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

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16. Abstract
Because virtually all transportation fuels are based on petroleum, it is essential to include petroleum refining in any assessment of potential changes in the transportation system. A number of changes in the automotive fleet have been proposed to improve efficiency and reduce pollutant emissions. Some of these changes would have an impact on the petroleum refining industry. A mathematical model of the U.S. petroleum refining industry was developed to provide a technologically sound basis for the assessment of such impacts. Case studies performed and included in this report are the following:

- A Potential Shift from Gasoline to Diesel Engines--In a 1995 conservation scenario, automotive diesel-to-gasoline ratios were studied over a range of 0.17/1 to 0.8/1. A minimum refining cost was reached at a ratio of 0.3/1, with a saving of about 2.2 cents per gallon of gasoline plus diesel compared with the cost for the 0.17/1 case. Refining energy consumption reaches a minimum at the 0.5/1 ratio, but it is only 0.08 percentage points below the base of 6.25 percent.
- The Potential Requirement of Sulfur Removal from Gasoline and Diesel Fuel--In the same scenario, gasoline hydrodesulfurization (HDS) to an average sulfur content of 100 ppm costs about 2 cents per gallon, and diesel HDS to 200 ppm costs about 3 cents per gallon.

This work was performed during the 1975-1977 time period. Therefore, it predates and does not consider the possible implications of the current synfuels program.

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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.

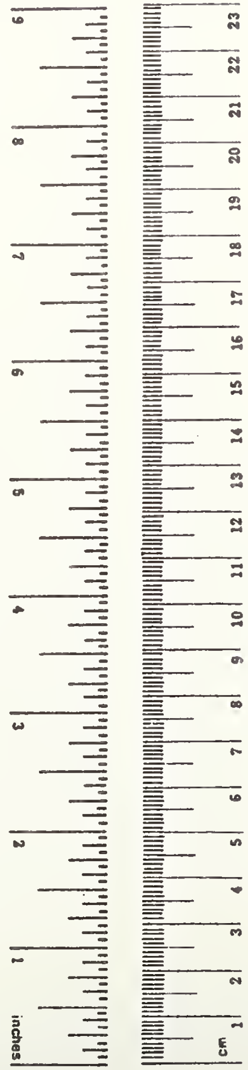
The author wishes to acknowledge the contributions of Mr. Jerry Horton and Mr. Norman Rosenberg of the Transportation Systems Center and of Mr. K. Ushiba and Ms. Meera Rao of SRI.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

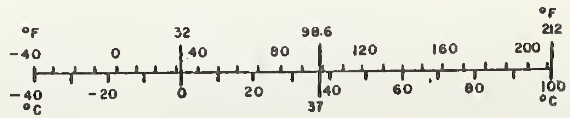
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



METRIC CONVERSION FACTORS

CONTENTS

CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES (Continued)

ABBREVIATIONS AND SYMBOLS

b	barrel
b/d	barrels per day
BERC	Bartlesville Energy Research Center
BuMines	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
M	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):

(1) 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 Oil and Gas Journal, were used to adjust the refining costs to 1979 values.

Table 1-1

CASES STUDIED

Case No.	Description
Case 1	RIM validation with 1974 industry data
Case 2	1995 base case for dieselization study
Case 3	1995 scenario with 15 percent diesel penetration of the automotive fuel market
Case 4	1995 scenario with 30 percent diesel penetration 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 desulfurization 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	5.4	42
Jet fuel	2.3	18
Diesel	1.8	14
Distillate fuel oil	2.0	16
Residual fuel oil	1.3	10
Total major fuel products	12.8	100
Case 3--15% diesel penetration		
Gasoline	4.7	
Diesel	2.5	
	7.2	
Case 4--30% diesel penetration		
Gasoline	4.0	
Diesel	3.2	
	7.2	

*Barrels per calendar day.

Table 1-3

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	Case 5	Case 6
Diesel Penetration, %		30	
Gasoline desulfurization, % (100 ppm S)	0.0	100	100
Diesel desulfurization, % (200 ppm S)	0.0	0.0	100
Incremental cost, ¢/gal desulfurized gasoline*	Base	3.0	3.0
Incremental cost, ¢/gal desulfurized diesel*	--	Base	4.5
Incremental investment, 10^9 \$*			
For gasoline desulfurization	Base	2.7	
For diesel desulfurization		Base	4.8
Incremental energy consumption, % of domestic product (FOE basis)			
For gasoline desulfurization		1.1	
For diesel desulfurization			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 0.5/1 diesel/gasoline ratio, a decrease of 0.08 percentage points below the 1995 base case.

Two fuels desulfurization cases were examined with the RIM:

(1) 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

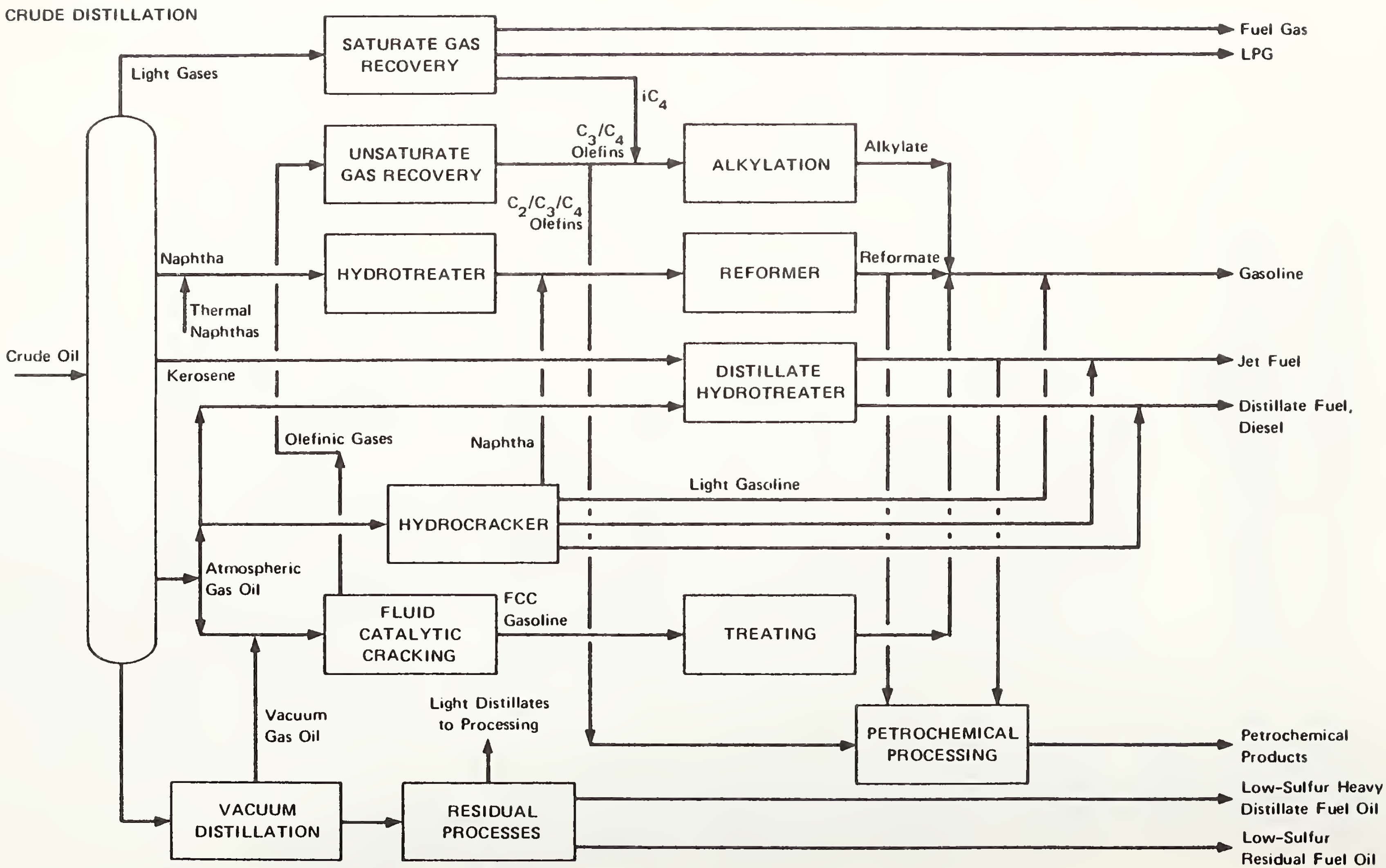
3.1.1 Petroleum Refining Overview

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.



SOURCE: R. M. DeVierman, Presentation at FEA-NPRA Conference, September 1974.

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*

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

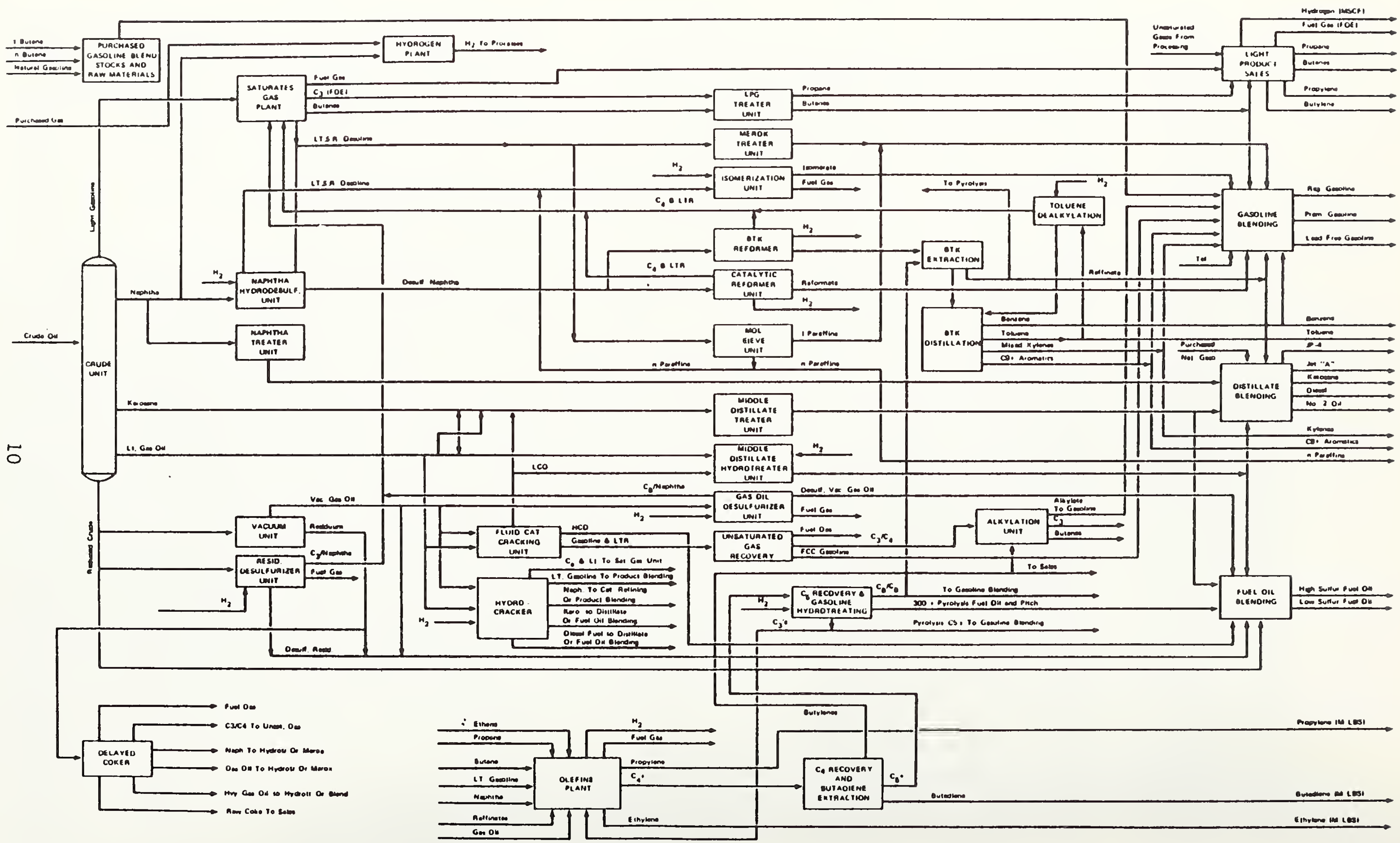

FIGURE 3.1.2-1 REFINING AND PETROCHEMICAL LP MODEL

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

REFINING INDUSTRY GEOGRAPHICAL DISTRIBUTION

Region	PAD District	Number of Refineries*		Capacity (10^3 b/d)		Percent of U.S. Capacity	
		1974	1977	1974	1977	1974	1977
East Coast	I	28	28	1,678	1,732	11	11.2
Midwest	II	68	69	4,030	4,145	28	26.1
Gulf Coast	III	83	96	6,132	6,837	41	43.1
Rocky Mountain	IV	29	29	547	546	4	3.4
West Coast	V	51	51	2,432	2,550	16	16.1
Total		259	273	14,819	15,862	100	100.0
Average				57.2	58.1		

*Reported as operating.

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 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

REFINING INDUSTRY PLANT SIZE DISTRIBUTION

Class (10^3 b/d)	Number of Plants*		Percent of Plants		Capacity (10^3 b/d)		Percent of Capacity	
	1974	1977	1974	1977	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

*Refineries operating on 1 January of given year.

Source: "Annual Refining Surveys," Oil and Gas Journal (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

REFINING INDUSTRY PROCESS APPLICATION

Process	Process Capacity as Percent of Crude Oil Capacity 1974	1977
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

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

3.2.2 Refining Industry Model--Objectives, Scope, and Conceptual Design

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 investment-related 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.

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*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 single-district refining industry matrix includes large and small refineries 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.

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*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	-100.00	-100.00	-100.00	-100.00	-100.00			
Sour crude						-100.00	-100.00	-100.00
California crude								
Alaskan crude								
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								
C_3 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)	0.63	0.61						
Coke (high-sulfur)						0.94	0.87	0.94
Coke (California crude)								
Benzene						0.14	0.14	0.14
Toluene						0.10	0.10	0.10
Mixed xylenes						0.19	0.19	0.07
Miscellaneous 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.

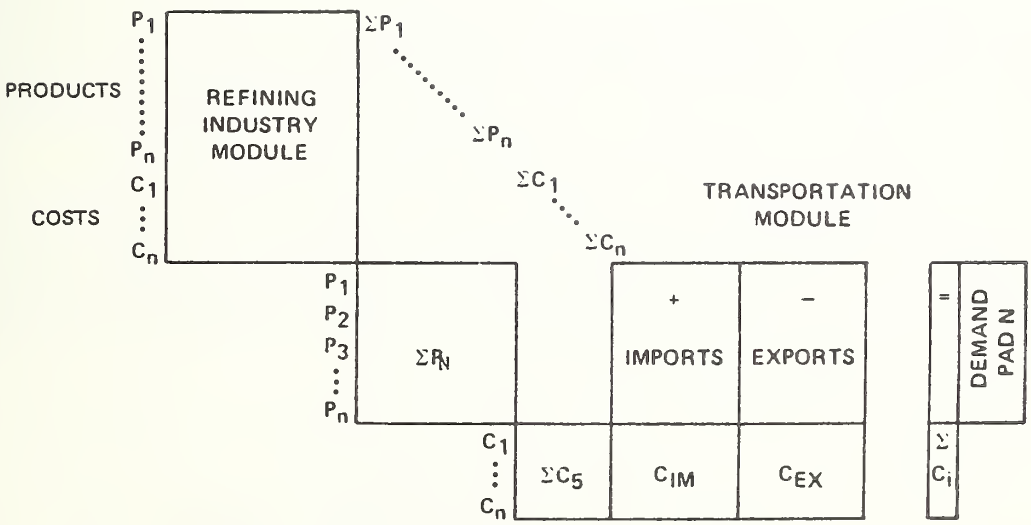

FIGURE 3.2.2-1 REFINING INDUSTRY MODEL CONCEPTUAL MATRIX FOR ONE DISTRICT

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 Validation of Refining Industry Model (RIM) for 1974 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	10.61
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)

	RIM	BuMines	RIM-BuMines	Percent 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.

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*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 study[6] 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 report[6] 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)

	PAD District					Total
	I	II	III	IV	V	United States
1995 base case						
Gasoline	1.85	1.92	0.645	0.170	0.790	5.375
Avgas and military (est.)	0.02	0.02	0.020	0.005	0.020	0.085
Total gasoline	1.87	1.94	0.665	0.175	0.810	5.460
Jet fuel (Jet A)	0.773	0.386	0.242	0.048	0.628	2.080
Kerosene fuel oil	0.070	0.050	0.040	0.003	0.008	0.171
Total kerosene-type fuel	0.843	0.436	0.282	0.051	0.636	2.251†
Diesel, No. 1	--	--	--	--	--	--
Diesel, No. 2	0.605	0.630	0.210	0.055	0.260	1.760
Distillate fuel	0.870	0.608	0.242	0.091	0.180	1.991
Residual fuel	0.784	0.131	0.131	0.044	0.217	1.307
1995--15 percent diesel penetration						
Gasoline	1.610	1.680	0.580	0.155	0.700	4.735
Diesel, No. 1	0.250	0.260	0.085	0.020	0.110	0.725
Diesel, No. 2	0.605	0.630	0.210	0.055	0.260	1.760
Total diesel	0.855	0.890	0.295	0.075	0.370	2.485
1995--30 percent diesel penetration						
Gasoline	1.370	1.420	0.495	0.130	0.595	4.010
Diesel, No. 1	0.500	0.520	0.170	0.045	0.215	1.450
Diesel, No. 2	0.605	0.630	0.210	0.055	0.260	1.760
Total diesel	1.105	1.150	0.380	0.100	0.475	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

PETROLEUM SUPPLY LIMITS IN REFINING INDUSTRY
MODEL CASE STUDIES

	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			

*NL means not explicitly limited.

4.1.3 Facilities

4.1.3.1 Refining. 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 Transportation. 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*)

Limits	PAD District					United States
	I	II	III	IV	V	Total
Lower	1,337	2,425	4,226	410	1,912	10,310
Upper†	1,693	3,937	6,497	518	2,422	12,645
Model usage	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).

Table 4.1.3.2-1

TRANSPORTATION CAPACITY LIMITS AND COSTS

From PAD District	To PAD District: I		II		III		IV		V	
	10^6 b/cd	$/b	10^6 b/cd	$/b	10^6 b/cd	$/b	10^6 b/cd	$/b	10^6 b/cd	$/b
Pipeline										
I	--		200	0.30	0		0		0	
II	80	0.27	--		100	0.99	10	0.58	0	
III	2,000	0.42	600	0.50	--		40	0.60	65	1.00
IV	0		30	0.38	15	0.60	--		60	0.60
V	0		0		0		0		--	
Marine (cost only)										
III		1.20		1.50						2.50

Sources: Limits based on pipeline movements for 1974, multiplied by 1.25, as reported in U.S. Bureau of Mines, Mineral Industry Surveys, Petroleum Statement (February 1975) Representative costs in $/b derived from various issues of "Platt's Oil Price Service" daily

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 Technology for Diesel Production and Sulfur Removal 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 Impact of Increased Diesel to Gasoline Production Ratio 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 1977[7]) 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.

Table 4.2.2-1

SUMMARY OF RIM RESULTS FOR DIESELIZATION CASES

	Case 1--1974	Case 2--1995	Case 3--1995	Case 4--1995
Percent diesel penetration*	--	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, 10^3b/cd				
Jet A, 10^3 b/cd			174	400‡
No. 2 Fuel Oil, 10^3b/cd	51	400‡	400‡	400‡
No. 6 Fuel Oil, 10^3b/cd	1,971	273	338	433
Domestic Crude runs, 10^3 b/cd	13,042	12,539	12,284	12,083
Cost differentials, \$/b gasoline + diesel§	Base	-0.61	-0.52	+0.05
New investment, 10^6 \$	--	54.4	98.8	1,479
Energy consumption, percent of domestic products (FOE basis)	6.31	6.25	6.17	7.30
Percent reduction from base	Base	-0.06	-0.14	+0.99

*Substitution of light diesel for motor gasoline, as forecast by DOT/TSC.

†Total 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 before-tax simple return on new investment; constant 1974 dollar values for costs, including crude oil and imported products.

- 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 "straight-run" distillate content of these products. Some cracked distillate by-products 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

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*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.[a] 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.

