
-1.00000000. P 40CBSLC	-1.00000000 P 400858A	1.0000000 P 400BIN	E4 144 0.000000600 0.000000000	40CBID RMS LOI RMS UPI
-1.000300000 P 40CASHC	-1.00000000 P 40CAS8A	1.00000000 L 40CAIN	E9 163 0.000000000 0.00000000000000000000000	40CAID RHS LOI RHS UPI
-1.000000000 P 40CBSHC 1.000000000 L 40TSML	-1.000000000 P 40C8SLC -1.000000000 P 40CASLC	-1.60000000 P 40CBSBA -1.60000000 P 40CBSHC	EQ 182 0.000000000 0.00000000	405ML RH5 LJ1 RHS UP1
-6.300000000 P 40NGFN -12.4200000 P 40BTU .300000000 X 40ZPREM	-9.330C00000 P 40CBIN 02000000 P 40KWH 9956900000 P 40INV -1.000000000 P 40IPCST	-9.25~J.(JUO [4JCAIA -7.330005JUOG P 40TIC4 -1.6L(JUC4UO P 4008JT 1.6U(JU006G P 4008JT	E u 161 0.000c03000 0.000c03000	4008J RHS LQI RHS UPI
	1.00000000 P 30MISC	-1.00000000 P 30MIS	69 180 0.00000000 0.0000000	30MISD RMS LJ8 RMS UP8
	1.00000000 P 30148C	-1.CU0000000 P 301A8	EQ 179 0.00000000 0.33000300	301 ABO RHS LOI RHS UPI
	1.00100000 P 361A7C	-Loi JUULULDU F BUIAT	E 3 178 C. OUOUJOOUU O. OGJCCJJCO	301 A 7U RHS 1-31 RHS UP1
	1.406060000 P 30146C	attne 4 vyngologia.	e a 177 3. Usucut 916 6. Juu Caburu	301 A00 RH5 1.1: RH5 U.1
		P 301A6C P 3000000000 P 4000000000 P 4000000000 P 4000000000 P 4000000000 P 4000000000 P 400033900000 P 400033900000 P 400033900000 P 400033900000 P 400033900000 P 400033100000 P -0.0031000000 P <t< td=""><td>-1.00000000 P 301AC 1.00000000 P 301AC -1.00000000 P 301AC -9.30000000 P 301AC -1.00000000 P 400KH -1.00000000 P 301AC -1.00000000 P 400KH -1.00000000 P 400KG -1.00000000 P 400KG -1.00000000 P 400KG 1.00000000 P 400KG -1.000000000 P 400KG</td><td>(0.0.00000 > 301.00C (0.0.000000 > 301.00C </td></t<>	-1.00000000 P 301AC 1.00000000 P 301AC -1.00000000 P 301AC -9.30000000 P 301AC -1.00000000 P 400KH -1.00000000 P 301AC -1.00000000 P 400KH -1.00000000 P 400KG -1.00000000 P 400KG -1.00000000 P 400KG 1.00000000 P 400KG -1.000000000 P 400KG	(0.0.00000 > 301.00C (0.0.000000 > 301.00C

15000000 F 40CA58A 150000000 L 400LHC2	.639700000 P 40CASBA 150000000 L 40DLHC2	1.00000000 P 4040A	.023400000 P 40CAS8A	.056200000 P 406A58A 1.00000000 P 40588X	 209700000 P 40CASBA 974000000 L 400LMC2 - 600000000 P 405BBX 	.132000000 P 40CAS8A 005000000 P 40DSHTA	.002400000 P 40CAS8A	.03200000 P 40CASBA	.032000000 P 4004471 022000000 P 4004471	.054500000 P 40CASBA	-1.00000000 P 40CKA	-1.00000000 P 40CKB			
.175030000 P 400654C	.17500000 P 4008SHC 15000000 P 400LHC1	1.000000000 P 404CA	 030900000 P 40685HC −1,000000000 P 4054A 	.045600000 P 4058BHC -1.000030000 P 40588	.146000000 P 40C85HC 1.235000000 P 40DLHC1 1.000000000 P 405CXX		.002400000 P 400685HC -1.000000000 P 40V60	.032000000 P 4058HC -1.000000000 P 4050A	.032000000 P 40085HC 458000000 P 400LHC1	.056400000 P 40085HC -1.0003330000 P 40VR0	.004600000 P 40CASLC	.005800000 P 40CBSHC			
.14(00000 P 40CBSLC .121500000 P 40CASLC	<pre>。140000000 P % CBSLC .121500000 P % CASLC 1.000000 C % 02PPEM</pre>	1.00000000 P \$U\$AA	.035200300 P 40CBSLC .023400000 P 40CASLC	.043300000 P 40C8SLC .053860030 P 40C8SLC	<pre>~268900000 P 40C85LC ~304300000 P 40C85LC ~1.000000000 P 405CA</pre>	*088060000 P 40C85LC •113600000 P 40C85LC •1.00000000 P 40C85LC	.002400000 P 40CBSLC .002400000 P 40CASLC	.032000000 P 40CBSLC .032000000 P 40CASLC	.032000000 P 40C85LC .032000000 P 40C85LC	.054500000 P 40CBSLC	.004600030 P 40CASHC	.005800000 P 40CBSLC			
«୯୬୨୬୯୯୬୯୦ ዮ 400୫୬୪୫ «၂୭೭୯୯୯୬୦ ዮ 4408ጵ6 -1.୧୦୧୦୦୦୦ ዮ 4046	.039700000 P 4608584 .152300000 P 4608560 -1.000000000 P 40404	1.000000000 P 4048A -1.000000000 P 4016AS	.(35200000 P 400858A .(23400000 P 400A5MC	.445760000 P 406858A .653806000 P 406ASH6	<pre>。16860503U P 460858A 。190305033 P 400ASHC 1.0000500000 P 400LMTL</pre>	.00880000000 P 400858A .132000000 P 400A5HC -1.00000000 P 435C8	.002400000 P 40CBS8A .6v2400000 P 40CASHC	.v32040000 P 400856A .63204000 P 400ASHC	.03200000 P 400858A .u52500000 P 400ASHC -1.000300000 P 40508	.054500000 P 400858A .054500000 P 400ASHC	.0U3200600 P 40CASBA	.005300000 P 40CBSBA	-1.000300000 P 40146	-1.600004030 P 401A7	-1.(000000 P 40148
ές 193 0.00000000 0.00000000	EQ 3300000000000000000000000000000000000	64 145 0.033300000 0.303300000	EQ 196 0.002000000 0.0000000	00000000000 0000000000 251 n2	ξ q 198 0.00000000 0.00000000	EQ 159 0.00000000000000000000000000000000000	EQ 200 0.00000000 0.00000000	E4 201 0.0000400000 0.000000000	EQ 242 0.010000666 0.300063040	EQ 203 0.00000000 0.0000000	EQ 2C4 6.60000000 6.0000000	EG 245 C.ŬUUUDOVO O.OOOOOOCO	EQ 206 0.000000000 0.000000000	EQ 267 0.00000000 0.00000000	Eu 2.66 0.003603060 U.360017060
404CAP RMS LJI RMS UPI	40404P RH5 L31 RHS UP1	4056A5P RHS LJ1 RHS UP	405AAP RHS LJ1 RHS UP1	405888 RHS LQ1 RHS UP1	A. 405CAP A. RHS LOB RHS UPI	405CBP RHS LUC RHS UP 1	40460P RMS 201 RMS UP1	4050AP 845 Lũi Rhs UPI	40508P RHS LJI RHS UPI	46VRDP RHS LJ1 RHS UP1	40CKAP RHS LOI RHS UPI	40CKBP RHS EUI RHS UPI	40146P RHS LUFE RHS UPE	401A7P RHS LDI RHS UPI	401AdP RHS LUI RHS UVI

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0 P 40CASBA 0 P 400LHT1	0 P 40CASBA 10 P 4005HTA	0 P 40CASBA 10 L 40DLHC2 0 P 40ENE	0 P 40CASBA	0 P 40CASBA 0 1 400LHC2 10 P 400PC	O P 40DSHTA	0 P 30C3P04P 0 P 40C3P03P 0 L 40C3PC	0 P 30C4P04P 0 P 40C4P03P 0 L 40C4PC	0 P 30NAP04P 0 P 40NAP03P 10 P 40NAPC	0 P 3048A04P 0 P 4048A03P 0 P 4048AC	10 P 304AA04P 10 P 404AA03P 10 P 404AAC	0 P 3046404P	0 P 3040A04P 0 P 4040A03P 0 P 4040AC	0 P 4040AC	0 P 305AA04P 0 P 405AA03P 0 L 405AAC	0 P 3058804P 0 P 4058803P
2.72900000 .66800000	.051630000	-0000000000000000000000000000000000000	5 • C 6000000	.170200000 557000000 -1.000000000	• +0000000	-1.000000000 1.0000000000000000000000000	-1.0000000 1.00000000 1.00000000	-1.000000000 1.0000000000000000000000000	-1.000000000 1.0000000000000000000000000	-1.00000000 1.000000000	-1.00000000	-1.00000000 1.00000000000000000000000000	-1.00000000	-1.000000000 1.000000000	-1.00000000 1.00000000
P 40CBSHC P 400LHC1 P 40KWH	P 40CBSHC L 40DLHC2	P 40CBSHC P 400LHC1 P 400SHTC	P 40CBSHC P 40DLHC1 P 40LAB	P 40CBSHC P 46DLHC1 P 40DSHTC	P 400LHT1	P 20C3P04P P 40C3P02P P F0C3P04P	P 20C4P04P P 40C4P02P P F0C4P04P	P 20NAP04P P 40NAP02P P FONAP04P	P 2048A04P P 4048A02P P F048A04P	P 204AA04P P 404AA02P P F04AA04P	P 204CA04P P 404CA62P P 404CA6	P 2040A04P P 4040A02P P F040A04P	P 404CAC	P 2054464P P 4054402P P 6054404P	P 2058804P P 4058802P
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P 40C85LC P 40C85LC P 40D5HTC	P 40CBSLC P 40CASLC P 40BTU	P 40CBSLC P 40CBSLC P 40DSHTA	P 40CBSLC P 40CASLC P 40DSHTC	P 40CBSLC P 40CBSLC P 40DSHTA	L 4CDLHC2 P 405MLN	P 10C3P04P P 40C3P04P P 50C3P64P	P 10C4P04P P 40C4P01P P 50C4P04P	P 10NAP64P P 40NAP01P P 50NAP04P	P 1048A04P P 4048A01P P 5048A04P	P 104A04P P 404A01P P 504A4U4P	P 104CAU4P P 404CAU1P P 504CA04P	P 1040A04P P 4040AU1P P 5040AC4P	P 4048AC	P 1054464 P 4654461 P 5654464 P 5654464	P 1003804P P 4308801P
3.24140C000 3.096600600 3.12660600	•053170000 •054380000 •1-	.059260000 .06020000 .01800000	5.33000000 5.00000000 .60000000	0000001660° 0000001260° 00000001260°	•100000000 ••000000000	-1.00000000 1.30000000 -1.000000000	-1.000000000 1.000000000 -1.0000000000	-1.00000000 1.00000000 -1.00000000	-1.00000000 1.00000000 -1.00000000	-1.000000000 1.000000000 -1.0000000000	-1.00660000 1.0060000 -1.0060000	-1.00000000 1.00000000 -1.00000000	-1.000000	-1.00000000 1.0000000 -1.0000000	-1.00000000 1.00000000
4668584 4068586 4005414	4 UCBS BA 4 UCBS BA 4 CDAS HC 4 CDAS H C	40CBSBA 4UCASHC 4ULATI	40C858A 40C85HC 40D5HTA	40C858A 46C85AC 40DLHT1	21H2005 70H1005	40C3P 40C3P0FP 40C3P05P	40C4P 40C4PUFP 4UC4P05P	4 UNAP 4 ONAP CFP 4 ONAP OSP	4048A 4048ACEP 4048ACEP	40488 404846 4048465P	404CA 404CALFP 404CALFP	4040A 4040ACFP 4040A05P	424AAC 4076ASC	405.44 46.544.0F2 42544.J5P	40268 4028150F2
3.265306000 P 2.625700000 P 1.05030000 P	4 000014 50. • 05440000 P	9 000000000 • 00000000 • 00000000000000	• • • • • • • • • • • • • • • • • • •	.195000600 P .128900000 P .012500000 P	3.60000000 P 1.134000000 P	-1.000000000 -1 1.00000000000000000000000000000000000	-1.000000000 P 1.0000000000 P 1.0000000000 P	-1.66000000 P	-1.60000000 P	-1.00000000 P		-1.000000000 P 1.000000000 P 1.000000000 P	-1.66000000 A	-1.000330000 P 1.000000 P 1.000000 P	-1. Ctuatter P 1. 1. 1. 60000 P
c.03)04000400 0.0000400	EU 211 0.00000000 0.00000000	EQ 212 0.00000000 0.00000000	E 0 213 0.0000000000 0.000000000	EQ 214 0.300003360 0.00000000	EQ 215 6.00000000 0.00000000	EQ 216 0.000000000 0.000000000	EQ 217 0.000060000 0.00000000	E 4 218 0.000000000 0.000000000	E 9 219 0.000000060 0.00000000	EQ 220 0.ju0000000 0.0000000	EQ 221 0.000000000 0.00000000	69 222 0.360603363 0.301600566	20 223 0.0033003060 v.0000060	5 G 2 4 4 6 + 5 + 5 0 2 2 4 0 + 0 0 2 5 1 3 1 0 3	10 H C C C C C C C C C C C C C C C C C C
40K MHR RHS LOI RHS LOI	408 TUR R HS 101 R HS UP1	42EAER RHS LOB RHS UPB	40LABR RHS LOI RHS UPI	400PCR RHS LJ: RHS UP:	401 NVR R HS LJ: R HS UP:	40C3P0 RHS LD1 KHS UP1	40C4PD RHS LD1 RHS UP1	40MAPD RHS LU: RHS UP:	4048AD RHS LQI RHS UP:	404 AAD RHS LQ: RHS UP:	404CAD RHS L91 RHS UP1	404 CAD R H5 LQ1 K H5 UP 1	4056ASU RH3 LU RHS UP8	402 AAD R 1 2 1 2 1 R 1 2 1 2 1	445650 R MS 1 18 M M 1.23

-1.00000000 P 3056A04P 1.000000000 P 4056A03P 1.000000000 L 4056AC	-1.000000000 P 3056804P 1.000000000 P 4056803P 1.000000000 L 405686						-8.756000000 L 50CDIN 020000000 P 50K4M 958900000 P 50INV -1.000000000 P 50IPCSI	-1.000000000 P 50CCL8A 1.000000000 L 50TLR6	1.000000000 L 50TSML
-1.000100100 P 205CAC4P 1.000100010 P 405CA04P -1.000100000 P 405CA04P	-1.00000000 P 2055804P 1.000000000 P 4055802P -1.000000000 P 6055804P						-8.500000000 P 50CCIM -7.300700000 P 50TIC4 -1.000300000 P 50DRJT 1.0003300000 P 50DRJT	-1.000000000 P 50CALLC. -1.00000000 P 50CDL8A	-1.0003030300 P 50CASLC
-1.)U(000000 P 105CA04P 1.000000000 P 405CA04P -1.000000000 P 505CA04P 1.000000000 L 435CCC	-1.000000000 P 1056804P 1.000000000 P 405681P -1.0000000000 P 5056804P 1.0000000000 P 40V68C	1.000000000 L 4050AC 1.000000000 L 4050BC	4 0000000.	1.000000000 P 40048C 1.000000000 P 401A6C	1.00000000 P \$01A7C 1.00000000 P \$01A8C	1.006600000 P 40MISC	-9.000300000 P 50CBIN -6.90000000 P 50TMC4 005450000 P 501A8 092000000 P 505CXX	-1.000000000 P \$UCALHC -1.000000000 P \$0CCLHC	-1.00100000 P 50CASHC
14 216 -1	Eq 228 -1.40000000 P 40568 0.000000000 1.00000000 P 405686P 0.000000000 1.0000000 P 4056805P Eq 229 -1.00000000 P 40V60 0.000000000	E0 232 -1.00000000 P 4050A 0.300000000 0.3000000000 E0 231 -1.000000000 P 40508 0.000000000 E0 232 -1.000000000 P 40400	4 000000001.1-	E4 234 -1.06~000000 P 406K8 0.000000000 0.000000000 E4 235 -1.60000000 P 401A6 0.000000000 0.00000000	E0 236 -1.00000000 P 401A7 0.000000000 0.000000000 E0 237 -1.00000000 P 401A8 0.000000000	EQ 236 -1.66600000 P 40MIS 0.00000006 0.00000060	EQ 239 -5.2500000U L 56CAIN 0.00000000 -6.30000000 P 50N6FA 0.00000000C -10.80000000 P 508TU -30000000 X 502PREM -1.00000000 P 507ACST	EQ 246 -1.00000000 P 500484 6.00000000 -1.000000000000000000000000000	EQ 241 -1.000300.0 P 5004564
402 CAJ RMS LUI RMS UPI AODULIN RMS LUI	•	405040 RHS L01 RHS U21 405080 RHS L01 RHS U21 40V R00	ADCKAD RHS LOI RHS LOI RHS LOI RHS LOI RHS UP	40CKBD 8H5 LU1 8h5 UP1 401A60 8H5 LU1 8H5 LU1 8H5 UP1	401 A70 RHS LG3 RHS LP3 401 A60 RHS L01 RHS L01 RHS L01 RHS UP3	40MISO RHS LU:	SUDEJ RHS LUE RHS UPE	DOLKG RHS LUI RHS UPJ	14505

-1.60000000 P 50CALLC	-1.00000000 P 50CCLHC	.014000000 P	P 50C0L8	•004000000 P 5005	.015000000 P 50CCL8A .015000000 P 50CASBA -1.000000000 P 50C3P	.003100000 P 50CCL8A .010000000 P 50CAS8A -1.000000000 P 50C6P	.009600000 P 50CCLBA .037000060 P 50CA5BA	•163000000 P 50CCLBA •045000000 P 50CASBA •300000000 L 50DLHC2	.316000000 P 50CCLBA .105000000 P 50CASBA 400000000 L 500LHC2	.062400000 P 50CCLBA .022000000 P 50CASBA 150000000 L 50DLHC2	.062500000 P 5056LBA .023000000 P 505A5BA 150000000 L 500LHC2	1.00000000 P 5040A
-1.00000000 P 50CALHC -1.000000000 P 50CASLC	-1.00000000 P 50CCLLC	.014000000 6 5	014700000 P 50CGLHC 014700000 P 50CASLC 011700000 P 50CALHC 015200000 P 50CGLHC	.01000000 P 5	 015000000 P 50CALLC 015300900 P 50CDLBA 027100000 L 500LHC2 	 005500000 P 50CALLC 010000000 P 50C0L8A 035000000 L 500LHC2 	 006400000 P 50CALLC 0096000000 P 50C0LBA 1.0000000000 P 50NAP 	 133200000 P 50CALLC 114000000 P 50C0LBA 300000000 P 500LHC1 	.044200000 P 50CALLC .316000000 P 50C0LBA 400000000 P 50DLHC1	 133200000 P 50CALLC 062400000 P 50C0LBA 150000000 P 500LHC1 	 133200000 P 50CALLC 041600000 P 50C0LBA 150000000 P 50DLHC1 	1.000000000 P 504CA
-1.00000000 P 50CALBA -1.000000000 P 50CASHC	•336000000 P 50CCLB	.00000000 P 5	01400000 P 50CCLLC 01720000 P 50CASHC 01500000 P 50CALBA 01500000 P 50CCLLC	4 0000009400.	.015000000 P 50CALHC .015000000 P 50CCLHC .0123000000 P 50CALHC	.010000000 P 50CALHC .004300000 P 50CCLHC .010300030 P 50CASLC	.036400000 P 56CALHC .00500000 P 50CCLHC .037800000 P 50CASLC	 1646600000 P 50CALHC 181100000 P 50CALHC 058600000 P 50CASLC 	.055500000 P 50CALHC .060400000 P 50CCLHC .023100000 P 50CALHC -1.000000000 X 502PREM	•166600000 P 50CALHC •1811400000 P 50CCLHC •05000400 P 50CASLC	 195600000 P 50CALHC 27900000 P 50CCLHC 056600000 P 50CASLC 1.0000000000 X 50ZPREM 	1.JOC 000000 P 504AA
1.6663566394 L 20641N -1.663564662 P 2064584 3.664496496 P 20681N	10005 4 00000000°.	00 P 5	00 00 00 00	P 50CCLL	.615006000 P 5UCALBA 015000060 P 50CCLLC .616430600 P 50CASHC	.009100053 P 50CALBA .0619u6u60 P 50CCLLC .021u00000 P 50CASHC	.03900000 P 50CALBA .005300000 P 50CCLLC .00300003 P 50CASHC	 135560000 P 50CALBA 154000600 P 50CCLLC 07390000 P 50CASHC 1.6030000 P 504AA 	 315000000 P 50CALBA 51300000 P 50CCLLC 626600000 P 50CASHC -1.000000000 P 5048A 	.c62400000 P 50CALBA .154360000 P 50CCLLC .c6760000 P 50CASMC -1.00000000 P 504CA	.041500000 P 50CALBA .154060000 P 50CCLLC .0799060JU P 50CASMC -1.660000000 P 5045A	1.66-9-0000 P 5648A -1.600000 P 5676AS
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.033660000 P 50CCL8A .022400000 P 50CAS8A	 071400000 P 50CCL8A 051800000 P 50CAS8A 1.00000000 P 50588X 	.059200000 P 50CCLBA .120000000 P 506A5BA .974000000 L 500LHC2 ~.60000000 P 505BBX	.0544300000 P 50CCLBA .118700000 P 50CASBA 005000000 P 50DSHTA	.010200060 P 50CCLBA .010300000 P 50CASHC	.072800000 P 50CCL88 .167000000 P 50CA588	.072800000 P 50CCL8A .16700000 P 50CL8A 022000000 P 50DLHT1	.020000000 P 50CCLBA .079800000 P 50CASBA	.002200000 P 50CASLC		-1.000000000 P 50CKC	-001400000 P 50CCL8A -1.000000000 P 50146	-002900000 P 50CCL8A -1.000000000 P 50147	.0022600000 P 50168 -1.000000000 P 50148	.005000000 P 50CASLC	- 47*ANCACO P 50CCLAA
.022400000 P 50CALLC .022400000 P 50CDLBA -1.00000300 P 565AA	.069400000 P 50CALLC .065600000 P 50C0LBA -1.000300000 P 50588	<pre>.274200000 P 50CALLC .095100300 P 50C0LBA 1.2353300000 P 50DLHC1 1.000300000 P 505CXX</pre>	.036810700 P 50CALLC .055200000 P 50CDL8A -1.00000000 P 500LMT1 400000000 P 505BBX	.010200000 P 50CALLC .010300000 P 50CASBA	.072900000 P 50CALLC .072900000 P 50C0L8A -1.000000000 P 5050A	•072800000 P 50CALLC •072800000 P 50CDLBA ••458000000 P 50DLHC1	.020000000 P 50CALLC .020000000 P 50C0L8A -1.00000000 P 50VRD	002700000 P 56CASHC		•016200000 P 50CCLHC	.001200000 P 50CALLC .001370000 P 50CDL8A	.002900000 P 56CALLC .002900000 P 50CDLBA	.002600000 P 50CALLC .003500000 P 50CDLBA	.014400000 P 50CASHC	
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<pre>.case0.cc.v P %.CALBA .c2%;cc.vv P %0.ccLLC .c2750cu30 P 56CASHC</pre>	 (7140000 P 500AL#A (0440000 P 500LLC (0490000 P 500AKHC 	.cce8800000 P 50CALBA .2124000000 P 50CCLLC .120000000 P 50CASHC 1.0000000 P 50DLMTL	.055260000 P 50CALBA .036602000 P 50CCLLC .C74560060 P 50CASHC -1.60600000 P 50568	.010200000 P 500ALBA .010200000 P 500CLLC .005600000 P 500ALC	.C7280CCJC P 50CALBA .G728U0600 P 50CCLLC .14750U060 P 50CASHC	.672800000 ; 500AL8A .672800000 P 500CLLC .147500000 P 500ASHC -1.00000000 P 50508	.C2UJU0000 P 50CALBA .C2CUDCOUO P 50CCLLC .C798COUOO P 50CASHC	•€01400000.P >00ALHC −1.¢000000000000000000000000000000000000	.LISSOUGUE P SUCDLBA	.C.06500040 P 500048A	.CJ120C0J0 P 50CALBA .LU120C0J0 P 50CCLLC	.002900000 P 50C4L6A .002900000 P 50CCLLC	.Cu260Cu0C P 50CCLLC .Cu2560cu0C P 50CCLLC	-1.00000000 P -004188	
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		-1.00000000 P 5CT6AS	1.00000000 P 5005HTA	EQ 262 0.00000000 0.0000000	500 5645 RHS LOI RHS UPI
		-1.00000000 P 4076AS	1.000000000 P 4005HTA	EQ 281 0.00000000 0.0000000	40056A5 RF5 LJ1 RH5 UP1
		-1.000006000 P 3076AS	1.CG0000000 P 3005HTA	EQ 260 6.030000000 0.00000000	30056AS RHS LQI RHS UP1
		-1.00000000 P 20TGAS	1.0000000 P 2JD5HTA	EQ 279 0.00000000 0.00000000	2005645 RHS L01 RHS UP1
		-1.00000000 P 1076AS	1.00000000 P 1005HTA	EQ 278 0.00000000 0.03000000	1005645
-4000000000 P 500HTA -1.000000000 P 50THV 2.000000000 X 50TFP04	E0414106 4 000000000°C NTWS05 4 00000000°C 11H1005 4 0000000°C	.100000000 L 500LHC2 4.000000000 P 50LR6N 4.000000000 X 50TPIP02	3.800000000 P 500LHC1 1.134000000 P 5005H7C 5.00000000 X 501P1P01	EQ 277 0.003003030 0.00020000	SOLAVR RHS LOI RMS UP 1
.096700000 P 50CALLC .235900000 P 50C0LBA 0382000000 P 500LHCL .006000000 P 50D5HTC	.125900000 P 50CALHC .144800000 P 50CCLHC .043700000 P 50CASLC .013200000 P 50DSHTA	.215100030 P 50CALBA .105400000 P 50CCLLC .356300030 P 50CASHC .012500300 P 500LHT1	 *235904000 P 3400484 *219460340 P 5000484 *043700300 P 5004844 *55700400 P 5004402 *1.60000000 P 500490 	£9 0.000000000 0.00000000 0.000000000	500PCR RHS LUI RHS UP1
9.000000000 / 50CALLC 5.00000000 / 50C0L8A .800000000 / 50CLHAL -1.000000000 / 50LHAL	5.000300000 P 50CALMC 5.0003300000 P 50CCLMC 5.000300000 P 50CASLC 6.00000000 P 500SMTC	5.306360300 P 5664LBA 5.006600030 P 5066LLC 5.306669900 P 506ASHC 600060000 P 5005HTA	5.000000000 P 3000184 5.00030000 P 9000148 5.000300000 P 5004884 5.00000000 P 5004884	E4 275 0.030003000 0.0330000	501.484 845 101 845 UP 6
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	00 P 205C805M 10 P 405C805P 10 P 505C801P 10 P 505C803P 10 L 505C803P	0 P 30V6005M	0 P 3050A05N	00 P 3050805M									0 L F044A 0 L F054A 0 P F050A 0 P F016KA 0 P F01AC 0 P F01AC	0 P 10C3P0FP 0 P 30C3P0FP
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JUSCAL	1000 100 1000 1	SOVGDUFM	5050ACFM 5050ACFM 5050AC	50508 505080FM 50508C	SOVRO	SJCKA	5 0 C K B	SOCKC	5 01 46	26147	50148	SIMOS	F0C3F F040a F040a F0508 F0508 F01ad F01ad F01ad	FucaP 2003PUrM
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Fu5DLTM Rh5 LJ+ Rh5 U2+	F05CdD RMS L31 RMS U21	" F05DAD RHS L01 RHS UP1	FOSCBO RHS LOI	F0V60D R45 L01 R45 UP1	- FOVRDD RHS LÚI RHS UPI	FOCKAD RHS LUI RHS UPI	FOCKBD RHS LU1 RHS UP1	FOCKCD RHS LU1 RHS UP1	FOIA6D RHS LD1 RHS UP1	F01A7D RHS LU RHS UP1	F01A8D Rhs LJ: RhS UP:	FONISD RHS LD: RHS UP:	10PCAP02 RH5 L01 RH5 U/1	10PCAPC3 RHS LU1 RHS U21	JCPCAP)4