Table 4.2.3-1

DIESELIZATION CASE DATA SUMMARY

	Case 1--1974 Validation Case		Case 2--1995 Base		Case 3--1955, 15 Percent Diesel Penetration		Case 4--1995, 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	6,582	(50.7)	5,460	(43.8)	4,734	(38.9)	4,010	(33.8)
JP-4	181	(1.4)	165	(1.3)	166	(1.4)	171	(1.4)
Jet-A	947	(7.3)	1,350	(10.8	1,176	(9.6)	950	(8.0)
Diesel	1,127	(8.7)	1,767	(14.2)	2,492	(20.5)	3,211	(27.0)
No. 2 fuel oil	1,784	(13.7)	1,591	(12.8)	1,591	(13.1)	1,591	(13.4)
No. 6 fuel oil	1,063	(8.2)	1,001	(8.0)	936	(7.7)	841	(7.1)
Other	1,301	(10.0)	1,141	(9.1)	1,083	(8.9)	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)	--		--		174		400	
No. 2 fuel oil	51		400		400		400	
No. 6 fuel oil	1,471		273		338		433	
Total imports	1,522		674		912		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)	--		54.4		90.8		1,479	
Facilities for diesel (10^3 b/cd)								
Existing hydrocracker conversion	--		486		811		856	
New hydrocracking	--						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.

SECTION A. 25

Table 4.2.3-2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, BASE

REFINERY INPUT/OUTPUT SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	IMPORT	EXPORT	TOTAL
INPUT									
SWEET CRUDE	690.0	1376.2	2454.0	240.0	478.0	5238.2			5238.2
SOUR CRUDE	957.0	2425.0	1772.0	228.8		5382.7			5382.7
CALIF CRUDE					1434.0	1434.0			1434.0
ALASKAN CRUDE									
NATURAL GASOLINE	16.5	74.3	105.7	26.2	26.8	249.4			249.4
NORMAL BUTANE	9.9	52.6	42.7	3.5	26.3	135.0			135.0
ISOBUTANE	1.9	52.6	29.6	1.5	14.3	99.9			99.9
TOTAL INPUT	1675.3	3980.8	4403.9	500.0	1979.4	12539.3			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
NAPHTHA	1.8	21.3	37.2		24.9	85.1			85.1
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	729.1	1922.8	1823.0	196.5	788.5	5460.0			5460.0
JP-4 JET FUEL	9.7	43.9	54.9	13.7	42.8	165.0	1.5		166.5
JET A JET FUEL	353.0	318.8	266.2	30.0	382.0	1350.0			1350.0
DIESEL	89.3	476.3	815.8	138.9	247.0	1767.3			1767.3
NO. 2 FUEL OIL	183.0	620.9	731.8	48.9	6.4	1591.0	400.0		1991.0
HI SULFUR NO. 6	81.0	107.9	118.3	15.0	184.2	506.4	130.6		637.0
LO SULFUR NO. 6	69.6	107.9	118.3	15.0	184.2	495.0	142.0		637.0
LUBE STOCKS	40.8	29.6	84.5	1.1	19.6	175.6			175.6
ASPHALT AND ROAD OIL	63.9	178.3	73.3	25.5	66.8	407.9			407.9
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
TOLUENE	.9	2.3	25.3		4.2	32.7			32.7
MIXED XYLENES	.7	4.7	25.6		3.7	34.6			34.6
MISC. PRODUCTS	12.9	52.8	22.3		2.4	90.4			90.4
TOTAL OUTPUT	1709.2	4012.7	4256.9	492.2	2004.0	12475.1	674.0		13149.1
OUTPUT/INPUT,PCT	102.0	100.8	96.7	98.5	101.2	99.5			104.9

Table 4.2.3-3

SECTION 8. 11

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, BASE

PRODUCT CONSUMPTION SUMMARY

	P. A. D. DISTRICT 1	2	3	4	5	U.S.	EXPORTS	EXP TOT	TOTAL
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
NAPHTHA	1.8	21.3	37.2		24.9	85.1			85.1
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1870.0	1940.0	665.0	175.0	810.0	5460.0			5460.0
JP-4 JET FUEL	42.8	31.5	36.0	6.8	49.5	166.5			166.5
JET A JET FUEL	506.0	262.0	170.0	30.0	382.0	1350.0			1350.0
DIESEL	605.0	630.0	210.0	62.3	260.0	1767.3			1767.3
NO. 2 FUEL OIL	870.0	608.0	242.0	91.0	180.0	1991.0			1991.0
HI SULFUR NO. 6	392.0	65.0	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	40.8	29.6	84.5	1.1	19.6	175.6			175.6
ASPHALT AND ROAD OIL	63.9	178.3	73.3	25.5	66.8	407.9			407.9
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
TOLUENE	.9	2.3	25.3		4.2	32.7			32.7
MIXED XYLENES	.7	4.7	25.6		3.7	34.6			34.6
MISC. PRODUCTS	12.9	52.8	22.3		2.4	90.4			90.4
TOTAL	4872.2	4015.8	1781.5	429.3	2050.3	13149.1			13149.1

Table 4.2.3-4

SECTION C. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, BASE

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
ELEC. PWR (1000KWH/D)	6056.5	13906.1	16615.7	1443.6	9448.3	47464.2
FUEL REQD. (1000FOEB/D)	76.6	204.1	243.7	23.3	113.1	660.6
ENERGY CONS. (1000FOEB/D	94.6	232.6	291.7	28.0	133.1	779.9
LABOR (NO. EMPLOYEES)	8235.0	19006.1	21130.0	2343.8	9560.0	60274.8
OPER COSTS (M$/D)	136.1	491.6	296.8	30.6	149.3	1104.5
INVESTMENTS (MM$)	12.0	4.5	30.2	3.7	4.1	54.4

Table 4.2.3-5

SECTION A. 25

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 15 PCT DIESEL

REFINERY INPUT/OUTPUT SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	IMPORT	EXPORT	TOTAL
INPUT									
SWEET CRUDE	690.0	1413.0	3132.0	240.0	478.0	5953.0			5953.0
SOUR CRUDE	647.0	2425.0	1126.4	228.8		4427.1			4427.1
CALIF CRUDE					1434.0	1434.0			1434.0
ALASKAN CRUDE									
NATURAL GASOLINE	13.4	75.1	106.6	26.2	26.8	248.0			248.0
NORMAL BUTANE	8.0	53.2	37.0	3.8	24.7	126.6			126.6
ISOBUTANE	1.9	53.2	23.5	1.9	14.3	94.9			94.9
TOTAL INPUT	1360.3	4019.5	4425.4	500.6	1977.8	12283.6			12283.6
OUTPUT									
C3 LPG	39.3	79.4	27.2	4.7	22.9	173.5			173.5
C4 LPG	9.8	7.9		.2	1.7	19.4			19.4
NAPHTHA	1.8	21.3	42.2		25.2	90.6			90.6
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	546.9	1704.7	1628.4	194.0	661.0	4735.0			4735.0
JP-4 JET FUEL	8.3	44.4	57.4	13.7	42.8	166.5			166.5
JET A JET FUEL	231.0	262.0	271.0	30.0	382.0	1176.0	174.0		1350.0
DIESEL	139.6	744.7	1034.2	141.3	432.4	2492.2			2492.2
NO. 2 FUEL OIL	173.1	652.4	710.1	49.0	6.4	1591.0	400.0		1991.0
HI SULFUR NO. 6	68.9	169.3	120.6	15.0	180.9	494.7	142.3		637.0
LO SULFUR NO. 6	57.5	109.3	120.6	15.0	139.2	441.6	195.4		637.0
LUBE STOCKS	37.1	29.6	85.4	1.1	17.3	170.5			170.5
ASPHALT AND ROAD OIL	51.3	181.1	70.3	25.5	56.2	384.5			384.5
COKE (LO SULFUR)	1.9		11.6	.9	1.1	15.5			15.5
COKE (HI SULFUR)	2.9	21.0	6.8	1.3		32.0			32.0
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	.9	3.4	13.8		1.7	19.9			19.9
TOLUENE	.6	2.3	25.4		4.2	32.5			32.5
MIXED XYLENES	.5	4.7	27.6		3.7	36.5			36.5
MISC. PRODUCTS	10.4	53.3	30.0		2.4	96.1			96.1
TOTAL OUTPUT	1381.8	4030.6	4262.7	491.9	1991.7	12178.7	911.7		13090.3
OUTPUT/INPUT, PCT	101.6	100.3	96.8	96.2	100.7	99.1			106.6

Table 4.2.3-6

SECTION 8. 11

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 15 PCT DIESEL

PRODUCT CONSUMPTION SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	EXPORTS	EXP TOT	TOTAL
C3 LPG	39.3	79.4	27.2	4.7	22.9	173.5			173.5
C4 LPG	9.8	7.8		.2	1.7	19.4			19.4
NAPHTHA	1.8	21.3	42.2		25.2	90.6			90.6
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1620.0	1680.0	580.0	155.0	700.0	4735.0			4735.0
JP-4 JET FUEL	42.8	31.5	36.0	6.8	49.5	166.5			166.5
JET A JET FUEL	506.0	262.0	170.0	30.0	382.0	1350.0			1350.0
DIESEL	855.0	890.0	295.0	82.2	370.0	2492.2			2492.2
NO. 2 FUEL OIL	870.0	608.0	242.0	91.0	180.0	1991.0			1991.0
HI SULFUR NO. 6	392.0	65.0	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	37.1	29.6	85.4	1.1	17.3	170.5			170.5
ASPHALT AND ROAD OIL	51.3	181.1	70.3	25.5	56.2	384.5			384.5
COKE (LO SULFUR)	1.9		11.6	.9	1.1	15.5			15.5
COKE (HI SULFUR)	2.9	21.0	6.8	1.3		32.0			32.0
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	.9	3.4	13.8		1.7	19.9			19.9
TOLUENE	.6	2.3	25.4		4.2	32.5			32.5
MIXED XYLENES	.5	4.7	27.6		3.7	36.5			36.5
MISC. PRODUCTS	10.4	53.3	30.0		2.4	96.1			96.1
TOTAL	4834.1	4005.4	1793.4	428.8	2028.5	13090.3			13090.3

Table 4.2.3-7

SECTION C. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 15 PCT DIESEL

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
ELEC. PWR (1000KWH/D)	4781.4	13996.9	16091.7	1420.7	9448.3	45739.1
FUEL REQD. (1000FOEB/D)	59.8	192.8	236.5	22.9	103.3	615.5
ENERGY CONS. (1000FOEB/D	75.5	234.5	283.7	27.6	130.2	751.4
LABOR (NO. EMPLOYEES)	6685.0	19190.2	21291.8	2343.8	9560.0	59070.7
OPER COSTS (M$/D)	93.8	364.6	269.5	36.6	79.6	844.1
INVESTMENTS (MM$)	12.0	26.0	30.5	3.7	16.6	90.8

Table 4.2.3-8

SECTION A. 25

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL

REFINERY INPUT/OUTPUT SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	IMPORT	EXPORT	TOTAL
INPUT									
SWEET CRUDE	690.0	1920.0	3132.0	240.0	478.0	6460.0			6460.0
SOUR CRUDE	647.0	1127.0	1724.1	228.8		3726.8			3726.8
CALIF CRUDE					1434.0	1434.0			1434.0
ALASKAN CRUDE									
NATURAL GASOLINE	13.4	58.2	124.1	22.7	26.8	245.1			245.1
NORMAL BUTANE	8.0	41.5	43.7	1.3	26.3	120.9			120.8
ISOBUTANE	1.9	41.5	36.8	2.1	14.3	96.7			96.7
TOTAL INPUT	1360.3	3188.1	5060.7	494.9	1979.4	12083.4			12083.4
OUTPUT									
C3 LPG	39.3	63.8	32.2	5.0	24.2	164.5			164.5
C4 LPG	9.8	5.2		.2	1.7	16.8			16.8
NAPHTHA	1.8	21.3	49.9		24.9	97.9			97.9
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	546.9	1259.3	1478.8	167.0	558.0	4010.0			4010.0
JP-4 JET FUEL	8.3	34.3	71.9	13.7	42.8	171.0			171.0
JET A JET FUEL	71.4	148.7	317.9	30.0	382.0	950.0	400.0		1350.0
DIESEL	235.4	804.2	1505.7	166.3	499.0	3210.7			3210.7
NO. 2 FUEL OIL	237.0	509.4	793.6	44.5	6.4	1591.0	400.0		1991.0
HI SULFUR NO. 6	68.9	78.5	162.8	15.0	184.2	509.5	127.5		637.0
LO SULFUR NO. 6	57.5	57.9	65.0	15.0	136.0	331.4	305.6		637.0
LUBE STOCKS	37.1	29.6	102.2	1.1	19.6	189.6			189.6
ASPHALT AND ROAD OIL	51.3	120.6	114.3	25.5	66.8	378.6			378.6
COKE (LO SULFUR)	1.9	7.9	8.8	1.1	1.3	21.0			21.0
COKE (HI SULFUR)	2.9	9.8	10.3	1.3		24.4			24.4
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	.9	1.6	13.9		1.7	18.1			18.1
TOLUENE	.6	1.1	25.5		4.2	31.4			31.4
MIXED XYLENES	.5	2.2	28.8		3.7	35.2			35.2
MISC. PRODUCTS	10.4	42.5	63.4		2.4	118.7			118.7
TOTAL OUTPUT	1381.6	3197.9	4845.3	485.7	1969.5	11880.2	1233.1		13113.3
OUTPUT/INPUT,PCT	101.6	100.3	95.7	98.1	99.5	98.3			108.5

Table 4.2.3-9

SECTION 8. 11

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL

PRODUCT CONSUMPTION SUMMARY

	P. A. D. DISTRICT 1	2	3	4	5	U.S.	EXPORTS	EXP TOT	TOTAL
C3 LPG	39.3	63.8	32.2	5.0	24.2	164.5			164.5
C4 LPG	9.8	5.2		.2	1.7	16.9			16.8
NAPHTHA	1.8	21.3	49.9		24.9	97.9			97.9
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1370.0	1420.0	495.0	130.0	585.0	4010.0			4010.0
JP-4 JET FUEL	42.8	31.5	36.0	11.3	49.5	171.0			171.0
JET A JET FUEL	506.0	262.0	170.0	30.0	382.0	1350.0			1350.0
DIESEL	1105.0	1150.0	380.0	100.7	475.0	3210.7			3210.7
NO. 2 FUEL OIL	870.0	608.0	242.0	91.0	180.0	1991.0			1991.0
HI SULFUR NO. 6	392.0	65.0	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	37.1	29.6	102.2	1.1	19.6	189.6			189.6
ASPHALT AND ROAD OIL	51.3	120.6	114.3	25.5	66.8	378.6			378.6
COKE (LO SULFUR)	1.9	7.9	8.8	1.1	1.3	21.0			21.0
COKE (HI SULFUR)	2.9	9.8	10.3	1.3		24.4			24.4
COKE (CAL CRUDE)					10.6	10.6			10.6
BENZENE	.9	1.6	13.9		1.7	18.1			18.1
TOLUENE	.6	1.1	25.5		4.2	31.4			31.4
MIXED XYLENES	.5	2.2	28.8		3.7	35.2			35.2
MISC. PRODUCTS	10.4	42.5	63.4		2.4	118.7			118.7
TOTAL	4834.1	3907.0	1962.5	427.2	2042.5	13113.3			13113.3

Table 4.2.3-10

SECTION C. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
ELEC. PWR (1000KWH/D)	4781.4	12825.9	24725.5	1485.0	12940.4	56758.1
FUEL REQD. (1000FOEB/D)	59.8	152.7	252.1	23.2	106.2	594.0
ENERGY CONS. (1000FOEB/D	68.9	197.3	396.4	26.0	178.7	867.2
LABOR (NO. EMPLOYEES)	6685.0	15270.9	24451.2	2343.8	9644.2	58395.0
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

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 study[9] for EPA indicates a maximum saving of about $0.50/b of automotive fuel (diesel plus gasoline) at a 1/1 ratio of diesel to gasoline. This is compared with a base case of a 1/10 diesel-to-gasoline 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 on-stream 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 1/1 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.

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

Table 4.2.4-1

COMPARISON OF DIESELIZATION STUDIES

Study	Range of Diesel/Gasoline (D/G) Ratios Studied	Maximum Cost Saving (corresponding D/G volume ratio)		Maximum Refinery Energy Saving, Percent of Domestic Products (FOE)			Industry Incremental Investment at Maximum Energy Saving, 10^6 1974 $	
		$/b D + G	D/G	Base	Saving	D/G	Total	$/b/d, D + G
SRI/DOT	0.17-0.80	0.61	0.32	6.31	0.14	0.53	90.8	12.5
Kant et al.[9]	0.11-2.7	0.52	1.0	9.1	1.9	0.76	*	16.1
Bonner and Moore[10]	0.11-1.20	2.34 (1.57)†	0.69	8.1	1.1	1.2	720	102.7
Shearer and Wagner[13]	0.09-0.69	None‡		15.4	1.4	0.46	*	41.0

*Single refinery effect, not extrapolated to U.S. industry.

†Deflated to 1974 costs at 3 percent per year.

‡This study[13] 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 Wagner[13] 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.

Table 4.2.4-2

PRODUCT DISTRIBUTION

	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	**	
Gasoline	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	--	--	
Heating oil	25.0	--	--	
Residual	27.3	--	54.4	
All products (volume percent of total domestic demand)				
Domestic	94.9	--	93.5	--
Imported	5.1	--	6.5	--
	100.0		100.0	

*Case 2, 1995 base domestic refinery output.

†Low fuel oil case.

‡Baseline scenario for 1995.

§Case of maximum energy savings.

**LPG included in "Other" product category.

††Produced coke instead of residual fuel oil.

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.

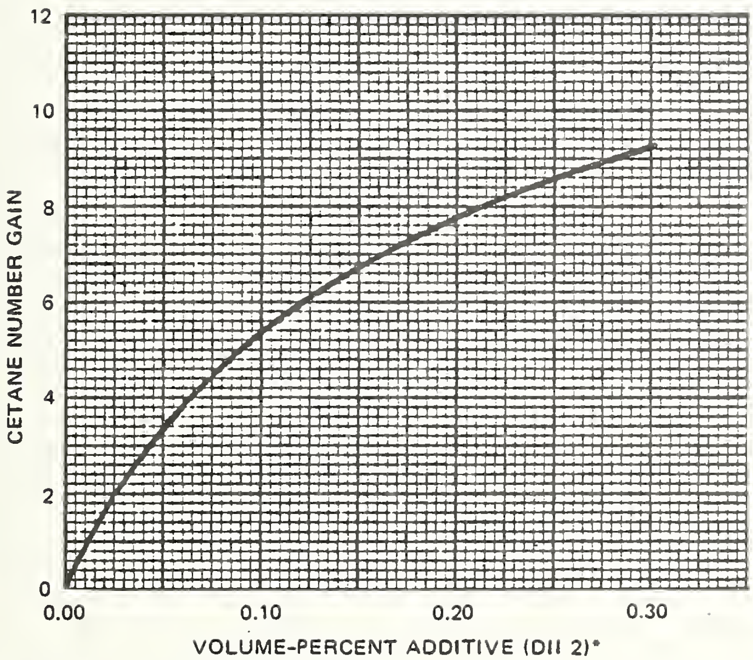
4.2.5.1 Additives for Cetane Improvement. Amyl and hexyl nitrates produce cetane number improvement, as shown in Figure 4.2.5.1-1. The cost of a four-point cetane index improvement resulting from additives is about 0.22 cents/gallon of diesel fuel, based on a recent price of 45 cents per pound in tank-car 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 BERC[16] 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



*Mixture of Primary Hexyl Nitrates

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 SO_2 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 Hydrocracking for Diesel. 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-to-cracked-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.

CALCULATED CETANE INDEX

BASED ON EQUATIONS:

$$\text{CALC. C.I.} = 0.49083 + 1.06577(x) - 0.0010552(x)^2$$

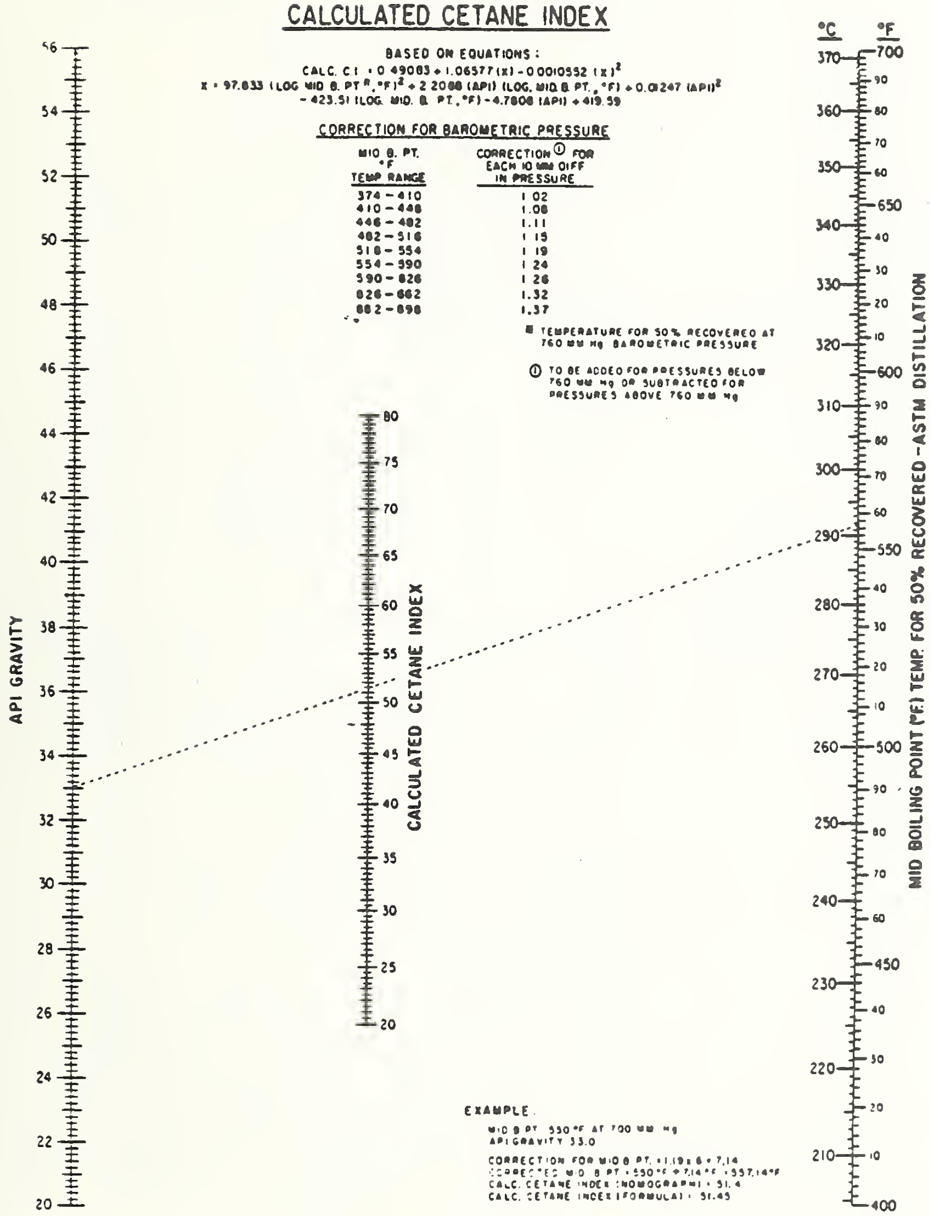
$$x = 97.833(\text{LOG MID B. PT}^{\blacksquare}, °F)^2 + 2.2088(\text{API})(\text{LOG. MID B. PT.}, °F) + 0.01247(\text{API})^2 - 423.51(\text{LOG. MID. B. PT.}, °F) - 4.7808(\text{API}) + 419.59$$

CORRECTION FOR BAROMETRIC PRESSURE

MID B. PT. °F TEMP RANGE	CORRECTION ① FOR EACH 10 MM DIFF IN PRESSURE
374 – 410	1.02
410 – 446	1.08
446 – 482	1.11
482 – 518	1.15
518 – 554	1.19
554 – 590	1.24
590 – 626	1.26
626 – 662	1.32
662 – 698	1.37

■ TEMPERATURE FOR 50% RECOVERED AT 760 MM Hg BAROMETRIC PRESSURE

① TO BE ADDED FOR PRESSURES BELOW 760 MM Hg OR SUBTRACTED FOR PRESSURES ABOVE 760 MM Hg



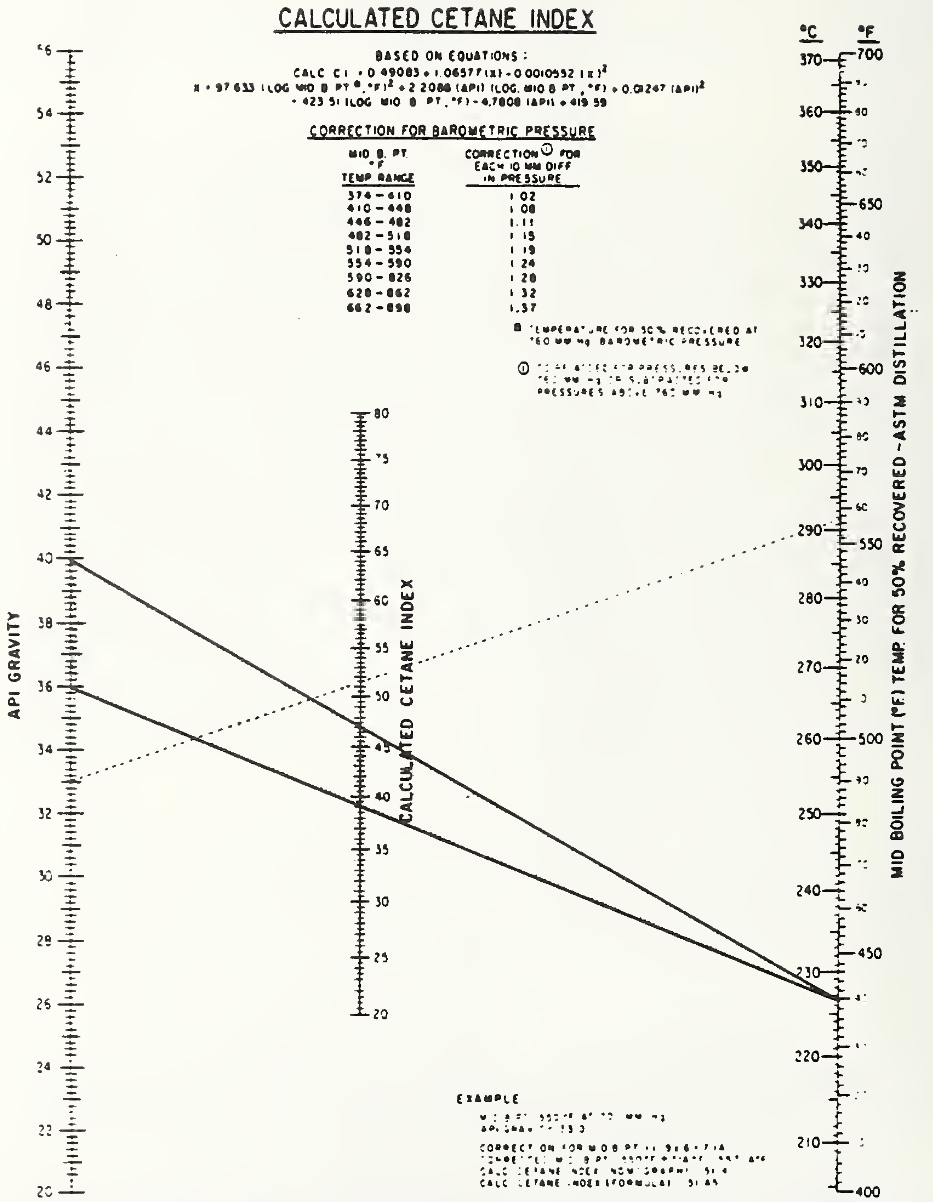
NOTE—The Calculated Cetane Index equation represents a useful tool for *estimating* cetane number. Due to inherent limitations in its application, Index values may not be a valid substitute for ASTM Cetane Numbers as determined in a test engine.

FIG. 1 Nomograph for Calculated Cetane Index (ECS-I 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 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



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.

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 Letters Patent nor assume any such liability.

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

FIGURE 4.2.5.2-1 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

Table 4.2.5.3-1

INCREMENTAL HYDROCRACKING FOR DIESEL PRODUCTION

	High Gasoline	High Diesel	Difference	Difference per Barrel of Gasoline
Yields, volume percent of crude				
C_3 LPG	0.83	0.83	--	--
C_4 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 × 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/10^3 b/d)				0.8
Energy consumption (FOE b/b gasoline)				0.520
				Investment 10^6 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

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

Investment per barrel of gasoline reduction: $43.0/11.32 = $3.8 × 10^3 b/day.

*Included with No. 6 fuel reduction.

†Based on Nelson Inflation Index, published periodically in Oil and Gas Journal.

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 Impact of Transportation Fuel Desulfurization on the Refining Industry

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.

Table 4.3.2-1

FUELS DESULFURIZATION SUMMARY

	Case 4	Case 5	Case 6
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‡	1.01§
Incremental cost, $/b desulfurized product	--	Base	0.18
Incremental investment, 10^6 $**	Base	1,940	5,580
Incremental investment, 10^6 $	--	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" process[19] 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-Kellogg[21] 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., study[20] 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.

Table 4.3.3-1

FUELS DESULFURIZATION CASE DATA

	Case 4 (1995)-- 30% Diesel Penetration		Case 5 (1995)-- Case 4 with Gasoline Desulfurization		Case 6 (1995)-- Gasoline and Diesel Desulfurization	
Refining industry cost,* 10^3 \$/day	139,913		143,157		147,185	
Total refinery input,† 10^3 b/cd	12,083		12,090		12,090	
Domestic refinery production, 10^3 b/cd (vol%)						
Gasoline	4,010	(33.8)	4,010	(33.9)	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	(7.1)	786	(6.6)	786	(6.6)
Other	1,106	(9.3)	1,100	(9.3)	1,100	(9.3)
Total production	11,880	(100.0)	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/cd--FOE	867		990		1,035	
Incremental investment, 10^6 \$, 1974	Base		1,941		5,581	
Facilities for desulfurization, 10^3 b/cd feed						
Light naphtha HDS	--		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 dollars).

†Crude oil and natural gas liquids.

‡Imports of Jet A and No. 2 as shown are at maximum value allowed.

SECTION A. 25

Table 4.3.3-2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL, W/CASC. DESU F.--CASE 5

REFINERY INPUT/OUTPUT SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	IMPORT	EXPORT	TOTAL
INPUT									
SWEET CRUDE	690.0	1920.0	3132.0	240.0	478.0	6460.0			6460.0
SOUR CRUDE	647.0	1292.1	1531.4	228.8		3699.3			3699.3
CALIF CRUDE					1434.0	1434.0			1434.0
ALASKAN CRUDE									
NATURAL GASOLINE	13.4	61.7	118.5	22.7	26.8	243.0			243.0
NORMAL BUTANE	8.8	45.6	44.7	1.6	27.1	127.7			127.7
ISOBUTANE	5.8	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			12089.8
OUTPUT									
C3 LPG	39.3	67.1	30.6	5.0	24.2	166.1			166.1
C4 LPG	9.8	5.8		.2	1.7	17.4			17.4
NAPHTHA	1.8	21.3	46.1		24.9	94.0			94.0
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	546.9	1221.8	1516.3	167.0	558.0	4010.0			4010.0
JP-4 JET FUEL	8.3	36.4	70.6	13.7	42.8	171.8			171.8
JET A JET FUEL	93.2	137.5	307.3	30.0	382.0	950.0	400.0		1350.0
DIESEL	222.3	974.6	1347.8	166.3	499.0	3210.0			3210.0
NO. 2 FUEL OIL	225.5	547.1	771.1	43.7	3.6	1591.0	400.0		1991.0
HI SULFUR NO. 6	68.9	84.9	149.2	15.0	184.2	502.3	134.7		637.0
LO SULFUR NO. 6	57.5	9.9	65.0	15.0	136.0	283.4	353.6		637.0
LUBE STOCKS	37.1	29.6	96.8	1.1	19.6	184.2			184.2
ASPHALT AND ROAD OIL	51.3	133.2	100.1	25.5	66.8	377.0			377.0
COKE (LO SULFUR)	1.9	6.9	8.8	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	10.6			10.6
BENZENE	.9	1.8	13.9		1.7	18.3			18.3
TOLUENE	.6	1.2	25.4		4.2	31.5			31.5
MIXED XYLENES	.5	2.5	27.9		3.7	34.5			34.5
MISC. PRODUCTS	10.4	44.7	64.9		2.4	122.4			122.4
TOTAL OUTPUT	1379.1	3327.6	4659.9	484.9	1966.7	11819.2	1288.3		13107.5
OUTPUT/INPUT,PCT	101.0	99.0	95.5	97.7	99.1	97.8			108.4

Table 4.3.3-3

D. O. T. TRANSPORTATION SYSTEMS CENTER

SECTION 8. 11

REFINING INDUSTRY MODEL - 1995, 30 PCT. DIESEL, W/GASO. DESU F.--CASE 5

PRODUCT CONSUMPTION SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	EXPORTS	EXP TOT	TOTAL
C3 LPG	39.3	67.1	30.6	5.0	24.2	166.1			166.1
C4 LPG	9.6	5.8		.2	1.7	17.4			17.4
NAPHTHA	1.8	21.3	46.1		24.9	94.0			94.0
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1370.0	1420.0	495.0	130.0	595.0	4010.0			4010.0
JP-4 JET FUEL	42.8	31.5	36.1	12.0	49.5	171.8			171.6
JET A JET FUEL	506.0	262.0	170.0	30.0	382.0	1350.0			1350.0
DIESEL	1105.0	1150.0	380.0	100.0	475.0	3210.0			3210.0
NO. 2 FUEL OIL	870.0	608.0	242.0	91.0	180.0	1991.0			1991.0
HI SULFUR NO. 6	392.0	65.0	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	37.1	29.6	96.6	1.1	19.6	184.2			184.2
ASPHALT AND ROAD OIL	51.3	133.2	100.1	25.5	66.8	377.0			377.0
COKE (LO SULFUR)	1.9	6.9	8.8	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	10.6			10.6
BENZENE	.9	1.8	13.9		1.7	18.3			18.3
TOLUENE	.6	1.2	25.4		4.2	31.5			31.5
MIXED XYLENES	.5	2.5	27.9		3.7	34.5			34.5
MISC. PRODUCTS	10.4	44.7	64.9		2.4	122.4			122.4
TOTAL	4834.1	3926.9	1876.7	427.2	2042.5	13107.5			13107.5

Table 4.3.3-4

SECTION C. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

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

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
ELEC. PWR (1000KWH/D)	5355.6	18559.7	24871.8	1660.4	13526.2	63973.7
FUEL REQD. (1000FOEB/D)	68.6	180.4	272.1	25.9	115.1	662.1
ENERGY CONS. (1000FOEB/D	78.7	290.2	403.1	29.0	188.7	989.7
LABOR (NO. EMPLOYEES)	7013.1	16924.8	24374.1	2444.0	9979.0	60735.1
OPER COSTS (M$/D)	101.0	293.6	357.5	27.5	82.8	862.4
INVESTMENTS (MM$)	230.8	1139.6	1339.2	70.5	640.0	3420.0

Table 4.3.3-5

D. O. T. TRANSPORTATION SYSTEMS CENTER

SECTION A. 25

REFINING INDUSTRY MODEL

REFINERY INPUT/OUTPUT SUMMARY--CASE 6

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	IMPORT	EXPORT	TOTAL
INPUT									
SWEET CRUDE	690.0	1920.0	3132.0	240.0	478.0	6460.0			6460.0
SOUR CRUDE	647.0	1292.1	1531.4	228.8		3699.3			3699.3
CALIF CRUDE					1434.0	1434.0			1434.0
ALASKAN CRUDE									
NATURAL GASOLINE	13.4	61.7	118.5	22.7	26.8	243.0			243.0
NORMAL BUTANE	9.8	45.6	44.7	1.6	27.1	127.7			127.7
ISOBUTANE	5.8	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			12089.8
OUTPUT									
C3 LPG	39.3	67.1	30.6	5.0	24.2	166.1			166.1
C4 LPG	9.8	5.8		.2	1.7	17.4			17.4
NAPHTHA	1.8	21.3	46.1		24.9	94.0			94.0
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	546.9	1221.8	1516.3	167.0	558.0	4010.0			4010.0
JP-4 JET FUEL	8.3	36.4	70.6	13.7	42.8	171.8			171.8
JET A JET FUEL	93.2	137.5	307.3	30.0	382.0	950.0	400.0		1350.0
DIESEL	222.3	974.6	1347.8	166.3	499.0	3210.0			3210.0
NO. 2 FUEL OIL	225.5	547.1	771.1	43.7	3.6	1591.0	400.0		1991.0
HI SULFUR NO. 6	68.9	84.9	149.2	15.0	184.2	502.3	134.7		637.0
LO SULFUR NO. 6	57.5	9.9	65.0	15.0	136.0	283.4	353.6		637.0
LUBE STOCKS	37.1	29.6	96.8	1.1	19.6	184.2			184.2
ASPHALT AND ROAD OIL	51.3	133.2	100.1	25.5	66.8	377.0			377.0
COKE (LO SULFUR)	1.9	6.9	8.8	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	10.6			10.6
BENZENE	.9	1.8	13.9		1.7	18.3			18.3
TOLUENE	.6	1.2	25.4		4.2	31.5			31.5
MIXED XYLENES	.5	2.5	27.9		3.7	34.5			34.5
MISC. PRODUCTS	10.4	44.7	64.9		2.4	122.4			122.4
TOTAL OUTPUT	1379.1	3337.6	4650.9	484.9	1966.7	11819.2	1288.3		13107.5
OUTPUT/INPUT.PCT	101.0	99.0	95.5	97.7	99.1	97.8			108.4

SECTION B. 11

Table 4.3.3-6

U. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL

PRODUCT CONSUMPTION SUMMARY--CASE 6

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	EXPORTS	EXP TOT	TOTAL
C3 LPG	39.2	67.1	30.6	5.0	24.2	166.1			166.1
C4 LPG	9.8	5.8		.2	1.7	17.4			17.4
NAPHTHA	1.8	21.3	46.1		24.9	94.0			94.0
REGULAR GASOLINE									
PREMIUM GASOLINE									
LOW LEAD GASOLINE									
LEAD FREE GASOLINE	1370.0	1420.0	495.0	130.0	595.0	4010.0			4010.0
JP-4 JET FUEL	42.8	31.5	36.1	12.0	49.5	171.8			171.8
JET A JET FUEL	506.0	262.0	170.0	30.0	382.0	1350.0			1350.0
DIESEL	1105.0	1150.0	380.0	100.0	475.0	3210.0			3210.0
NO. 2 FUEL OIL	870.0	608.0	242.0	91.0	180.0	1991.0			1991.0
HI SULFUR NO. 6	392.0	65.0	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	37.1	29.6	96.8	1.1	19.6	184.2			184.2
ASPHALT AND ROAD OIL	51.3	133.2	100.1	25.5	66.8	377.0			377.0
COKE (LO SULFUR)	1.9	6.9	8.8	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	10.6			10.6
BENZENE	.9	1.8	13.9		1.7	18.3			18.3
TOLUENE	.6	1.2	25.4		4.2	31.5			31.5
MIXED XYLENES	.5	2.5	27.9		3.7	34.5			34.5
MISC. PRODUCTS	10.4	44.7	64.9		2.4	122.4			122.4
TOTAL	4834.1	3926.9	1876.7	427.2	2042.5	13107.5			13107.5

Table 4.3.3-7

SECTION C. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL

UTILITY SUMMARY--CASE 6

	PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)					
	1	2	3	4	5	U.S.
PURCH ELECTRIC POWER	6049.3	21600.3	29076.9	2179.1	15083.3	73988.9
TOTAL FUEL REQUIRED	70.4	188.2	282.9	27.2	119.1	687.7
REFY ENERGY CONSUMPTION	81.8	303.9	422.0	31.3	195.7	1034.7
LABOR	7146.5	17509.6	25182.8	2543.7	10278.5	62661.1
OPERATING COSTS	102.3	299.5	365.5	28.5	85.8	681.6
INVESTMENTS	482.9	2244.7	2867.6	259.1	1205.9	7060.1

Table 4.3.4-1

COMPARISON OF DESULFURIZATION COST

Study	Investment (millions of first-quarter 1976 $)*	Increased Gasoline Cost, ¢/gal (first-quarter 1976)	Average Gasoline Sulfur Level (wppm)	Percent of Total Gasoline 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	0.23	100	60	23
	580	0.30	50	60	26
Total desulfurization	975	0.37	100	100	36
	1,181	0.50	50	100	52
Restricted Cat gasoline splitting (United States excluding California only)	2,963	1.01	74	100	94.1
NPRA survey	4,460		100	100	100-200†
			50‡		
Pullman Kellogg/EPA study	2,520	1.98 to 0.83§	80	100	82
ADL/EPA	780	0.49	100	60	18
	1,440	1.23	50	60	68
	2,880	0.86	100	100	42
	4,430	1.81	50	100	160
Battelle/API study	4,450		100	49	82
	15,580		30	49	287
	4,570		100	86	84
	15,930		30	86	292
Texaco EPA testimony	8,440 to 12,060	4.86 to 6.00	100**	100	180
	9,650 to 13,270	5.46 to 6.80	50**	100	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 dollsrs, 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.