P 10%AP05P P 1040405P P 105C805P	P 104406P P 104046F P 1056806F	P 2064P01P P 2046401P P 2056401P	P 2006P03P P 2040403P P 2090403P	P 20NAP04P P 2040A04P P 2056804P	P 2014P05P P 2040A05P P 205C805P	P 20NAPOFP P 2040A0FP P 205C80FP	P 3064P01P P 3046A01P P 3056A01P	P 3054P02P P 3046402P P 3056402P	P 30NAP04P P 304DA04P P 305C804P	P 30NAP05P P 304DA05P P 305CB05P	P 30NAPOFP P 304DAOFP P 305CBOFP	P 40NAP01P P 405C801P	P 40MAP02P P 4040402P P 405CB02P	P 40NAP03P P 4040A03P P 405C803P
1.000000000 1.0000000000 1.000000000	1.000000000 1.000000000 1.000000000	1.000000000 1.0000000000 1.0000000000	1.000000000 1.000000000 1.000000000	1.000000000 1.000000000 1.000000000	1.00000000 1.000000000 1.000000000	1.00000000 1.000000000 1.000000000	1.00000000 1.000000000 1.000000000	1.00000000 1.000000000 1.0000000000	1.000000000 1.000000000 1.000000000	1.00000000 1.000000000 1.60000000	1.000000000 1.000000000 1.000000000	1.00000000 1.000000000 1.000000000	1.000000000 1.000000000 1.000000000	1.000000000 1.000000000 1.000000000
9000 P 10C4P05P 0300 P 104CA05P 0000 P 105CA05P	30000 P 1054PUFP 00000 P 1056A0FP 00000 P 1056A0FP	0000 P 20C3P01P 00000 P 2048AC1P 00000 P 2058801P	0000 P 2053P03P 0000 P 2048A03P 0000 P 205863P	00000 P 2064P04P 330000 P 2046A04P 00000 P 2056A04P	0000 P 2064P05P 0000 P 2046A05P 0000 P 2056A05P	00000 P 2054P0FP 00000 P 2045A0FP 00000 P 2055A0FP	10000 P 3053P01P 10000 P 3048A01P 10000 P 3058801P	00000 P 30C3P02P 00000 P 304BA02P 00000 P 305B802P	0000 P 3054P04P 0000 P 3046A04P 03000 P 3056A04P	00000 P 3064P05P 00000 ° 3046A05P 00000 P 3056A05P	00000 P 3064P0FP 00000 P 3046A0FP 00000 P 3056A0FP	00000 P 40C4P01P 000000 P 404CA01P 000000 P 405CA01P	00000 P 40C4P02P 00000 P 404CA02P 00000 P 405CA02P	00110100 P 4064P03P 00000000 P 404403P 00100000 P 4056403P
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1 P 1058805 P P 1048AU5 P P 1058805	0 P 1003P0F	P 20%P1P0 P 20%AAG1 P 205AA01	P 20NPIP6 P 204AA03 P 205AA03	0 P 20C3PU4 0 P 2048AU4 0 P 20588C4	0 P 20C3P05 0 P 2048A05 0 P 2058805	0 P 20C3P0FP 0 P 2048A0FP 0 P 205880FP	0 P 30NPIP0 0 P 304AA01 0 P 305AA01	0 4 307P1P02 U P 364AA62P 0 P 365AA62P	0 P 30C3P04 0 P 3048A04 0 P 3058804	U P 30C3P05 0 P 3048A05 0 P 3058845	P 30C3PCF P 305880F P 305880F	P 40C3P01 P 4048AL1 P 4058861	0 P 40C3P02 0 P 404BA02 0 P 405BB02	P 40C3P03 P 4048A03 P 4058803
1.33000000000 1.35000000000	1.300000000 1.300000000 1.300000000	-1.00000000 1.00000000 1.00000000	-1.00000000 1.000000000 1.000000000	00000000°1 100000000°1 100000000°1	1.0000000000 1.000000000000000000000000	1 • 00000000000 1 • 0000000000 1 • 0000000000	-1.00000000 1.3000000000 1.0000000000	-1.00000000 1.000000000 1.000000000	1.00000000 1.00000000 1.00000000	1.000000000 1.000000000 1.000000000	1.000000000 1.00000000 1.00000000	1.00000000 1.000000000 1.000000000	1.0060000000 1.0000000000000000000000000	1.000000000 1.000000000 1.0000000000
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<pre>% * * * * * * * * * * * * * * * * * * *</pre>	- 1 - 600000000 - 1 - 000000000 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	-1.00000000 1.000000000 1.00000000 1.00000000	-1.00000000 1.000000000 1.000000000 1.00000000	-1.00000000 1.000000000 1.000000000	-1.60000000 1.60000500 1.600000000	-1.00000000 1.000000000 1.000000000	-1-00000000 1.00000000 1.000000000 1.00000000	1 00000000000 1 0000000000 1 0000000000	-1.000000000 1.000000000 1.00000000	-1.466300444 1.600000066 1.00000000	-1.000000000 1.0000000000000000000000000	-1.000000000 1.000000000 1.00000000	-1.000000000 1.0000000000 1.00000000000	-1.0000000000 1.000000000 1.000000000
ະບີ341 ບູດບ່ວຍບ່ວຍເບີ ບູນເ ບັດດວຍເຜັ	к. 343094350 6.063960350	E 0 0,0000000 0,000000 0,000000	EQ 344 J. 0000000 0. 0000000	EU 345 0.000300000 0.423003240	E U 346 Ú.000000000 0.00000000	EQ 347 0.00000000 0.00000000	EQ 346 0.0000000 0.0000000	E G 349 0.00300000 0.000000	EQ 0.000000000 0.00000000000000000000000	E0 351 0.0000000000 0.000000000	E 9 352 0.000000000000000	E4 835 0.00000000 0.00000000	EQ 354 0.000000000 0.00000000	EQ 355 U. FCJUD00CO C. JUJUD0CCL
LUP CAPUD RH5 EUC RH5 U28	LUPCAPOF RMS LUS RMS UPS	20PCAPUL RHS LOS RHS UPS	ZOPCAPO3 RHS LJ: RHS UP3	20PCAP04 RMS LJ1 RMS UP1	20PCAP05 RM5 LU1 RM5 UP1	L ZOPCAPJF R hs LOP R hs UP =	BOPCAPUL RHS LUS RHS UPS	30PCAP02 RHS LO: RHS UP1	30P CAP 04 MMS LO1 RMS UP1	30PCAP0> RHS LUE RHS UPE	30P CAPUF RHS LU RHS UP 1	40PCAP31 RHS L3 RMS UP3	40PCAP02 RMS LJ1 RMS UP1	40PCAP03 RHS LD1 RHS UP1

1.000000000 P 40MAPOFP 1.600000000 P 4040A0FP 1.000000000 P 405680FP	1.000000000 P 50NAP01P 1.000000000 P 5040A01P 1.000000000 P 5050801P	1.60000000 P 50MAP02P 1.000000000 P 5040A02P 1.000000000 P 5056802P	1.00000000 P 50MAP03P 1.000000000 P 5040A03P 1.000000000 P 5056803P	1.000300000 P 50NAP04P 1.00000000 P 5040A04P 1.00000000 P 5050804P	1.000000000 P 50MAP0FP 1.000000000 P 5040A0FP 1.000000000 P 505CB0FP	1.000000000 P FOMAPOIP 1.000000000 P F040A01P 1.000000000 P F05CA02P	1.000000000 P FOMAP02P 1.000000000 P F040A02P	1.00000000 P FONAP03P 1.00000000 P F04DA03P	1.000000000 P FOMAP04P 1.00000000 P FOSAA04P	1.000000000 P FONAP05P 1.000000000 P F040405P 1.000000000 P F05C805P	1.000000000 P 100AP02M 1.000000000 P 1040A02M 1.000000000 P 1050B02M	1.000000000 P 10MAP03M 1.600000000 P 104DA03M 1.000000000 P 105C803M	1.000000000 P 100AP05M 1.000000000 P 1040A05M 1.000000000 P 1050B05M	1.000000000 P 10NAPOFM 1.ccuucudo P 1040A0FM 1.uu000000 P 105CB0FM
1.000300000 P 40C4P0FP 1.000303030 P 405CA0FP 1.000303030 P 405CA0FP	1.000000000 P 5064P01P 1.000000000 P 5046A01P 1.0000000000 P 5056A01P	L.0003330000 P 5054P02P L.0000030000 P 504CA02P L.000000000 P 505CA02P	1.000300000 P 5064P03P 1.000300000 P 5046403P 1.000000000 P 5056403P	1.000000000 P 5054P04P 1.0007303030 P 5645404P 1.0003030300 P 5655404P	1.000000000 P 5054P0FP 1.000300000 P 5045A0FP 1.000300000 P 5055A0FP	1.000000000 P F 05401P 1.00000000 P F045401P 1.000000000 P F055401P	1.000300000 P F0C4P02P 1.000300000 P F04C402P 1.000000000 P F05C802P	1.000300030 P F0C4P03P 1.000000000 P F04C403P 1.000300000 P F05C803P	1.000000000 P F0C4P04P 1.000000000 P F640A04P 1.000000000 P F656A04P	1.0003000000 P F0C4P05P 1.000300030 P F04CA05P 1.000000000 P F05CA05P	1.000300000 P 1064P02M 1.000300000 P 1046402M 1.000000000 P 1056402M 1.000000000 P 1046002M	1.00000000 P 1004003M 1.000000000 P 106603M 1.000000000 P 1056403M 1.000000000 P 1076003M	1.000070000 P 1454058 1.00000000 P 14564058 1.000000000 P 14564058 1.000000000 P 1440058	1.00000000 P 100406M 1.00000000 P 1040A0FM 1.0000000000 P 1040A0FM
1.00000000 P 40C3P0FP 1.00000000 P 4048ACFP 1.0000000 P 405880FP	1.300000330 P 50C3P01P 1.300000000 P 5048A01P 1.000000000 P 50588U1P	1.000000000 P 50C3PC2P 1.00000000 P 5048A02P 1.000000000 P 5058802P	1.000000000 P 50C3P03P 1.000000000 P 5048A63P 1.000000000 P 5058803P	1.000000000 P 5003P04P 1.000000000 P 504BAC4P 1.000000000 P 505BBC4P	1.000000000 P 50C3P0FP 1.000000000 P 504BACFP 1.000000000 P 505BB0FP	1.000000000 P F0C3P01P 1.000000000 P F048421P 1.000000000 P F058861P 1.000000000 P F056801P	1.00000000 P FGC3P02P 1.000000000 P F04BA62P 1.000000000 P F05BB02P	1.300000000 P F0C3PU3P 1.00000000 P F048A63P 1.000000000 P F058803P	1.300000000 P F0C3P04P 1.300000000 P F04BA04P 1.000000000 P F05CA04P	1.000000000 P F0C3P05P 1.0000000000 P F04BA05P 1.000000000 P F05B805P	1.000000000 P 10C3PC2M 1.000000000 P 104BAA2M 1.0000000000 P 105BBC2M 1.000000000 P 105BBC2M	1.000000000 P 105963M 1.000000000 P 1058AA3M 1.000000000 P 1058BA3M 1.000000000 P 1058BA3M	1.07000000 P 1053P05M 1.17000000 P 1058A5M 1.07000000 P 1058B05M 1.07000000 P 1050B05M	1.00000000 P 1009PCFM 1.000000000 P 1064ACFM 1.000000000 P 1054B0FM
-1.«.(.)0000) x 491P1Pur 1.«.(.)0000) 494ALFP 1.«.(.)0) 435AALFP	10414104 X 60000000000000000000000000000000000	-1.00000000 x 50171702 1.00000000 f 504A4627 1.00000000 f 505AA422	-1.00000000 X 50TPLP.3 1.000000000 P 505AA03P 1.00000001 P 505AA03P	-1.000000000 X 50TP1P04 1.0JUCC00000 P 504A444 1.0CU000000 P 505AA04P	-1.0vc000033 L 50TP1P0F 1.cc000050 P 505AA0FP 1.cc0300000 P 505AA0FP	-1.0060300300 X FOTP1P01 1.000000000 P F54AA01P 1.000000300 P F05AA01P 1.000000300 P F05AA01P	-1.60000000 x f0[P]PU2 1.000360000 p f04AA02P 1.000300030 p f05AA32P	-1.00300000 X FOTPIPU3 1.00000000 P F04A43P 1.0000000.P F05A463P	-1.6C0300600 X FOTFIP05 1.006006636 P FU4AA44P 1.6C13300000 P FU5BB04P	-1.0003464244 x FJTFIF45 1.0003030 P F04AA05P 1.0003330 P F05AA05P	-1.«.UOUUUUUC P 10TMAKO2 1.«CCOCUUUV P 144A462M 1.«CCOOUJOJ P 1C>AA62M 1.«CUUOCOUUV P 105A42M	-1.600000000 P 101MAKG3 1	-1.400000000 P 101MARC5 1.44 04(1.4 P 144A42M 1.4(1000000 P 101A402M 1.4(1000000 P 101A402M	-1
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40PCAPCF RHS LUI RHS UPI	SOPCAPUL Rms L01 Rms UP1	50PCAPO2 RHS LJ: RHS UP:	SUP CAPO3 RHS LO3 RHS UP 1	50P CAP 04 RHS L01 RHS UP 1	SOPCAPOF RHS LOI RHS UPI	FOPCAPOL RHS LOU RHS UP1	FOPCAPO2 RHS LO1 RHS UP1	FOPCAP33 RHS LU1 RHS U21	FOPCAPO4 RMS LO: RMS UP:	FOPCAPOS RMS LO: RMS UP:	JONCAPO2 FHS LOI RHS UPI	LUM CAPO3 RMS LO1 RMS UP1	104CAP35 RH5 L31 RFS L21	JumCaruf Rhs Li Rhs Ur

ZONAPOIM ZO5DAOIM ZO5CBOIM	20 NA P03N 20 40 A03N 20 50 B03N	2014 P05 N 2040 A05 N 2050 805 N	20NAPOFN 2040A0FN 2050B0FN	3044 PO1M 3040401M 3056801M 3056801M	30MAP02N 3040A02N 3056902N	P 30NAP05M P 3040A05M P 305CB05M	P 30NAP0FM P 3040A0FM P 305C80FM	5044P01M 5040401M 5050801M	50MAPO2N 505DA02N 505C802M	50NAP03N 5040A03N 5056803N	SONAPOFN 504DAOFN 505CBOFN	FOMAPOIN F040A01N F05C801N
1.000000000 P 1.000000000 P 1.00000000 P	1.00000000 P 1.00000000 P 1.00000000 P	1.000000000 P 1.000000000 P 1.000000000 P	1.000000000 P 1.000000000 P 1.000000000 P	1.00000000 P 1.000000000 P 1.0000000000 P 1.000000000000000000000000000000000000	1.000000000 P 1.000000000 P 1.000000000 P	1.000000000 1.600000000 1.000000000	1.000000000 1.000000000 1.000000000	1.000000000 P 1.000000000 P 1.000000000 P	1.000000000 P	1.000000000 P 1.000000000 P 1.000000000 P	1.00000000 P	1.000000000 P
P 2004P01M P 2046A01M P 2056A01M P 2056A01M P 20V6001M	P 20C4P03M P 204CAC3M P 205CA03M P 20VG003M	P 20C4P65M P 204C405M P 205C405M P 20V6065M	P 20C4P0FM P 204CA0FM P 205CA0FM P 20V600FM	P 30C4P01M P 304CA01M P 305CA01M P 30V6001M	P 30C4P02M P 304CA02M P 305CA02M P 30V6002M	P 30C4P65M P 364CA05M P 305CA05M P 30V6005M	P 30C4P0FM P 304CA0FM P 305CA0FM P 305CA0FM	P 50C4P01M P 504CA01M P 505CA01M	P 50C4P02M P 504CA02M P 505CA02M	P 50C4P03M P 504CA03M P 505CA03M	P 50C4P0FM P 504CA0FM P 505CA0FM P 50V600FM	P FCC4PG1M P F04CAU1M P F05CA01M
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P 20C3PLIM P 2048AC4M P 2058801M P 2050801M	P 20C3PC3A P 2048AC3M P 20588C3M P 2050803M	P 20C3P05N P 2048A05M P 2058805M P 2050805M	P 20C3P6FN P 2048A0FN P 205886FM P 205080FM	P 30C3P01M P 3048A01M P 3058801M P 3050801M	P 30C3P02M P 3048A02M P 3058802M P 3050802M	P 30C3PC5M P 3C48A05M P 3058805M P 3050805M	P 3CC3PCFM P 3048A0FM P 305880FM P 305880FM	P 50C3PC1M P 5048A01M P 5058801M P 5050801M	P 50C3P02M P 5048AU2M P 5058862M	P 50C3PC3M P 5048A03M P 5058803M P 5050803M	P 50C3P0FM P 5048A0FM P 505880FM P 505080FM	P FOC3PU1M P F048AC1M P F0588C1M
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2714464 244461M 2050461M 2050461M	207 MAKU3 204AA U3N 2 v5 AA J3M 2050A G3M	2 J T MARUS 2 U 6 AAG5M 2 2 5 AA 0 5 M 2 2 5 0 A 0 5 M	20TMAKJF 2364A0FM 235AAGFM 205AAGFM 205DACFM	30TMARQ1 306AA01M 305AAu1M 305DAúim	30 T MA K 02 30 4 A 4 0 2 M 30 5 A 4 6 2 M 30 5 D 4 0 2 M	30TMARU5 304AAU5M 305AA05M 305DA05M	301MAROF 364AAUFM 305AAĉfm 305DAĜFN	501MAR01 504AA01M 505AA41M 205DAG1M	50TMANU2 504AAU2M 505AAU2M	501 MA R03 504AA03M 505AAU3M 5050AU3M	501 MA KOF 504 A A UFM 505 A A UFM 505 D A OFM	FOTMARUL Fogmauln Fogmauln
-1	-1.00000000 % 1.00000000 % 1.00000000 % 1.00000000 %	-1	-1.660006000 P 1.660006000 P 1.0060000 P 1.600000000 P	-1.00000000 P 1.000000000 P 1.00000000 P	-1.000000000 P 1.00000000 P 1.0000000 P 1.0000000 P	-1.00000000 P 1.00000000 P 1.00000000 P 1.00000000 P	-1.00000000 P 1.00000000 P 1.00000000 P 1.00000000 P	-1. (C (0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-1.00000000 P 1.000000000 P		-1.00000000 P 1.00000000 P 1.00000000 P 1.000000000 P 1.000000000 P	-1.0000000 P 1.0000000 P
ξι 372 υ.ούθυθας υ.οσσυμοτι	⊾ч 373 ⊍.000∪⊎30€0 0.000∪⊍30€0	EQ 374 0.600000000 0.00000000	EQ 375 0.0000000 0.0000000	EQ 376 0.003409066 0.0000066	EU 377 0.000000000 0.0000000000000000000000	E 0 378 0.00000000 0.00000000	616 01000000000000000000000000000000000	E a 3 80 0.0030300 66 0.303364664	EU 361 0.030//JJ00 0.000000000	EQ 3E2 0.00000000 0.00000000	E 0 363 C. 00000000 C. 00000000	EQ 344 0300000
20MCAPUL RHS LUI RHS UPE	20HCAP03 RHS LOF RHS UP 8	20NCAP65 RHS LUI RHS UPI RHS UPI	20MCAPOF RMS LUI RMS UPI	30MCAPO1 RHS LU: RHS UP:	30MCAP02 - RHS L01 RHS UP1	30ACAP05 RHS 401 RHS UP1	30MCAPOF RMS LJI RMS UPI	SONCAPGI RHS LOT RHS UPT	50MCAPO2 Rhs LJ: Rhs UPI	SONCAPO3 RNS LOI RNS UPI	SONCAPOF RHS LDI RHS UP I	FONCAPUL RHS LOB RHS UPS

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FUNCAPEZ KHS LJ1 RHS UP1	202 EJ 0.00101010 0.0010010 0.0000000	-1.(LUGULUU P FUTMARUZ 1.(LUDCCGUU P FUSARUZM 1.(LUJCUCJU P FUSARUZM 1.(LUCCJUUJU P FUSDAUZM	L.JJC400040 P FCC3P42M 1.4000440040 P F048A62M 1.4000000000 P F058802M 1.400000000 P F058802M		1.000000000 P	F 064P 02 H F 446 4 6 2 H F 056 4 0 2 M	1.00000000 P F0NAP02N 1.00000000 P F040A02N 1.00000000 P F050802M
FONCAPU3 RFS Lůt RHS UP t	1 0 3 6 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-1.600306.JU P FUTMAKU3 1.6000300000 P FU4AA03M 1.00000000 P FU5AAU3M 1.0001300000 P FU5DA03M	I.«CUODOOUGO P FCC3PC3M I.«O0COOCOO P F04BA03M I.«O0000000 P F05BC3M I.«O0CG003U P F05DBC3M		1.000000000000000000000000000000000000	F0C4P03N F04C403N F05C403N	1.000000000 F FOMAPO3M 1.000000000 P F040A03M 1.000000000 P F05C803M
FONCAPOS RMS LUI RMS UPI	E 0 387 0.60000000 0.90000000	-1.600300000 P F0TMARG5 1.000000000 P F04A65M 1.600000000 P FU5A465M 1.600000000 P F050A65M	1.000000000 P F0C3P05M 1.000000000 P F048455M 1.000000000 P F048805M 1.00000000 P F058805M 1.00000000 P F050805M		1.000000000 P 1.000000000 P 1.000000000 P	F 0 C 4 P 0 5 N F 0 4 C 4 0 5 N F 0 5 C 4 0 5 N	1.000000000 P F0NAP05H 1.000000000 P F040A05H 1.000000000 P F05C805H
10PCOST RMS LOI RMS UP1	EQ 366 0.000307060 0.00360000	30000000 1 JJTP1P02 -9.90000000 X 101P1P05	300000000 P 10NPIP02 -12.00000000 L 10TPIP05		-9.90000000 X	101P1P03 101PCST	58000000 X 10TP1P04
20PC0ST RMS LD1 RMS UP1	ξα 359 6.000000000 0.000000000		270000000 P 20NPIP01 -9.400606030 X 20TPIP05	- 10	990000000 L	201 P I P03 201 P I P0F	990000000 P 20NFIP03 1.000000000 P 20TPCST
30PC0ST RHS LD: RHS UP:	EQ 350 0.000000000 0.00000000	426000000 L 301P1P61 660000000 L 301P1P64	420000000 30NPIP05 -1.000000000 30TPIP05	1	500300000 P	30NPLP62 30TPLP0F	500000000 L 301PLP02 1.000000000 P 301PCST
40P COST R HS LJ1 R HS UP1	EQ 391 0.00000000 0.00000000	-4.901000000 × 40191905 -12.00000000 × 40191905	580000000 L 40TPLP02 1.00000000 P 40TPC5T	1	1 000000009.	401 PI P03	60000000 L 401P1905
SUPCOST RHS LUI RHS UPI	ξυ 392 0.00000000 0.0030023000	-4.90000000 X 50TPIPUL -12.00000000 L 50TPIPOF	-9.900000000 x 50TPLP02 1.000000000 P 50TPC5T	1	• 05000000 K	501 PL P03	800000000 X 50191P04
FOP COST RMS L11 RMS UP1	£93 0.033500000 0.000000000	-1.16006300 x FOTPIPOL 6660306000 x FUTPIPOS	750000000 x FOTP160	0°-1	X 00000006°	F01P1P03	50000000 h fotptp04
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ZOMCOST RHS LUI RHS UPI	E 4 355 0.0000000 0.0000000	-9.56030000 P 2JIMAROL 1.000300000 P 201MC5T	634004040 P 201MAR0	6	• • • • • • • • • • • • • • • • • • • •	20TMAR05	-12.00000000 P 20TMAROF
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Appendix C

REFINING INDUSTRY MODEL VALIDATION

Appendix C

REFINING INDUSTRY MODEL VALIDATION

C.1 Background and Overview

From a statistical analysis of U.S. refining industry capacity data (see Appendix D), the capacity limits shown in Table C-1 were developed for each PAD for large, medium, and small refinery size classifications.

Table C-1

REFINING CAPACITY LIMITS--1974 VALIDATION CASE (Thousands of Barrels per Calendar Day)

		PAD	Distric	t		
	I	<u> II </u>	III	IV	V	<u>U.S. Total</u>
Small refineries *						
Lower limit	180	700	700	420	500	
Upper limit	190	890	835	550	630	
1974 reported ^T	211	888	832	547	627	3,102
Large refineries [‡]						
Lower limit	1,200	2,500	4,520		1,400	
Upper limit +	1,300	3,150	6,130		1,850	
1974 reported	1,466	3,142	5,300		1,850	11,712
						14,814

 $*0-50 \times 10^3$ b/d.

Reported stream-day capacities as of 1 January 1975, reported in <u>Oil and Gas Journal</u> (7 April 1975).

More than 50 \times 10³ b/d.

Product requirements were based on those reported in Appendix D. Because the product categories reported in the "Petroleum Statement" do not in all cases correspond to those in the model, it was necessary to allocate as shown in Table C-2. Lower demand limits at the reported values were established for each of the major products in each district. For the validation work, the minor products were left unbounded. Limits were set

Table C-2

ALLOCATION OF BUREAU OF MINES PRODUCT CATEGORIES TO MODEL CATEGORIES

Product	BuMines Category	Industry Model Category*
Liquefied gases	x 🦳	0.77
C3LPG		0.23 X
CLPG		x
Naphtha	х	X
Premium gasoline		0.25 X
Regular gasoline		0.40 x
Low-lead gasoline		0.20 X
Lead-free gasoline		0 15 X
Mogas and avgas	X	
JP-4	Х	X
Jet-A	Х	X
Kerosine	х	
Distillate fuel oil	X	0.332
Diesel		0.6 68X
No. 2 fuel oil		x
Vacuum gas oil		x
Lubricants	x	
Wax	X	
Asphalt	X	
Road oil	х	
Vacuum residual		X
Residual fuel oil	X	0.5
Low-sulfur residual		0.5 X
High-sulfur residual		x
Petrochem feeds	X	0.60
Benzene	\sim	0.25 X
Toluene		0,10 X
Xylenes		05 X
C ₉ aromatics		×
Coke	X	
Low-sulfur coke		x
High-sulfur coke		x
*	d on the f	

Allocations were based on the following sources: Gasoline--"National Petroleum News, Factbook Issue" (May 1975) Distillates--<u>Mineral Industry Surveys</u>, "Fuel Oil Sales, Annual" (1974) Others--SRI estimates. on inter-PAD pipeline capacities at an arbitrary 120 percent of reported 1974 rates (Appendix D) because actual capacities are not readily available in published literature. No minimum utilization requirements were set on either pipeline or marine shipments.

The remaining category of case-specific input data is that of prices of crude oil, natural gas liquids (NGL), and imported products. The prices used in the 1974 validation case are presented in Table C-3. Domestic product prices are not required for operating the refining industry model (RIM) in a cost-minimizing objective mode. Similarly, investment for existing facilities is considered a "sunk cost" and is not included in the validation process.

Detailed comparisons of RIM and BuMines data, by major product, are presented in Tables C-4 to C-6 for each PAD district. Refinery output, interdistrict movements by transportation mode, imports, and district demands are presented. Full output of the RIM validation case follows the comparison tables.

Table C-3

REFINING INDUSTRY MODEL FEEDSTOCK AND IMPORTED PRODUCT PRICES* (Dollars per Barrel)

		PA	D Distri	ct	
	1	2	_3		5
Feedstocks					
Sweet crude	9.65	9.65	9.25	9.25	9.25
Sour crude	9.40	9.40	9.00	9.00	9.00
California blend					8.50
Natural gasoline	8.30	8.30	8.30	8.30	8.30
Isobutane	7.30	7.30	7.30	7.30	7.30
Normal butane	6.90	6.90	6.90	6.90	6.90
Product imports					
C ₃ LPG	8	.19			
C ₄ LPG	9	.03			
Naphtha	14	.15			
Gasoline (no-lead)	15	.83			
JP-4	14	.53			
Jet A	15	.75			
Diesel (No. 2)	14	.32			
No. 2 fuel oil	14	.32			
No. 6 fuel oil (low S)	12	.48			
No. 6 fuel oil (high S)	10	.48			

* Feedstock prices are estimated composite representative 1974 refinery acquisition costs. Product imports are representative 1974 prices FOB Caribbean refinery.

Sources: <u>Platt's Oil Price Handbook and Oil Manual</u>, 1974 prices, McGraw-Hill, New York (1974) Federal Energy Administration, "Monthly Energy Review" (July 1976) Table Cal

Table C-4	0. J. T. TRANSPORTATION SYSTEMS CENTER	N ** 0 Refining industry model - 1974 Validation Casê	GASOLINE BLEND (MBPD)	PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)	1 2 3 4 4 5 U.S. REFINERY DUTPUT 814.5 (700) 2004.4 (1947)2527.0 (260) 256.3 (223) 9A;.1(883) 6582.0(6365)	INTER-PAD HOVEMENTS FRO4	DISTRICT 1 (126) PIPF-LINE (126)	MAQINE	DISTRICT 2 (34) (54)	
	IS GENTER	VALIDATION CASE	RD DU CT	NSE DISTRICTS (PAD)	4 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				(1)	

MOTE: Figures in parentheses are from the Bureau of Mines for 1974.

			~			$\begin{array}{cccccccccccccccccccccccccccccccccccc$			(36)1605.1 (1929) 1490.5 114.6	2160.6 (2160)2249.0(2249)1003.0(1003) 211.U (211)959.0 (959)6582.0 (6582)
			(96)				21 • 1 (12)	(1)	(36	659 °C (959)
	(2)	(14)				(33)	45.U (50)	(1)	(33)	:11.U (211)
	(95)		15.0 15.0			15.C (54) 15.0	(95) 1539.0 (1646) 45.0 (50)	(19)	15.6 (54) 15.0	003.0(1003) 2
(126)		214.6 (259) 214.6	33.0 (14) 30.9			244.6(399) 244.6	(95) 1	(1)	244°6 (399) 244°6	:249.0(2249)1
	(34)	1324.4 (1373) 214.6 (259) 12310.9 214.6 93.5		21 • 1	21.1	1345.5 (1407) 244.6 (399) 1230.9 244.6 114.6	(126)	(176)	1345.5(1407) 244.6 (399) 1230.9 244.6 114.6	2160 . C (2160)2
DISTRICT 1 DISTRICT 1 PIPE-LINE	HARINE District 2 Pipe-Line Harine	DISTRIGT 3 PIPE-LINE Marine	DISTRICT 4 FIDE-LINE Marine	DISTRICT 5 PIPE-LINE	MARINE	TOTAL DOMESTIC RECEIPTS Pipe-Line Marine	DONESTIC SHIPMENTS	FOREIGN IMPORTS/-EXPORTS PIPE-LINE Marine	TOTAL SUPPLY MOVEMENTS PIPE-LINE Marine	DISTRICT DEMANO

JET A JET FUEL SUPPLY DEMAND BALANCE BY PRODUCT SUPPLY DEMAND BALANCE BY PRODUCT PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS a structure of a structure and administration for the properties of a structure and a structure a	REFINING INDUSTR SUPPLY DEMAND BALANCE BY PRODUCT EUM AOMINSTRATION FOR DEFENSE DI 2 177.4(163) 473.6(405) 25.0(16) 24.6 (23) 25.0(16) 24.6	REFINING INDUSTRY MODEL - LANCE BY PRODUCT A FOR DEFENSE DISTRICTS (1 3 4 5 5 6(405) 25.0(16) 224.0(- 1974 VALIDATION CASE 5 (PAD)
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47 93 93	ATTON FOR DEFEN	se District	
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339.0 (266) 339.0		5	5 U.S. 224.0 (170) 947.0 (796)
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TOTAL DUMESTIC RECEIPTS 339.0 (206) 24.6 (23) PIPE-LINE 24.6 (23) MARINE 339.0		ŕı	9 363.6 (313) 24.6 339.0
DOMESTIC SHIPMENTS	363 . 6 (306)	3	0 • 0
FOREIGN TWPORTS/-EXPORTS 79 5 PIPE-LINE MARINE	6		14
TOTAL SUPPLY MOVEMENTS 339.0(345) ⁻ 24.6 (29) PIPE-LINE 339.0 MARINE 339.0	6	n	9 363.6 24.6 339.0

Table C-6

D. D. T. TRANSPORTATION SYSTENS GENTER Véfining Industry Model - 1974 Validation Gase	SUPPLY DEMAND PALANGE BY PKUDUCT (MePD) Petpoleum Anminstration For Defense districts (Pad)	1 2 2 3 3 2 2 3 3 2 2 1 2 2 1 2 2 2 3 2 2 2 2
SECTION 4. 13	MIODLE DISTILLATE BLEND	REFINERY OUTPUT

DISTRICT 1 PIPE-LINE		(32.0)				
PAKING DISTRICT 2 DIPE-LINF	66.4 (3.0) 66.4	0	(15.0)	0.	(1.0)	
DISTRICT 3 DISTRICT 3 PIPE-LINE DISTRICT 4 DISTRICT 4 HARINE DISTRICT 5 PIPE-LINE PIPE-LINE HARINE	866. 2 (731.0 769.1 91.1	966.°2(731.0)147.7 (86.0) 769.1 91.1		(3.	(2.0) 23.3 (19.0) 23.3 53.1 53.1	(0.61)
TOTAL 0945STIC RÉCÉIPTS Pipe-line Marinè	926°6 835°5 91°1	147°7 147°7			76 . 3 76 . 3	1150.7 5 59.6 91.1
ODYESTIC SHIPHENTS		66.4	1031.1	53.1		
FOREIGN IMPORTS/-EXPORTS PIPE-LINE Marine	50.7(257.0) C.5 50.7	0) (1.0)	(15.0)			(7.0) 54.7 0.0 5(.7
TOTAL SUPPLY FOVÉMENTS PIPE-LINE Haptye	377 • 1 875 • 1 141 • 8	147°7 147°7			76 . 3 76 .	1261•3 1659•6 141•8
DISTOTA DEMAND	9661)					

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NOTE: The figures in parentheses are from the Bureau of Mines for 1974_{\circ} .

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126.6 (154) 155.4 (180) 355.8 (362) 34.0 (34) 126.6 (154) 155.4 (180) 355.8 (362) 34.0 (34)
126.6 (154) 155.4 (180) 355.8 (362) 34.0 (34)
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1573.4 (1558) 24.6 (58) 1 1573.4 24.6
1573.4 24.6

NOTE: The figures in parentheses are from the Bureau of Mines for 1974.

C.2 Refining Industry Model: Full Output for 1974 Validation Case

The output tables on the pages that follow cover the matters tabulated below.

Section	Content
Α.	Refinery output, inter-PAD transfers, imports, and demand by product
Β.	Refinery output, inter-PAD transfers, imports, and demand by PAD district
C.	Refinery capacity utilization by PAD district, size, crude type, and conversion severity
D.	Refinery utility, manpower, operating costs, and energy requirements
E.	Summary of refinery input and output options existing in the industry model

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u.s. ------62.7 62.7 PETPOLEUM ADMINSTRATION FOR DEFENSE DISTRIFTS (PAD) REFINING INDUSTRY MODEL - 1974 VALIDATION CASE ഹ 13.5 10 11 D. D. T. TRANSPORTATION SYSTEMS CENTER SUPPLY DEMAND BALANCE BY PROJUCT .+ 1.6 1.5 2 13.4 13.4 2 17.9 17.9 • (MBPD) ---0 8 8 0 0 0 0 19.1 19.1 INTER-PAD MOVEMENTS FRO1.. FOREIGN IMPOFIS/-EXPORIG PIPE-LINE Marine TOTAL DOMESTIC RECEIPTS PIPE-LIME FARINE TOTAL SUPPLY MOVEMENTS PIPE-LINE Marine REFINERY OUTPUT **NOMESTIC SHIPMENTS UTSTRICT DEMAND** DISTRICT 4 PIPE-LINE MARINE DISTRICT 5 DISTRICT 1 PIPE-LINE MAPINE DISTRICT 2 PIPE-LINE MAPINE DISTRICT 3 PIPE-LINE MARINE PIPE-LINE MARINE N SECTION A. 54 LPG

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u.s. 106.2 166.2 PETROLEUM ADMINSTRATION FOP DEFENSE DISTRICTS (PAD) REFINING INDUSTRY MOD'L - 1974 VALIDATION CASE 25.5 25 °5 "). J. T. TPANSPORTATION SYSTEMS CONFIC SUPPLY DEMAND RALANCE BY PRODUCT m 7 د قل 45°2 29.1 29.1 . (HPF0) -INTER-PAD MOVEMENTS FROM .. FOREIGN IMPORTS/-FXPORTS PIPE-LINE Marine TOTAL DOMESTIC RECEIPTS PIPE-LINE PARINE TOTAL SUPPLY MOVEMENTS PIPE-LINL Faring REFINERY OUTPUT DOMESTIC SHIPHENTS **DISTRICT DEMAND** DISTRICT 4 PIPE-LINE Maring DISTRICT 5 PIPE-LINE Marine MARINE DISTRICT 3 FIPE-LINE MARINE DISTRICT 1 PIPE-LINE DISTRICT 2 PIPE-LINE PARINE m SECTION A. NAPHTHA

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PIPE-LINE MARINE	21.1						
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FOREIGH IMPORTS/-EXPORTS PIPE-LINE FARINE							
TOTAL SUPPLY MOVEMENTS	114 · F	4 • 4	15.0			134°C	
PIPE-LINE Marine	114.6	2 ° 2	15.0			19.4 114.6	
NISTRICT DEMAND	363 e r	312.8	7.717	57.3	294 .1	1745.4	

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SECTION A. 4	JP-4 JET FUEL	REFINERY OUTPUT	INTER-PAD HOVEHENTS FROM	PARINE PARINE DISTRICT 2 PIPE-LIFE	DISTRICT 3 DISTRICT 3 PIPE-LINE MARINE	DISTPICE S MARINE DISTPICT 5 PIPE-LINE PARINE	TOTAL ROMESTIC RECEIPTS PIPE-LINE Marine	DAMESTIC SHIPMENTS FOREIGN IMPOPTS/-EXPORTS PIPE-LINE	MARINE Total Supply Movements Pipe-liné Mariné	DISTRICT DEMAND

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		SUPPLY DEM	SUPPLY DEMAND BALANCE	BY PRODUCT		
NIESEL	(U44N)	0 0 0 0 0 0 0 0 0 0 0	U 0 0 0 0 0 0 0 0			
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	PCTP 01	FUN ADMINS	TRATION FOR	PCTPOLFUM ADMINSTRATION FOR DEFENSE DISTPICTS (PAD)	STPICTS (PA	01
		د،		\$		
REFINERY OUTPUT		232. 3	552.1	153.9	113.2	1127.0
INTER-PAD MOVEMENTS FROM						
DISTRICT 1 PIPE-LINE						
MARINE DISTRICT 2 PIPE-LINE						
NAKINE DISTRICI 3 PIPE-LINE	172 . 4 172 . 4	147°7 147°7				
MARINE DISTRICT 4					46.8	
PIPE=LINE MARINE Distote e					, en e	
PIPE-LINE						
TDTAL DOMËSTIC RECEIPTS PIPE-LINE Marinë	172 °4 172 °4	147°7 147°7			46°E 46°B	365.9 366.9
DOMESTIC SHIPMENTS			322.4	4 F . B		
FOREIGN IMPJPTS/-EXPORTS PIPE-LINE HARINE						
TOTAL SUPPLY MOVEMENTS PIPE-LINE	172 • 4 17 2 • 4	147.7			46 e 8 4 6 e 8	36 c.9 366.9
MARINE						
TOTAL DISTRICT DEMANO LIGHT DIESEL Heavy diesel	266°5 134°3 134°0	383.ŭ 192.) 193.u	232.c 116.5 116.6	C • K K C • K K C • F 5	1 bû • î 8 û • ĵ 8 £ • ĵ	127.6 53.0 574.C

	n•	U. J. I. IKANSPORTALION STSTERS USHER	PORTALION S	VSIE45 GUILT		
0101101 No 110	808	REFINING INDUSTRY NUDEL		- 1974 VALINATION CASE	AFICH CASE	
		SUPPLY DEM	SUPPLY DEMAND BALANCE RY PRUBUCT	RY PRUDUCI		
NO. 2 FUEL OIL	(6489)					
	Petro	PETPALEUM ADMINSTRATION FOP DEFENSE DISTRICTS (PAD)	TRATION FOP	Drfense DI	STRICTS (PA	(0)
	1	2		.+. 9 9 9 9 9 9 9 9 9	5 I	U.S.
REFINERY DUTPUT	265.1	566 . 4		47.2	7.1.5	1784.3
INTER-PAD MOVÉMENTS FROM						
DISTRICT 1 PIPE-LINE						
DISTRICT 2	66 . L					
PIPE = LINE Marine	66°4					
DISTRICT 3 PIDE-LINE	687.8 626.7				23.3	
MARINE	91.1				2 2 4	
DISTRICT 4 PIPE+LINE MADINE					5 • 2 6 • 2	
DISTRICE PIPE-LINE MARINE						
TOTAL DOMÉSTIC RECEIPTS Pipe-line Marine	754.2 663.1 91.1				23°5 29°5	763.7 692.6 91.1
DOMESTIC SHIPHENTS		6 ú. 4	711.2	6 • 2		
FOREIGN IMPDKIS/-EXPORTS PIPE-LINE Marine	56.7 2.6 5.6					50.7 0.02
TOTAL SUPPLY NOVEMENTS PIPE-LINé Marine	834°5 663°1 141°8				29°5 29°5	834°4 692°6 141°8
OTATATO	20 20 20 20 20 20 20 20 20 20 20 20 20 2	c U	, ,	د م		
ULTRICI DEMANU	1976.5	50 J. 0	124 . ;	+1 • Ü	100	1855.2

0. 3. T. TRANSPORTATION SYSTEMS GENTER

SECTION A. 14

D. J. T. TRANSPORTATION SYSTENS. CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

HI SULFUP NO. 6

(ГЧВН)

PETPOLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

U. S.	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	523°4
ŝ	0 0 0 0 0 0 0 0	195.4
.+	11 0 0 0 0 0 0 0 0 0 0 0	17.3
2	0 0 0 0 0 0 0 0	176.0
N		87.7
***	8 8 8 8 8 8 8 8 8 8 8 8	63 ° 3
		OUTPUT
		REFINERY OUTPUT

INTER-PAD MOVEHENTS FROM.