§The incressed cost increases with decreasing refinery size.

**Texaco referred to the 100 snd 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) <u>Option 2: Desulfurize Process Feedstocks</u>

(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 cat-cracker 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 petroleum-derived 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

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 consumption 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.

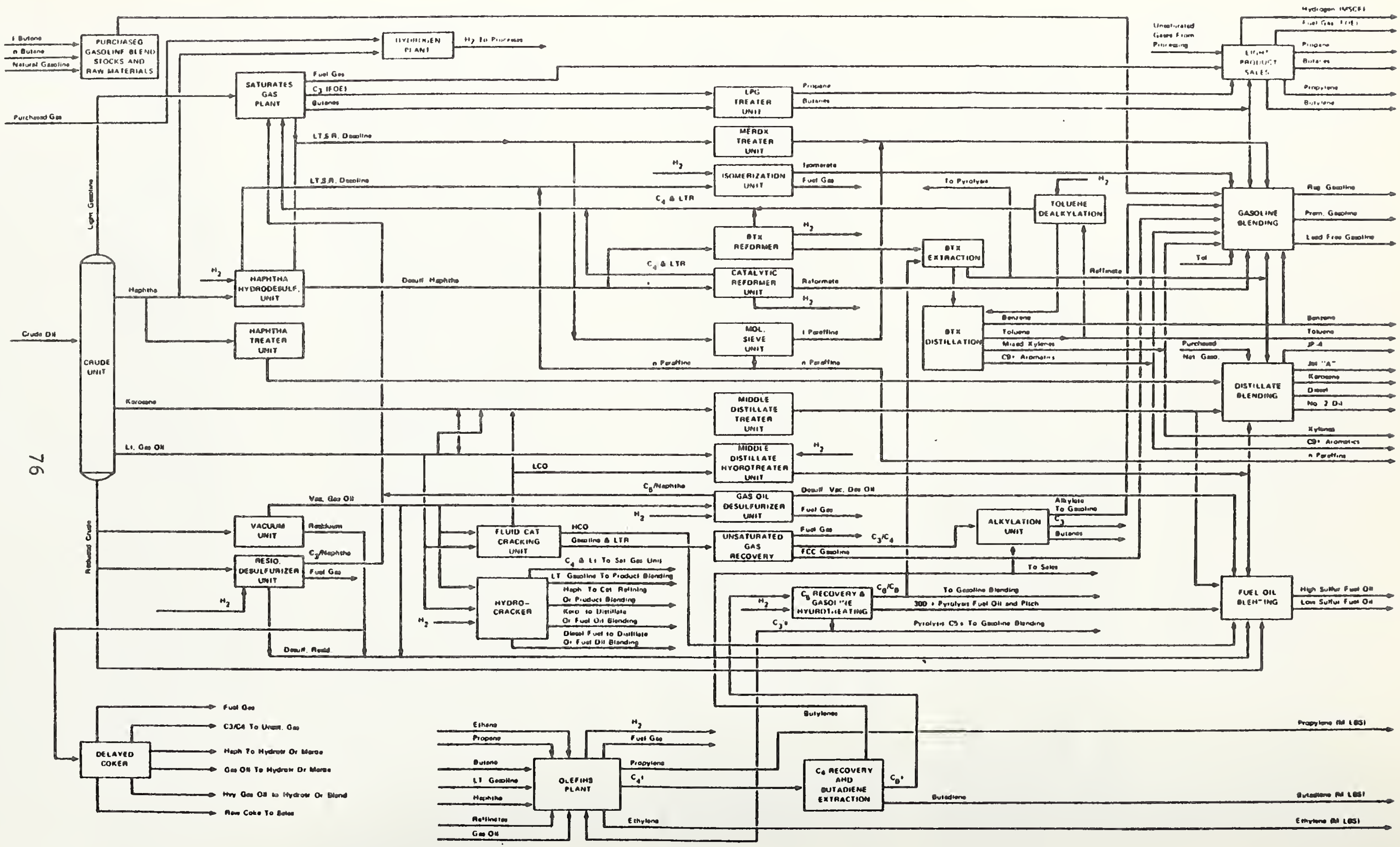

FIGURE A-1 REFINING AND PETROCHEMICAL LP MODEL

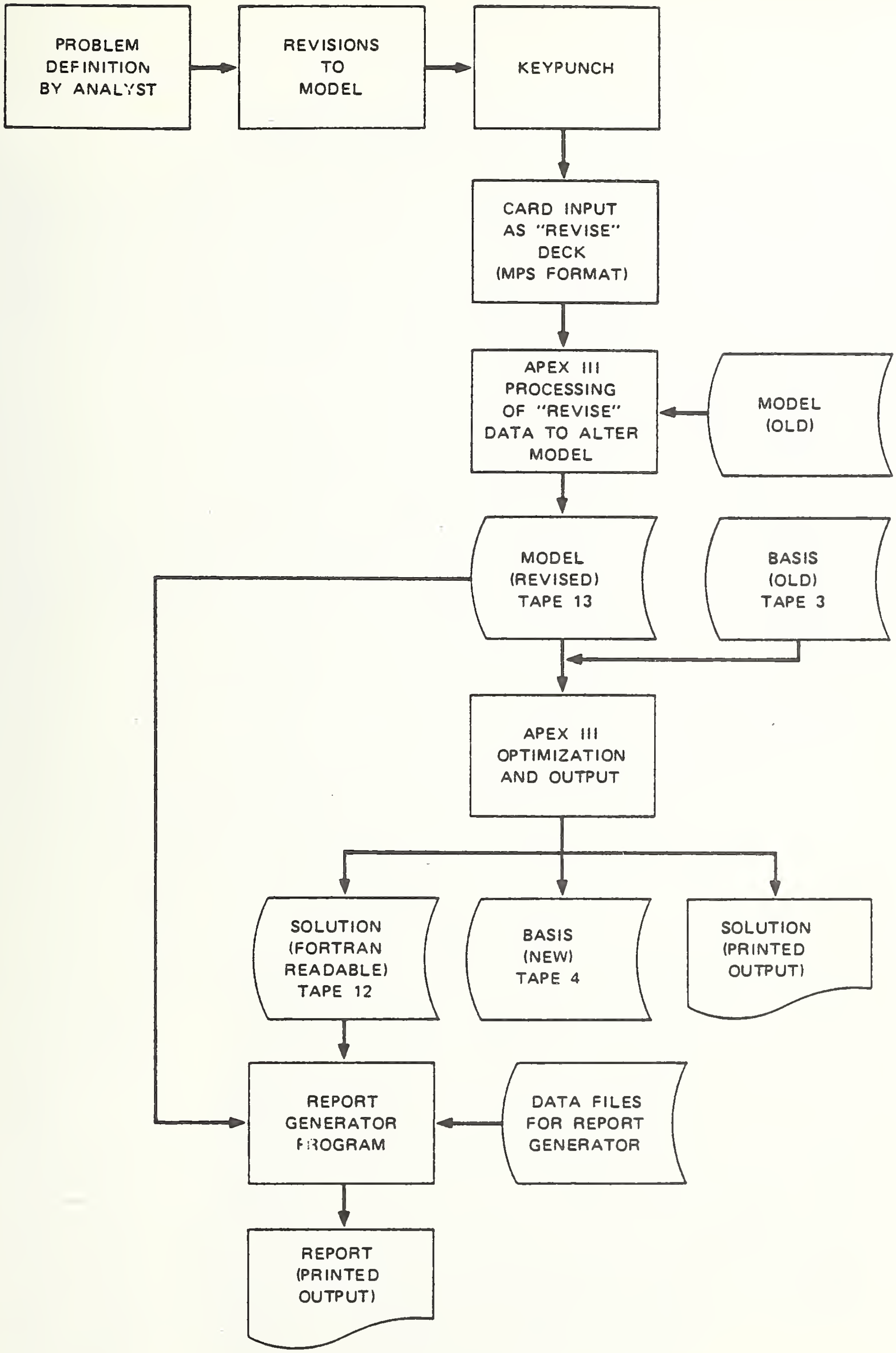

FIGURE A-2 LINEAR PROGRAMMING SYSTEM

Table A-1

CRUDE OIL YIELDS AND PROPERTIES

CRUDE NAME: Delta - Ostrica FIELD, LOCATION Plaquemine, La.

TOTAL CRUDE, NAPHTHAS, AND DISTILLATES								
CUT NAME	Total Crude	Light Gasoline	Light Gasoline	Medium Naphtha	Medium Naphtha	Heavy Naphtha	Kerosene	Light Gas Oil
TBP Cut Points, °F		C5/160	C5/175	160/295	175/295	295/375	375/530	530/650
Yield, LV%	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/Bbl	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	9.6	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					
+0.5 gm Pb/gal		78.7	78.6					
+1.0 gm Pb/gal		83.7	82.7					
+2.0 gm Pb/gal		88.2	87.3					
+3.17 gm Pb/gal		91.1	90.2					
Motor Octane, Clear		69.2	68.8					
+0.5 gm Pb/gal		76.9	76.7					
+1.0 gm Pb/gal		81.5	80.8					
+2.0 gm Pb/gal		87.0	86.0					
+3.17 gm Pb/gal		91.1	90.0					
Total Paraffins, LV%		100.0	88.7	43.9	43.4	41.2		
Total Naphthenes, LV%		0.0	8.8	46.4	47.1	43.8		
Total Aromatics, LV%		0.0	2.5	9.7	9.5	15.0	22.0	
Freeze Point, °F				-105.0	-105.0	-88.0	-43.0	
Freeze Point Index				16.0	16.0	25.0	105.0	
Pour Point, °F	-40.0						-60.0	0.0
Pour Point Index							63.0	360.0
Smoke Point, mm						21.7	13.6	
Aniline Point, °F						130.0	145.0	164.0
Diesel Number								
Cetane Number								
Cetane Index							47.5	55.0
Viscosity, cs @ 122°F				0.75	0.77	1.03	1.75	4.1
, cs @ 210°F								
Viscosity Index @ 122°F				79.0	78.0	70.0	60.0	48.0
Nitrogen Content, Wt.%								
Nickel Content, ppm wt.								
Vanadium Content, ppm wt.								
ASTM Distillation Temp., °F, IBP		93	94	178	191	309	408	567
10%		105	109	192	204	320	420	570
30%		113	119	208	216	325	439	589
50%		121	130	220	229	332	454	601
70%		136	145	234	241	337	471	614
90%		152	171	258	261	351	498	634
EP		173	228	282	290	362	529	656
VABP, °F		128	142	227	235	335	452	590

RESIDUES					
CUT NAME	Topped Crude	Vacuum Gas Oil	Vacuum Bottoms		
TBP Cut Point, °F	650+	650/1050	1050+		
Yield, LV%	43.5	33.2	10.3		
Yield, Wt.%	47.17	35.25	11.92		
Gravity, °API	20.7	24.0	11.1		
Density, Lbs/Bl	325.1	318.3	347.1		
Specific Gravity	0.9295	0.9100	0.9923		
UOP K		11.90			
VABP, °F		811.0			
Sulfur Content, Wt.%	0.669	0.533	1.070		
Pour Point, °F	85.0	75.0	100.0		
Viscosity, cs @ 122°F	420.0	120.0	70,000		
, cs @ 210°F					
Viscosity Index @ 122°F	20.5	25.0	6.0		
Nitrogen Content, Wt.%	0.139	0.063	0.364		
Nickel Content, ppm Wt.	4.05	0.08	15.80		
Vanadium Content, ppm Wt.	3.01	0.11	11.60		
Aniline Point, °F		192.0			
Aromatics, Wt.%					
Conradson Carbon, Wt.%	4.34	0.80	14.80		
Asphaltenes, Wt.%	1.0	0.053	3.8		
Refrac. Index @ 67 °C		1.4894			

LIGHT HYDROCARBONS	% in Crude Wt.	% in Crude 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
Isohexanes		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
C_8 Cyclopentanes		0.69
C_8 Cyclohexanes		0.37
Ethylbenzene		0.07
Paraxylene		0.09
Metaxylene		0.14
Orthoxylene		0.12
C_9 Paraffins		
C_9 Naphthenes		
C_9 Aromatics		

Table A-2

REFINERY PRODUCTS AND FEEDSTOCKS

Products

- C_3 LPG
- C_4 LPG
- Propylene
- Propane
- Butylenes
- Isobutane
- Normal butane
- Benzene
- Toluene
- Mixed xylenes
- C_9 aromatics
- Regular 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

Table A-3

REFINERY MODEL PRODUCT SPECIFICATIONS

Gasoline Specification

	Density (lb/b)	Sulfur (wt%)	RVP Index	TEL (G/gal)	Vaporization (vol%) 130°F	235°F	356°F	RON*	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
Maximum	265	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 (lb/b)	RVP Index	Sulfur (wt%)	Aromatics (vol%)	Smoke Point	Vaporization (vol%) 290°F	350°F	370°F	400°F	450°F	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 (lb/b)	Sulfur (wt%)	Pour Point Index	Cetane Index	Visc Index	Vaporization (vol%) 540°F	590°F
Diesel							
Minimum	--	--	--	50	--	--	90
Maximum	297.2	0.5	410	--	--	90	--
No. 2							
Minimum	--	--	--	40	--	--	--
Maximum	306.4	0.5	615	--	--	90	--
No. 6 (low sulfur)							
Minimum	--	--	--	--	19.1		
Maximum	350	1.0	--	--	--		
No. 6 (high sulfur)							
Minimum	--	--	--	--	19.1		
Maximum	350	3.0	--	--	--		

LPG Specifications

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

*Clear (lead-free) octane numbers.

Table A-4

PROCESS UNITS IN REFINERY LP MODEL

Process	Type
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--aromatics 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
Hydrocracking--gas 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 manufacture--steam 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	

Table A-5

FRACTIONATION OF LOUISIANA CRUDE
(Barrels per Barrel of Feed)

Operating Mode	Atmospheric Distillation	Vacuum Distillation	Gas Recovery
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)

Feedstock	Kerosene	Atmospheric Gas Oil (AGO)	Light Cycle Gas Oil (LCGO)	VGO	Atmospheric 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			1.000		
Desulfurized VGO				0.980	
Desulfurized residual					0.8542
Unit Liquid Volume (LV) loss (gain)	0.00411	0.00633	0.0066	0.0025	-0.0073

Table A-7

HYDROGEN CONSUMPTION IN NAPHTHA HYDROTREATING FOR CATALYTIC REFORMER FEED
(FOE Barrels of H_2 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
Hydrogen (FOE)	0.0459	0.0359
Hydrogen lost to fuel	0.0115	0.0090
Methane	0.0049	0.0074
Ethane	0.0073	0.0130
Propane	0.0191	0.0304
Isobutane	0.0090	0.0123
Normal butane	0.0120	0.0158
94 RON reformate	0.8880	
93 RON reformate (heavy naphtha)		0.8870
Unit LV loss (gain)	0.0023	-0.0109

	Severity Range RON Clear	Corresponding Gasoline Yield Range (b/b of feed)
Full-range and medium naphtha feeds	91-103	0.908-0.783
Heavy naphtha feeds	91-103	0.903-0.769

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

Table A-9

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.

Table A-10

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 lb)	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

Table A-11

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

Atmospheric gas oil	-1	
Vacuum gas oil		-1
Hydrogen (FOE)	-0.0922	-0.1251
Hydrogen losses (FOE)	0.0128	0.0128
Hydrogen sulfide (FOE)	0.0006	0.0020
Methane (FOE)	0.0023	0.0027
Ethane (FOE)	0.0067	0.0068
Propane	0.0364	0.0370
Isobutane	0.0965	0.0920
Normal butane	0.0504	0.0480
C5/180 Hydrocrackate	0.3483	0.3340
180/400 Hydrocrackate	0.7086	0.7911
Unit LV loss (gain)	-0.1704	-0.2013

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 Alkylation	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
H_2 consumption (FOE b/d)	-0.0097
Products (b/d)	
Methane (FOE)	0.00095
Ethane (FOE)	0.00167
Propane (FOE)	0.01398
Isomerate	1.000

Table A-15

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 mid-distillate 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	Naphtha
Hydrogen (FOE)	1.0	1.0
Fuel gas (FOE)	-0.8747	
Naphtha (10^3 lb)		-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_2S (FOE)	0.0019
CH_4 (FOE)	0.0360
C_2U (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 ($b/10^3$ lb)	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.

Table A-18

TOLUENE DEALKYLATION YIELDS
(Barrels per Barrel of Feed)

Operating mode	TDA
Feed (b/d)	
Toluene	-1.00
H_2 consumption (FOE)	-0.0753
Product (b/d)	
H_2 (FOE)	0.0050
Methane (FOE)	0.2072
Ethane (FOE)	0.0053
Propane	0.0072
I-Butane	0.0040
N-Butane	0.0019
Benzene	0.800

Table A-19

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	K	L	M	N	O	P	Q	R	S
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

Table A-19 (Concluded)

	GASO. POOL				MEROX TREAT		TEL G/GAL	DENSITY LBS/BBL	SULFUR WT PCT	RVP PSIA	RVP INDEX	LV PCT EVAPORATED AT T F				
												130	158	235	356	365
	A	B	C	D	GT	NT	Z	A	B	C	D	E	F	G	H	I
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	1	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	0	0	100	100	100
MIXED XYLENES	1	1	1	1				304.8	0.0005	0.4	4.2	0	0	0	100	100
C9+ AROMATICS	1	1	1	1				308.4	0.001	0.2	2.0	0	0	0	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	0	7	49	92	94
C5/375 VHT NAPHTHA		1				1		269.7	0.01	1.0	11.8	0	2	23	97	99
C5/375 RHT NAPHTHA	1	1				1		269.7	0.01	1.0	11.8	0	2	23	97	99
91 RON REFORMATE	1	1	1	1				273.9	0.0	3.0	40.1	0	5	43	93	94
94 RON REFORMATE	1	1	1	1				276.0	0.0	3.2	43.1	0	6	42	92	94
97 RON REFORMATE	1	1	1	1				278.2	0.0	3.4	46.1	1	7	43	92	93
100 RON REFORMATE	1	1	1	1				281.4	0.0	3.6	49.2	2	8	43	92	93
103 RON REFORMATE	1	1	1	1				285.8	0.0	3.9	53.8	3	10	43	92	93
91 RON REFORMATE (HN)	1	1	1	1				286.6	0.0	0.8	9.2	0	1	7	59	71
93 RON REFORMATE (HN)	1	1	1	1				287.6	0.0	1.0	11.8	0	2	8	58	70
95 RON REFORMATE (HN)	1	1	1	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

Table A-20

DISTILLATE BLENDING PROPERTIES

	Density Lbs/bbl	Sulfur Wt Pct	Rvp, Psia	Rvp Index	Lv Pct Aro-matics	Freeze Point		Pour Point		Smoke Point MM
						Deg F	Index	Deg F	Index	
	A	B	C	D	E	F	G	H	I	J
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	-43.0	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	-37.0	126.0	-37.0	126.0	19.2
LT GAS OIL B	303.3	1.345						23.0	665.0	
REDUCED CRUDE B	328.6	2.175								
VACUUM GAS OIL A	318.3	0.533						75.0		
VACUUM RESID A	347.1	1.070						100.0		
VACUUM GAS OIL B	319.5	1.774						92.0		
VACUUM RESID B	351.5	3.000								
HVY NAPH A VIA KHT	276.3	0.003	0.9	10.5	16.0	-88.0	25.0			25.7
KEROSENE A VIA KHT	290.8	0.006	0.1	0.9	22.0	-43.0	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			31.4
KEROSENE B VIA KHT	287.7	0.083	0.1	0.9	25.0	-37.0	126.0	-37.0	126.0	23.2
DESULF 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	360.0	
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	13.0	213.0	0.0					
180/400 HYDROCRACKATE	270.5	0.001	1.0	11.8	8.0					
180/300 HYDROCRACKATE	261.3	0.001	1 4	17.1	5.0					
180/345 HYDROCRACKATE	264.0	0.001	1 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					
LCGO 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					
LCGO 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 Index	Diesel Index	Viscosity at 122 F		LV Pct Evaporated at Temp T (Deg F)								
			CS	Index	290	350	370	400	450	470	540	590	625
	K	L	M	N	O	P	Q	R	S	T	U	V	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			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			0.95	73.0	0	90	100	100	100	100	100	100	100
KEROSENE B VIA KHT	48.5	54.2	1.5	63.0	0	0	0	0	50	70	100	100	100
DESULF FCC HVY NAPH	33				7	30	49	88	100	100	100	100	100
LT GAS OIL A VIA GHT	55.0	52.6	4.1	48.0	0	0	0	0	0	0	0	30	80
LT GAS OIL B VIA GHT	53.5	49.5	3.7	49.5	0	0	0	0	0	0	0	30	80
LCGO (DESULFURIZED)			1.8	60.0	0	0	0	0	0	0	0	0	0
LCGO (DESULFURIZED)			1.8	60.0	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
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
FCC HVY NAPH 300-430	32				5	29	47	85	100	100	100	100	100
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					70	100	100	100	100	100	100	100	100
300/550 HYDROCRACKATE	50.0	61.6	1.5	63.0	0	16	33	48	67	74	96	100	100
345/650 HYDROCRACKATE	56.0	63.5	2.1	57.0	0	2	6	12	28	36	66	85	100
COKER GASO C5-400					50	75	90	100	100	100	100	100	100
LCGO 400-650	42.5	40.0	1.8	60.0	0	0	0	10	25	50	85	100	100
HCGO 650-950			100.0	26.0	0	0	0	0	0	0	0	0	0
COKER GASO C5-400					50	75	90	100	100	100	100	100	100
LCGO 400-650	42.5	40.0	1.8	60.0	0	0	0	10	25	50	85	100	100
HCGO 650-950			100.0	26.0	0	0	0	0	0	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