	76.l 76.ù		737.6 6.6 737.6	813°6 813°6	1267.0
			1+•6 0•0 14•6	14 • 6 14 • 6	0 0 2
					17.3
		70.3			1 č 0 • č
			12°3 0°0 12°3	1 2 • 3 1 2 • 3	10.1.0
76.5	76.U 76.0		716°7 0°1 710°7	746.7 785.7	d56 • t
DISTRICT 1 PIPE-LIMÉ MARINE DISTRICT 2 PIPE-LIME MARINE MARINE DISTRICT 4 DISTRICT 4 DISTRICT 4 DISTRICT 4 DISTRICT 4 DISTRICT 4 DISTRICT 5 PIPE-LIME MARINE DISTRICT 5 PIPE-LIME	TOTAL DOMESTIC RÉCEIPTS PIPÉ-LINE Marine	DOMESTIC SHIPHENTS	FOREJGN INPJFTS/~EXPOPTS Pipe-Line Marine	TOTAL SUPPLY MOVEMENTS PIPE-LINE Marine	DISTRICT DE4AND

u.S. 79.8 C•U 733•B 533.2 613.6 79.8 013.6 733.8 PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICIS (PAD) PEFINING INDUSTAY MODEL - 1974 VALIDATION CASE 2 1 1 1 14°6 14.6 135.4 14.6 14.6 9. 0. T. TRANSPORTATION SYCHEMS CENTER SUPPLY DEMAND HALANCE BY PRODUCT ********************************* .4 8 8 8 8 8 8 17.J 3 179.8 74.0 1203 000 1203 12.3 ~ 37.7 12.3 (040W) 79°6 4.97 0°C 76637 796.7 -63.3 4.67 79°A 786.7 706.5 INTER-PAD MOVENENTS FROM .. FOREIGN IMPDUTS/-EXPOUTS PIPE-LINE Marine TOTAL DOMESTIC RECEIPTS PIPE-LINE MARINE TOTAL SUPPLY NOVEMENTS REFINERY OUTPUT DOMESTIC SHIPMENTS LO SULFUP NJ. 6 DISTRICT 1 PIPE=LINE MARINE DISTPICE 2 PIPE-LINE MAPINE DISTRICT 4 PIPE-LINE MARINE DISTRICT 5 PIPE-LINE Marine DISTRICT 3 PIPE-LINE PIPE-LINE MARINE **JNI SAM** SECTTON 4. 15

1267.6

20:00

17.3

160.0

103.6

85C • C

DISTRICT DEMAND

				U.S.	216.0																		-		210.0
111			P A D)	U.S	51												e								21.
TON CAS			PICTS (5	4.61																				4+61
SYSTEMS CTHEER - 1974 VALIDATION CASE	BY PPDDUCT		DEFENSE UISI	.+.	1 • 3																				1.3
	SUPPLY DEMAND JALANCE		PETFOLEUM ADMINSTRATION FOR DEFENSE UISTRICTS (PAD)	£	122.4														-						122.4
). (). (). TRANSPORTATION SEFTHING INDUSTRY MOHEL	SUPPLY DEMA		FUN ADMINS		32.9														•						32.9
) * (5 *E		(Udù4)	PE T+ 01		34.5																				39 ° 5
SECTION A. 16	-	LUBE STOCKS	9		REFINERY DUTPUT	INTER-PAD MOVEMENTS FRO4.	DISTRICT 1	PIPE-LINE	DISTRICT 2	PIPE-LINE	DIDIALO S	PARINE	DISTRICT 4	PIPE-LINE	DISTRICT	PIPE-LINE MARINE		TOTAL DOMESTIC RECEIPIS PIPE-LINë Marine	NOVĖSTIG SHIPHĒNTS	FOREIGN IMPORIS/+EXPORIS PIPE-LINE	MAPINE	TOTAL SHOPS A DUCK TOTAL	PIPELLINE MANANANANANANANANANANANANANANANANANANAN	L'AT LUC	OISTRICT DEMAND

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				10	U.S.	424.9															40.4° 0
2	ATION CASE			STRICTS (PAI	5	6, 19															67 .)
STERS CLAT	- 1974 VALINATION CASE	BY PRODUCT		DEFENSE DI	+	29.]															۰ ۳ ۲
0. 0. T. THANSPOPTATION SYSTEMS CINTER		SUPPLY DEMAND BALANCE BY PRODUCT		PETROLFUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)	۳ ۳																1 5
. T. THANSI	REFINING INDUSTRY MODEL	SUPPLY DEMAND		FUM ADMINS	2	1 1 2 2 2															1340 8
•0	RE FI		(Odew)	PETROL	**	2 ° 2 2 S															ي د د.
SECTION A. 17			ASPHALT AND POAD OILS			REFINERY OUTPUT	INTER-PAD MOVÉMENTS FROM	DISTRICT	PIPE-LINE Marine	DISTRICT 2 DIDE-11NE	DISTRICT 3 PIPE-LINE	MARINE	DISTPICT 4 PIPE-LINE	MARINE DISTRICI 5	PIPE-LINE	TOTAL DOMESTIC RECEIPTS PIPE-LINE	MAKINE Dove Stil Shidhenis	FOPEIGN IMPOPTS/=EXPORTS PIPE-LINE Maring	TOTAL SUPPLY MOVEMENTS PIPS-LING	JNIOTH	OFSTPICT DEFEND

a	0°J	T. TRANSPO	DRTATION S	D. J. I. TRAMSPORTATION SYSTEMS GENTER	2	7
SECTION A. 10	4EFI 4	REFLAING INDUSTRY APPEL	א אניחפון -	1474 VALIDATTON CASE	ATTON CASE	
	6	SUPPLY BEMAND JALANGE	NO JALANGE	BY PPODUCT		
COKE (LO SULFUR)	(1484)					
	PF Lours	UM ADMINST	ATION FOP	DEFENSE DI	PETPOLEUM ADMINSTRATION FOP DEFENSE DISTRICTS (PAD)	
	-	2	~	+ 0	5	U.S.
REFINERY OUTPUT	1		ता - २	4 0	1.04	
INTER-PAD HOVENENTS FROM						
DISTRICT 1						
PIPE+LINE MARINE						
DISTRICT 2 PIPE-LINE						
MARINE DISTRICT 3		•				
PIP2+LINE MAPINE						
DISTRICT 4 PIPE-LINE						
MARINE DISTRICT 5						
PIPE-LINE Marine						
TOTAL DOMESTIC RECEIPTS PIPE-LINE Marine						
JONESTIC SHIPHENTS						
FOREIGN IMPJPIS/-EXPORIS BIL-EALINE MADINE						
JANSTANIS						
TOTAL SUPPLY MOVERENTS PIPF-LINE Marine						
			-			
~						
UISTATCE DE4AND			\$ • 0	•1	1.4	6°9

	1 SE			(PAD)	5 U.S.																	и. 9 С
O. T. TRANSPORTATION SYSTEMS CENTER	- 1974 VALIDATION CASE	SUPPLY DEMAND NALANCE NY PRODUCT		PETROLĜUM ADMINSTRATION FOR DËFËMSË DISTRICIS (PAD)																		* • 0:
PORTATION S		AND BALANCE		TRATION FOH	2	19•3																0 + £ +
. T. TPANS	FFFINING INDUSTRY MUDEL	SUPPLY DEM		CUM ADMINS	2																	29.2
u• 0	555		(เปยพ)	PETROL	F																	
	SECTION A. 19		COKE (HI SULFUR)			REFINERY OUTPUT	INTER-PAD MOVENENTS FPD4.	OISTRICT 1	MIPE -LINE MARINE	DISTRICT 2 PIPE-LINE	MARINE	DISTRICT 3 PIPE-LINE	MARINE	DISTRICT 4	MARINE	DISTRICT 5	PIPE-LINE Marine	TOTAL DOMESTIC RECEIPTS PIPE-LINE Marine	DOVESTIC SHIPHENTS	FAREIGN THPDFIS/-EXPORTS PIPE-LINE MARINE	TOTAL SUPPLY MOVEMENTS PIPE-LINE NAPINE	OHAMEU DISTRIC

D. C. T. TRANSPORTATION SYSTEMS CENTER Refining industry model - 1974 Validation Case Supply demand malance by product D)	PETPOLEUM ADMINSTRATION FOR DEFINGE DISTRICTS (PAD)	2 10.5. 23.9 20.9									
Dection A. 2) Rection A. 2) Refinition Supi Supi Coke (cal Crude)	0	1 PĒFINĒRY GUTPUT	INTER-PAD MOVEMENTS FROM	OISTRICT 1 PIPE-LINU Marine Oistrict 2	PIPE-LINE MARINE DISTRICT 3 DISTRICT 3 PIPE-LINE MAPTNF	OISTRICT 4 PIPE-LINE HARINE DISTRICT 5 PIPE-LINE HARINE	TOTAL DOMESTIC RECEIPIS PIPE-LINE Marine	DOMESTIC SMIPMENTS	FOREIGN IMPOPIS/-EXPORIS PIPE-LINE Harine	TOTAL SUPPLY MOVEMENTS PIPE-LING MARINE	

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OISTPICT DEMARD

U. S. 23.0 PETPOLEUM ADMINSTFATION FOR DEFENSE DISTPICTS (PAD) REFINING INDUSTRY MODEL - 1974 VALIDATION CASE 1.7 9. 0. T. TRANSPORTATION SYSTEMS GENIE? SUPPLY DEMAND RALANCE BY PRODUCT .7 0 0 0 0 0 0 0 ~7 16.3 2 3.8 (MIPD) **4**78 1.8 INTER-PAD MOVENENTS FROM.. REFINERY OUTPUT DISTRICT 1 PIPE-LINE Marine SECTION A. 21 RENZENE

FARETGN TMP2PTS/-EXPORTS PIPE-LINE HAPINE TOTAL DOMESTIC RECEIPTS PIPE-LINE Marine DOMESTIC SHIPPENTS DISTAICT 2 PIPALINE MARINE DISTRICT 3 PIPE-LINE PARTNE DISTRICT 4 DISTRICT 4 DISTRICT 5 PIPE-LIME MARINE MARINE

TOTAL SUPPLY MOVEMENTS PIPE-LINE Marine

0131PICT DEMAND

1r + 3

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1.7

23°6

U. S. 35.5 PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD) PEFINING INDUSTPY NOBEL + 197+ VALIDATION 6451 S 1.4 0. 0. T. TRANSPORTATION SYSTEMS JENTER SUPPLY DEMAND RALANCE BY PRODUCT ************************ .† m 27.6 ~ 2.6 ÷ (C98M) -4 0 0 0 0 0 0 0 0 0 0 1.2 INTER-PAD MOVEMENTS FPO4.. FOREIGN TMPOPTS/-EXPORTS PIPE-LINE MARINE TOTAL DOMESTIC RECEIPTS PIPE-LINE MARINE TOTAL SUPPLY HOVEMENTS PIPE-LINE Maqine REFINERY OUTPUT DOMESTIC SHIPMENTS DISTRICT 2 PIPE-LINE MARINE DISTRICT 3 PIPE-LINE MARINE DISTRICT 4 DISTRICT 1 PIPE-LINE MARINE PIPE-LINE MARINE DISTRICT 5 PIPE-LINE MARINE SECTION A. 22 TOLUENE 9 4 8 9 8 9 8 9 8 8

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DISTRICT DEMAND

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	C °U	Shbar .T .	0. T. TPANSPORTATION SYSTEMS GENTER	STEMS CENTER	
ECTIV A. 23	REFI	REFLAING TUNUSTRY MODEL		1974 VALIDATION CASE	
		SUPPLY DEM	SUPPLY DEMAND GALANCE	10f.Cod AB	
MIXED XALENES	(Caum)		}		
	PF. TROL	EUN ADMINS	TRATION FOR	PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)	(U)
		2	47	-2-	n• S•
REFINEPY OUTPUT	ۍ ۲	5 • 2	23.0	~	m
THTER-PAD MOVEMENTS FROM					
DISTRICT 1 PIPE-LINE					
MARINE DISTRIGT 2 PIPE-LINE					
MARIHE DISTAICT 3 DIDELIINE					
MACINE MISTRICT 4					
PIPE-LINE MARINE					
DISTPICT 5 PIPE-LINE MARINE					
TOTAL DOMESTIC RECEIPTS PIPE-LINE Haring					
DOMESTIC SHIPMENTS					
FOREIGN IMPORTS/-EXPORTS PIPE-LINE Marine					
TOTAL SUPPLY MOVEMENTS PIPE-LINE Marine		· ·			
OTSTPICT DEMAND	0	5	0.02	~	7 . 7
	•	246	C 70L	2 0 1	1000

		(0)	n• 5.	164+1																		104.1
D. J. I. TPANSPOPTATION SYSTEMS GUNTER Pefiuing industry honel - 1974 valijation Case	SUPPLY DEMAND BALANCE RY PROUNCT	PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)	.+										,									5° 7
SPOPTATION S STRY HONEL -	MAND BALANCE	STRATION FOR	P) (40.24
N. J. I. TPANSPOPTATION P€FI4ING INDUSTRY HONGL	SUPPLY DEMAN	OLEUM ADMIN	2																			4 F. 4
b c	(14840)	PETR	41 1	11 • 9	0 9																	2,11
Section &. 24	MISC. PRODUCIS			REFINERY OUTPUT	INTER-PAD MOVENENTS FROM	DISTRICT 1	PIPE-LINE Marine	DISTRICT 2	PIPE-LINE MADIAE	DISTRICE 3	PIPE-LINE	MARINE	DISTRICT 4 PIPE-LINE	MARINE	DISTRICT 5	PIPE-LINE Marine	TOTAL DOMESTIC RECEIPTS ' PIPE-LINE Marine	DOME STIC SHIPMENTS	. FOREIGN INPORIS/-EXPORIS PIPE-LINE Marine	TOTAL SUPPLY MOVEHENTS	PIP5-LINE 1221115	DISTRICT DEWARD

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SECTION A. 25

1. J. T. TRANSPORTATION SYSTEMS NEWLER

REFINENCE INDUSTRY MODEL - 1974 VALIDATION CASE Case 1-

		ď	• A. O. OIST	OISTRICT					
		F	ope	of barrels per cal	calendar day ⁽²⁾				
	-1	2	m		ſ	0.S.U	I MPORT	EXPORT	TOTAL
				1		2 			P 0 - P
SMEET CRUDE		10.00	20100	5° 47	1 *r 7 G	0 - 0 - 0	(Hete 1)		
SOUR JAUPE	1 % jC • U	21-43-15	1141.6	5 • CP S		1040°4			10404
CALTE CRUDE					240003	14:1•0			1400.0
ALASKAN CPUCE			4 5						
NATUPAL GASOLINE	14.9	6°°9	133.5	22 .7	20.2	202 °E			242.5
NOPMAL BUTANE	6°9	2 7 8 8 8	54.0 5.1 7	3.5	20°0 0'0	139.1	Å		109.8
	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0							0 0 0 0 0 0 0 0 0	
TOTAL INPUT	0	5	ę,	5 60 ° 0	~	, 1 4			130+1.6
0017P1JT					-				
	i				:				
C3 (P3	54.6	6.67	50°E	2 9 9	6.3.5	214.0			C14.0
	14.1	11.9	3°71	1.0	ŝu		,		000
NAPH THA		24.1	5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	4 1 1	0 ° 0 ° 1 ° 1 ° 1 ° 1 ° 1 ° 1 ° 1 ° 1 °	2°501			20101
PEGULAR GASOLINE	6.212	7 2 1 • 4	0.54/	0.11	0 • P / 7	1.22.13			C12301
PREMIUM GASOLINE	128.6	513.1	285.3	55 • 6	135.6	16 45 . 6			1845.5
LOW LEAD GASOLINE	223.7	356°5	632.0	76.4	259.1	1647.7			100 /.1
LEAD FREE GASOLINE	249.2	305°4	196.2	10.4	51 2º 5	2/45.4			1/45.4
JP-4 JET FUEL	7.7	46.el	67.8	18.2	4200	191.2			101.2
JET A JET FUEL	47.3	177.4	473.6	25 °C	22403	947°0			947.0
DIESEL	35°6	232 • 3	552°1	133.9	11 3.2	1127.6			1127.0
NO. 2 FUEL OIL	265 .1	566°4	835°1	2.74	13.5	1784.3	2.05		193591
HI SULFUP NO. 6	53.3	F 7 .7	176.0	17.6	135.4	523.4	737.6		12010
LU SULFUF NU. 6	63.5	87.1	17 9.0	1/ • 0	133.4	5.1.5	135.0		126/01
	39.5	37.43	122.8	1 • 5	13.4	216.6			210.0
ASPHALT AND ROAD OIL	58°3	134 • B	134.3	29°0	67.9	414 ° 9			424.3
FORE (LO SULFU?)			5 ° C	•1	1 . 4	6°4			6.4
COKE (HI SULFU?)	5.9	25 °2	•	2°3		52°3			52°3
COKE (CAL CRUDE)					2.3.9	21.9			20.3
BENZENE	1 • 8	3.5	15.3		1.7	23.6			23°5
TOLUS	1.2	2 e f.	27.6		4.1	32°5			35.3
MIXEO XYLENES	6.	5.5	24.6		3.0 13	34 .7			38.7
MISC. PRODUCTS	11.9	10 2 00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	42.4		6.5 	1 14 .1			1.411
TUSTAL OUTPUT	110	15	1 12	5	Ŧ.	· · · ·	1522.1		14566.7
OUTPUT/INFUT, PCT	1,3,1	10.15	97°3	5°66	1.1.7	غره ۵٬۴			111.2

Note 1.-- Model does not currently define sources of the sweet and sour crudes as to domestic and imported. 2.-- Petroleum coke is reported in millions of pounds per day.

			10101010	DEMAND	54.6	19.1		751.9	128°6	915°7	363. B	42.8	386.0	134.0	1070.0
			01010101		5 4 6	19.1		212.9	128.6	223.7	249.2	1.1	47.0	95 • 6	265•1
			TOTAL	MOVEMENTS				539.0 539.0		692.0 692.0	114°6 114°6	35°1 13°6 21°5	339.J	17204 17204	804.9 663.1 141.8
			THOODY	/-Export											50.7 50.7
GENTE? Validation Case	PICT		TOTAL					539°6		692.0 6 9 2.0	114°E 114°E	53°1 13°6 21°5	339°U 339°U	172.4	754.2
SYSTEMS GENTER - 1974 VALIDAT	ANCE BY DISTRICT			0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			、				21 • 1 2 1• 1				
	DEMAND BALANCE		FIPTS FROM	0 0 0 0 0 0 0											
۲.	SUPPLY		INTEM-STATE RECEIPTS FROM	0 0 0 0 0				539°ť 539°ť		692.(692.0	93°5 93°5	21.5 21.5	339 ° U 339 ° ů	172.4	6.47.8 546.7 91.1
0, 0. Refini	٠		E INT	2							د	130E			Сб. t Л f . <u>1</u>
				0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0											
SECTION B. 1		DISTRICT			C3 LPG PIPE+LINE MAPTNE	G4 LPG PIPE-LIME MAQIVE	NAPMTHA PIPE-LINE MARINE	REGULAR GASOLINE PIPE-LINE Marine	PREMIUM GASOLINE PIPE-LINE Mapine	LOW LEAD GASOLINÉ PIPE-LINÉ Mariné	LFAD FZEF GASOLINE PIPF-LINE Marine	JP-4 JET FUEL PIPE-LINE MAQINE	JET A JET FUEL PIPE-LINE MAPIVE	DIESEL PIPE-LIHE MAVINE	NO. ? FUEL OIL Pipe-Line Mapine

		DISTRICT DEMAND	85 J. C		85 ú • O		39.5	50.9		5° 9		1.8	1.2	б [.] °	11.9	5686.6
		01 STRICT OUTPUT	63.3		63°3		39°5	58°9		б° и		1.8	1 • 2	6°	11.9	
		TOTAL MOVEMENTS	786.7	786.7	786.7	786.7										
		IMPORT /-Export	710.7	710.7	706.9	706.9										1465+3 1465+3 1465+3
-220 NCI		TOTAL	76.6	76.5	19.8	79.8										
D. D. T. TPANSPORIATION SYSTERS CERTER Refermed industry model - 1974 validation CASE	SUPPLY DEMAND RALANCE BY DISTALGT	INTEP-STATE RECEIPTS FROM 2 3 4 5	76.6	76. ú	8°64	79.8							,			2/
SECTION 4. 2	DISTRICT	7	Q	PIPE-LINE Marine	LO SULFUR NO. 6	717E - LINE MARINE	LUBE STJCKS PIPE-LINE Mariye	ASPHALT AND ROAD OIL Pipe-line Marine	COKE (LO SULFUR) PIPE-LINE Marine	COKE (HI SULFUR) PIPE-LIPE MAPINE	COKE (CAL CRUDE) PIPE-LINE MARINÉ	BENZENE PIPE-LINE MAPINE	TOLUFNE PIPE+LING MAFINE	MIXEN XVLFFS PIPE-LINE P.APINE		TOTAL TYPELIC PICE-LICE PAULYS

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			DISTRICT DEHAND	79°6	17.9	29°1	1035.0	544.7	356°5	312.8	31.5	202.0	190.0	500.0
			DISTRICT OUTPUT	79.6	17.9	29.1	820.4	519.1	356°5	308°4	45 e 1	177.4	232.3	560 °4
			TOTAL HOVEHENTS				21406 21406	25.6 25.6		2 • 2 2 • 2 2		24.6 24.6	147 • 7 147 • 7	
			THPORT /-EXPORT				,							
ء TIDN CASE	TRICT		TOFAL DOVESTIC				214°E 214°E	25° ć 25° ć		1 0 2 1 0 2 1		240E 240E	147°7 147°7	
TPANSPORTAFION SYSILMS GENTE? Industry Model - 197+ Validation Case	BALANCE BY DISTRICT		5											
	DEMAND	NOCO STOLO						25°6 25°6		202 202 2				
1.	Y JPPL Y						214.E 214.6					24 ° 6 24 ° E	1 ~ 7 ~ 7 1 4 7 ~ 7	
D, 7.	·													
		2												
SECTION 9. 3		DISTRICT		C3 LPG PIPE-LIHE Mapine	C4 LPG PIPE-LINE MAPINE	NAPHTHA PIPE-LINE Marine	REGULA? GASOLINE PIPE-LINE MARINE	PREMIUM GASOLINE PIPE-LINE Marine	LOW LEAD GASOLINE PIPE-LINE MAPINE	LEAD FRE GASOLINE PIPE-LINE Marine	JP-4 JEI FUEL PIPE-LINE MAPINE	JET & JET FUEL PIPE-LINE Hapine	DIESEL PIPE-LINE MAPINE	NO. 2 FUEL OIL PIPE-LINE MAPINE

0. 0. T. THANSPORTATION SYSTEMS CENTER

DISTRICT DEMAND	4 5 ° 0	13°4	4 5 0		285.3		71.7.7	4 6 ° 2	110.0	116.0	124°C
DISTRICT	4° E • 0	23.4	45.5	753.6	265.3	692 • Û	796.2	67.8	473.6	552.1	A35.a1
TOTAL							15•3 15•0				
I HP 0KT 											
GENIE? ALIDATION CASE Y DISTRIGY TOTAL							15°L 15°0				
51645 1974 V ANCF 9											
C 1 0 4 1							4 5 6 1 5 6 1 5 6 6				
D. J. T. TPANSPOPTATION REFINING INJUSTRY MODEL Supply Demann INTER-STATE RECETPTS F											
m											
SECTION A. 5 nistrict	: LPG PIPE-LINE Marine	, LPG PIPE -LINE MAPINE	APHTMA PIPF-LINE MARINE	REGULÂR GASOLINE PIPE-LINE Maqine	PREMIUM GASOLINE PIPE-LINE Maqine	LOW LEAD GASJLINE Pipe-line Mapine	LEAD FREE GASOLINE PIPE-LINE Mapine	JP-4 JET FWEL PIPF-LINE MAPIVE	JET & JET FUEL PIPE-LINE Marine	PIPE-LINE Pipe-Line Ssi	NO. 2 FUEL DIL Pist-Line Mavite
5 1	C3 LPG PIPE MART	C4 LPG PIPE- MAPI	NAPHTHA PIPE-I MARINI	REGUI PTI MAS	PREM PI MA	LOW I PIF MAF	LEAD PII Ma	JP-4 PII MAi	JET PIH MAR	DTE SEL PTPF MAPT	.VM .DM

SECTION A. 6	140	INDUSTRY NOCL - 1974 V Supply Demand Ralance 9	TATENS CONTRACTON CASE 1974 VALIDATION CASE ANGE AV DISTRICT	CASE					
			8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	:					
	INTER-STATE RECEIPTS FROM	TS FROM				1			
	e e		5	DATESTIC	IMPORT /-Export 	T0TAL MOVEMENTS 	DI STRICT OU TPUT	DISTRICT DEMAND	
HI SULFUR NO. 6 PIPE-LINč Maqinë	·						176.6	100.0	
LO SULFUR NO. 6 PIPE-LINE Marine							179.8	100.0	
LUBE STJCKS PIPE-LIME MAPINE							122.8	122.8	
ASPMALT AMD ROAD OIL PIPE-LINE Maəine							134°3	13403	
COKE (LO SULFUR) PIPE-LIME Marine							5 ° C	5° 4	
COKE (HI SULFUR) PIPE-LINE Marine							1A . 3	18.3	
COKE (CAL CKUDE) PIPF-LINC Maqine									
BFNZENE PIPE-LINE Maping							16.3	16.3	
TOLUZNE PIPE-LINE MAPINE							27.f	27.6	
MIKEN XYLÉNES PIPE-LINE Mapine							29°J	29° L	
							1 ° 1 1	4204	
					0 0 0 0 0 0 0 0 0	15.J	5311.5	2699.4	

0. 0. T. TPANSPORTATION SYSTEMS CONTER

DISTRICT	6 • 8	1.6		77.6		76.4	57.0	11.3	25.0	3.0	41.0
DISTRICT OUTPUT	09 L	1.6		77.6	25•6	76 • 4	76.4	10.2	25 • û	13.9	47.2
TOTAL MOV?HENTS											
Тмрокт 1 мрокт 		·		,							
- ITINH CASE IRICE DOMESTIC											
0. 0. T. THAUSPORTATION SYSTEMS CZNTF? HEFTYLNG TNDUSTPY HOUEL - 1574 VALIDATINH CAST SUPPLY NEMAND RALANCE AY DISTRICT INTER-STATE RECEIPTS FPOM INTER-STATE RECEIPTS FPOM TOTA 2 3 4 5 0046STT											
SECTION 9. 7 DISTRICT 4	C3 LPG PIPE-LINE MAPINE	C4 LPG PIPE-LINE Marine	NAPHTHA PIPE-LINE Marine	REGULAR GASOLINE PIPE-LINE Mapine	PREMIUM GASOLINE PIPE-LINE Marive	LOW LEAD GASOLINE PIPE-LINE Marive	LEAD FREE GASOLINE PIPE-LINE Magine	JP-4 JET FUEL PIPE-LIME MARIVE	JET A JET FUEL Pipe-line Marive	DIESFL PIPE-LINE Mapive	NO. ? FUEL OIL PIPF-line Mapive

D. J. T. TRAUSPOPTATION SYSTEMS CENTER	REFINING INDUSTRY MODEL - 1974 VALIDATION CASE	SUPPLY DEMAND BALANCE 97 DISTFICT	
			1
e c mettudas			DISTRICT

		0157R1C7 06man0 	17.0	17.0	1 e 3	29°0	• 1	2•9						397.1
		015781CT 0017PUT	0°21	17 ° U	1 • 3	29•C	• 1	2°3						
		TOTAL MOVÊMENIS												- 0 0 0 0 0 0 0 0 0 0 0
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	INTER-STATE PECEIPTS	~												* 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
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nISTRICT 4			HI SULFUR NO. 6 PIPE-LINE MAPINE	LO SULFUR ND. 6 PIPE-LINE MARINE	LURE STOCKS PIPE-LINE MAPINE	ASPHALT AND ROAD OIL PIPE-LINE Marine	COKS (LO SULFUR) PIPE-LINE MAPINF	COKE (HI SULFUR) PIPE-LINE MAPINE	COKE (SAL CRUDE) PIPE-LINE Mapine	BFNZENE PIPE-LINE MARINE	TOLUENZ PIPE-LINE MAPTNE	MIXED XYLENES PIPE+LINE MAXINE	MISC. P÷ONUCTS PIPE -LINF MAPINE	PIPE-LINE PIPE-LINE MAVINE

DISTRICT	28°5	10.5	25°5	270.6	135.2	259.1	294.1	49°5	224。0	0 ° 0	100.0
01STRICI CUTFUT	28.5	10.5	25°5	270.6	\$ 35°2	259 .1	315.2	42 . 6	224.0	117.2	76.5
TOTAL MOVEMENTS								6.9 6.3		4 6 e A 4 6 e A	29°5 29°5
IMPORT /-Export								σ		Ŧ	ú.
GENTER VALIDATTON CASE BY DISTRICT TOTAL								6 • 9 6 • 9		2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	ц. 4. • С.
SY STEMS - 1974 3ALANGE - 1074								6°9 6°9		4 6° X 46 ° A	دع ف رج ف
0. 0 REFI INT 2									`		23.3 23.3
SECTION R. 9 DISTRICT 5	C3 LPG PIDE-LINE Marine	G4 LPG PIFE-LINE Marine	NAPHTHA PIPE-LINE Marine	REGULAR GASOLINE PIPE-LINE Marine	PREMIUY GASOLINE Pipe-line Mapine	LOW LEAD GASOLINE PIPE-LINE Marine	LEAD FREE GASOLINE PIPE-LINE Marine	JP-4 JET FUEL Pipe-Line Madine	JET A JET FUEL PippLine Manive	DTESEL Ptde-ling Mavine	ND. Z FUEL AIL PTPE-LTNE MAPTHE

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		0 I S TP I C T DEMAND	26 0° 0	200.0	1904	67.9	2.04		20°9	1.7	40 1	3 ° D	2 • 5	1998.5
		01 STRTCT 01 TPUT	185.4	185°4	19.4	67°9	4 • 4		20°9	. 1.7	40 a 1	ы. Б	2°2	1987.2
		TOTAL Hovë4ënts	14°6 14°6	14.66										12.4 83.3 29.2
		IMPORT /-E XP	14°6 14°6	1406 1406			-							
S CENTER		TUTAL												1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
TRANSPOPTATION SYSTLMS GENTER Industry Model - 1974 Valimat	10 X 0	in I												0 0 0 0 0 0 0 0 0 0 0 0
PTATION SY V modél -	SUPPLY DEMAND RALARICE	EIPTS FROM												60.6 60.6
T.		INTE4-STATE REGELPTS FROM												5 4 4 5 4 4 5 4 4 5 4 4 5 4 7
0 * 0 * 1 1 1 5 6	:	1NT 5												0 0 0 0 0 0 0 0 0
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3. 15	ICT 5		NO. 6 IE	N0. 6 1E	S	ID ROAD OIL	ULFUR) IE	iul FUR) IE	CRUDE) IE	ш	ш.	NE S Itë	UC T S	RTS 16
SECTION 8.	OISTRICT		MI SULFUP NO. PIPE-LINE MAPINE	LO SULFUR NO. PIPE-LINE MARINE	LUBE STOCKS PIPE-LINE MARINE	ASPHALT AND F PIPE-LINE Marine	COKE (LO SULFUR) PIPE-LINE MAºINE	COKE (HI SULFUR) PIPE-LINE MARIVE	COKE (CAL CRUDE) PIPE-LINE MARIVE	BENZENE PIPE-LINE MARINE	TOLU ^C NE PIPE-LINE MARINE	MIXEN XYLENE PIPE-LINE Mapine	MISC. PRODUCTS PIPE-LINE MARINE	TOTAL IMPORTS PTPE-LINE MAPINE

		9	PROPUGT	PRODUCT CONSUMPTION SUPPLY	74 SUPPAGE	0			
		ć	P. 4. D. NISIPICI	151a					
	1	бя	۲	2	ŝ	•S•fi	51 909 Y 3	54P 101	10745
•		3.67	1	1 6 ° C	23.5		0 0 0 0 0 0 0 0 0	8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	214.5
	19.1	6°21	13.4	1.5	1 J. 5	62.7			62°7
		T°t.c	45.5		2°5°	101.2			166.2
LIVE	751.9	1615 °F		77.6	27.1.6	21.75.1			2135.1
LINE	128.6	544.7	285.3		135.2	6.76 h1 .			1093.9
SOL I NE	915.7	3000		76.4	253.1	16.27.07			1607.7
LEAN FREE GASOLINE	3:53.8	312 .*	717.7	57.5	234.1	1745.4			1745.4
L	42.9	3 * 1 #/	46.2	11.3	4, 9° 5	181.2			1.1.2
ĒL	196.3	202 00	110.0	25 ° 3	22 4 . 3	0°176			947.3
	264.0	1995	232.C	87.0	162.5	1127.0			1127.0
IL	1376.9	نون ° ژ	12400	1.1.2	130.0	19.35 .6			1875.3
• •	450°J	100.0	103.6	17 °C	230.0	1267.3			1267.3
• 6	950.0	120.0	100.0	17.0	239.3	1267.0			1267.3
	\$6\$	52 ° 3	122.6	1.3	1 3.4	215.C			216.3
P04N 01L	5.9.3	174.09	134.3	29.5	57.4	6°727			424.3
FURI			5.4	4°	1.4	6°9			6.3
COK= (HI SULFUR)	5.3	26:22	18.3	2.9		52°3			52.3
1200					23.9	21.5			20.3
	1.8	3 • F	16.3		1.7	23.6			23.5
	e: -1	2.6	27.6		4.1	35 ° F			10.57
SINITATU SINITATU SINITATU SI	6.	دي ما	29.0		3.6	39.7			30.7
MISC. PRODUCTS	11.3	4.7.L	42.4		2*2	104.1			104.1
TOTAL		3941.1	2215.4	451.1	2179.5	14535.7	8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	8 9 9 8 9 9 9 9 9 9 9 9 9	14566.7

1. 7. T. TPANSPORIATION SYSTEMS GENER

SECTION R. 11

PERIMING THOUSTOY MODEL - 1974 VALIDATION CASE

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0. 0. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

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REFINERY CAPACITY UIILIZATION (MAPP)

TROLEUM ADMINSTRATION FOR DÉFENSE DISTRICTS (PAD)

	PETROLEUM	AOHINSTRAT	PETROLEUM AOMINSTRATION FOR DEFENSE DISTRICTS (PAD)	NSE DISTRIC	ITS (PAD)		
	1	2	100 H		۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲	U. S.	
LAPGE REFINERY							
SMEET CRUDE Arse Case High Conv Low Conv Subtotal							
SOUR CRUOE Rase Case High Conv	1346.0	2698.8	3°1552			2698.3 4251.6	
SUBTOTAL	1300.0	2698.8	2950 . Ú			694 9 . 8	
CALIF CRUDE Rase case High conv Lom conv Surtotal					1195.7 201.5 2406.0	1198°7 201°3 1460°0	
ALASKAN CRUJE RASE CASE HIGH Conv Lom Conv Surtotal Total For Large refinery	130C • (2693 . 8	(°1562		1403 .0	834.9.8	
MEO REFINERY							
SMEET CRUDE RASF CASE HIGH CONV LOM CONV SUBTOTAL			1378.1 1378.1			1378°4 1378°4	
SOUP CFUDE PASE CASE HTGH CONV LOW CONV SUGTOTAL			191.6 191.5			191.6 191.6	

ION SYSTEMS CENTER DEL - 1974 VALIDATION CASE ITY UTILIZATION (NAPD) OFFENSE DISTRICTS (PAD) 3 4 5 U.S.	1570.0	.0 25.3 503.0 1900.0 25.3 180.0 25.3 180.0 180.0 0.0 25.3 503.0 2165.3 180.0 2165.3 180.0 18	.0 5%1.2 550.0 2611.3 .6 531.2 1940.0 2631.3
D. D. T. TRANSPORTATION SYSTEMS CENTER REFLMING INDUSTRY MODEL - 197, VALIDAT PEFINERY CAPAGITY UTILIZATION 4 PETROLEUM AOMINSTRATION FOR DEFENSE DISTRICTS 1 2 3 4	י י ע ע ע ע	0°752 0°752 0°752 0°752	700.6 740.6 3598.8 5223.6
PETROL	, RERY	ः न • • • • • • • • • • • • • • • • • • •	REFINERY 1496.4
SECTION C. Z	HEN REFINERY CALIF CRUDE MASE CASE MIGH CONV LOH CONV SUBTOTAL ALASKAN CRUDE ALASKAN CRUDE ALASKAN CRUDE ALASKAN CRUDE ALASKAN CRUDE NICH CONV LOH CONV LOH CONV SUBTOTAL TOTAL REFINERY SMALL REFINERY	SWEET CRUDE TASF CASE HIGH CONV LOM CONV LOM CONV SUBTOTAL SOUR CRUDE AASE CASE HIGH CONV LOM CONV LOM CONV	CALIF CPUDE RASE CASE HIGH CONV LON CONV SUBTATAL ALASKAN CRUDE ALASKAN CRUDE ALASKAN CRUDE ALASKAN CRUDE LON CONV LON CONV SUBTOTAL TOTAL FOR SHALL REFINERY GRAHD TOTAL

SECTION C. 3

J. J. T. TRANSPORTATION SYSTEMS GUILER

PEFINING INDUSTRY MUDEL - 1974 VALIDATION CASE

RFFINERY CAPACITY WILLTATION (MBPO)

PETROLFUM AUMINSTRATION FOR DEFENSE DISTMICTS (PAD)

INCPEMENTAL PROCESSES

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155-10

HYDROCCACKING FXIST. HC FOR DSL Hydrotzeating Gaso oesulf Diesel desulf

TOTAL FOR DIESEL

TOTAL FOR DESJLFURIZATION

	4 <u>.</u>	SOUNT SNIFT	REFINING INDUSTRY MODEL - 1974 VALIDATION CASE	1974 VALID	ATION CASE	
			UTILITY SUMMARY	1A P. Y		
	3 10-13a	UPI AD 41 NSTE	PETTOLEUM AD4INSTRATION FOR DEFENSE DISTRICTS (PAD)	EFENSE DIST	(UVJ) SIDIa	
	1 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	~	5 7 6 5 5 6 6 8 9	1 1 1 1 1	5	U.S.
SLEC. PWR (16UUKWH/D)	4°623	13964.1	19730.0	1714.9	19638.2	5186.6°5
FUEL PEQD. (1066F0E3/7)	76.2	190.7	302 - 2	26.5	121.2	722.2
ENERGY CONS. (1000FOE3/0	37.C	216.9	342。8	1 = 7 2	241.3	819.7
LAGOR (NO. EMPLOYEES)	7406.6	1E 994. 2	26136.0	2656.3	9503 • 0	62650.5
CPEP COSTS (M\$/D)	190.3	521.5	592°7	54.7	215.6	1575.9
INVESTMENTS (MHS)						

D. O. T. TRANSPORTATION SYSTEMS SENTER

SECTTON D. 4

U.S. 12063.8 18368.6 8440°1 1182°0 9622°1 30432.4 PEFINING INDUSTRY MODEL - 1974 VALIDATION CASE S 8442 •1 1142 •6 9622 •1 0. 3. T. TPANSPORTATION SYSTEMS GENTER . SUMMARY OF FLEC. PWP. (1606KWH/D) \$ ~ 12977.3 12977.3 • 12663.8 12463.8 -4 5 341.2 5331.2 LARGE REFINERY RASE CASE HIGH CONV Lom Conv Subtotal RASE CASE MIGH CONV Lom Conv Surtofal BASE CASE HIGH CONV LOM CONV Subtotal RASE CASE HIGH CONV Low Conv Surtotal ALASKAN CRUDE CALIF CRUDE SHEET CRUDE SOUP CPUDE -SECTION D.

179

4363。8 4360。8

4369.8 4366.8

40054.5

9622.1

12977.3

12663.8

5391.2

TOTAL FOR LARGE REFINERY

SWEET CRUDE

MED REFINERY

BASE CASE MIGH CONV Low Conv Surtata

U. S.	653.A	653°8	5 6 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	4654.5 7401 36422 529607	1¢0°1 1480°7 1640°5
22 41 Inhi CASE				11 70 . 1 1ú7ó . 1	
D. J. T. TRANSPORTATION SYSTEMS CENTER Refining industry model - 1974 validation case Summary of Elec. PWP (1661KMH/J) 1 2 3 5 4 5 5				74°1	156.1 1486.7 1640.9
RANSPORTATION S NDUSTRY MODEL - OF ELEC, PWP 1	وہ تا م	653.8	5614°5	1738°1	
D. J. T. FRANSPORTATION REFINING INDUSTRY MODEL SUNNARY OF ELEC. PWP.				1847。3 1843.3	
0. REF				368°2 364°2	
SECTION D. 2	MER REFINERV Soyr Grude Basë Casë High Conv	LDN CONV SURTDTAL CALIF CRUDE BASE CASE HTGM CONV LON CONV SUBTOTAL	ALASKAN CRUDE AASE CASE HIGH Covv Lom Covv Subtotal Total for med refinery Small Pefinery	SWZET CRUDE RASE CASE HIGH CONV Low CONV Surtotal Sour Crude	BASE CASE HTGH COVV Loh Conv Surtal

....... u.s. 51406.52 6737.5 REFINING INDUSTRY MODEL - 1974 VALIDATION CASE 13639.17 5 1675.1 D. D. T. TRANSPORTATION SYSTEMS SENTER SUMMARY OF ELEC. PHP (LCLKNH/D) 1714.95 æ 1714.9 8 19729.48 PT: 1739.1 13994.13 0 1644.3 £759.29 -364.2 TOTAL FOP SHALL REFINERY HYDROCRACKING FXIST.HC FOR DSL Hydrotraitig Gaso desulf DIESEL DESULF Subtotal INCREMENTAL PPOCESSES HYDROCCACKING EXIST. HC FOR DSL HYDROTREATING GASO DESULF Diesel desulf Surtotal DF SULFURIZATION SMALL REFINERY BASE CASE HIGH CONV Lom Conv Subtotal BASE CASE HIGM CONV Lom Conv Subtotal ALASKAN CRUDE UTILITY TOTAL CALIF CRUDE 3 SECTION D. DIESEL

	·1.S.					157.0 256.9	424.7		87.5 13.5 160.9			515.6			78.5 78.5
arron GASE									87.5 13.5 101.9			9°CU1			
0. 0. T. TRAYSPORTAFION SYSTEMS GENTE? Reflying troustry model - 1974 validation case Summary of energy combumption (foem)						-									
PORTAFIUN SV TRY MODEL - Enepgy Comsu	۰ ۱					186.1	186.1					186 .1			2°°2 78°5
0. J. T. TRA45PORTAFION Refiging Industry Model Summary of Energy Con	2					157.8	157.8					157.8			
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					70.8	7ù . H					76 . 8			
section n. 4		LA35E REFINERY	SWEET CRUDE	RASE CASE HIGH CONV Lon Conv Subtotal	SOUR CHUDE	BASE CASE HIGH CONV	LUM LUNV SUBTOTAL	CALIF CRUDE	RASE CASE HIGH COVV Low Conv Subtotal	ALASKAN CRUDE	BASE CASE HIGH GOVV Low Conv Subtotal	TOTAL FOR LAPGE REFINERY	MED REFINERY	SWEET CRUDE	BASE CASE HIGH CONV Low Conv Subtotal

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'n SECTION D.

0. D. T. TRANSPURTATION SYSTEMS CLUTE?

PEFINING INDUSTRY MODEL - 1474 VALIDATION CASE

................. SUPMARY OF FUFL REGD. (1002FUE3/D)

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11.0

11.6

HED REFINERY

SOUR CRUDE

RASE CASF HIGH CONV Low Conv Surtotal

CALIF CRUDE

BASE CASE HIGM CONV Low Conv Subtotal

ALASKAN CRUDE

BASE CASE HIGM CONV Lom Conv Subtotal

TOTAL FOR MED REFINERY

89.5

3.68

SMALL PEFINEPY

83.2 1.4 91.1 2.1.3 M- 0 10 10 23.03 2.2 1.4 *** 31.6 () • 32.9 32.9 4 4 9 6 9 6 BASE CASE MIGM CO4V Lom Conv Surtotal BASE CASE HIGH CONV Low Gonv Surtatal SULCHUDE SCUP CRUDE

U.S. 722.15 9 9 9 9 8 9 9 8 9 9 9 8 9 8 9 8 9 8 9 117.0 PEFINING INDUSTRY MODEL - 197- VALIDATION CASE ഹ 121.18 23 °3 9. 0. T. TRANSPORTATION SYSTEMS GENTER SUMMARY OF FUEL REQD. (1003F02370) 28.46 \$ 28.5 8 9 9 8 9 8 9 8 9 8 9 8 9 8 9 3.5.66 m 33.6 9 9 9 9 9 9 9 9 9 9 9 9 N 0 9 9 9 9 9 9 9 9 9 9 9 9 9 9 190.76 32.9 76.15 -1 3° 61 TOTAL FOR SMALL REFINERY HYDROCRACKING Exist, HG For Osl Hydrofraating Gaso Desulf Difsel Desulf Suhtotal HYPROCRECKING EXIST. - 1C F04 DSL Hydrotkeating Gaso Dfsulf Oifsel Jesulf Subtotal INCREMENTAL PROCESSES ***************** **NE SULFURI7ATION** SMALL PEFINERY BASÉ CASE HIGH COVV Low Conv Surtotal BASE CASE HIGH COVV Low Conv Subtotal ALASKAN CRUJE UTILITY TOTAL **FALIF** CRUDE £. SECTION D. DIESEL

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SECTION P. 7

0. 0. T. TPANSPORTATION SYSTEMS CLATER

RFFINIMG INDUSTRY MODEL - 1974 VALIDATION CASE Summary of Energy Cons. (1)0.0029/0)

U.S. 80.7 80.7 180.6 291.5 591.1 472.1 153.3 15.7 119.0 ŝ 0.611 1:53.7 1:5.7 1:5.1 3 0 5 212.6 86.7 86.7 216 .6 21.j.t ~ 194.6 183.6 18].6 -6..9 8°°9 80°5 TOTAL FOR LAFGE REFINEPY MFD REFINERY LARGE PEFINERY BASE CASE HIGH CONV Low Conv Surtotal RASE CASE HIGH CONV Low Conv Suetotal RASE CASE HIGH CONV Lom Conv Subtotal BASE CASE HIGH SOVV Low Conv Subtotal RASE CASE HIGH CONV Low Conv Surtotal ALASKAN CRUTE SWEET CRUDE CALIF CRUDE SWEET CRUDE SOUR CRUDE

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U.S. 624.72 8 0 0 0 0 0 0 0 129.7 PEFINING INDUSTRY MODEL - 1974 VALIDATION CASE ŝ 0 0 0 0 0 0 0 0 0 0 0 1-1.57 22,•3 SUMMARY OF ENERGY CONS. (1900F050) 1. D. T. TPANSPOPTATION SYSTEMS GENTER 10.11 3 8 8 8 8 8 31.7 ~7 3-2 .34 33°3 210.94 • 36.4 96. ° 1: 3 -........ 6.1 TOTAL FOR SHALL REFINERY HYDPOCRACKING Exist. AC for dsl hydrotreating Gaso desulf difsel desulf HYDROCRACKING EXIST. 4C FOP DSL HYDROTHEFTING INCREMENTAL PPOCESSES 0 0 0 0 0 GASO DESULF DIESEL DESULF SUBTOTAL **DESULFURIZATION** SMALL REFINERY RASE CASE HIGM CONV LCM CONV SUBTOTAL BASE CASE HIGH CONV Lom Conv Subtotal UTILITY TOTAL ALASKAN CRUDE SUBTOTAL CALIF CRUDE σ SECTION D. DIESEL

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	U.S.				13494°2 21250.0	3474402		5993.4 1066.6 7300.0			4174402		6892.1 6892.1
co Attou Case	U' 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0							5393.4 1066.6 7603.0			7603 • 0		
IY STEAS GENTE? . 1474 - VALTSATTOY CASE Employees)	0 0 0 1 0 0 0 0 0 0												
0814110N_SY 147 HUNEL - 	8 1 1 8 8 8 8 8 8 1 1				14750.0	14755					1475C .u		6992 .1 6842 . 1
D. T. T. TRANSPORTATION SYSTEMS GENTCO Meetining thoustry momen - 1974 validat Summary of Lagoa (No. Employees)	5				:3494°2	13494.2					13494.2		
			,		65JQ.C	6500 ° V					65JC • C		
SECTION N. 1J	LARGE REFINERY	8	BASE CASt HIGH CONV Low Conv Surtal	SOUR FRUDE	BASE CASE HIGH CONV - OH CONV	SUBTOTAL	GALIF CRUDË	BASE CASE HIGM COVV Low Conv Subtotal	ALASKAN CRUJE	BASE CASE HIGH COVV LCM CONV Suntotal	TOTAL FOR LAPGE REFINERY Mey rffinepy	SWEET CRUDE	BASE CASE HIGH CONV Low Conv Surfotal

SECTION D. 11

D. D. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY NUDEL - 197+ VALIDATION CASE

SUMMARY OF LABOR (110. EMPLOYEES)

U.S. . 5 ÷ m ~ -

MED RFFINERY							
SOUR CRUDE							
BASE CASE HIGH CONV Loh Conv Surtotal			6°136			957 . 9	
CALIF CRUDE							
BASE CASE MIGN CONV Lon Conv Subtotal							
ALASKAN GRUDE							
PASE CASE MIGH CONV Lom Conv Subtotal							
TOTAL FOR MEN REFINERY			7850.0			7856.6	
SMALL REFIMENY							
SMEET CRUDE							
AASE CASE MIGM CONV		350.0.0	3562.j	126.6	2530 °0	9560.0 126.6	
SUBTOTAL	990.006	35.J.J. 0	35 j. d	126.0	25J0.0	10526.6	
SOUR CRUDE							
BASE CASE Migh conv Low conv Subtotal				245.0 2634.1 2529.7		245.6 2284.0 2529.7	

	u.s.				13056.3			626 5 J. + 7
E² Aljon Casê	2				2560.0			0 J + 0 0 SF
D. J. T. TRAUSPORTATION SYSTEMS CIMTER Refining Industry Mydel - 197, validation Case Summary of Lagor (ND. Employees)	m M				2656 . 3			2674.23
PORTATION S TRV MJDEL - Labor (ND.	0 M3 U 0 M3 U 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				35µ4 ° č			žŕ16°
 Т. ТРАНБРОКТАТІОN Т. ТРАНБРОКТАТІОN INING INDUSTRY MIDEL Summary of Labor (но. 					3560.6			16 494.22
• त ह					. ° 006			7+36+.6
SECTION D. 12		SMALL REFINERY Calif Crude Calif Crude	HASE CASF HIGH CONV LON CONV SURTOTAL ALASKAN CRUJE	BASÉ CASE HIGH Conv Lon Conv Surtotal	TOTAL FOR SMALL REFINERY Ingremental processes	DIESEL HYDROCPACKING Exist, ac for DSL. Hydrotreating Gaso Desulf Diesel Desulf Subtotal	DESULFURIZATION HYDROCRACKING Exist, HC FOP OSL Hydrotreating 6650 desulf Difsel desulf Suatotal	יודורודע זמדאנ

SECTION D. 13

D. D. T. TRANSPORTATION SYSTEMS GATTA

PEFINING INDUSTRY MURL - 147- VALIDATION CASE

SUMMARY OF OPER COSTS (M1/7)

LARGE REFINEPY

SWEET CRUDE

BASE CASE HIGH CONV LOM CONV Subtotal

SOUR CRUDE

RASE CASE HIGH CONV Lom Conv Subtotal

442.6 535.2 977.8

357.8

442.6

177.3

173.6 21.2 194.8

173.6 21.2

SUBTOTAL 177.3 442.6 357.8 Calif CPUDE Base Casé High Conv

BASE CASE HIGH CONV Low Conv Subtotal

ALASKAN CRUDE

RASE CASE Migh Conv Lom Conv Subtotal TOTAL FOP LARGE REFINERY 177.3 442.6 357.9 HED Refinery

1172.6

SMEET CRUDE

BASE CASE HIGH CONV Low Conv Subtotal

135°9 135°9

135,9 135,9

			u.s.						246.6				8 8 8 8 8 8 8 8	1575.88
2 1 11	AFTON CASE	5 0 0 8 8 8							21.9				0 0 0 0 0 0 0	216•E4
VSTERS CEN	1474 VALIN	(U/§H)	-1" 						54.7				0 0 0 0 0 0 0	54.63
PORTATION S	TRY MOREL -	SUMMARY OF OPEP COSTS (M&/0)	••••••••••••••••••••••••••••••••••••••						78.2				0 0 0 0 0 0 0 0 0	592.72
0. Q. T. TRANSPORTATION SYSTEMS CERTER	REFINING INDUSTRY MONEL - 1474 VALIDATION CASE	SUMMARY OF OPEP COSTS (M&/)	N						73.9				8 0 0 0 0 0 0 0 0 0 0	521.52
•0	926		+4 						13.6				0 0 0 0 0 0	19i • 33
	SECTION 11. 15			SMALL REFINERY	GALIF CRUDE	HASE CASE HIGH CDNV Lom CDNV Subtotal	ALASKAN CRUJE	BASE CASE HIGH COVV Lom Conv Subtotal	TOTAL FOP SMALL REFINERY	INCREMENTAL FROCESSES	DIESEL HVDROCRACKING HVDROCRACKING Exist. HC FOR DSL HVDROTREATING GASO DESULF DIESEL DESULF Subtotal	DFSULFURIZATION 		UTILITY TOTAL