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

XX = PAD District No. (extra digit for future subdistrict)

YYY = Product Code (see Table B-1)

Z = P for production

D for distribution

R for utility requirement

Example:

105CAP = PAD 1 production of diesel

Others:

ØJBF = Overall objective function

XXØBJ = 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
M	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	JP-4 jet fuel
5BB	Jet A jet fuel
5CA	Diesel (No. 1)
5CB	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

(5) Inter-PAD transfers, by product

XXYYYZZK

XX = PAD Dist source of product

YYY = Product code

ZZ = PAD Dist destination of product

K = P = pipeline

M = marine

(6) Total transfers, by transport mode

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

B.3 Model Listing

```
MAP NAME =                        **********   E Q U A T I O N   L I S T I N G   **********

                                  KEY TO COLUMN TYPES ( SEE SELECTION FOR EFFECTIVE VECTORS )

                  X : FIXED VARIABLE      L : PLUS VARIABLE WITH BOUND(S)      B : BIVALENT VARIABLE
                  P : PLUS VARIABLE       R : MINUS VARIABLE WITH BOUND(S)     1 : INTEGER VARIABLE
                  M : MINUS VARIABLE      1 : VARIABLE IS SOS-1 SET MEMBER
                  F : FREE VARIABLE       2 : VARIABLE IS SOS-2 SET MEMBER

OBJF         FR          1   1.000000000 P 10OBJT    1.000000000 P 20OBJT    1.000000000 P 30OBJT    1.000000000 P 40OBJT
  RHS LO:  -INF              1.000000000 P 50OBJT    1.000000000 P FOOBJT
  RHS UP:  +INF

10OBJ        EQ          2  -9.650000000 L 10CAIN   -9.400000000 P 10CBIN   -8.300000000 P 10NGFN   -6.900000000 P 10TNC4
  RHS LO:  0.000000000      -7.300000000 P 10TIC4    -.023000000 P 10KWH   -13.74000000 P 10BTU     -.006010000 P 10LAB
  RHS UP:  0.000000000      -1.000000000 P 10OPC     -.956900000 P 10INV     .300000000 X 10ZPREM   -.092000000 P 10SCXX
                             1.000000000 P 10OBJT   -1.000000000 P 10TPCST  -1.000000000 P 10THCST

10LRG        EQ          3  -1.000000000 P 10CBLBA  -1.000000000 P 10CBLLC  -1.000000000 P 10CBLHC  -1.000000000 P 10CALBA
  RHS LO:  0.000000000      -1.000000000 P 10CALHC  -1.000000000 P 10CALLC   1.000000000 L 10TLRG    1.000000000 P 10LRGN
  RHS UP:  0.000000000

10SML        EQ          4  -1.000000000 P 10CASBA  -1.000000000 P 10CASHC  -1.000000000 P 10CASLC   1.000000000 L 10TSML
  RHS LO:  0.000000000       1.000000000 P 10SMLN
  RHS UP:  0.000000000

10CAID       EQ          5   1.000000000 L 10CAIN   -1.000000000 P 10CALBA  -1.000000000 P 10CALHC  -1.000000000 P 10CALLC
  RHS LO:  0.000000000      -1.000000000 P 10CASBA  -1.000000000 P 10CASHC  -1.000000000 P 10CASLC
  RHS UP:  0.000000000

10CBID       EQ          6   1.000000000 P 10CBIN   -1.000000000 P 10CBLBA  -1.000000000 P 10CBLLC  -1.000000000 P 10CBLHC
  RHS LO:  0.000000000
  RHS UP:  0.000000000

10NGFD       EQ          7   1.000000000 P 10NGFN    -.010000000 P 10CBLBA   -.010000000 P 10CBLLC   -.010000000 P 10CBLHC
  RHS LO:  0.000000000       -.010000000 P 10CALBA   -.010000000 P 10CALHC   -.010000000 P 10CALLC   -.010000000 P 10CASBA
  RHS UP:  0.000000000       -.010000000 P 10CASHC   -.010000000 P 10CASLC

10NC4D       EQ          8   1.000000000 P 10TNC4    -.006000000 P 10CBLBA   -.006000000 P 10CBLLC   -.006000000 P 10CBLHC
  RHS LO:  0.000000000       -.006000000 P 10CALBA   -.005700000 P 10CALHC   -.006000000 P 10CALLC   -.006000000 P 10CASBA
  RHS UP:  0.000000000       -.006000000 P 10CASHC   -.006000000 P 10CASLC   -.001400000 P 10DSHTA

10IC4D       EQ          9   1.000000000 P 10TIC4    -.002800000 P 10CBLBA   -.006000000 P 10CBLLC   -.003100000 P 10CALBA
  RHS LO:  0.000000000       -.002900000 P 10CALLC   -.002500000 P 10CASBA   -.002500000 P 10CASHC   -.002500000 P 10CASLC
  RHS UP:  0.000000000       -.007500000 P 10DSHTA

10C3PP       EQ         10    .034000000 P 10CBLBA    .030400000 P 10CBLLC    .040000000 P 10CBLHC    .027400000 P 10CALBA
  RHS LO:  0.000000000        .034000000 P 10CALHC    .027400000 P 10CALLC    .014500000 P 10CASBA    .014500000 P 10CASHC
  RHS UP:  0.000000000        .014500000 P 10CASLC   -.027100000 L 10DLHC2  -1.000000000 P 10C3P

10C4PP       EQ         11    .007100000 P 10CBLBA    .000600000 P 10CBLLC    .014700000 P 10CBLHC    .008600000 P 10CALBA
  RHS LO:  0.000000000        .015000000 P 10CALHC    .008600000 P 10CALLC    .000100000 P 10CASBA    .000100000 P 10CASHC
  RHS UP:  0.000000000        .000100000 P 10CASLC   -.035000000 L 10DLHC2  -1.000000000 P 10C4P

10NAPP       EQ         12    .003400000 P 10CALBA    .003400000 P 10CALHC    .003400000 P 10CALLC   -1.000000000 P 10NAP
  RHS LO:  0.000000000
  RHS UP:  0.000000000

10+BAP       EQ         13    .234000000 P 10CBLBA    .049900000 P 10CBLLC    .095000000 P 10CBLHC    .146000000 P 10CALBA
  RHS LO:  [illegible]        [illegible]             [illegible]  10CALLC    [illegible]  10CASBA    .030400000 P 10CASHC
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104AAP        EQ        14    [illegible] P 10CBLBA      .149700000 P 10CBLLC      .152100000 P 10CBLHC      .193500000 P 10CALBA
  RHS LO:   0.000000000       .148200000 P 10CALHC       .138300000 P 10CALLC      .115000000 P 10CASBA      .091300000 P 10CASHC
  RHS UP:   0.000000000       .084500000 P 10CASLC      -.300000000 P 100LHC1     -.300000000 L 100LHC2    -1.000000000 P 104AA

104CAP        EQ        15    [illegible] P 10CBLBA      .149700000 P 10CBLLC      .160400000 P 10CBLHC      .077000000 P 10CALBA
  RHS LO:   0.000000000       .148200000 P 10CALHC       .138300000 P 10CALLC      .049900000 P 10CASBA      .091300000 P 10CASHC
  RHS UP:   0.000000000       .084500000 P 10CASLC      -.150000000 P 100LHC1     -.150000000 L 100LHC2    -1.000000000 P 104CA

104DAP        EQ        16    .068000000 P 10CBLBA       .149700000 P 10CBLLC      .180000000 P 10CBLHC      .056000000 P 10CALBA
  RHS LO:   0.000000000       .148200000 P 10CALHC       .138300000 P 10CALLC      .042000000 P 10CASBA      .091300000 P 10CASHC
  RHS UP:   0.000000000       .084500000 P 10CASLC      -.150000000 P 100LHC1     -.150000000 L 100LHC2    -1.000000000 P 104DA
                             1.000000000 X 10ZPREM

105GASP       EQ        17   1.000000000 P 104BA        1.000000000 P 104AA       1.000000000 P 104CA       1.000000000 P 104DA
  RHS LO:   0.000000000     -1.000000000 P 10TGAS
  RHS UP:   0.000000000

105AAP        EQ        18    .007000000 P 10CBLBA       .004500000 P 10CBLLC      .004500000 P 10CBLHC      .007000000 P 10CALBA
  RHS LO:   0.000000000       .007000000 P 10CALHC       .007000000 P 10CALLC      .010000000 P 10CASBA      .010000000 P 10CASHC
  RHS UP:   0.000000000       .010000000 P 10CASLC     -1.000000000 P 105AA

105BBP        EQ        19    .032000000 P 10CBLBA       .020000000 P 10CBLLC      .032000000 P 10CBLHC      .032000000 P 10CALBA
  RHS LO:   0.000000000       .032000000 P 10CALHC       .032100000 P 10CALLC      .050000000 P 10CASBA      .050000000 P 10CASHC
  RHS UP:   0.000000000       .036000000 P 10CASLC     -1.000000000 P 105BB       1.000000000 P 105BBX

105CAP        EQ        20    .063000000 P 10CBLBA       .210500000 P 10CBLLC      .050000000 P 10CBLHC      .097000000 P 10CALBA
  RHS LO:   0.000000000       .097000000 P 10CALHC       .146000000 P 10CALLC      .150000000 P 10CASBA      .150000000 P 10CASHC
  RHS UP:   0.000000000       .170000000 P 10CASLC      1.235000000 P 100LHC1      .974000000 L 100LHC2     1.000000000 P 100LHT1
                            -1.000000000 P 105CA        1.000000000 P 105CXX     -.600000000 P 105BBX

105CBP        EQ        21    .177100000 P 10CBLBA       .127000000 P 10CBLLC      .179300000 P 10CBLHC      .195000000 P 10CALBA
  RHS LO:   0.000000000       .195000000 P 10CALHC       .195100000 P 10CALLC      .175000000 P 10CASBA      .155000000 P 10CASHC
  RHS UP:   0.000000000       .178000000 P 10CASLC     -1.000000000 P 100LHT1     -.005000000 P 100SHTA    -1.000000000 P 105CB
                            -1.000000000 P 105CXX      -.400000000 P 105BBX

10VGOP        EQ        22    .012000000 P 10CBLBA       .012000000 P 10CBLLC      .012000000 P 10CBLHC      .012000000 P 10CALBA
  RHS LO:   0.000000000       .012000000 P 10CALHC       .012000000 P 10CALLC      .133000000 P 10CASBA      .133000000 P 10CASHC
  RHS UP:   0.000000000       .133000000 P 10CASLC     -1.000000000 P 10VGO

105DAP        EQ        23    .039000000 P 10CBLBA       .039000000 P 10CBLLC      .039000000 P 10CBLHC      .061000000 P 10CALBA
  RHS LO:   0.000000000       .061000000 P 10CALHC       .061100000 P 10CALLC      .070000000 P 10CASBA      .070000000 P 10CASHC
  RHS UP:   0.000000000       .070000000 P 10CASLC     -1.000000000 P 105DA

105DBP        EQ        24    .039000000 P 10CBLBA       .039000000 P 10CBLLC      .039000000 P 10CBLHC      .052600000 P 10CALBA
  RHS LO:   0.000000000       .039000000 P 10CALHC       .039000000 P 10CALLC      .070000000 P 10CASBA      .070000000 P 10CASHC
  RHS UP:   0.000000000       .070000000 P 10CASLC      -.458000000 P 100LHC1     -.022000000 P 100LHT1    -1.000000000 P 105DB

10VRDP        EQ        25    .058200000 P 10CBLBA       .046000000 P 10CBLLC      .040400000 P 10CBLHC      .037000000 P 10CALBA
  RHS LO:   0.000000000       .057000000 P 10CALHC       .037000000 P 10CALLC      .035000000 P 10CASBA      .035000000 P 10CASHC
  RHS UP:   0.000000000       .035200000 P 10CASLC     -1.000000000 P 10VRO

10CKAP        EQ        26    .003600000 P 10CALBA       .003600000 P 10CALHC      .003600000 P 10CALLC     -1.000000000 P 10CKA
  RHS LO:   0.000000000
  RHS UP:   0.000000000

10CKBP        EQ        27    .004500000 P 10CBLBA       .004500000 P 10CBLLC      .004500000 P 10CBLHC     -1.000000000 P 10CKB
  RHS LO:   0.000000000
  RHS UP:   0.000000000

101ACP        EQ        28    .001400000 P 10CBLBA       .001300000 P 10CBLLC      .001400000 P 10CBLHC      .001420000 P 10CALBA
  RHS LO:   [illegible]     -1.000000000 P 101A?
  RHS UP:   [illegible]
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101AEP      EQ       30   .001920000 P 10CBLBA      .001920000 P 10CBLLC      .000700000 P 10CBLHC      .000710000 P 10CALBA
  RHS LO:   0.000000000  -1.000000000 P 101AB
  RHS UP:   0.000000000

10MISP      EQ       31   .004000000 P 10CBLBA      .002700000 P 10CBLLC      .008300000 P 10CBLHC      .009400000 P 10CALBA
  RHS LO:   0.000000000   .009400000 P 10CALHC      .007400000 P 10CALLC      .008200000 P 10CASBA      .008200000 P 10CASHC
  RHS UP:   0.000000000   .008200000 P 10CASLC    -1.000000000 P 10MIS

10KWHR      EQ       32  4.030000000 P 10CBLBA     3.928400000 P 10CBLLC     4.147100000 P 10CBLHC     3.442000000 P 10CALBA
  RHS LO:   0.000000000  3.591500000 P 10CALHC     3.356200000 P 10CALLC     2.106000000 P 10CASBA     2.147000000 P 10CASHC
  RHS UP:   0.000000000  2.645300000 P 10CASLC    33.160000000 P 10DLHC1      .068000000 P 10DLHT1     1.050000000 P 10DSHTA
                         3.120000000 P 10DSHTC    -1.000000000 P 10KWH

10BTUR      EQ       33   .054230000 P 10CBLBA      .050050000 P 10CBLLC      .054440000 P 10CBLHC      .050700000 P 10CALBA
  RHS LO:   0.000000000   .050090000 P 10CALHC      .050100000 P 10CALLC      .030800000 P 10CASBA      .031400000 P 10CASHC
  RHS UP:   0.000000000   .029900000 P 10CASLC     -.055000000 L 10DLHC2      .016000000 P 10DSHTA      .008000000 P 10DSHTC
                        -1.000000000 P 10BTU

10ENER      EQ       34   .061800000 P 10CBLBA      .057430000 P 10CBLLC      .062240000 P 10CBLHC      .057170000 P 10CALBA
  RHS LO:   0.000000000   .056840000 P 10CALHC      .056450000 P 10CALLC      .034800000 P 10CASBA      .035500000 P 10CASHC
  RHS UP:   0.000000000   .033750000 P 10CASLC      .520000000 P 10DLHC1     -.055000000 L 10DLHC2      .025000000 P 10DLHT1
                          .016000000 P 10DSHTA      .014000000 P 10DSHTC    -1.000000000 P 10ENE

10LABR      EQ       35  5.000000000 P 10CBLBA     5.000000000 P 10CBLLC     5.000000000 P 10CBLHC     5.000000000 P 10CALBA
  RHS LO:   0.000000000  5.000000000 P 10CALHC     5.000000000 P 10CALLC     5.000000000 P 10CASBA     5.000000000 P 10CASHC
  RHS UP:   0.000000000  5.000000000 P 10CASLC      .800000000 P 10DLHC1      .500000000 P 10DLHT1      .600000000 P 10DSHTA
                          .600000000 P 10DSHTC    -1.000000000 P 10LAB

10DPCR      EQ       36   .166000000 P 10CBLBA      .113100000 P 10CBLLC      .136400000 P 10CBLHC      .147600000 P 10CALBA
  RHS LO:   0.000000000   .069800000 P 10CALHC      .116000000 P 10CALLC      .072300000 P 10CASBA      .072300000 P 10CASHC
  RHS UP:   0.000000000   .072300000 P 10CASLC     -.038200000 P 10DLHC1     -.557000000 L 10DLHC2      .012500000 P 10DLHT1
                          .013000000 P 10DSHTA      .006000000 P 10DSHTC    -1.000000000 P 10DPC

101NVR      EQ       37  3.800000000 P 10DLHC1      .100000000 L 10DLHC2      .510000000 P 10DLHT1      .400000000 P 10DSHTA
  RHS LO:   0.000000000  1.134300000 P 10DSHTC     4.000000000 P 10LRGN      6.000000000 P 10SMLN     -1.000000000 P 10INV
  RHS UP:   0.000000000  2.000000000 P 10NP1PJ2

10C3PO      EQ       38 -1.000000000 P 10C3P       1.000000000 P 10C3P0FM    1.000000000 P 10C3P0FP    1.000000000 P 10C3P02M
  RHS LO:   0.000000000  1.000000000 P 10C3P02P    1.000000000 P 10C3P03M    1.000000000 P 10C3P03P    1.000000000 P 10C3P04P
  RHS UP:   0.000000000  1.000000000 P 10C3P05M    1.000000000 P 10C3P05P   -1.000000000 P 20C3P01M   -1.000000000 P 20C3P01P
                        -1.000000000 P 30C3P01M   -1.000000000 P 30C3P01P   -1.000000000 P 40C3P01P   -1.000000000 P 50C3P01M
                        -1.000000000 P 50C3P01P   -1.000000000 P F0C3P01M   -1.000000000 P F0C3P01P    1.000000000 L 10C3PC

10C4PD      EQ       39 -1.000000000 P 10C4P       1.000000000 P 10C4P0FM    1.000000000 P 10C4P0FP    1.000000000 P 10C4P02M
  RHS LO:   0.000000000  1.000000000 P 10C4P02P    1.000000000 P 10C4P03M    1.000000000 P 10C4P03P    1.000000000 P 10C4P04P
  RHS UP:   0.000000000  1.000000000 P 10C4P05M    1.000000000 P 10C4P05P   -1.000000000 P 20C4P01M   -1.000000000 P 20C4P01P
                        -1.000000000 P 30C4P01M   -1.000000000 P 30C4P01P   -1.000000000 P 40C4P01P   -1.000000000 P 50C4P01M
                        -1.000000000 P 50C4P01P   -1.000000000 P F0C4P01M   -1.000000000 P F0C4P01P    1.000000000 L 10C4PC

10NAPD      EQ       40 -1.000000000 P 10NAP       1.000000000 P 10NAP0FM    1.000000000 P 10NAP0FP    1.000000000 P 10NAP02M
  RHS LO:   0.000000000  1.000000000 P 10NAP02P    1.000000000 P 10NAP03M    1.000000000 P 10NAP03P    1.000000000 P 10NAP04P
  RHS UP:   0.000000000  1.000000000 P 10NAP05M    1.000000000 P 10NAP05P   -1.000000000 P 20NAP01M   -1.000000000 P 20NAP01P
                        -1.000000000 P 30NAP01M   -1.000000000 P 30NAP01P   -1.000000000 P 40NAP01P   -1.000000000 P 50NAP01M
                        -1.000000000 P 50NAP01P   -1.000000000 P F0NAP01M   -1.000000000 P F0NAP01P    1.000000000 P 10NAPC

104BAD      EQ       41 -1.000000000 P 104BA       1.000000000 P 104BA0FM    1.000000000 P 104BA0FP    1.000000000 P 104BA02M
  RHS LO:   0.000000000  1.000000000 P 104BA02P    1.000000000 P 104BA03M    1.000000000 P 104BA03P    1.000000000 P 104BA04P
  RHS UP:   0.000000000  1.000000000 P 104BA05M    1.000000000 P 104BA05P   -1.000000000 P 204BA01M   -1.000000000 P 204BA01P