		2 CC AL BA	•	-100.00	-1.88 -1.35 -1.35	4.58		2.48	• • 09 1 • 09	24.41	10• 36 9• 15	6.91	1 • 36 6 · 46	7.88	15.86	2.77	1.52	3.06	10.0	. 14	. 10		10 3. 66	92		40.8.60	5° 56	500.00	14.58
		16 GRLM3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-136.63	-1.03 63	63		4 • 0 J	1.447	15.21	16.04	16.03	• • • • • • • • • • • • • • • • • • •	00.0	17.93	3,94	1.23	40.4	• 4 5	•1.		1	105.40	3.85		414.71	5 • t + 0 • 1 4	500.04	13.64
		1CGRLLC		-100.00	-1.00 60 66	-102.		3.04		14.97	14.97	14.97	, 45 2 , 63	21.05	12.70	3.90 2	1.20	4 - 60	• 45	.13	.10		103.94	1.74		392.84	5.74	500°30	
		16 C HL R A		-106.64	-1.50 28 60	1.8		3.40	-	9.	9°6	0.00	02.	6.30	17.71	0 0 0 7 7	1.20	5°82	• 4 5	•14	• 1 C • 1 Y	5 1 1 • 1 • 1	104052	2.64		403.00	5.42 6.18	=00 -CC	16.6.
1 V J 110	:	7758777	:	-166	- 1. 00 20 20 20 	- u		1.45	3	à. 45	2 • 0 C	Z • 45	1. CC	17.65	17.80	7. CL	1 3. 35	3.52			;	• ;	10.67	-1.78		234.53	55. • Z	1. 1. 0.	7.25
STEPS CENTER 167. VALINATION C	•	11 CA SHC	5 8 8 8 8 8 9 8	09°717-	-1.60 - 255 - 613	-101.8		1.45	3	9.13	37°0	3.13	1.00	15.60	15.51	5 	13.30	3 °50					100.61	-1 •3 4		-	5.14	19.103	<u>.</u>
SY	INPUT		8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	-106.00		1.85		1.45	. 41	11.50	16°1	4.25	1.60 6.01	:	17.50	7.00	13.30	m				•	9.68	-2.17		21 4.66	2° 6 8 20 6 8	5. 4. 60	7.23
T. TRANSPORTATION	NEPY UAT	16 CALLC	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	-160.30	-1. -29 -60	- -		2.74	03 09 09	2 4 ° 5 T	4 4 6 2 1	13.63	92°	14.66	19.51	6.11 2 00	1 • 1 • • 1	3.70	0 *		i	1.	104.07	2.16		335.6.2	الله الله الله الله الله الله	560.44	11.64
0. 0. T.		1	1	- 4 - 1 - 4 -	57	-101.		3.40		14.42	4 • 54 14 - 82	14.42	. 70	9.7.6	19.50	6 • 1 C	1.20	3.75	• 16				163.94	2.37		353.15		5.0.6	5 ° 5
		1.5 AL 14	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	-16j.0	- 1. 50 - 31 - 60	-131.91		2.74	49°°	13.35	14.0U	5.63	°75	9.70	13.51	6.13 # 26	<i>•</i> •	3.70	•	.14	.07	****	102.16	• 25	:	144.21	10.0	534. JO	1 76
SECTION 4.			INPUT	SMEFT CRHDE Soup 29ude Calte frude	ALAYAAN LADUE Natural Gasoling Isogutang Normal Butang	TOTAL	0UTPUT	C3 LP5	C4 LPS NAPHTHA	FEGULAR GASOLINE	LOW LEAD GASOLINE	LEAD FRE GASOLINE	JP-4 JET FUEL 157 A 157 EUCI	DIESEL	2 FUEL OIL	HI SULFUR NO. 5	LUBE STOCKS	ESPHALT AND ROAD OIL	COKF (HI SULFUR)	CURE ILAL CRUDET RENTENE	TOLUENE MIXED XYLENES		TOTAL	I NPUT-OUTPUT	OPERATING COST FACTORS	ELEC. PWP (1u06KHH/D	ENEL KEUN, LIULFOEN Energy Cons, (illuifo	LABOR (NO. EMPLOYEES	(1748) SISDE ADAO (1748) SISDE ADAO

D. J. T. TRANSPORTATION SYSTEMS CENTER

SECTION F. 2

REFIMING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

30CAMLC		- 10 8. 00	2.50 1.00	-103.50		. 63	• 25	10.50		-4 -	-		2	-	2.60	2° 00	1.40	. 23		2	• • •	. 87	2.17	102.99	51			316.36	5.70	500.60	6
30 CAMPA	9 0 0 0 0 0 0 0 0	-100.03	2.5 1.0 1	-103.65		• 83	.25	10.49	6 0° 6	5°53	1.93	7.13	69.61	10.03	.	5.64	4	: 0		ú	1 (F) 	.87	2 • 63	9	-7.41			۳. ۱	5.63	- 4	10.1
20CBLHC		-100.00	80 M M 	-104.50		2 . 44	. 54	27.07	16.07	13024	1.09	4.59	5.69	11.48	1.78	1.22	A = 0.1		•96•		• 1 0	.07	1.40	105.93	1.42			. 65 . 0U	6.19 6.27	500.01	2 1
2000410	8 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-100.00	0 M M • • • • • • •	-104.51		2044	111 ·	21.56	16.07	7.20	1.09	4.37	15.51	15.61	2.24	1 2 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	4 0 C	0	. 67		5 U 0 10 10	.19	1.40	C 6.	1.65			42 4 . [[10 40 - 14 - 14 - 14	501.65	د - 0 - 0 - 0 - 7 - 7 - 1
2 C C BL BA	0 0 0 0 0 0 0 0 0 0 0 0	- 109.66	-1.8 -1.3 -1.3	-164.51		2 . 44		25.39	10.67	11.64	40 04 1 0 34	4.59	6 • 32	15.61	2.24	2020	3.03	9	• 94		• •	.19	1.46	• دان ا	• 92			41.1.444	له بال الا به الا به	· · · · · · · · · · · · · · · · · · ·	, , , , , , , , , , , , , , , , , , , ,
20 CA SL C	0 0 0 0 0 0 0 0 0 0	-10û.6J		-104.53		1.85	• 4 6	13.01	40.44	13.41	1.20	46°	23 °96	17.99	29°2	°.	5.72	•					1.29		- • 4 5			267.77			,
2 DC ASHC		-100.00	1.44	-1:5.10		2.30	• 59	14.	\$	14.91	14.91	4.01	10.60	20.69	3° 2'	10.5	7.65						1.51	0 4 • 9C	- 35			271.60	5 F		1.1.1
20 CASBA		-106.00	2 • 4 1 • 4	-105.19		1001	64*	19.31	12.20	9.37	1.27	4.01	11.00	22.19	3.84	2007	7.65						1.37		• • 2 2			2 F 2 B 2 C	i i d Re C Al d		
24'CALLS	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-100.00		-1.1+.51		2 . 44	÷	13.4.5	16.17	7.20 6.51	4.04 1.63	4.37	19.75	15.61	2°5'	2021 1.22	4 0 6 6 7 . f 1	. 61					1 + 4 -	9 °	2 • 1:			573.1.	τις 1.1.1. 		2 + 4 2 2 - 9 2 + 4
20CALHC	0 0 0 0 0 0 0	-10.0.0	- 1 • 33 - 1 • 33 - 1 • 33	-10 - 51		5 * 7 *	• 54	23.76	16.07	4C • 5	10001	5.36	1.75	15.61	1.78	2.13	3 ° C C	9	5				2.72				0 8 9	3 9 3 . 1	5 ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° °		
		SMEET JRUDE Sour Crude Calif Crude Massan Cours	ALASKAN CRUDE Natural Gasoline Isonutane Norhal Butane	TOTAL	0017917	C3 LP5	C4 LPG	PEGULAR GASOLIVE	PREMIUH GASOLINE	LOW LEAD GASOLINE LEAD EREE LASOLINE	JP-4 JET FUEL	JET A JET FUEL	DIESEL	NO. 2 FUEL OIL	HI SULFUR NO. 6	LU SULFUR NU. 6 I LIRF STACKS	ASPHALT AND ROAD OT!		COKE (HI SULFUR)	COKE (CAL CRUDE) Dentent	TOLUENS	MIXID XVLENES		10141	TNPUT-0UTPUT	SHOLDE LSCO SHILERS		ELEC. PWP (ICSCKWH/9	FUTL REDE. (IC. FOR ENFORM FORS, AT FE	LAND (NO. FUPLOYED	(0/4k) 51555 (Jay

Service District	SECTION E. 3		• U	T. TRANSPORTATIO	z z	12					
GFINGAR DATA TINUT GFINGAR TATA GEORGE SCORAGE			L.	-	ייזוגר -	÷					
JUCAME NICAUE NICAUE<			γ 1	FINERY DAT	 Ndh1						
194-00 -101-10 <th< th=""><th>Ĩ</th><th>а с аннс 210 аннс</th><th>30CAL BE</th><th>33 GALHG</th><th>3CCALLC</th><th>3 u CA S6</th><th>* C C A S HC</th><th>34 CASL C</th><th>Ĕ</th><th></th><th></th></th<>	Ĩ	а с аннс 210 аннс	30CAL BE	33 GALHG	3CCALLC	3 u CA S6	* C C A S HC	34 CASL C	Ĕ		
Image: Section (1) -101.01											
MURE -2.59	LIF CRUDE LIF CRUDE LIF CRUDE	-194.GO	÷	⁰	° U C	103.6	1 J Ū • L	106.0	100.0		100.
at -173.45 -104.16 -1	IVPAL FRULE 14Pal Gasoline 39utane 24al Butanê	- 2,59 79 16	-2.	-2.50 11 -1.13	~ * * * ~ • • • •	-2 -9 1 1	1 - 2 - 3 - 5 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	-2.9 7 -1.1	- 2 • 5 4 • 0 4 • 1	2.5	- 2°50 - 1.00 - 1.32
RSOLING ASSOLING	TOTAL	-103.45		-103.74	104.0	1.14.8	14	104.8	-100.4	03.5	104.6
	L P S	.83 26	. ð 3 25	. 8 3 2 6	. 8 ° 2 C	1.67	1. L 2 20	1.07	6 8 °	685 35	. 8 . 7 .
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	HTHA	- CP		9 2 9 9 2 9	• •	יא מים מ •	. 79	. 80		1.32	. 88
	CHINE GASOLIVE	11.15	-	14.76	~ 3	15°('	11.70	10.63 3.60		11.63	33
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	I LEAD GASOLINE	11.15		14.76	ŝ	0.0 Q	11.70	16.63	5		: -
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	ND FREE GASOLINE	14.15	٠	17.73	å.	4 • 1 U	11.7U	10.63	6.10		2.
11.00 9.00 29.05 10.01 10.01 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 19.05 6.50 2.00 2.01 2.00 2.01 <td< td=""><td>A JET FUEL</td><td>7.30</td><td></td><td>6.30</td><td>6.33</td><td>6 . 3 3 6 . 3 3</td><td>6. U7</td><td>6.33</td><td>6.30</td><td>6.1]</td><td>6.30</td></td<>	A JET FUEL	7.30		6.30	6.33	6 . 3 3 6 . 3 3	6. U7	6.33	6.30	6.1]	6.30
16.00 13.00	ESEL Serus an	11.80		9°40	°° c	15.51	10.91	23.42	9	6	ů,
4.20 2.80 2.80 2.80 2.80 2.81	SULFUR NO. 6			20°00 2°80	5.	27°72	< 1 · 1 2 ·	11.01	2 0	v N	3
6.20 2.00	SULFUP NC. 6	4.20	•	2.00	2.80	1.66	4.72	4.92	4.20		(** B 0
1.49 1.42 1.44 $4,7$ $6,56$ $6,56$ $6,56$ $2,20$ $2,23$ $2,33$ $2,69$ $6,69$ <		6.23		2.00	2.65	2.62	2 . 70	2.61	7.10	6.31	6.07
• 59 • 24 • 24 • 24 • 57 • 57 • 57 • 57 • 59 • 69		1.49		1.40	1.4C .47	6.56 .32	6.30 .31	6.56 .32	2.20	2.23	2•20
• 59 • 24 • 24 • 24 • 69	CF (HI SULFU?) CF (CAL CPUDF)								Ň	Ň	
69 67 69 102:23 10:20 20 10:20 20 10:20 20 20 29 10:20 20 20 20 20 20 20 20 60 06 06 06 06 10:20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 <t< td=""><td>17ENE</td><td>• 59</td><td>.9 I QJ 1 0</td><td>~</td><td>~ ~ ·</td><td></td><td></td><td></td><td>.61</td><td>62.</td><td>• 59</td></t<>	17ENE	• 59	.9 I QJ 1 0	~	~ ~ ·				.61	62.	• 59
1.61 $2.1h$ 1.52 1.67 1.63 2.57 1.63 1.29 $1.12.12$ $1.1.7h$ $1.5.31$ $1.9.61$ $1.5.31$ $1.9.61$ $1.2.23$ 1.223 -1.41 $-1.4k$ $-3.4t$ -1.25 -1.51 -4.63 -2.11 -2.34 -2.92 -2.59 -1.41 $-1.4k$ $-3.4t$ -1.25 -1.51 -4.63 -2.11 -2.34 -2.92 -2.59 -1.41 $-1.4k$ -1.25 -1.25 -1.51 -4.63 -2.11 -2.34 -2.92 -2.59 $1.1.47$ $-1.4k$ -1.55 -4.63 -2.11 -2.32 -2.59 -2.59 $1.1.7.07$ $1.1.7.07$ $1.1.7.07$ $1.1.7.07$ $1.1.7.07$ 5.17 <td< td=""><td>LIFN: Sintings</td><td>.69</td><td></td><td>un u</td><td>เม่</td><td></td><td></td><td></td><td>.69 </td><td>E9°</td><td>. 69</td></td<>	LIFN: Sintings	.69		un u	เม่				.69 	E9°	. 69
1)2.12 1.1.7° 1.1.33 1.5.01 1.1.51 ~4.64 162.71 98.36 105.69 102.23 -1.47 -1.56 -3.42 -1.05 -1.51 ~4.63 -2.11 -2.34 -2.92 -2.59 721.59 10.10 0.10 0.10 0.10 0.10 0.10 0.10 0.	SC. PPNOUCTS		~ '		•	:	1.57	- 3	2.57	•	1.29
-1.64 -1.46 -3.42 -1.05 -1.51 -4.63 -2.11 -2.34 -2.92 -2. -2.4 -2.92 -2.4 -1.05 -1.05 -1.05 -1.03 -2.11 -2.34 -2.92 -2.4 -2.4 -2.4 -2.4 -2.4 -2.4 -2.4 -2.	TOTAL		113				1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	62.7		9.)	2.2
	109100-10981	-1.43	-	3.4		ۍ •	÷.	2.1	•	- F	
Prise Pris Prise Prise <thp< td=""><td>RATING COST FACTORS</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></thp<>	RATING COST FACTORS										
Sign Sign <th< td=""><td>Er. PHS [LL. KHH/1</td><td></td><td>2 11</td><td>442 55</td><td>93". 88</td><td></td><td>24. 5 . 2</td><td>5 . 5 4</td><td>~</td><td>- 6.</td><td>-</td></th<>	Er. PHS [LL. KHH/1		2 11	442 55	93". 88		24. 5 . 2	5 . 5 4	~	- 6.	-
	L 2509. (1.3.F0ch	9		1.	در بو بو						5
7.63 $1.7.5$ $1.7.52$ $1.5.54$ $1.5.54$ $1.5.54$ $1.5.54$ $1.5.54$ $1.5.54$ $1.5.54$ $1.5.54$ $1.5.54$	DE THOUSE CLEAR		- 1 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2	7 4				~ · · ·	ۍ ک •	5	ہ م
	THE REPAIRS AND		· · ·						() # () #	א ני ס	: -

9. 0. T. TRANSPORTATION SYSTEMS CENTER

SECTION 4 . 4

D. D. T. IRANSPOWTATION SYSTEMS GENIER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

			FIRERY UAIA							
		3(0366	GAL	C DL A	c GA Si3	ч uCASHC	40CASL	4JC859	CBSL	4 0CBSHC
I NPUT	0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	000000000000000000000000000000000000000	0 0 0 0 0 0 0	6 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	6 0 0 0 0 0 0 0 0 0 0 0 0 0	6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	6 0 0 0 0 0 0 0 0 0 0 0 0
SWEET CRUDE Sour Crude Saite Crude	00.121-	-1iC.0i	-160.00		00.001-	- 16û. u u	-100.00	-110.00	-100 °J J	-100.60
ALLEN FULE ALTUPAL GASOLIYE ISONUTANE NORMAL BUTANE	-2.53 -1.90 -1.53	-2.51 82 -1.15	- 2 . 5 0 - 1 . 5 0 - 1 . 5 0	- 10 10 - 10 - 10 - 10 - 10 - 10 - 10 -	-7.36 - 455 - 1.10	-7.3(06 91	- 5 . 8 k	-7.30 34 -1.26	53 53 - 53	-7.36 67
TOTAL	-105.40		-115.60	-103.36		-108.27	-106.17	-136.30	-104.97	
0UTP!JT										
	, e	5		1	•		•		•	
C4 LPG	• 8 5	•	500	10001	1.40	1.28	1.58	1.25	1.25	1.25
NAPHTHA	.88	1 . 32	- 40 - 40 - 40	. 96					•	
REGULAR GASOLINE	25.67	12 • 9ú		11.40	27.03	17.30	12.15	34.62	14.03	18.87
PREMIUM GASOLINE	15.99	1 · M	5 . 3 B	31.06	13.6A	م	4.05	13.60	4.70	م
LOW LEAD GASOLINE	0.10	12.91	16.13	6.24	5°95	15.2L	12.15	5 . 95	14.63	17.50
LEAU FREE GASOLINE 10-1 151 5051	E.10	12.93	19.95	4.16	16.5		12.15	16.2	14.00	÷.,
1111 1111 1111 1111 - 1111 11111		PC 91	37 0 0 1	6 ((A	5 ° ° 5	50 07 U		20.00	0.00	2007
JET M JET FUEL Difeei	0.5.6	24.63	0 ° 0 ° 0	0.50	2000	n a	2000 1000	10.4	4 ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° °	0 · · · · · · · · · · · · · · · · · · ·
NO. 2 FUEL OIL	15.33	12.65	15.87	5.52	13.20	13.20	11.36	0.90	8.60	6.60
HI SULFUP NO. 6	2.83	2 8	2.60	7.28	62.2	m	3.20	3.20	3~21	3.20
LO SULFUP NO. 5	2 . 30	2 °	2.40	7.29	3.23	3.26	3.20	3.20	3.20	3.20
	2.03	2.0.	2.56		400		.24	• •	.2+	. 24
ASPHALT AND ROAD OIL	2.20	2 ° 2 Ù	2.20	2.05	5.45		1.3	5.45	5.45	5.64
					. 3 2		3	•		
COKE (HI SULFUR)	• • 0	. 6	1. 3.	1.55			•	.58	.58	. 50
COKE (CAL CRUDE)										
BEN7ENE	1 t 1 V 9	•	* 1 * 1 *	• 14						
	.51	• 26		÷2°						
MIXTO XYLENES MISC. PRODUCTS	. E 3 2 . 34	• 71	•	•						
TOTAL	16 - • • 0	112.13	101.25		116.54	10.85	104.15	106.23	104.50	105.17
I NPUT-OUTPUT	-5.5 ()	- 3 - 45	-3.75	- 3.78	-2.31	-1.42	-2.02	- 2 • 67	- + 4 7	-2.80
OPERATING COST FACTORS										
ELEC. PHF (1563KNH70		415.67	141	643.AU		24.2.67	109.605	126.50	324.14	325.67
FUEL 2600. (1205F050	60 m) · 0	P			5.4	ົ		ŧ.
FNERGY COMS. (1503F0	0.6.0	(, ,)	7.14	8.43			6.02	6.07	£6°5	6.28
LABOR (NO. ENPLOYEES	516.10	5,1,6,	5 . 6 C	54.2.00	C ù. ù .?	۲ ۲	500.60	560.03	506.00	500.00
OPES 20515 (M6/D) Thurstments (M41)	15+21	9° 3H	2 • 1	23.53		2	9°71	or -	9°61	13.04

u SECTION

0. 0. T. TPANSPORTATION SYSTEMS SEVIES

		50C0LBA			-100.00		-1.50	1 PD 1 PD		1.50	1.00	11.40	31.60	6.24	4.16	6 6 6 6 6 7 6 6	9.51	5.52	7.28	7.28	09 6	A A 4 7	1.55	46.	. 29	• 35	99.58	- 3, 78		64 3. 60	7.22	500.00	ň
		SUCCLHS			-109.63	-1.4]	-1.53	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1.51		10.11	6.04	10.11	22.75	4 0 ° 9	5.92	3.69	7.25	7.29	1.02	60.0	,	1 • 0 ×	62.	°25	106.03	2.53			7.30	0.0	4 • 4
		500040			-100.00	- 2 - 4 U		-103.9		1.50	0 1 9	15.40	S	5	15.40	4 7 4 7 9 7 9 7	21.24	1 (77)	7.28	7.28	1.02	00.02	i	• 7 t	.29	• 26	106.61	2.71		587.14	6°69	500.00	10.54
		50CCLBA			-100.00	-1.40		103.5		1.50	50	16.30	ം	6 • 2 4	~ "	n -	• 3	• ه	N	N (•	1	. 65	62.	. 50		- • C 8		ം	8.4J		21.9
NH CASE		5604560		-164.60		-1.45	- 66	-102.0		1.23	1.30	5.80 5.80	2,31	5.00	5.86	C . C4	• •	11.07	ê	7.28	.56 5		1			• 54	16.66	-2.1F		215.22	3.46 7.26	F13.66	;
Not Inat Inat ↔/		50 CASHC		-163.63		-1.72	-1.84	-103.56		1.84	2.10	7.99	2 °66	6.76	2°09		12.63	- 1	14.75	- 21 -	Pi 1 .3 C	7 5 . 7				1.44		-4.57		9		2	41 • 12
+791 - 1300H	INPUT	50CASRA		-168.80		- 1 - 40	- 1. 06	13 2.46		1.51	1.00	4 - 5ù	10.50	\sim	2°30	C. 24	: ~	11.07	16.70	ŝ.	1.03	1.5 v				° 5	106.17	-2.23		215.22	8.3	500.03	7
VG LUDUSTRY	FINEPY DATA	50 CALLC		07.301-		-1.40		-1(3.93		1.50	• 5 5 • 1	13.32	4.42	11,32	13,32	47 47 6 01	27.62	3.68	7.28	7.28	1.02	2 • 5			u 0 	.26	1 . 5 . 60	1.76		5 26 . 93		500.66	9 . 6
PEFINING	RE	FGCALHC		-1.0.15		-1.45		-112.57		1 . C.	•	.6.60		ŝ	•	•	• •			•	•	• •		-	52.	N	104.27	1.76		t5].21	7.35	5.1.6.2	2
		5 JC AL RA		-136.48		-1.40	-1.53	-102.97		1.50	.91 01	13.56	31.56	6.24	4.15 	3 ° 3 0	9.8.8	5.52	7.29	17.28	1.02			C F	.29	. 26	112.34	93		661.52	7.27	50.00	21.51
SECTION L. 5		•	INPUT	SWEET CRUDE	CALTE CRUCE CALTE CRUCE Al ASMAN CONDE	PATUPAL GASOLINE	NORMAL BUTANE	TOTAL	1117110	C3 LP5	C4 LPG	PEGULAP GASOLINE	PREMIUM GASOLIVE	LOW LEAD GASOLINE	LEAD FREE GASOLINE	JP=4 J21 FUEL 16T A 16T 51121	DIETEL	NO. 2 FUEL OIL	HI SULFUR NO. 5	LO SULFUR NO. 6	LUBE STOCKS	COKF (LO SULFUZ)	COKE (HI SULFUR)	COKF (CAL CRUDE) Benjene	TOLUENE	MIXED XYLENES MISC. PRODUCTS	TOTAL	IN9UU-IU9NI	OPERATING COST FACTORS	ELEC. PWP (16JJKHH/D	FUEL REON. (1030FOEB PNERK FONS - 111. PEO	LABOR IND. EMPLOYEES	OPER COSIC (48/0) Investrents (444)

15.22.43.02 (Juritzh HAMD) - FILF ANEJI , HC 40, 51 15.22.43.191.4 eNirku ANEUC 10.10.11 (22.43.40.10.41 15.22.49.1004 5.14.03.51.3423 FROM /51 15.14.03.1P L030576 MOPDS - FILE THPUT , UC 31. 31 15.14.03.85600EN26.333. 5.18.39.LABEL (MAG2.R. VSN=P1 +276.L=PIM74BASEN12.1 5.22.43.KFWINOITAPE16,TAPE17,TAPE18,TAPE19,TAPE2 .5.14.12.LAREL (MAG1.R.VSN=P16501.L=N0V77I NUUSPL J. IS.18.39. 9.696 CP SCOMOS COMPILATION TIME IS.18.39.COPYCR(INPUT, TAPES) 3644, MOPPS (247246 FAX 21) 400E+448 11/L 1/77 15.19.11.MT23 VOLUME SERIAL NUMMER IS P14276 15.19.11.MT23 ASSIGNED TO M462 15.19.14.\$VSN= P14276. RD AGGESS GRANTED 15.15.44.MT22 VOLUME SERIAL NU'ARER IS PICSAI 15.15.44.MT22 ASSIGNED TO MAGI 15.15.49.\$VSN= P16561. RD ACCESS GRANTED 5.14.11. ATTENTION - PLEASE CHANGE YOUP COS NOV77INDUSPL60 15.15.52.UPD4TE(P=0L01,N=NEM1,C=COM1,0,F) RIM749ASCH12 .5.16.13.FINII=COM1.R=2.DPT=2.L=0.B=B1) IS.19.29.86.MIND(31,TAPES,TAPE12.TAPE1.3)
IS.19.28.8FL(22U)Cu) 77311 77316 6001 1000 000 000 61 15.19.14.COPYCF (MAG2.T APE13.1) 5.19.26. COPYBF (MAG2, TAPE12, 1) 17.005 900. 2.0.1r 360. 15.15.48. LA9EL READ WAS 15.15.49. Enition Numrer 15.15.48. Petention Cycle 15.22.43.COPY (TAPE16, 0UTPUT) 15.22.47.COPY (TAPE 19.00T90T) 15.22.49.COPY (TAPE 20.00TPUT) 5.22.47.COPY (TAPE18,001901) "the Lobelly I 5.22.45.COPY (TAPE 17,0UTPUT) RETENTION CYCLE 15.14.11. SUPPLIED PASSHORD. 5.15.48.COPYRIMAG1,0L01,1) 15.19.14. LABEL READ WAS 15.19.14. ENITION NUMBER IS.15.55. UPDATE COMPLETE. IS.15.55.REWIND(COM1) 5.14.09.RADP.P4.T1U6.MT1. CREATION DATE Rel number CREATION DATE 5.19.24.COPYCF (4462,0.1) HGP 500PE 3.4.3 5.15.51. COPYR COMPLETE REEL NUMBER 5.14.11.USER (JMA72WC .) 5.19.28. UNLOAD (1462) 5.15.51. UNI DAD (MAG1) 5.15.52.REWIND (DL 01) 15.22.42.RFL(15000) Ļ 5.14.12. NORING) STOP 5.18.39.0PING) 15.22.43.EXIT. F.22.49.C1L 5.19.33.01. 15.22.43.MS 5.22.43.C) 01.64.55.61 19.02.43.04 15.22.42. 15.15.48. 5.15.48. 5.15.43. 5.19.14. 5.19.14. 5.19.14.