                        -1.000000000 P 304BA01M   -1.000000000 P 304BA01P   -1.000000000 P 404BA01P   -1.000000000 P 504BA01M
                        -1.000000000 P 504BA01P   -1.000000000 P F04BA01M   -1.000000000 P F04BA01P    1.000000000 P 104BAC

104AAD      EQ       42 -1.000000000 P 104AA       1.000000000 P 104AA0FM    1.000000000 P 104AA0FP    1.000000000 P 104AA02M
  RHS LO:   [illegible]  1.000000000 P 104AA02P    1.000000000 P 104AA03M    1.000000000 P 104AA03P    1.000000000 P 104AA04P
                                                                                                      -1.000000000 P 204AA01P
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104CAD      EQ      43  -1.000000000 P 104CA       1.000000000 P 104CA0FM    1.000000000 P 104CA0FP    1.000000000 P 104CA02M
  RHS LO:   0.000000000  1.000000000 P 104CA02P    1.000000000 P 104CA03M    1.000000000 P 104CA03P    1.000000000 P 104CA04P
  RHS UP:   0.000000000  1.000000000 P 104CA05M    1.000000000 P 104CA05P   -1.000000000 P 204CA01M   -1.000000000 P 204CA01P
                        -1.000000000 P 304CA01M   -1.000000000 P 304CA01P   -1.000000000 P 404CA01P   -1.000000000 P 504CA01M
                        -1.000000000 P 504CA01P   -1.000000000 P F04CA01M   -1.000000000 P F04CA01P    1.000000000 P 104CAC

104CAD      EQ      44  -1.000000000 P 104DA       1.000000000 P 104DA0FM    1.000000000 P 104DA0FP    1.000000000 P 104DA02M
  RHS LO:   0.000000000  1.000000000 P 104DA02P    1.000000000 P 104DA03M    1.000000000 P 104DA03P    1.000000000 P 104DA04P
  RHS UP:   0.000000000  1.000000000 P 104DA05M    1.000000000 P 104DA05P   -1.000000000 P 204DA01M   -1.000000000 P 204DA01P
                        -1.000000000 P 304DA01M   -1.000000000 P 304DA01P   -1.000000000 P 404DA01P   -1.000000000 P 504DA01M
                        -1.000000000 P 504DA01P   -1.000000000 P F04DA01M   -1.000000000 P F04DA01P    1.000000000 P 104DAC

105GASD     EQ      45  -1.000000000 P 104AAC     -1.000000000 P 104BAC     -1.000000000 P 104CAC     -1.000000000 P 104DAC
  RHS LO:   0.000000000  1.000000000 X 10TGASC
  RHS UP:   0.000000000

105AAD      EQ      46  -1.000000000 P 105AA       1.000000000 P 105AA0FM    1.000000000 P 105AA0FP    1.000000000 P 105AA02M
  RHS LO:   0.000000000  1.000000000 P 105AA02P    1.000000000 P 105AA03M    1.000000000 P 105AA03P    1.000000000 P 105AA04P
  RHS UP:   0.000000000  1.000000000 P 105AA05M    1.000000000 P 105AA05P   -1.000000000 P 205AA01M   -1.000000000 P 205AA01P
                        -1.000000000 P 305AA01M   -1.000000000 P 305AA01P   -1.000000000 P 405AA01P   -1.000000000 P 505AA01M
                        -1.000000000 P 505AA01P   -1.000000000 P F05AA01M   -1.000000000 P F05AA01P    1.000000000 L 105AAC

105BBD      EQ      47  -1.000000000 P 105BB       1.000000000 P 105BB0FM    1.000000000 P 105BB0FP    1.000000000 P 105BB02M
  RHS LO:   0.000000000  1.000000000 P 105BB02P    1.000000000 P 105BB03M    1.000000000 P 105BB03P    1.000000000 P 105BB04P
  RHS UP:   0.000000000  1.000000000 P 105BB05M    1.000000000 P 105BB05P   -1.000000000 P 205BB01M   -1.000000000 P 205BB01P
                        -1.000000000 P 305BB01M   -1.000000000 P 305BB01P   -1.000000000 P 405BB01P   -1.000000000 P 505BB01M
                        -1.000000000 P 505BB01P   -1.000000000 P F05BB01M   -1.000000000 P F05BB01P    1.000000000 L 105BBC

105CAD      EQ      48  -1.000000000 P 105CA       1.000000000 P 105CA0FM    1.000000000 P 105CA0FP    1.000000000 P 105CA02M
  RHS LO:   0.000000000  1.000000000 P 105CA02P    1.000000000 P 105CA03M    1.000000000 P 105CA03P    1.000000000 P 105CA04P
  RHS UP:   0.000000000  1.000000000 P 105CA05M    1.000000000 P 105CA05P   -1.000000000 P 205CA01M   -1.000000000 P 205CA01P
                        -1.000000000 P 305CA01M   -1.000000000 P 305CA01P   -1.000000000 P 405CA01P   -1.000000000 P 505CA01M
                        -1.000000000 P 505CA01P   -1.000000000 P F05CA01M   -1.000000000 P F05CA01P    1.000000000 L 105CAC
                         1.000000000 L 105CCC

105DLIM     GE      49   -.750000000 L 105CAC      1.000000000 L 105CCC
  RHS LO:   0.000000000
  RHS UP:   +INF

105CBD      EQ      50  -1.000000000 P 105CB       1.000000000 P 105CB0FM    1.000000000 P 105CB0FP    1.000000000 P 105CB02M
  RHS LO:   0.000000000  1.000000000 P 105CB02P    1.000000000 P 105CB03M    1.000000000 P 105CB03P    1.000000000 P 105CB04P
  RHS UP:   0.000000000  1.000000000 P 105CB05M    1.000000000 P 105CB05P   -1.000000000 P 205CB01M   -1.000000000 P 205CB01P
                        -1.000000000 P 305CB01M   -1.000000000 P 305CB01P   -1.000000000 P 405CB01P   -1.000000000 P 505CB01M
                        -1.000000000 P 505CB01P   -1.000000000 P F05CB01M   -1.000000000 P F05CB01P    1.000000000 L 105CBC

10VGOD      EQ      51  -1.000000000 P 10VGD       1.000000000 P 10VGD0FM    1.000000000 P 10VGD02M    1.000000000 P 10VGD03M
  RHS LO:   0.000000000  1.000000000 P 10VGD05M   -1.000000000 P 20VGD01M   -1.000000000 P 30VGD01M    1.000000000 P 10VGDC
  RHS UP:   0.000000000

105DAD      EQ      52  -1.000000000 P 105DA       1.000000000 P 105DA0FM    1.000000000 P 105DA02M    1.000000000 P 105DA03M
  RHS LO:   0.000000000  1.000000000 P 105DA05M   -1.000000000 P 205DA01M   -1.000000000 P 305DA01M   -1.000000000 P 505DA01M
  RHS UP:   0.000000000 -1.000000000 P F05DA01M    1.000000000 L 105DAC

105DBD      EQ      53  -1.000000000 P 105DB       1.000000000 P 105DB0FM    1.000000000 P 105DB02M    1.000000000 P 105DB03M
  RHS LO:   0.000000000  1.000000000 P 105DB05M   -1.000000000 P 205DB01M   -1.000000000 P 305DB01M   -1.000000000 P 505DB01M
  RHS UP:   0.000000000 -1.000000000 P F05DB01M    1.000000000 L 105DBC

10VRDD      EQ      54  -1.000000000 P 10VRD       1.000000000 P 10VROC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

10CKAD      EQ      55  -1.000000000 P 10CKA       1.000000000 P 10CKAC
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10CKBO        EQ      56  -1.000000000 P 10CKB       1.000000000 P 10CKBC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

101A6O        EQ      57  -1.000000000 P 101A6       1.000000000 P 101A6C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

101A7O        EQ      58  -1.000000000 P 101A7       1.000000000 P 101A7C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

101A8O        EQ      59  -1.000000000 P 101A8       1.000000000 P 101A8C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

10MISO        EQ      60  -1.000000000 P 10MIS       1.000000000 P 10MISC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

20OBJ         EQ      61  -9.650000000 L 20CAIN     -9.400000000 P 20CBIN     -8.300000000 P 20NGFN     -6.900000000 P 20TNC4
  RHS LO:   0.000000000   -7.330000000 P 20TIC4     -.017000000 P 20KWH      -8.520000000 P 20BTU      -.005780000 P 20LAB
  RHS UP:   0.000000000   -1.000000000 P 20DPC      -.958900000 P 20INV       .300000000 X 20ZPREM    -.092000000 P 20SCXX
                           1.000000000 P 20OBJT     -1.000000000 P 20TPCST    -1.000000000 P 20TMCST

20SML         EQ      62  -1.000000000 P 20CASBA    -1.000000000 P 20CASHC    -1.000000000 P 20CASLC     1.000000000 L 20TSML
  RHS LO:   0.000000000    1.000000000 P 20SMLN
  RHS UP:   0.000000000

20LRG         EQ      63  -1.000000000 P 20CBLBA    -1.000000000 P 20CBLLC    -1.000000000 P 20CBLHC    -1.000000000 P 20CALBA
  RHS LO:   0.000000000   -1.000000000 P 20CALHC    -1.000000000 P 20CALLC     1.000000000 L 20TLRG      1.000000000 P 20LRGN
  RHS UP:   0.000000000

20CBIO        EQ      64   1.000000000 P 20CBIN     -1.000000000 P 20CBLBA    -1.000000000 P 20CBLLC    -1.000000000 P 20CBLHC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

20NGFO        EQ      65   1.000000000 P 20NGFN     -.018500000 P 20CBLBA    -.018500000 P 20CBLLC    -.018500000 P 20CBLHC
  RHS LO:   0.000000000   -.018800000 P 20CALBA    -.018500000 P 20CALHC    -.018500000 P 20CALLC    -.021400000 P 20CASBA
  RHS UP:   0.000000000   -.021400000 P 20CASHC    -.020100000 P 20CASLC

20CAIO        EQ      66   1.000000000 L 20CAIN     -1.000000000 P 20CALBA    -1.000000000 P 20CALHC    -1.000000000 P 20CALLC
  RHS LO:   0.000000000   -1.000000000 P 20CASBA    -1.000000000 P 20CASHC    -1.000000000 P 20CASLC
  RHS UP:   0.000000000

20NC4O        EQ      67   1.000000000 P 20TNC4     -.013300000 P 20CBLBA    -.013300000 P 20CBLLC    -.013270000 P 20CBLHC
  RHS LO:   0.000000000   -.013500000 P 20CALBA    -.013300000 P 20CALHC    -.013300000 P 20CALLC    -.014800000 P 20CASBA
  RHS UP:   0.000000000   -.014600000 P 20CASHC    -.011300000 P 20CASLC    -.001400000 P 20DSHTA

20IC4O        EQ      68   1.000000000 P 20TIC4     -.013300000 P 20CBLBA    -.013300000 P 20CBLLC    -.013270000 P 20CBLHC
  RHS LO:   0.000000000   -.013500000 P 20CALBA    -.013300000 P 20CALHC    -.013300000 P 20CALLC    -.014800000 P 20CASBA
  RHS UP:   0.000000000   -.014800000 P 20CASHC    -.013900000 P 20CASLC    -.007000000 P 20DSHTA

20C3PP        EQ      69   .024400000 P 20CBLBA     .024400000 P 20CBLLC     .024400000 P 20CBLHC     .024800000 P 20CALBA
  RHS LO:   0.000000000    .024400000 P 20CALHC     .024400000 P 20CALLC     .019700000 P 20CASBA     .023000000 P 20CASHC
  RHS UP:   0.000000000    .018500000 P 20CASLC    -.027100000 L 20DLHC2    -1.000000000 P 20C3P

20C4PP        EQ      70   .005380000 P 20CBLBA     .004400000 P 20CBLLC     .005380000 P 20CBLHC     .005460000 P 20CALBA
  RHS LO:   0.000000000    .005400000 P 20CALHC     .005370000 P 20CALLC     .004900000 P 20CASBA     .005900000 P 20CASHC
  RHS UP:   0.000000000    .004600000 P 20CASLC    -.035000000 L 20DLHC2    -1.000000000 P 20C4P

20NC4P        EQ      71   [illegible]              [illegible] P 20CBLLC    [illegible] P 20CBLHC     .010900000 P 20CALBA
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204BAP         EQ     72   .160700000 P 20CBLBA    .160700000 P 20CBLLC    .160700000 P 20CBLHC    .163200000 P 20CALBA
  RHS LO:  0.000000000     .160700000 P 20CALHC    .160700000 P 20CALLC    .122000000 P 20CASBA    .049700000 P 20CASHC
  RHS UP:  0.000000000     .043400000 P 20CASLC   -.400000000 P 20DLHC1   -.400000000 L 20DLHC2  -1.000000000 P 204BA
                         -1.000000000 X 20ZPREM

204AAP         EQ     73   .253900000 P 20CBLBA    .215600000 P 20CBLLC    .270700000 P 20CBLHC    .211100000 P 20CALBA
  RHS LO:  0.000000000     .207800000 P 20CALHC    .194500000 P 20CALLC    .193100000 P 20CASBA    .149100000 P 20CASHC
  RHS UP:  0.000000000     .130100000 P 20CASLC   -.300000000 P 20DLHC1   -.300000000 L 20DLHC2  -1.000000000 P 204AA

204CAP         EQ     74   .110400000 P 20CBLBA    .072000000 P 20CBLLC    .132400000 P 20CBLHC    .091500000 P 20CALBA
  RHS LO:  0.000000000     .065100000 P 20CALHC    .072000000 P 20CALLC    .083700000 P 20CASBA    .149100000 P 20CASHC
  RHS UP:  0.000000000     .130100000 P 20CASLC   -.150000000 P 20DLHC1   -.150000000 L 20DLHC2  -1.000000000 P 204CA

204DAP         EQ     75   .095400000 P 20CBLBA    .095400000 P 20CBLLC    .124000000 P 20CBLHC    .089100000 P 20CALBA
  RHS LO:  0.000000000     .133100000 P 20CALHC    .095400000 P 20CALLC    .072700000 P 20CASBA    .149100000 P 20CASHC
  RHS UP:  0.000000000     .133100000 P 20CASLC   -.150000000 P 20DLHC1   -.150000000 L 20DLHC2  -1.000000000 P 204DA
                          1.000000000 X 20ZPREM

205GASP        EQ     76  1.000000000 P 204BA     1.000000000 P 204AA     1.000000000 P 204CA     1.000000000 P 204DA
  RHS LO:  0.000000000   -1.000000000 P 20TGAS
  RHS UP:  0.000000000

205AAP         EQ     77   .013400000 P 20CBLBA    .010900000 P 20CBLLC    .010900000 P 20CBLHC    .013600000 P 20CALBA
  RHS LO:  0.000000000     .013400000 P 20CALHC    .010900000 P 20CALLC    .012700000 P 20CASBA    .012700000 P 20CASHC
  RHS UP:  0.000000000     .012000000 P 20CASLC  -1.000000000 P 205AA

205BBP         EQ     78   .045900000 P 20CBLBA    .043700000 P 20CBLLC    .045900000 P 20CBLHC    .054500000 P 20CALBA
  RHS LO:  0.000000000     .053600000 P 20CALHC    .043700000 P 20CALLC    .040100000 P 20CASBA    .040100000 P 20CASHC
  RHS UP:  0.000000000     .009400000 P 20CASLC  -1.000000000 P 205BB     1.000000000 P 205BBX

205CAP         EQ     79   .063200000 P 20CBLBA    .155100000 P 20CBLLC    .056900000 P 20CBLHC    .078000000 P 20CALBA
  RHS LO:  0.000000000     .077500000 P 20CALHC    .187500000 P 20CALLC    .110000000 P 20CASBA    .100000000 P 20CASHC
  RHS UP:  0.000000000     .239600000 P 20CASLC   1.235000000 P 20DLHC1    .974000000 L 20DLHC2   1.000000000 P 20DLHT1
                         -1.000000000 P 205CA     1.000000000 P 205CXX   -.600000000 P 205BBX

205CBP         EQ     80   .156100000 P 20CBLBA    .156100000 P 20CBLLC    .114800000 P 20CBLHC    .158600000 P 20CALBA
  RHS LO:  0.000000000     .156100000 P 20CALHC    .156100000 P 20CALLC    .221900000 P 20CASBA    .206900000 P 20CASHC
  RHS UP:  0.000000000     .179900000 P 20CASLC  -1.000000000 P 20DLHT1   -.005000000 P 20DSHTA  -1.000000000 P 205CB
                         -1.000000000 P 205CXX   -.400000000 P 205BBX

20VGOP         EQ     81   .012200000 P 20CBLBA    .012200000 P 20CBLLC    .012200000 P 20CBLHC    .015200000 P 20CALBA
  RHS LO:  0.000000000     .012200000 P 20CALHC    .012200000 P 20CALLC  -1.000000000 P 20VGO
  RHS UP:  0.000000000

205DAP         EQ     82   .022400000 P 20CBLBA    .022400000 P 20CBLLC    .017800000 P 20CBLHC    .027700000 P 20CALBA
  RHS LO:  0.000000000     .017800000 P 20CALHC    .022400000 P 20CALLC    .038900000 P 20CASBA    .035400000 P 20CASHC
  RHS UP:  0.000000000     .036500000 P 20CASLC  -1.000000000 P 205DA

205DBP         EQ     83   .022400000 P 20CBLBA    .022400000 P 20CBLLC    .017900000 P 20CBLHC    .027700000 P 20CALBA
  RHS LO:  0.000000000     .027300000 P 20CALHC    .022400000 P 20CALLC    .038900000 P 20CASBA    .035400000 P 20CASHC
  RHS UP:  0.000000000     .036500000 P 20CASLC   -.458000000 P 20DLHC1   -.022000000 P 20DLHT1  -1.000000000 P 205DB

20VRDP         EQ     84   .030100000 P 20CBLBA    .030100000 P 20CBLLC    .030100000 P 20CBLHC    .030600000 P 20CALBA
  RHS LO:  0.000000000     .030100000 P 20CALHC    .030100000 P 20CALLC    .076500000 P 20CASBA    .076500000 P 20CASHC
  RHS UP:  0.000000000     .057200000 P 20CASLC  -1.000000000 P 20VRD

20CKAP         EQ     85   .006140000 P 20CALBA    .006250000 P 20CALHC    .006100000 P 20CALLC  -1.000000000 P 20CKA
  RHS LO:  0.000000000
  RHS UP:  0.000000000

20CKBP         EQ     86   .009350000 P 20CBLBA    .006670000 P 20CBLLC    .009420000 P 20CBLHC  -1.000000000 P 20CKB
  RHS LO:  0.000000000
  RHS UP:  [illegible]
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201A7P          EQ         88    .000960000 P 20CBLBA     .000960000 P 20CBLLC     .000960000 P 20CBLHC     .000970000 P 20CALBA
   RHS LO:   0.000000000  -1.000000000 P 201A7
   RHS UP:   0.000000000

201A8P          EQ         89    .001920000 P 20CBLBA     .001920000 P 20CBLLC     .000700000 P 20CBLHC     .000710000 P 20CALBA
   RHS LO:   0.000000000  -1.000000000 P 201A8
   RHS UP:   0.000000000

20MISP          EQ         90    .014000000 P 20CBLBA     .014000000 P 20CBLLC     .014000000 P 20CBLHC     .024600000 P 20CALBA
   RHS LO:   0.000000000     .027200000 P 20CALHC     .014000000 P 20CALLC     .013700000 P 20CASBA     .015100000 P 20CASHC