Appendix D

INDUSTRY DATA SOURCES

201/202

Appendix D

INDUSTRY DATA SOURCES

The primary sources of refining industry data used in this work are listed below. The data are summarized in Tables D-1 through D-4.

- Refining capacity by PAD district and size class: <u>0il and</u> <u>Gas Journal</u>, pp. 100-118 (4 April 1975)
- Supply and demand by PAD districts: Bureau of Mines, <u>Mineral</u> <u>Industry Surveys</u>, "Petroleum Statement," monthly, Table 32, pp. 36-40, U.S. Department of the Interior (January 1975)
- Movements of petroleum products by pipeline: Bureau of Mines, "Petroleum Statement," monthly, Table 12, p. 13, U.S. Department of the Interior (December 1974)
- Movements by tanker and barge: Bureau of Mines, "Petroleum Statement," monthly, Table 13, p. 14, U.S. Department of the Interior (December 1974)
- Crude oil and product prices: Crude oil--Federal Energy Administration, "Monthly Energy Review" (July 1976); products--<u>Platt's Oil Price Handbook and Oilmanac</u>, 1974 prices, McGraw-Hill, New York (1975).

Table D-1

REFINERY CAPACITY ANALYSIS

PAD District	U.S. Total	10 ³ b/cd	205	2,249	3,002	4,149	4,614	14, 819
	U.9	No.	109	65	40	30	15	259
	V	10 ³ b/cd	197	430	647	928	230	2,432
		No.	22	13	8	7	-	51
	IV	103 b/cd	67	427	52	8	:	547
		No.	15	13	1	8		29
	III	10 ³ b/cd	228	604	915	606	3,476	6, 132
		No.	35	18	12	7	11	83
	II	10 ³ b/cd	197	691	854	1,645	643	4,030
		No.	22	19	13	12	-7	68
	T	10 ³ b/cd	115	96	534	667	265	1,678
		No.	15	2	9	4	-	28
Refinery	Capacity	(10 ³ b/cd)	0-20	20-50	50-100	100-200	200+	

Source: Oil and Gas Journal, p. 100-118 (7 April 1975)

Table D-2

SUPPLY, DEMAND AND STOCKS OF ALL OILS BY PAD DISTRICTS FOR YEAR 1974 (Thousands of Barrels per Day)

III IV 206 691 1,336 691 206 61 25 52 12 52 52 63 115 11 252 45 115 11 115 11 115 11 115 11 115 11 115 12 118 844 8,481 884 8,481 884 118 81 8,490 899 8,490 899 9,92 209 118 31 118 31 118 31 119 31 118 31 119 31 119 31 294 23 204 10 11 21 21 21 21 21								
laaa condanata 120 915 5,959 691 gas plant liquida 2,947 2,610 206 61 and plant condanata 1,114 687 795 45 ydrogen tiput 2,046 8,481 884 23 ydrogen tiput 6,360 4,604 8,481 884 cruda ot1 6,360 4,604 8,481 884 cruda ot1 6,360 4,604 8,481 884 cruda ot1 6,360 4,773 8,570 893 of all ot1 6,344 4,741 8,670 893 of all ot1 6,434 4,741 8,670 893 of all ot1 17 10 992 209 of all ot1 13 2,44 2,11 3,102 4,23 of relatry aupply 6,434 4,741 8,670 893 21 of relatry 2,44 2,11 3,12 22 42 of relatry 2,44 2,13 3,12 24 24 24 24 24 24 <th></th> <th>I</th> <th>II</th> <th>III</th> <th>PI</th> <th>NI-I</th> <th>Þ</th> <th>U.S. Totel</th>		I	II	III	PI	NI-I	Þ	U.S. Totel
gas plant liquida		120	915	5,959	169	7,685	1,080	8,765
and plant condanate B S_2 $$ 23 ydrogen input- 39 32 $$ $2,046$ 85 113 16 ydrogen input- $2,046$ 85 113 16 $1/2$ of all oil- $2,046$ $85,437$ $4,797$ 894 $4,991$ $$ $5,434$ $4,797$ $8,92$ 496 12 $$ $5,434$ $4,797$ 899 905 12 $$ -10 $+56$ $4,790$ 899 211 211 211 $2,1209$ 111 11 211	Natural gas plant liquids	2.947	249	1,336	61	1,656	. 32	1,666
and plant condanate 8 92 23 ytrogen input- 2,046 85 18 16 1 ytrogen input- 6,360 4,604 8,481 884 16 12 of all oil- 138 187 10 10 10 10 of all oil- 5,434 4,797 8,582 906 12 of all oil- 138 107 935 905 10 of all oil- 10 $+56$ $+77$ 8,582 906 12 of all oil- - 10 $+56$ $+77$ 8,592 905 12 of all oil- - - 0 $+56$ $+77$ 8,93 211 22 of all vividual Dist. 1 1 2 8 1 2					`			
1,174 687 795 45 39 3 52 39 3 115 11 $2,046$ 8 115 16 $2,046$ 8 115 10 $$ 58 187 10 $$ 135 866 12 $$ -10 $+56$ $+92$ $+7$ $6,434$ $4,774$ $8,430$ 899 10 10 $+56$ $+92$ $+7$ -10 -21 $0,434$ $4,774$ $8,430$ 899 -21 $0,434$ $4,774$ $8,430$ 899 -21 $0,414$ $2,110$ $2,110$ $2,110$ $2,111$ $2,111$ $2,111$ $0,103$ $2,112$ $2,120$ $2,111$ $2,120$ $2,111$ $2,111$ $0,103$ $2,112$ $2,120$ $2,120$ $2,111$ $2,111$ $2,111$ $0,103$ $2,120$ $2,120$ $2,120$ $2,120$ $2,111$ $2,111$	rts: Natural easolfna and plant condansata-	- 40	52	;	23	83	9	88
39 39 3 52 $ydrogen$ input- 2,046 85 115 115 12 $cruda$ oil- 6,360 4,664 8,481 884 12 $cruda$ oil- 6,360 4,664 8,481 884 12 $cruda$ oil- 6,434 4,741 8,490 899 47 $cruda$ oil- $cruda$ $4,741$ 8,490 899 47 $cruda$ oil- $cruda$ $4,741$ 8,490 899 47 $cruda$ $b,434$ $4,741$ 8,490 899 47 $cruda$ $b,434$ $4,741$ $8,490$ 899 47 $cruda$ 10 10 10 11 10 11 11 $cruda$ 11 $2,140$ $2,120$ 118 21 21 $cruda$ 11 $2,120$ $2,120$ $2,120$ 21 22 $cruda$ 21 $2,120$ $2,120$ 21 22 21 22 21 21	Crude of 1	1,174	687	795	45	2,701	776	3,477
ydrogen input 2,046 85 115 16 1/ ydrogen input $$ 2 360 $4,604$ 8/481 884 eruda oll $$ $6,300$ $4,604$ $8,481$ 884 of all oll $$ $$ $6,304$ $4,741$ $8,490$ 899 of primery supply $6,434$ $4,741$ $8,690$ 899 $$ -100 $+,644$ $2,123$ 992 299 $$ -100 $+,741$ $8,690$ 899 $$	Unfinished of la	39	m	52	1		27	121
ydrogen Input	Rafinad products	2,046	85	115	16		2/ 139	2,401
$ \begin{array}{c} \operatorname{cruda oil} \ldots \ldots$		2 2	E 103 1	18	1 00	24	12.	36
64 135 187 10 of all otl	l'harrowrad for stude of sectors.	00100	4 20 4 4 0 4	0,401 -86	12	14,020		//C'OT
of primary supply 6,424 4,797 8,582 906 of primary supply 6,434 4,741 8,490 899 17 10 13 211 5,102 429 18 244 211 5,102 429 19 1 2 10 211 2 10 12 2 992 209 10 11 2 992 209 10 192 118 912 209 10 192 118 992 209 11 21 370 192 118 31 10 192 118 32 40 25 11 138 352 473 25 15 30 240 252 34 15 30 240 255 34 15 30 240 255 34 19 13 30 286 31 19 13 30 286 27 19 13 30 286 294 19 13 30 286 31 10 136 161 36 <	Processing gein	3	135	187	19	396	85	481
of all ot1 -10 +56 +92 +7 of primary supply 6,434 4,741 8,490 899 17 10 99 21 18 2,160 2,249 1003 211 2,150 2,239 992 209 10 10 11 11 2 10 10 11 11 2 10 10 192 118 31 2,150 2,239 992 209 2,150 2,239 992 209 2,150 2,131 11 2 2,150 2,133 352 473 25 10 192 118 352 473 25 11 138 352 473 25 12 30 236 107 21 30 236 107 21 30 236 240 21 30 236 247 22 10,03 236 247 23 352 473 25 240 236 240 236 25 36 240 26 26	Total supply	6.424	161.2	8,582	906	14,908	2,342	17,042
of primery supply 6,434 4,741 8,490 899 cres - - 3 dots 244 211 5,102 229 dots 2,44 211 5,103 211 ucts: 2,160 2,239 992 209 ucts: 2,160 2,239 992 209 10 192 118 31 ucts: 370 192 118 31 13 2,0 133 40 22 hylene) 313 40 294 1 13 2,0 2,40 23 34 14 31 4,0 286 23 15 352 4,0 28 23 15 352 4,0 28 23 10 193 10 286 23 11 10 21 30 21 21 30 21 36 40 21 30 21 36 40 22 34 28 24 27 23 36 41 26 24 24 36 46 21	Changa in stocks of all oil	-10	+56	+92	4	+145	+34	+179
- $ -$	Total disposition of primery supply	\$5434	4 • 741	067*8	668	14,763	2,308	16,863
17 10 99 20 44 211 $5,102$ 429 101 2160 $2,249$ 1003 211 101 2160 $2,249$ 1003 211 $2,150$ $2,2349$ 1902 209 $2,150$ $2,2349$ 192 219 $2,150$ $2,2349$ 192 211 $2,150$ $2,2349$ 192 209 $2,150$ $2,2349$ 192 209 $2,12$ 313 400 22 101 192 118 31 22 101 192 118 32 40 22 101 123 809 322 40 22 101 136 240 222 40 211 102 211 103 211 22 40 211 102 212 213 212 212 212 212 212 222 <td>rta:</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	rta:							
44 21 5,103 47 adividual Dist. 1-1V)- 1 2,160 2,249 1,003 211 ucts: 2,160 2,239 992 209 211 2 10 192 118 31 2 10 10 192 118 31 2 11 313 50 2,239 992 209 12 310 192 118 31 2 13 370 123 40 22 40 22 13 57 4,0 29,4 21 31 22 14 352 4,0 29,4 21 23 34 23 15 1,706 240 252 34 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 24	Cruda of 1	:	0	2	:	.	0	
Advidual Dist. I-TV)- Image: Constraint of the constra	Rafinad products	11	10	66	1 5	126	92	218
uctes: 2,150 2,249 1,003 211 2,150 2,238 992 209 10 11 11 31 370 192 118 31 370 42 48 9 371 42 48 9 373 40 294 1 1,338 879 355 40 373 40 286 61 38 79 355 107 1,738 879 355 107 1,738 879 355 107 1,706 240 286 61 38 79 225 94 21 22 40 21 21 22 40 21 21 22 40 21 21 22 40 21 21 22 40 20 21 22 40 20 20 21 20 21 22 40 20 21 22 40 20 21 22 40 20 21 22 40 20 21 20 20 21 20 20 20 21 20 20 20 21 20 20 20	ments to other utstricts	1	117	301 °C	£ 7 #	10	g -	51
2,160 2,249 1,003 211 2,150 2,238 992 209 370 191 11 11 371 42 48 9 373 42 48 9 373 13 250 70 370 121 11 31 373 42 48 9 373 1,38 352 40 25 352 40 3 1,338 879 355 107 1,338 879 355 107 26 240 234 23 1,338 879 355 107 2 1,338 879 355 107 2 1,338 879 355 107 2 1,36 240 252 34 2 31 30 21 21 2 136 154 84 27 2 136 154 84 27 2 136 154 84 27 2 136 16 12 26 2 11 26 12 26 2	stic demand for products:	•	4	2	•	:	•	2
2,150 2,238 992 209 10 11 11 31 37 42 48 9 37 42 48 9 37 42 48 9 313 150 294 1 313 158 352 470 25 313 53 470 284 1 1,938 879 355 107 1,938 879 355 107 2 30 206 26 2 30 286 2 30 286 2 30 286 2 30 286 2 1,706 240 286 2 30 286 2 136 11 2 2 136 122 206 2 136 122 206 3 122 206 15 2 136 16 12 2 136 469 3 10,400 15,607 2 10 10 10,00 2		2,160	2,249	1,003	211	5,623	959	6,582
370 191 11 11 31 57 42 48 9 57 42 48 9 57 42 48 9 57 42 48 9 53 54 294 1 55 352 473 25 73 53 355 107 1,706 240 252 34 0 30 286 1,706 240 252 34 0 30 286 1,706 240 252 34 0 30 286 1,706 240 286 1,706 240 286 21 38 41 21 38 41 21 136 15 64 21 11 2 22 136 64 27 23 136 16 1 24 64 3,278 469 25 10 30 20 23 122 206 15 <td< td=""><td>Motor gasolina</td><td>2,150</td><td>2,238</td><td>992</td><td>209</td><td>5,589</td><td>8%6</td><td>6,537</td></td<>	Motor gasolina	2,150	2,238	992	209	5,589	8%6	6,537
57 4.2 4.8 9 57 4.2 4.8 9 57 4.0 2.94 1 58 352 4.73 25 1,336 879 355 107 1,336 879 355 107 1,336 240 252 34 0.1,706 240 252 34 0.1,706 240 286 1,706 240 286 1,706 240 286 1,706 240 286 21 38 41 2 21 38 41 2 21 38 41 2 21 38 41 2 22 136 154 84 23 136 154 84 23 136 122 206 24 39 3,278 469 25 10 30 20 26 122 206 15 27 11 2 28 3,578 3,650 2 29 66,73 3,660 2		10	11	110	7 6	¥ ;	11	C4
jjj 150 70 22 hylene) 5 40 294 1 158 352 473 25 25 158 352 473 25 158 352 473 25 1,338 879 355 107 25 240 252 34 26 21 30 30 286 21 30 30 286 30 30 286 21 30 30 286 21 31 30 21 30 21 32 154 84 21 33 154 84 21 34 11 2 35 154 84 2 32 154 84 2 33 154 84 2 34 10 2 35 10 2 36 122 206 15 41 2 2 35 10 1 36 1 1			57. C.1	97		156	404	222
hylene) 5 40 294 1 158 352 473 25 158 352 473 25 1,338 879 355 107 1,706 240 252 34 0 30 20 255 34 0 30 240 252 34 0 30 286 26 1,706 240 252 34 0 30 286 1,706 30 286 21 30 21 26 13 136 154 84 136 154 84 27 136 154 84 27 23 136 11 24 11 11 25 122 206 15 26 122 206 15 26 17 20 27 11 2 28 3,278 3,278 469 27 10 30 20 27 21 3,0600 2 28 <td< td=""><td>kerosina - typekerosina - type</td><td>313</td><td>150</td><td>70</td><td>22</td><td>555</td><td>216</td><td>111</td></td<>	kerosina - typekerosina - type	313	150	70	22	555	216	111
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0 0 0 0 0 0 0 1,706 240 252 34 0 30 240 252 34 1,706 240 252 34 1,706 240 252 34 1,706 21 30 286 21 30 286 21 27 1 32 98 69 11 136 154 84 27 136 154 84 27 136 122 206 15 137 122 206 15 136 122 206 15 137 122 206 15 13 122 206 15 13 122 206 15 13 122 206 15 13 122 30 30 14 21 10 15 6,172 4,518 3,278 15 20 20 26	Liquatied gases	158	352	473	25	1,008	8°	1,064
0.0648	Kerosinator di 201	1 230	20	40	201	201 201	8 090	0/1
ocks 30 30 286 21 30 21 30 21 21 30 21 21 7 9 6 41 2 7 9 6 9 11 32 136 154 64 27 136 154 64 27 1 11 2 53 122 206 15 53 122 206 15 6,172 4,518 3,278 469 barrals) 16,664 79,553 110,410 15,607	Astilists fuel oil	1.706	240	555 575	5 2	210.2	190	2.624
21 30 21 61 38 41 2 7 4 6 11 7 98 69 11 136 154 84 27 136 122 206 15 53 122 206 15 53 122 206 15 53 122 206 15 6,172 4,518 3,278 469 barrals) 16,864 79,553 110,410 15,807		30	30	286		346	17	363
61 38 41 2 7 4 6 7 98 69 11 136 154 84 27 1 1 2 1 11 2 1 11 2 1 11 2 23 122 206 15 24 17 2 25 122 206 15 21 17 2 21 17 2 25 17 10 30 2664 79,553 110,410 15,607 2000 15,057 15,571 10,610		21	30	21	;	72	15	87
32 98 69 11 136 154 64 27 136 154 64 27 13 12 206 15 13 12 206 15 23 122 206 15 23 12 206 15 24 17 21 25 17 10 30 26 172 4,518 3,278 27 16,864 79,553 110,410 2607 2 30 2,907	Lubrican terrererererererererererererererererere	61	38	41	61	142		155
136 154 84 27 1 1 1 - 2 53 122 206 15 1 17 - 21 17 - 2 21 17 - - 21 17 - - 21 10 30 - 21 10 30 - 21 10 30 - 21 10,410 15,607 2		10	1 4			210		010
1 11 - 2 53 122 206 15 - 17 - 2 - 21 10 30 - 21 10,410 369 barrals) 16,864 79,553 110,410 condanate 15,655 27,13 36,607 2		136	154	3	27	401	62	463
53 122 206 15 17 17 21 10 30 21 10 30 21 10 30 21 10 30 21 4,518 3,278 469 berrale 16,864 79,553 110,410 15,807	load of 1	1	11	8	2	14	s	19
ta	Still gas for fuel	53	122	206	15	396	85	481
6,172 4,518 3,278 469 berrale) 10,410 15,607 3,000	Mant Condensatarrererererererererererererererererere	: 5	12	-	:	/1	:	11
barrals) [6,864 79,553 110,410 15,807 2 condaneata 16,864 79,553 110,410 15,807 2 300 2 900		6.172	A. 518	3.278	697	14.437	2.192	16.629
condanaata 16,864 79,553 110,410 15,807 2	ks of all oils (10 ³ barrals)						6 6	
	Crude oil and lesse condensata	16,864	79,553	110,410	15,807	222,634	42,386	265,020
165 1 622 5 458 218	Willingnad olls	CC0, C1	22,143	5 458	2,900	19,096	20,333	100,031
- 194.129 201.596 213.178 17.705 65	Mefinad products	194.129	201,596	213,178	17.705	626.608	68.437	695,045
226,213 304,914 368,646 36,630	Total	226,213	304,914	368,646	36,630	936,403	137,243	1,073,646

Table D-2 (Continued)

		Naturel gas liquida	e liquide	Other 2/		P 4	DONESTIC by D	T C A E C E I P T S by Diatricta	115				Shimenta		Inventoriae 5/	1ae 3/
	Rafinery	at	produc-	carbona	<u> </u>	From	From	From	From	From	St ock		to other	Local	First of	End of
	Output	relinery	110n	blanded	leporte	-	=		2	>	change	Esporto	- Platricka -	domend	Yeer	YAAL
	688	= ;	•	~ •	176	. 3	*	1,364		•	7 :		971	2,150	168.85	349.96
=	2	5				071	. :	5 5	2						10.4.44	
	2,123			<u>-</u>		•	ž •		• •		1		05	209	1629	7 402
2		200	ŀ		401									6 609	104 757	101 101
A1-1	8.149	40/	•	: 2					90	:	: •		22	846	23.221	24.219
U B. Total	5.575	146	-	9	204						+24			6.537	209,478	218,410
Aviation ganoliga -																
	-	•	•	•	•	•	•	•	•	•	•		•	2:	397	69
	•	•	•	•	•	•	•	~	•	•					414	104
Ξ	2.	•	•	•	• •	•	•	• •			,		<u>.</u>	=~	900° 1	472 1
		·											ľ	1	1 240	1 100
	3 =	• •							•				•	:=	201	0.0
	17										1			53	3,939	1411
Bachtha type lat (vel -																
ĕ	•	•	•	•	:	•	•	30	•	•	•	•	-	57	293	221
11	41	•	•	•	•	-	•		-	•	Ŧ	•	-	27	1.214	1, 529
101	8	•	•	•	~	•	-	•	•	•	•		57	70	2,254	2,119
AI	21	•					•	•			•	•			662	14
Al-1	291	•	•		2	•		•			-	•		136	166 6	4,147
		•	·	•		t	•			·			·			
U.I. Totel		•		-	3	Ť	Î			T	·	·		,,,	1111	1111
Kerosine Type jat tuel -	2.0	•	,		22			214	•	•	•		4	616	5.235	5.276 .
11	125		•			*	•	5	•	•	7	•	•	150	6.026	5,400
III	312	•	•	•	•	•	•	•	•	•	1	•	246	20	6,178	1.536
~1	4	•	·	•		•	-	01		-	•	-		~		
Al-1	6.17	•	•	•	8	•			•		¢,		•	505	12.024	147.81
ft. 9. Total	107							+			(+			11	22.945	21,906
Rehene (Incl. ethylene) -																
Dlatfict 1	•	•	•	•	•	•	•	•	•	•	•	•	•	5	•	•
	-	•	40	•	•	•	•	•	•	•	Ŧ	•	•	9	1,225	1.530
H	5	•	277	•	•	•	•	•	•	•	-	•	•	4.	3,795	68°
AI	-	•		•	•		•	•	•	•	·	·	•			
3-1 2	2 -	•	223	•	• •	• •		• •	• •		7,	• •		091	E20.4	- 792
	ŀ		1	ſ		T					-			17	10.0	\$.362
I famelind acces																
District Buse District 1	19	7	16	•	15		29	4		•	1			061	5.390	4.111
11	2	ą	132	•	2	•	•	207	•	•	01+			352	32,976	89°.85
Ξ.	3	10	169	•	92		2		2	• •	Ę	20	102		CD6"26	4.C. M
		2006	100		00		ŀ	ŀ			N/T	20		1.006	11.13	104.160
	3	-	1		=		•	•		•	1+	5	•	96	1.403	1.792
U.S. Total	321	-219	106		172						+14	25		1,064	919.61	107,980