   RHS UP:   0.000000000     .012900000 P 20CASLC   -1.000000000 P 20MIS

20KWHR          EQ         91   4.470000000 P 20CBLBA    4.240000000 P 20CBLLC    4.650000000 P 20CBLHC    4.080000000 P 20CALBA
   RHS LO:   0.000000000   3.980000000 P 20CALHC    3.790000000 P 20CALLC    2.629000000 P 20CASBA    2.700000000 P 20CASHC
   RHS UP:   0.000000000   2.677200000 P 20CASLC   33.160000000 P 20DLHC1     .068000000 P 20DLHT1    1.050000000 P 20DSHTA
                           3.120000000 P 20DSHTC   -1.000000000 P 20KWH

20BTUR          EQ         92    .058460000 P 20CBLBA     .058460000 P 20CBLLC     .060890000 P 20CBLHC     .056210000 P 20CALBA
   RHS LO:   0.000000000     .058550000 P 20CALHC     .056210000 P 20CALLC     .047040000 P 20CASBA     .048750000 P 20CASHC
   RHS UP:   0.000000000     .046190000 P 20CASLC    -.055060000 L 20DLHC2     .016000000 P 20DSHTA     .008000000 P 20DSHTC
                          -1.000000000 P 20BTU

20ENER          EQ         93    .066900000 P 20CBLBA     .066400000 P 20CBLLC     .069700000 P 20CBLHC     .063900000 P 20CALBA
   RHS LO:   0.000000000     .065860000 P 20CALHC     .063300000 P 20CALLC     .051980000 P 20CASBA     .053900000 P 20CASHC
   RHS UP:   0.000000000     .051220000 P 20CASLC     .520000000 P 20DLHC1    -.055000000 L 20DLHC2     .025000000 P 20DLHT1
                             .018000000 P 20DSHTA     .014000000 P 20DSHTC   -1.000000000 P 20ENE

20LABR          EQ         94   5.000000000 P 20CBLBA    5.000000000 P 20CBLLC    5.000000000 P 20CBLHC    5.000000000 P 20CALBA
   RHS LO:   0.000000000   5.000000000 P 20CALHC    5.000000000 P 20CALLC    5.000000000 P 20CASBA    5.000000000 P 20CASHC
   RHS UP:   0.000000000   5.000000000 P 20CASLC     .800000000 P 20DLHC1     .500000000 P 20DLHT1     .600000000 P 20DSHTA
                             .600000000 P 20DSHTC   -1.000000000 P 20LAB

20DPCR          EQ         95    .164000000 P 20CBLBA     .149000000 P 20CBLLC     .185700000 P 20CBLHC     .145800000 P 20CALBA
   RHS LO:   0.000000000     .160400000 P 20CALHC     .140100000 P 20CALLC     .112700000 P 20CASBA     .120000000 P 20CASHC
   RHS UP:   0.000000000     .093800000 P 20CASLC    -.038200000 P 20DLHC1    -.557000000 L 20DLHC2     .012500000 P 20DLHT1
                             .013000000 P 20DSHTA     .006000000 P 20DSHTC   -1.000000000 P 20DPC

20INVR          EQ         96   3.800000000 P 20DLHC1     .100000000 L 20DLHC2     .510000000 P 20DLHT1     .400000000 P 20DSHTA
   RHS LO:   0.000000000   1.134000000 P 20DSHTC    4.000000000 P 20LRGN     6.000000000 P 20SMLN    -1.000000000 P 20INV
   RHS UP:   0.000000000   1.200000000 P 20NPIP01   1.400000000 P 20NPIP03

20C3PD          EQ         97  -1.000000000 P 20C3P    -1.000000000 P 10C3P02M   -1.000000000 P 10C3P02P    1.000000000 P 20C3P0FM
   RHS LO:   0.000000000   1.000000000 P 20C3P0FP    1.000000000 P 20C3P01M    1.000000000 P 20C3P01P    1.000000000 P 20C3P03M
   RHS UP:   0.000000000   1.000000000 P 20C3P03P    1.000000000 P 20C3P04P    1.000000000 P 20C3P05M    1.000000000 P 20C3P05P
                          -1.000000000 P 30C3P02M   -1.000000000 P 30C3P02P   -1.000000000 P 40C3P02P   -1.000000000 P 50C3P02M
                          -1.000000000 P 50C3P02P   -1.000000000 P F0C3P02M   -1.000000000 P F0C3P02P    1.000000000 L 20C3PC

20C4PD          EQ         98  -1.000000000 P 20C4P    -1.000000000 P 10C4P02M   -1.000000000 P 10C4P02P    1.000000000 P 20C4P0FM
   RHS LO:   0.000000000   1.000000000 P 20C4P0FP    1.000000000 P 20C4P01M    1.000000000 P 20C4P01P    1.000000000 P 20C4P03M
   RHS UP:   0.000000000   1.000000000 P 20C4P03P    1.000000000 P 20C4P04P    1.000000000 P 20C4P05M    1.000000000 P 20C4P05P
                          -1.000000000 P 30C4P02M   -1.000000000 P 30C4P02P   -1.000000000 P 40C4P02P   -1.000000000 P 50C4P02M
                          -1.000000000 P 50C4P02P   -1.000000000 P F0C4P02M   -1.000000000 P F0C4P02P    1.000000000 L 20C4PC

20NAPD          EQ         99  -1.000000000 P 20NAP    -1.000000000 P 10NAP02M   -1.000000000 P 10NAP02P    1.000000000 P 20NAP0FM
   RHS LO:   0.000000000   1.000000000 P 20NAP0FP    1.000000000 P 20NAP01M    1.000000000 P 20NAP01P    1.000000000 P 20NAP03M
   RHS UP:   0.000000000   1.000000000 P 20NAP03P    1.000000000 P 20NAP04P    1.000000000 P 20NAP05M    1.000000000 P 20NAP05P
                          -1.000000000 P 30NAP02M   -1.000000000 P 30NAP02P   -1.000000000 P 40NAP02P   -1.000000000 P 50NAP02M
                          -1.000000000 P 50NAP02P   -1.000000000 P F0NAP02M   -1.000000000 P F0NAP02P    1.000000000 P 20NAPC

204BAD          EQ        100  -1.000000000 P 204BA    -1.000000000 P 104BA02M   -1.000000000 P 104BA02P    1.000000000 P 204BA0FM
   RHS LO:   0.000000000   1.000000000 P 204BA0FP    1.000000000 P 204BA01M    1.000000000 P 204BA01P    1.000000000 P 204BA03M
   RHS UP:   [illegible]   [illegible] P 204BA03P    1.000000000 P 204BA04P    1.000000000 P 204BA05M    1.000000000 P 204BA05P
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204AAO      EQ     101  -1.000000000 P 204AA       -1.000000000 P 104AA02M    -1.000000000 P 104AA02P     1.000000000 P 204AA0FM
  RHS LO:   0.000000000  1.000000000 P 204AA0FP     1.000000000 P 204AA01M     1.000000000 P 204AA01P     1.000000000 P 204AA03M
  RHS UP:   0.000000000  1.000000000 P 204AA03P     1.000000000 P 204AA04P     1.000000000 P 204AA05M     1.000000000 P 204AA05P
                        -1.000000000 P 304AA02M    -1.000000000 P 304AA02P    -1.000000000 P 404AA02P    -1.000000000 P 504AA02M
                        -1.000000000 P 504AA02P    -1.000000000 P F04AA02M    -1.000000000 P F04AA02P     1.000000000 P 204AAC

204CAO      EQ     102  -1.000000000 P 204CA       -1.000000000 P 104CA02M    -1.000000000 P 104CA02P     1.000000000 P 204CA0FM
  RHS LO:   0.000000000  1.000000000 P 204CA0FP     1.000000000 P 204CA01M     1.000000000 P 204CA01P     1.000000000 P 204CA03M
  RHS UP:   0.000000000  1.000000000 P 204CA03P     1.000000000 P 204CA04P     1.000000000 P 204CA05M     1.000000000 P 204CA05P
                        -1.000000000 P 304CA02M    -1.000000000 P 304CA02P    -1.000000000 P 404CA02P    -1.000000000 P 504CA02M
                        -1.000000000 P 504CA02P    -1.000000000 P F04CA02M    -1.000000000 P F04CA02P     1.000000000 P 204CAC

204DAO      EQ     103  -1.000000000 P 204DA       -1.000000000 P 104DA02M    -1.000000000 P 104DA02P     1.000000000 P 204DA0FM
  RHS LO:   0.000000000  1.000000000 P 204DA0FP     1.000000000 P 204DA01M     1.000000000 P 204DA01P     1.000000000 P 204DA03M
  RHS UP:   0.000000000  1.000000000 P 204DA03P     1.000000000 P 204DA04P     1.000000000 P 204DA05M     1.000000000 P 204DA05P
                        -1.000000000 P 304DA02M    -1.000000000 P 304DA02P    -1.000000000 P 404DA02P    -1.000000000 P 504DA02M
                        -1.000000000 P 504DA02P    -1.000000000 P F04DA02M    -1.000000000 P F04DA02P     1.000000000 P 204DAC

205GASO     EQ     104  -1.000000000 P 204AAC      -1.000000000 P 204BAC      -1.000000000 P 204CAC      -1.000000000 P 204DAC
  RHS LO:   0.000000000  1.000000000 X 20TGASC
  RHS UP:   0.000000000

205AAO      EQ     105  -1.000000000 P 205AA       -1.000000000 P 105AA02M    -1.000000000 P 105AA02P     1.000000000 P 205AA0FM
  RHS LO:   0.000000000  1.000000000 P 205AA0FP     1.000000000 P 205AA01M     1.000000000 P 205AA01P     1.000000000 P 205AA03M
  RHS UP:   0.000000000  1.000000000 P 205AA03P     1.000000000 P 205AA04P     1.000000000 P 205AA05M     1.000000000 P 205AA05P
                        -1.000000000 P 305AA02M    -1.000000000 P 305AA02P    -1.000000000 P 405AA02P    -1.000000000 P 505AA02M
                        -1.000000000 P 505AA02P    -1.000000000 P F05AA02M    -1.000000000 P F05AA02P     1.000000000 L 205AAC

205BBO      EQ     106  -1.000000000 P 205BB       -1.000000000 P 105BB02M    -1.000000000 P 105BB02P     1.000000000 P 205BB0FM
  RHS LO:   0.000000000  1.000000000 P 205BB0FP     1.000000000 P 205BB01M     1.000000000 P 205BB01P     1.000000000 P 205BB03M
  RHS UP:   0.000000000  1.000000000 P 205BB03P     1.000000000 P 205BB04P     1.000000000 P 205BB05M     1.000000000 P 205BB05P
                        -1.000000000 P 305BB02M    -1.000000000 P 305BB02P    -1.000000000 P 405BB02P    -1.000000000 P 505BB02M
                        -1.000000000 P 505BB02P    -1.000000000 P F05BB02M    -1.000000000 P F05BB02P     1.000000000 L 205BBC

205CAO      EQ     107  -1.000000000 P 205CA       -1.000000000 P 105CA02M    -1.000000000 P 105CA02P     1.000000000 P 205CA0FM
  RHS LO:   0.000000000  1.000000000 P 205CA0FP     1.000000000 P 205CA01M     1.000000000 P 205CA01P     1.000000000 P 205CA03M
  RHS UP:   0.000000000  1.000000000 P 205CA03P     1.000000000 P 205CA04P     1.000000000 P 205CA05M     1.000000000 P 205CA05P
                        -1.000000000 P 305CA02M    -1.000000000 P 305CA02P    -1.000000000 P 405CA02P    -1.000000000 P 505CA02M
                        -1.000000000 P 505CA02P    -1.000000000 P F05CA02M    -1.000000000 P F05CA02P     1.000000000 L 205CAC
                         1.000000000 L 205CCC

205DLIM     GE     108   -.750000000 L 205CAC      1.000000000 L 205CCC
  RHS LO:   0.000000000
  RHS UP:   +INF

205CBO      EQ     109  -1.000000000 P 205CB       -1.000000000 P 105CB02M    -1.000000000 P 105CB02P     1.000000000 P 205CB0FM
  RHS LO:   0.000000000  1.000000000 P 205CB0FP     1.000000000 P 205CB01M     1.000000000 P 205CB01P     1.000000000 P 205CB03M
  RHS UP:   0.000000000  1.000000000 P 205CB03P     1.000000000 P 205CB04P     1.000000000 P 205CB05M     1.000000000 P 205CB05P
                        -1.000000000 P 305CB02M    -1.000000000 P 305CB02P    -1.000000000 P 405CB02P    -1.000000000 P 505CB02M
                        -1.000000000 P 505CB02P    -1.000000000 P F05CB02M    -1.000000000 P F05CB02P     1.000000000 L 205CBC

20VGDO      EQ     110  -1.000000000 P 20VGD       -1.000000000 P 10VGD02M     1.000000000 P 20VGD0FM     1.000000000 P 20VGD01M
  RHS LO:   0.000000000  1.000000000 P 20VGD03M     1.000000000 P 20VGD05M    -1.000000000 P 30VGD02M     1.000000000 P 20VGDC
  RHS UP:   0.000000000

205OAO      EQ     111  -1.000000000 P 205OA       -1.000000000 P 105OA02M     1.000000000 P 205OA0FM     1.000000000 P 205OA01M
  RHS LO:   0.000000000  1.000000000 P 205OA03M     1.000000000 P 205OA05M    -1.000000000 P 305OA02M    -1.000000000 P F05DA02M
  RHS UP:   0.000000000  1.000000000 L 205OAC

205OBO      EQ     112  -1.000000000 P 205OB       -1.000000000 P 105OB02M     1.000000000 P 205OB0FM     1.000000000 P 205OB01M
  RHS LO:   0.000000000  1.000000000 P 205OB03M     1.000000000 P 205OB05M    -1.000000000 P 305DB02M    -1.000000000 P F05DB02M
  RHS UP:   0.000000000  1.000000000 L 205OBC
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20CKAD       EQ     114  -1.000000000 P 20CKA       1.000000000 P 20CKAC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

20CKBD       EQ     115  -1.000000000 P 20CKB       1.000000000 P 20CKBC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

201A6D       EQ     116  -1.000000000 P 201A6       1.000000000 P 201A6C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

201A7D       EQ     117  -1.000000000 P 201A7       1.000000000 P 201A7C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

201A8D       EQ     118  -1.000000000 P 201A8       1.000000000 P 201A8C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

20MISD       EQ     119  -1.000000000 P 20MIS       1.000000000 P 20MISC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

30OBJ        EQ     120  -9.250000000 L 30CAIN     -9.000000000 P 30CBIN     -9.000000000 P 30CDIN     -8.300000000 P 30NGFN
  RHS LO:   0.000000000  -6.900000000 P 30TNC4     -7.300000000 P 30TIC4      -.010000000 P 30KWH      -9.720000000 P 30BTU
  RHS UP:   0.000000000   -.006370000 P 30LAB      -1.000000000 P 30DPC       -.958900000 P 30INV        .300000000 X 30ZPREM
                          -.092000000 P 30SCXX      1.000000000 P 30OBJT     -1.000000000 P 30TPCST    -1.000000000 P 30TMCST

30LRG        EQ     121  -1.000000000 P 30CBLBA    -1.000000000 P 30CBLLC    -1.000000000 P 30CBLHC    -1.000000000 P 30CALBA
  RHS LO:   0.000000000  -1.000000000 P 30CALHC    -1.000000000 P 30CALLC    -1.000000000 P 30CDLBA     1.000000000 L 30TLRG
  RHS UP:   0.000000000   1.000000000 P 30LRGN

30MED        EQ     122  -1.000000000 P 30CAMBA    -1.000000000 P 30CAMLC    -1.000000000 P 30CAMHC    -1.000000000 P 30CBMBA
  RHS LO:   0.000000000  -1.000000000 P 30CBMLC    -1.000000000 P 30CBMHC     1.000000000 L 30TMED
  RHS UP:   0.000000000

30SML        EQ     123  -1.000000000 P 30CASBA    -1.000000000 P 30CASHC    -1.000000000 P 30CASLC     1.000000000 L 30TSML
  RHS LO:   0.000000000   1.000000000 P 30SMLN
  RHS UP:   0.000000000

30CAID       EQ     124   1.000000000 L 30CAIN     -1.000000000 P 30CAMBA    -1.000000000 P 30CAMLC    -1.000000000 P 30CAMHC
  RHS LO:   0.000000000  -1.000000000 P 30CALBA    -1.000000000 P 30CALHC    -1.000000000 P 30CALLC    -1.000000000 P 30CASBA
  RHS UP:   0.000000000  -1.000000000 P 30CASHC    -1.000000000 P 30CASLC

30CBID       EQ     125   1.000000000 P 30CBIN     -1.000000000 P 30CBMBA    -1.000000000 P 30CBMLC    -1.000000000 P 30CBMHC
  RHS LO:   0.000000000  -1.000000000 P 30CBLBA    -1.000000000 P 30CBLLC    -1.000000000 P 30CBLHC
  RHS UP:   0.000000000

30CDID       EQ     126   1.000000000 P 30CDIN     -1.000000000 P 30CDLBA
  RHS LO:   0.000000000
  RHS UP:   0.000000000

30NGFD       EQ     127   1.000000000 P 30NGFN      -.025000000 P 30CAMBA     -.025000000 P 30CAMLC     -.025000000 P 30CAMHC
  RHS LO:   0.000000000   -.025000000 P 30CBMBA     -.025000000 P 30CBMLC     -.025000000 P 30CBMHC     -.025000000 P 30CBLBA
  RHS UP:   0.000000000   -.025000000 P 30CBLLC     -.025000000 P 30CBLHC     -.025000000 P 30CALBA     -.025000000 P 30CALHC
                          -.025000000 P 30CALLC     -.014000000 P 30CDLBA     -.029300000 P 30CASBA     -.028100000 P 30CASHC
                          -.024300000 P 30CASLC

30NC4D       EQ     128   1.000000000 P 30TNC4      -.001500000 P 30CAMBA     -.001500000 P 30CAMHC      .010800000 P 30CBMBA
  RHS LO:   [illegible]   [illegible] P [illegible] -.015000000 P 30CBLBA     -.011500000 P 30CBLLC     -.015000000 P 30CBLHC
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301C4U	EQ 129	1.000000000 P 30TIC4	-.010000000 P 30CAMBA	-.010000000 P 30CAMLC	-.007900000 P 30CAMHC
RHS LO:	0.000000000	.010000000 P 30CBMBA	-.010000000 P 30CBMLC	-.010000000 P 30CBMHC	-.010000000 P 30CBLBA
RHS UP:	0.000000000	-.008200000 P 30CBLLC	-.016000000 P 30CBLHC	-.005200000 P 30CALBA	-.001100000 P 30CALHC
		-.009800000 P 30CALLC	-.004610000 P 30CDLBA	-.007500000 P 30CASBA	-.005100000 P 30CASHC
		-.007500000 P 30CASLC	-.007000000 P 30DSHTA		
30C3PP	EQ 130	.008300000 P 30CAMBA	.008300000 P 30CAMLC	.008300000 P 30CAMHC	.008300000 P 30CBMBA
RHS LO:	0.000000000	.008300000 P 30CBMLC	.008300000 P 30CBMHC	.008300000 P 30CBLBA	.008300000 P 30CBLLC
RHS UP:	0.000000000	.008300000 P 30CBLHC	.008300000 P 30CALBA	.008300000 P 30CALHC	.008300000 P 30CALLC
		.015000000 P 30CDLBA	.010700000 P 30CASBA	.010200000 P 30CASHC	.010700000 P 30CASLC
		-.027100000 L 30DLHC2	-1.000000000 P 30C3P		
30C4PP	EQ 131	.002500000 P 30CAMBA	.002500000 P 30CAMLC	.002500000 P 30CAMHC	.002500000 P 30CBMBA