Table D-2 (Continued)

		Satural man llaulda	a llaulda	Othar 3/		DOM	DOMESTIC	9 2 2 2 2 7 9					18			
		Blended	Plant	bydro-			- 2	lete					Bhipmento		Invatories	teo 2/
	Reflecty	at	produc-	carbone		From	Prom.	From	Prom.	Pron	0 tock		to other	Local	Virat af	Lad of
	output	retinery	1013	b ended	1 10011						chong	a stody a	Mattick			The second
Kareelse - District I	21	•	0	•	•		•	2	•	•	17	•				104.0
	₹:	•		•	•	-		•	•							
	2	•		•	-	•	•		•	•	7 1	•	3	2	2,016	78/ 6
		•	ŀ	•		·									102 00	
AI-1	2	9	-	•	^	• •	• •	• •		• •	;		• •		414	
			F		-						1			176	11.03	19.760
10501 - 010							Í		Ī							T T T T
Distillets ruet oil -	;;										-	,		1 110	20 470	24 210
7 10110010									-		17		: 2		101.10	41.154
		•		- -	-:	7		8	2				-		ALA TE	41 676
111	1.1.1	• •		 			3 -						26	101	1130	1.982
		ľ		-								ľ		3 670	102 614	111 711
AT-1		• •			5				14			~	, «	260	13.025	16.315
n a forel	3 66.8		F		380						01+	-		2.939	196.441	200.060
Bastdial fiel all -									T							
	31	•			1 610					•	*		0	1.706	23.610	27.639
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	100		•		76		•					•		12	TON.	510
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-1-1 -	2.5	0 (• •			• •					53	• =	•	. 201	11 622	11.016
		·	ľ			ľ	ľ					I			A A A A	
U.L. Total	9/0-1	•	·	2	12/21		Ì			Ī					AL IN	20.45
Petrochemical faadatocke -			_		0			9				•		\$	6.8	104
Oterice [2:	•	•	•	7	•	•	2 4						2.5	444	
	12	•	•	•		•	•	•	•	•	. :			2		
111	6.6.2	•		•	2	•	•		•	• •			2		246.4	6, 6JJ
	•	·	ſ								1	0		A.A.	3 074	9 000
A 9 - 7	Į	• •	• •	• •	- 14						: 7		•	2	110	205
U.B. Total	369	.			12						¢	1		163	1 100.2	3,606
farefall and the -							Ī									
District 1		•	•	•		•	•	21	•	•			•	21	24	1,167
II	2	•	•	•	-			•	•	•	+1	-	•	8	104	1,164
111		•	•	•	•	•	•	•	•	•	ç	~	2	31	1,990	2,719
1 11	•	•	•	•	•	•	•	•	•				•		2	~
A1-1	76	0		•	~	•		•	0	•	\$	4	•	22	C00°C	5,072
		·	·	•	·	•	•	•	·	·	•	•	•			
1910I . B.U		•	ľ	•		Ī	T		T	T					1177	14/47
Looricente - District 1	:	,	,					1		•	*	•	•	63	3.376	4.932
	2.5							:=					•	2	2.177	9.039
111	11	•	•	0	-	•	•		•	•	1	20	31	41	3,229	444
NR IN		•		•		-	•	•	•	-	•	0	-		THE OWNER	2
1-1A	179	0	0	0	-	0	•	•	•	4	+10	2	•	142	160,11	14, 504
		·	•	•	·	-	-									
U.S. Total	17%	-	•		2										120101	Non of

207

Table D-2 (Continued)

		Naturel ges liquids	liguide	Other <u>3</u> /		N O O	ESTIC REC by Districts	RECEIPT	2				Shipments		Inventorles	ee 3/
	Refinery	at	produc-	cerbone	1	From	Frem	From	From	From	Stock	Funnta	to other districts	local	Virst of	End of
Dise-las	ovtput	Tatinery	100	Plended	1 Jodur	+-	÷				-			-	204	222
01961144 F								4	•	•		•		+	228	270
112	•	•	•	•		•	•	•	•	•	•	2	en1	•	159	544
AL		•	-	•		•			•	•	•	•	·	•		
1-1A	91			•	-		•	•		•	1	2	•	5.	976	1,099
*	-				•	•	•	-	1	·	·	•	•		26	2
U.S. Totel	61	•		•	2					+	1	7		02	066	1414
Coite §/ -	;								•	•		\$		52	2.726	1.094
UISCIACE		•							•	•	-		•	86	2.533	494
							•	•		•	-	1	•	69	561	244
	_			•					•	•	•		•	11	1.822	1.631
1-1	252										6-	15		210	7.445	4,283
2			•	•	•	•	•	•	-	•	4	62	•	29	2,529	751-1
U.S. Jotel		•	·								-	611		239	978.6	2.420
	_				ç				,			1	4	136	4.229	3.335
Olatrict 3		•	•	•	2	•	•							154	4.614	100.7
		•	• •	• •			• •	2.		, ,	: 7	-	26		2.766	4.172
			, ,	•	•	•	•	•	•	-	+	•	•	27	1,270	1.631
NI -1	386				ī						+16	-	·	101	12,699	10,900
		•		•	•				•	·	-	•	-	62	2123	280.2
V.S. Total	450	·	•	·	10							-		463	15.024	21.070
	•								,			•	•		49	•
UISTICE &		• •	• •	• •					•	•		• -	•	11	101	551
111	•	•	•	•	•			•	•		•	•	•	•		•
1	~	•	•	•	-	•	-	•	•	•	·	•	•	~		9
VI-1	14							•	•			•		4	267	950
		-			•	·	•	•		·				61	661	1.000
		Ī														
nisceriansous produce - District 1		0		•	3	•	•	4	•	-	•	81	•	21	1001	229
11	•	•	•	•	•	•	•	\$	•	•	Ŧ	•	•	2	\$12	5.0
11	_	•	~	•	•	•	•	•	•	•	•	2	10	00	040	<u>8</u>
1	·				ľ	•	•	•	·	ŀ	•	•				
AI-I	19	• •	, ,	•••	•	• •	•••	•••	•••	•		,	1	5	276	141
					~						1+	4		66	466.1	1.025
64111 ges 1/ -										•		:	:			101 110
rice	_	23	2.5	~ *	2,046		99	2,637	. *	•		29	12	4.301	194.630	201.5%
			014	. :	591	<u> </u>	90	È,	12		28	1	000.6	5.270	104.676	213,176
	_		28	:~	2		3 -	29	•	20		•	101	469	17.005	12.703
AI-1	1	200	1.220	32	2,262			•		35	26+	126	6(1	14.420	\$90,065	626,608
>	1,976	2	2	61	60	•	•	2	9	·		74	67		1000	100.00

Table D-2 (Concluded)

						SUPPLY								DISTR	DISTRIBUTION				910016	50
					Domentic	Receipte		┢				Runs to stills	ot1110						(thoue.	(thous. berrele)
			from	From		_	_	Totel 1	Total					Translars				-un	Piret	End
	Yroduc-		Olat.	Diet.		Dist.	01et.	-	Nev	Stock	Total	Domatic Foraign	Foraign	ŝ	to other			accounted	lo	of
	tion .	Importe	-	1	111	_	- >		e u p p l y	change	eupply			producta	Districts	Exporte	Loss	for	7002	7001
Crude oil and lases condensate-								_												
District 1	120	1,174	•	ŝ	153	-	•	061	1.484	-	1.407	255	1,175	•	78	•	-	•	10.110	16,044
1	913	687	•	•	1.497	268		1,765	5, 367	+15	\$, 334	2,654	619	2	\$\$	•	~	95	67.425	79,553
111	5,959	795	70	1	•	-		100	6.862	÷	6.857	110.4	786	5	1.652	-	-	-06	100.705	110,410
N	169	43	1	•	,			•	736	11	729	576	44	1	515	•		12	12.251	12.902
1-1v	7.685	107.1					•		990.01	27+	10, 344	7,562	2,682	•	17		12	- 16	207.479	222.634
A	1.080	776	•	•	2	39	•	41	1.697	+20 1	1.077	1.099	770	-		•	-	•	34.999	42.386
U S. Toral	0.765	1.677							12.242	+62	12.160	0.691	3.452	13			Ē	-14	242.670	265.020
Natural gasoline, leopentane																		Local 2/		
		•		,					:	•	-	10		•		,	,			144
			,	,	,	,		1							•					
	2	25	•	•	-	•	•		911	-			•	•	•	•	•	11	8/7*2	1, 9/2
111	361	•	-	•	•	5	•	9	367	Ŧ	306	229	•	•	~	•	•	•	2,061	5,450
IV	5	23	•	•		-	-	•	38		36	20	•	•	•	•	•	•	392	210
1-1A	436	60		•	•			•	615	-	52D	200	•	•	-	•	•	11	7.745	197'6
>	16	9	•	•	•	16	•	1	27		27	1 27	•	•	•	•	1 1	•	06	0
U.S. Total	454	60							345		544	527	٠	•		•	•	17	1,035	2.350
Unfinished of is-							_													
District 1	16	59	•	-	8	,		31	-	-3	•	•	•	•	en1	•	0		15,712	15,055
11	-	-	•	•	•	•	•	•	8	7	•	•	•	•	2	•	•	•	20,126	22,145
111	6-	52	-	_	•	,	•	2	65	+9	•	•	•	•	53	•	•		36,709	59,600
A	-	•	•	•	4			4	-			•	•	•	-	•	•	•	2.195	2.900
A1-1	00	36							14	11+	•		•	•	~		·		75,342	069"61
•	22	22	•	•	1		-	2	2	1.2+	•	•	•	•	•	•	•	•	22.012	1 26.233
U.S. Totel	102	121							19	+19 1		•	•			•	·		124.134	106.031

C Crude.
1/ Includes bonded maptitu jet 4, bonded beroalma jet 39, M distillate fund 19, bonded famildum fund 30, and military offahore use of residual fund 4.
1/ Includes bonded maptitu jet 1, bonded beroalma jet 33, M distillate fund 19, bonded distillate fund 1, bonded maptitu jet 1, bonded beroalma jet 33, M distillate fund 1, bonded distillate fund 1, bonded residual fund 9, and military offahore use of residual fund 4.
1/ Includes crude and transfers Dist. 1 -, Dist. 111 5, Dist. 111 5, Dist. 1V 1, Oist. V 7, U.B. Total 15.
1/ Includes crude and transfers Dist. 1 -, Dist. 111 5, Dist. 1V 1, Oist. V 7, U.B. Total 15.
1/ Includes crude and furth alignments to and Iccs Dist. V 90; V. 0. 10: 111 65, Oist. V 7, U.B. Total 15.
1/ Include and another and a Dist. 1 -, Dist. 111 2, Dist. 111 55, Dist. 1V 15, Dist. 1V 8, Dist. 1V 8, Dist. 1V 15, Dist. 24, U.B. Total 160.

Bureau of Mines, "Petroleum Statement," monthly, Table 32, pp. 36-40, Source:

U.S. Department of the Interior (January 1975)

Table D-3

MOVEMENT OF PETROLEUM PRODUCTS BY PIPELINE BETWEEN PAD DISTRICTS (Thousands of Barrels)

	December	Howmber	December	January - De	camber (Incl.
	1974	1974	1973	1974	1973
rom District 1 to District 2:					
Gasoline, total	3,818	3,958	3,709	46,032	45,438
Notor. Avistica.	3,811	3,958	3,709	45,986	45,385
Jet fuel, total	148	158	212	46	2,612
Haphtha-type	-		35	302	595
Kerosine-type	148	158	177	1,484	2,017
Lerosine	37	30	50	270	403
Distillets fuel oil	1,134	1,101	991	11,605	11,662
rom District 2 to District 1: Gasoline, totsl	975	912	871	12,440	10,066
Notor	975	912	871	12,440	10,066
Jet fuel, total	_	-	-		57
Haphthe-type	-	-	-	-	57
Kerosins. Distillste fuel oil	21 147	4	69	45	49 980
Metural gas liquids	1,403	770	1,117	10,351	11,910
ton District 2 to District 3:					
Gesolins, total	1,659	1,556	1,555	19,582	18,591
Notor	1,659	1,556	1,555	19,582	18,591
Jet fuel, total		30	1	520 513	47
Karosine-type	1		ī	7	6
Distillets fuel oil	484	44	452	5,466	4,743
Natural gas liquids	364	307	330	3,886	3,267
com District 2 to District 4:	242	987	360	2 418	674
Gasolins, total	242	257	360	2,415	674
Distillets fuel oil	41	42	27	585	92
rom District 3 to District 1:					
Gesolins, totsl	28,998	26,973	27,035	321,271	329,835
Motor. Aviatica.	28,983 15	26,973	27,027	321,065 206	329,616
Jst fuel, totsl	4,815	5,066	4,952	51,375	55,504
Raphthe-type	142	133	116	1,423	747
Kerosine-type	4,673	4,933	4,836	49,952	54,257
Kerosine	1,007	838	1,022	8,147	11,134 180,331
Distillats fuel oil	14,932 2,447	14,110 1,383	17,591 1,875	173,417 15,846	18,112
rom District 3 to District 2:					
Gasoline, total	4,062	6,333	5,957	66,521	64,857
Hotor	3,948	6,217	5,852	65,254	63,669
Avistion	114	116	105	1,267	1,197
Jst fuel, total Nephtha-type	147	454	503	3,178	4,614
Kerosine-type	147	452	503	3,109	4,611
Kerosins	25	202	355	2,043	2,505
Distillats fuel oil	1,925	2,972	3,097	25,088	30,938
Watursl gas liquids	9,141	7,765	7,706	75,576	/1,698
rom District 3 to District 4: Gasolina, total	347	460	312	5,305	4,759
Hotor	336	452	297	5,146	4,499
Aviation	11	8	15	159	260
Jet fuel, total		309	345	3,824	4,175
Kerosine-type	340	309	345	3,824	4,175
Distillats fuel oil.	61	46	68	562	688
Natural gas liquids	153	106	155	963	1,259
ron District 3 to District 5:					
Gesoline, total	1,031	1,028	1,164	12,190	11,873
Hotor	241	1,028	1,104	2,146	1,708
Kaphtha-type	122	90	37	894	652
Lerosine-type Distillats fuel oil	119 419	109	85 322	1,252 4,481	1,056
rom District 4 to District 2: Gasoline, total	462	361	430	5,020	4,552
Notor	462	361	430	\$,020	4,552
Jet feel, total	44	67	16	450	310
llaphtha-type. Kerosina-type	-	7		61	•
Kerosine	9	-	2	19	59
Distillats fuel oil	349	321	320	3,720	3,304
roe District 4 to District 3: Materal gas liquids	288	252	285	3,751	3,699
Tom District 4 to District 5:					
Casolins, total	862	715	595	10,540	7,805
Hotor	862	715	595	10,540	7,805
Jet fual, total	131	112	79	1,566	828
Maphthe-type	72	59 53	69 10	704	477
Lerosine-type					

Source: Bureau of Mines, "Petroleum Statement," monthly, Table 12, p. 13, U.S. Department of the Interior (December 1974)

Table D-4

INTERDISTRICT MOVEMENTS BY TANKER AND BARGE OF CRUDE OIL AND PETROLEUM PRODUCTS (Thousands of Barrels)

	December	November	December	January - Dec	ember (Incl.)
Item	1974	1974	1973		
				1974	1973
Gulf Coast to East Coast, total:1					•
Crude oil	2,330	2,914	4,155	52,337	56,614
Unfinished oils	1,089	918	1,291	18,128	14,797
Gasoline, total	16,899	17,571	17,463	179.888	207.474
Motor	16,633	17,312	17,188	176,908	204,258
Aviation	266	259	275	2,980	3,216
Special maphthas	681	692	629	7,646	7,192
Kerosine Distillate fuel oil	1,224	1,076	1,328	10,879	15,078
Residual fuel oil	3,312	10,068	2,129	93,460 36,023	96,283
Jet fuel, total	3,072	3,136	3,734	37,475	16,960 41,034
Naphtha-type	608	643	1,226	9,481	9,480
Kerosine-type	2,464	2,493	2,508	27,994	31,554
Lubricating oil	1,134	1,402	1,198	12,922	12,342
Wax	15	28	32	353	573
Asphalt and road oil	364	440	276	5,796	5,689
Liquefied gases	144	111	131	1,541	1,304
Petrochemical feedstocks	192	211	463	3,757	3,226
Other products	338	222	121	2,536	1,654
Total	43,989	42,750	41.923	462.741	480,220
Gulf Coast to P.A.D. District II:					
Crude oil	1,010	1,300	974	12,841	10,250
Unfinished oils	-	-	-	59	120
Gasoline, total	2,497	2,659	3,184	27,890	32,730
Motor	2,470	2,614	3,121	27,357	31,998
Aviation	27	45	63	533	732
Special naphthas	252	238	365	3,275	3,187
Kerosine	-	96	144	764	956
Distillate fuel oil	620	524	855	6,449	9,224
Residual fuel oil	1,776	1,234	1,127	13,209	10,523
Jet fuel, total	276	175	184	2,698	2,626
Naphtha-type	276	-	-	-227	14
Kerosine-type	276	175 310	184	2,471	2,612
Lubricating oil	329		259	4,125	3,692
Wax	118	212	348	3,684	3,523
Asphalt and road oil Liquefied gases	110	13	112	71	654
Petrochemical feedstocks	98	78	184	1,381	1,872
Other products	28	11	47	1,095	993
Total	7,004	6,850	7,783	77,549	80,350
Gulf Coast to West Coast:		0,050	1,105	110,049	00,000
Crude oil	-	-	-	564	-
Unfinished oils	-	_	-	288	372
Motor gasoline	-	-	-	1,392	675
Kerosine	-	-	-	- '	36
Distiliate fuel oil	46	-	43	2,279	687
Residual fuel oil	-	-	315	316	1,898
Jet fuel, total	-	-	801	2,021	801
Naphtha-type	-	-	110	489	110
Kerosine-type	-	-	691	1,532	691
Lubricating oil	251	35	199	· 1,671	1,491
Wax	-	-	-	-	-
Petrochemical feedstocks	26	-		105	4
Other products		-	8	15	105
Total	323	35	1,366	8,651	6,069
West Coast to East Coast:	_	-	_	_	_
Motor gasoline	-	-	_		4
Special naphthas Distillate fuel oil	_	_			4
Residual fuel oil	-	-	-	-	-
Lubricating oil	88	41	29	785	690
Other products	22	16	11	324	242
Total	110	57	40	1,109	936
¹ Breakdown by region shown in Table					

1 Breakdown by region shown in Table 13a.

Source: Bureau of Mines, "Petroleum Statement," monthly, Table 13, p. 14, U.S. Department of the Interior (December 1974)



Appendix E

DEMAND FORECASTS FROM SRI STUDY FOR THE ELECTRIC POWER RESEARCH INSTITUTE .

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Appendix E

DEMAND FORECASTS FROM SRI STUDY FOR THE ELECTRIC POWER RESEARCH INSTITUTE

The petroleum product demands used in the diesel penetration and desulfurization study cases for 1990 are based on the "low demand" projections of an SRI report* produced for the Electric Power Research Institute (EPRI). This appendix presents the summary exhibits of primary petroleum product demands from this report.

Table E-1

ASSUMPTIONS

(a) Per Capita Gross National Products (1975 Dollars)

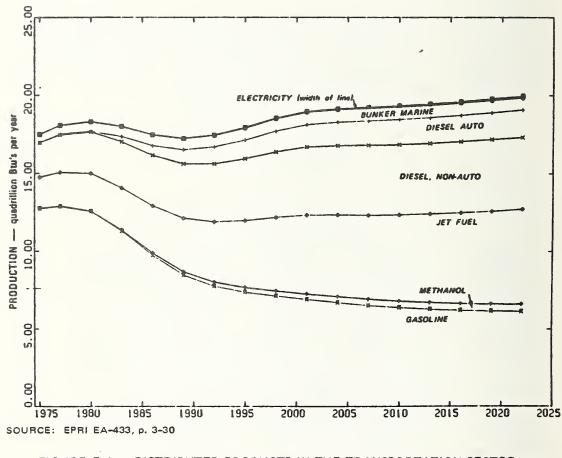
Case	1975	1985	2000	2025
High demand	\$7,030	\$11,200	\$18,700	\$40,600
Base	7,030	10,081	13,783	20,713
Low demand	7,030	8,800	10,100	9,600

(b) Growth in Per Capita Gross National Products

Case	<u> 1975-1985</u>	1985-2000	<u>1975-2000</u>	2000-2022
High demand	4.8%	3.5%	4.0%	3.1%
Base	3.7	2.1	2.7	1.6
Low demand	2.3	0.9	1.5	0.2

Source: EPRI EA-433, Vol. I, p. 3-2

Stanford Research Institute, Fuel and Energy Price Forecasts, report for the Electric Power Research Institute, EPRI Research Project 759-1 (June 1977).



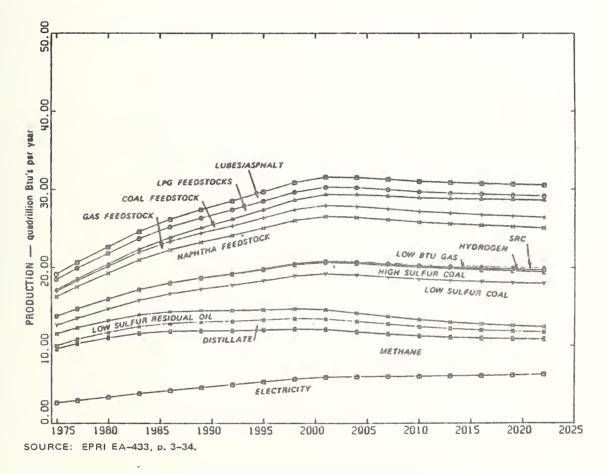


FIGURE E-2 DISTRIBUTED PRODUCTS IN THE INDUSTRIAL SECTOR - LOW DEMAND CASE

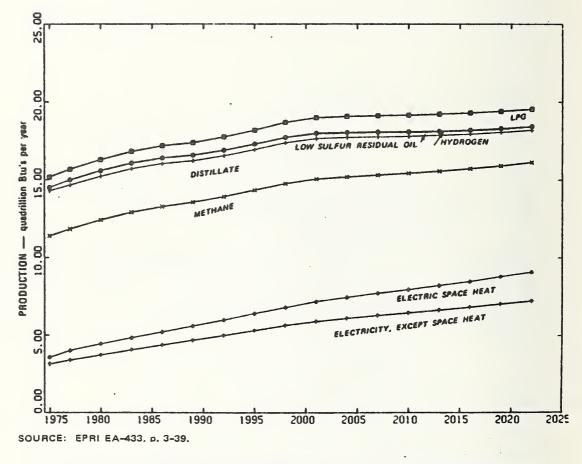
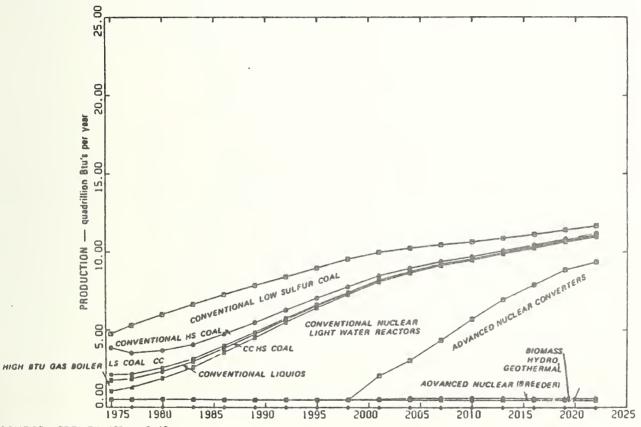


FIGURE E-3 DISTRIBUTED PRODUCTS IN THE RESIDENTIAL/COMMERCIAL SECTOR --- LOW DEMAND CASE



SOURCE: EPRI EA-433, p. 3-43.



Appendix F

REPORT OF NEW TECHNOLOGY

A mathematical model of the U.S. oil refining industry has been developed. This model covers refining and bulk product distribution for each of the five Petroleum Administration for Defense districts. The model was validated against historical capacity and product demands and, after modification, applied to several case studies relating to desulfurization of automotive fuel and dieselization of the automotive fleet.





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