RHS LO:	0.000000000	.002500000 P 30CBMLC	.002500000 P 30CBMHC	.002500000 P 30CBLBA	.002500000 P 30CBLLC
RHS UP:	0.000000000	.002500000 P 30CBLHC	.002500000 P 30CALBA	.002500000 P 30CALHC	.002500000 P 30CALLC
		.010000000 P 30CDLBA	.003000000 P 30CASBA	.002900000 P 30CASHC	.003000000 P 30CASLC
		-.035300000 L 30DLHC2	-1.000000000 P 30C4P		
30NAPP	EQ 132	.008800000 P 30CAMBA	.008800000 P 30CAMLC	.008900000 P 30CAMHC	.008800000 P 30CBMBA
RHS LO:	0.000000000	.013200000 P 30CBMLC	.008800000 P 30CBMHC	.008800000 P 30CBLBA	.013200000 P 30CBLLC
RHS UP:	0.000000000	.008800000 P 30CBLHC	.008800000 P 30CALBA	.008800000 P 30CALHC	.008800000 P 30CALLC
		.009600000 P 30CDLBA	.008200000 P 30CASBA	.007900000 P 30CASHC	.008000000 P 30CASLC
		-1.000000000 P 30NAP			
304BAP	EQ 133	.099500000 P 30CAMBA	.035300000 P 30CAMLC	.037200000 P 30CAMHC	.159000000 P 30CBMBA
RHS LO:	0.000000000	.039000000 P 30CBMLC	.048700000 P 30CBMHC	.159000000 P 30CBLBA	.043000000 P 30CBLLC
RHS UP:	0.000000000	.053800000 P 30CBLHC	.159000000 P 30CALBA	.049200000 P 30CALHC	.041000000 P 30CALLC
		.316000000 P 30CDLBA	.098000000 P 30CASBA	.036900000 P 30CASHC	.035400000 P 30CASLC
		-.400000000 P 30DLHC1	-.400000000 L 30DLHC2	-1.000000000 P 304BA	-1.000000000 X 30ZPREM
304AAP	EQ 134	.184000000 P 30CAMBA	.105000000 P 30CAMLC	.111500000 P 30CAMHC	.211900000 P 30CBMBA
RHS LO:	0.000000000	.116900000 P 30CBMLC	.146100000 P 30CBMHC	.256700000 P 30CBLBA	.129000000 P 30CBLLC
RHS UP:	0.000000000	.161300000 P 30CBLHC	.211100000 P 30CALBA	.147600000 P 30CALHC	.123000000 P 30CALLC
		.114000000 P 30CDLBA	.150000000 P 30CASBA	.117000000 P 30CASHC	.106300000 P 30CASLC
		-.300000000 P 30DLHC1	-.300000000 L 30DLHC2	-1.000000000 P 304AA	
304CAP	EQ 135	.055000000 P 30CAMBA	.105000000 P 30CAMLC	.111500000 P 30CAMHC	.055000000 P 30CBMBA
RHS LO:	0.000000000	.116900000 P 30CBMLC	.146100000 P 30CBMHC	.061000000 P 30CBLBA	.129000000 P 30CBLLC
RHS UP:	0.000000000	.161300000 P 30CBLHC	.061000000 P 30CALBA	.147600000 P 30CALHC	.123000000 P 30CALLC
		.062400000 P 30CDLBA	.062000000 P 30CASBA	.117000000 P 30CASHC	.106300000 P 30CASLC
		-.150000000 P 30DLHC1	-.150000000 L 30DLHC2	-1.000000000 P 304CA	
304DAP	EQ 136	.037000000 P 30CAMBA	.105000000 P 30CAMLC	.141500000 P 30CAMHC	.061000000 P 30CBMBA
RHS LO:	0.000000000	.117500000 P 30CBMLC	.178800000 P 30CBMHC	.061000000 P 30CBLBA	.129000000 P 30CBLLC
RHS UP:	0.000000000	.199500000 P 30CBLHC	.061000000 P 30CALBA	.177300000 P 30CALHC	.123000000 P 30CALLC
		.041600000 P 30CDLBA	.041000000 P 30CASBA	.117300000 P 30CASHC	.106300000 P 30CASLC
		-.150000000 P 30DLHC1	-.150000000 L 30DLHC2	-1.000000000 P 304DA	1.000000000 X 30ZPREM
305GASP	EQ 137	1.000000000 P 304BA	1.000000000 P 304AA	1.000000000 P 304CA	1.000000000 P 304DA
RHS LO:	0.000000000	-1.000000000 P 30TGAS			
RHS UP:	0.000000000				
305AAP	EQ 138	.019000000 P 30CAMBA	.013000000 P 30CAMLC	.013000000 P 30CAMHC	.013000000 P 30CBMBA
RHS LO:	0.000000000	.019000000 P 30CBMLC	.013000000 P 30CBMHC	.019000000 P 30CBLBA	.013000000 P 30CBLLC
RHS UP:	0.000000000	.013000000 P 30CBLHC	.019000000 P 30CALBA	.013000000 P 30CALHC	.013000000 P 30CALLC
		.022400000 P 30CDLBA	.012900000 P 30CASBA	.012400000 P 30CASHC	.012900000 P 30CASLC
		-1.000000000 P 305AA			
305BAP	EQ 139	.071000000 P 30CAMBA	.063000000 P 30CAMLC	.073000000 P 30CAMHC	.063000000 P 30CBMBA
RHS LO:	[illegible]	.063000000 P 30CBMLC	.063000000 P 30CBMHC	.063000000 P 30CBLBA	.063000000 P 30CBLLC
RHS UP:	[illegible]	[illegible] P 30CBLHC	.071000000 P 30CALBA	.063000000 P 30CALHC	.063000000 P 30CALLC

305CAP	EQ 140	.096000000 P 30CAMBA	.259900000 P 30CAMLC	.118300000 P 30CAMHC	.065000000 P 30CBMBA
RHS LO:	0.000000000	.198500000 P 30CBMLC	.065000000 P 30CBMHC	.065300000 P 30CBLBA	.240900000 P 30CBLLC
RHS UP:	0.000000000	.065000000 P 30CBLHC	.098000000 P 30CALBA	.098000000 P 30CALHC	.296500000 P 30CALLC
		.095100000 P 30CDLBA	.109100000 P 30CASBA	.109100000 P 30CASHC	.234200000 P 30CASLC
		1.235000000 P 30DLHC1	.974000000 L 30DLHC2	1.000000000 P 30DLHT1	-1.000000000 P 305CA
		1.000000000 P 305CXX	-.600000000 P 305BBX		
305CBP	EQ 141	.180000000 P 30CAMBA	.188600000 P 30CAMLC	.180000000 P 30CAMHC	.120000000 P 30CBMBA
RHS LO:	0.000000000	.120000000 P 30CBMLC	.120000000 P 30CBMHC	.153300000 P 30CBLBA	.120000000 P 30CBLLC
RHS UP:	0.000000000	.158700000 P 30CBLHC	.180000000 P 30CALBA	.180000000 P 30CALHC	.120000000 P 30CALLC
		.055200000 P 30COLBA	.202500000 P 30CASBA	.202500000 P 30CASHC	.131100000 P 30CASLC
		-1.000000000 P 30DLHT1	-.005000000 P 30OSHTA	-1.000000000 P 305CB	-1.000000000 P 305CXX
		-.400000000 P 305BBX			
30VGOP	EQ 142	.031800000 P 30CAMBA	.026000000 P 30CAMLC	.062000000 P 30CAMHC	.071000000 P 30CBMBA
RHS LO:	0.000000000	.063000000 P 30CBMLC	.086700000 P 30CBMHC	.020000000 P 30CBLBA	.020000000 P 30CBLLC
RHS UP:	0.000000000	.020000000 P 30CBLHC	.020000000 P 30CALBA	.020000000 P 30CALHC	.020000000 P 30CALLC
		.028100000 P 30CASBA	.027000000 P 30CASHC	.028100000 P 30CASLC	-1.000000000 P 30VGO
305DAP	EQ 143	.043000000 P 30CAMBA	.028000000 P 30CAMLC	.043000000 P 30CAMHC	.028000000 P 30CBMBA
RHS LO:	0.000000000	.028000000 P 30CBMLC	.026000000 P 30CBMHC	.028000000 P 30CBLBA	.028000000 P 30CBLLC
RHS UP:	0.000000000	.026000000 P 30CBLHC	.028000000 P 30CALBA	.028000000 P 30CALHC	.028000000 P 30CALLC
		.072800000 P 30COLBA	.070600000 P 30CASBA	.047200000 P 30CASHC	.049200000 P 30CASLC
		-1.000000000 P 305DA			
305DBP	EQ 144	.052000000 P 30CAMBA	.028000000 P 30CAMLC	.042300000 P 30CAMHC	.042000000 P 30CBMBA
RHS LO:	0.000000000	.048000000 P 30CBMLC	.048000000 P 30CBMHC	.028000000 P 30CBLBA	.028000000 P 30CBLLC
RHS UP:	0.000000000	.028000000 P 30CBLHC	.028000000 P 30CALBA	.028300000 P 30CALHC	.028000000 P 30CALLC
		.072800000 P 30CDLBA	.070600000 P 30CASBA	.047200000 P 30CASHC	.049200000 P 30CASLC
		-.458000000 P 30OLHC1	-.022000000 P 30DLHT1	-1.000000000 P 305DB	
30VRDP	EQ 145	.021800000 P 30CAMBA	.014000000 P 30CAMLC	.014000000 P 30CAMHC	.022000000 P 30CBMBA
RHS LO:	0.000000000	.022000000 P 30CBMLC	.022000000 P 30CBMHC	.022000000 P 30CBLBA	.022000000 P 30CBLLC
RHS UP:	0.000000000	.022000000 P 30CBLHC	.014600000 P 30CALBA	.014300000 P 30CALHC	.014000000 P 30CALLC
		.026000000 P 30CDLBA	.065600000 P 30CASBA	.063000000 P 30CASHC	.065600000 P 30CASLC
		-1.000000000 P 30VRD			
30CKAP	EQ 146	.002300000 P 30CAMBA	.002300000 P 30CAMLC	.002300000 P 30CAMHC	.003000000 P 30CALBA
RHS LO:	0.000000000	.004700000 P 30CALHC	.004700000 P 30CALLC	.003200000 P 30CASBA	.003100000 P 30CASHC
RHS UP:	0.000000000	.003200000 P 30CASLC	-1.000000000 P 30CKA		
30CKBP	EQ 147	.002900000 P 30CBMBA	.002900000 P 30CBMLC	.002900000 P 30CBMHC	.006000000 P 30CBLBA
RHS LO:	0.000000000	.006000000 P 30CBLLC	.006000000 P 30CBLHC	.015500000 P 30COLBA	-1.000000000 P 30CKB
RHS UP:	0.000000000				
301A6P	EQ 148	.005900000 P 30CAMBA	.005900000 P 30CAMLC	.005900000 P 30CAMHC	.006100000 P 30CBMBA
RHS LO:	0.000000000	.007900000 P 30CBMLC	.005900000 P 30CBMHC	.002400000 P 30CBLBA	.002500000 P 30CBLLC
RHS UP:	0.000000000	.002400000 P 30CBLHC	.002400000 P 30CALBA	.002400000 P 30CALHC	.002400000 P 30CALLC
		.001370000 P 30CDLBA	-1.000000000 P 301A6		
301A7P	EQ 149	.006900000 P 30CAMBA	.006900000 P 30CAMLC	.006900000 P 30CAMHC	.006900000 P 30CBMBA
RHS LO:	0.000000000	.006900000 P 30CBMLC	.006900000 P 30CBMHC	.005700000 P 30CBLBA	.005800000 P 30CBLLC
RHS UP:	0.000000000	.005700000 P 30CBLHC	.005700000 P 30CALBA	.005700000 P 30CALHC	.005700000 P 30CALLC
		.002900000 P 30CDLBA	-1.000000000 P 301A7		
301A8P	EQ 150	.008700000 P 30CAMBA	.006700000 P 30CAMLC	.008700000 P 30CAMHC	.008700000 P 30CBMBA
RHS LO:	0.000000000	.013300000 P 30CBMLC	.008700000 P 30CBMHC	.006900000 P 30CBLBA	.007100000 P 30CBLLC
RHS UP:	0.000000000	.005200000 P 30CBLHC	.005200000 P 30CALBA	.005200000 P 30CALHC	.005200000 P 30CALLC
		.003500000 P 30COLBA	-1.000000000 P 301A8		
30MISP	EQ 151	.026900000 P 30CAMBA	.021700000 P 30CAMLC	.030100000 P 30CAMHC	.025700000 P 30CBMBA
RHS LO:	0.000000000	.012900000 P 30CBMHC	.023400000 P 30CBLBA	.021900000 P 30CALBA	.014300000 P 30CASBA
RHS UP:	0.000000000	[illegible] P 30CASHC	.0143[illegible] P 30CASLC	-1.000000000 P 30MIS	

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30KWHR        EQ    152   3.203000000 P 30CAMBA      3.163600000 P 30CAMLC      3.215800000 P 30CAMHC      3.370700000 P 30CBMBA
  RHS LO:  0.000000000    3.350700000 P 30CBMLC      3.412500000 P 30CBMHC      4.334500000 P 30CBLBA      4.156700000 P 30CBLLC
  RHS UP:  0.000000000    4.399100000 P 30CBLHC      3.839700000 P 30CALBA      3.903800000 P 30CALHC      3.805600000 P 30CALLC
                          6.438000000 P 30COLBA      2.483000000 P 30CASBA      2.439100000 P 30CASHC      2.483000000 P 30CASLC
                         33.160000000 P 30DLHC1       .068000000 P 300LHT1      1.050000000 P 30DSHTA      3.120000000 P 300SHTC
                         -1.000000000 P 30KWH

30BTUR        EQ    153   .056940000 P 30CAMBA       .056960000 P 30CAMLC       .058960000 P 30CAMHC       .050660000 P 30CBMBA
  RHS LO:  0.000000000    .045400000 P 30CBMLC       .057300000 P 30CBMHC       .060870000 P 30CBLBA       .056190000 P 30CBLLC
  RHS UP:  0.000000000    .063100000 P 30CBLHC       .060560000 P 30CALBA       .063040000 P 30CALHC       .059000000 P 30CALLC
                          .072240000 P 30CDLBA       .042896000 P 30CASBA       .057330000 P 30CASHC       .042890000 P 30CASLC
                         -.055000000 L 300LHC2       .016000000 P 300SHTA       .008000000 P 30DSHTC     -1.000000000 P 30BTU

30ENER        EQ    154   .062960000 P 30CAMBA       .062910000 P 30CAMLC       .065010000 P 30CAMHC       .057000000 P 30CBMBA
  RHS LO:  0.000000000    .051700000 P 30CBMLC       .063700000 P 30CBMHC       .069920000 P 30CBLBA       .064000000 P 30CBLLC
  RHS UP:  0.000000000    .071400000 P 30CBLHC       .067780000 P 30CALBA       .070440000 P 30CALHC       .066150000 P 30CALLC
                          .084300000 P 30COLBA       .047560000 P 30CASBA       .061910000 P 30CASHC       .047560000 P 30CASLC
                          .520000000 P 300LHC1      -.055000000 L 30DLHC2       .025000000 P 300LHT1       .018000000 P 300SHTA
                          .014000000 ? 300SHTC     -1.000000000 P 30ENE

30LABR        EQ    155  5.000000000 P 30CAMBA      5.000000000 P 30CAMLC      5.000000000 P 30CAMHC      5.000000000 P 30CBMBA
  RHS LO:  0.000000000   5.000000000 P 30CBMLC      5.000000000 P 30CBMHC      5.000000000 P 30CBLBA      5.000000000 P 30CBLLC
  RHS UP:  0.000000000   5.000000000 P 30CBLHC      5.000000000 P 30CALBA      5.000000000 P 30CALHC      5.000000000 P 30CALLC
                         5.000000000 P 30CASBA      5.000000000 P 30CASHC      5.000000000 P 30CASLC       .800000000 P 300LHC1
                          .500000000 P 30DLHT1       .600000000 P 300SHTA       .600000000 P 300SHTC     -1.000000000 P 30LAB

30DPCR        EQ    156   .101300000 P 30CAMBA       .098600000 P 30CAMLC       .075000000 P 30CAMHC       .138200000 P 30CBMBA
  RHS LO:  0.000000000    .070600000 P 30CBMLC       .108500000 P 30CBMHC       .162100000 P 30CBLBA       .093800000 P 30CBLLC
  RHS UP:  0.000000000    .121300000 P 30CBLHC       .138600000 P 30CALBA       .104200000 . 30CALHC       .118400000 P 30CALLC
                          .111700000 P 30CASBA       .112900000 P 30CASHC       .111700000 P 30CASLC      -.038200000 P 30DLHC1
                         -.557000000 L 30DLHC2       .012500000 P 30DLHT1       .013000000 P 30DSHTA       .006000000 P 30DSHTC
                        -1.000000000 P 300PC

30INVR        EQ    157  3.800000000 P 30DLHC1       .100000000 L 30DLHC2       .510000000 P 300LHT1       .400000000 P 300SHTA
  RHS LO:  0.000000000   1.134000000 P 30DSHTC      4.000000000 P 30LRGN       6.000000000 P 30SMLN     -1.000000000 P 30INV
  RHS UP:  0.000000000   2.700000000 P 30NPIP01     1.700000000 P 30NPIP02

30C3PO        EQ    158 -1.000000000 P 30C3P       -1.000000000 P 10C3P03M    -1.000000000 P 10C3P03P    -1.000000000 P 20C3P03M
  RHS LO:  0.000000000  -1.000000000 P 20C3P03P     1.000000000 P 30C3P0FM     1.000000000 P 30C3P0FP     1.000000000 P 30C3P01M
  RHS UP:  0.000000000   1.000000000 P 30C3P01P     1.000000000 P 30C3P02M     1.000000000 P 30C3P02P     1.000000000 P 30C3P04P
                         1.000000000 P 30C3P05M     1.000000000 P 30C3P05P    -1.000000000 P 40C3P03P    -1.000000000 P 50C3P03M
                        -1.000000000 P 50C3P03P    -1.000000000 P F0C3P03M    -1.000000000 P F0C3P03P     1.000000000 L 30C3PC

30C4PO        EQ    159 -1.000000000 P 30C4P       -1.000000000 P 10C4P03M    -1.000000000 P 10C4P03P    -1.000000000 P 20C4P03M
  RHS LO:  0.000000000  -1.000000000 P 20C4P03P     1.000000000 P 30C4P0FM     1.000000000 P 30C4P0FP     1.000000000 P 30C4P01M
  RHS UP:  0.000000000   1.000000000 P 30C4P01P     1.000000000 P 30C4P02M     1.000000000 P 30C4P02P     1.000000000 P 30C4P04P
                         1.000000000 P 30C4P05M     1.000000000 P 30C4P05P    -1.000000000 P 40C4P03P    -1.000000000 P 50C4P03M
                        -1.000000000 P 50C4P03P    -1.000000000 P F0C4P03M    -1.000000000 P F0C4P03P     1.000000000 L 30C4PC

30NAPO        EQ    160 -1.000000000 P 30NAP       -1.000000000 P 10NAP03M    -1.000000000 P 10NAP03P    -1.000000000 P 20NAP03M
  RHS LO:  0.000000000  -1.000000000 P 20NAP03P     1.000000000 P 30NAP0FM     1.000000000 P 30NAP0FP     1.000000000 P 30NAP01M
  RHS UP:  0.000000000   1.000000000 P 30NAP01P     1.000000000 P 30NAP02M     1.000000000 P 30NAP02P     1.000000000 P 30NAP04P
                         1.000000000 P 30NAP05M     1.000000000 P 30NAP05P    -1.000000000 P 40NAP03P    -1.000000000 P 50NAP03M
                        -1.000000000 P 50NAP03P    -1.000000000 P F0NAP03M    -1.000000000 P F0NAP03P     1.000000000 P 30NAPC

304BAD        EQ    161 -1.000000000 P 304BA       -1.000000000 P 104BA03M    -1.000000000 P 104BA03P    -1.000000000 P 204BA03M
  RHS LO:  0.000000000  -1.000000000 P 204BA03P     1.000000000 P 304BA0FM     1.000000000 P 304BA0FP     1.000000000 P 304BA01M
  RHS UP:  0.000000000   1.000000000 P 304BA01P     1.000000000 P 304BA02M     1.000000000 P 304BA02P     1.000000000 P 304BA04P
                         1.000000000 P 504BA05M     1.000000000 P 304BA05P    -1.000000000 P 404BA03P    -1.000000000 P 504BA03M
                        -1.000000000 P 504BA03P    -1.000000000 P F04BA03M    -1.000000000 P F04BA03P     1.000000000 P 304BAC

304AAD        EQ    162 -1.000000000 P 304AA       -1.000000000 P 104AA03M    -1.000000000 P 104AA03P    -1.000000000 P 204AA03M
  RHS LO:  0.000000000  -1.000000000 P 204AA03P     1.000000000 P 304AA0FM     1.000000000 P 304AA0FP     1.000000000 P 304AA01M
  RHS UP:  [illegible]                             [illegible]                1.000000000 P 304AA02P     1.000000000 P 304AA04P
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304CAO          EQ     163  -1.000000000 P 304CA       -1.000000000 P 104CA03M    -1.000000000 P 104CA03P    -1.000000000 P 204CA03M
  RHS LO:   0.000000000     -1.000000000 P 204CA03P     1.000000000 P 304CACFM     1.000000000 P 304CA0FP     1.000000000 P 304CA01M
  RHS UP:   0.000000000      1.000000000 P 304CA01P     1.000000000 P 304CA02M     1.000000000 P 304CA02P     1.000000000 P 304CA04P
                             1.000000000 P 304CA05M     1.000000000 P 304CA05P    -1.000000000 P 404CA03P    -1.000000000 P 504CA03M
                            -1.000000000 P 504CA03P    -1.000000000 P F04CA03M    -1.000000000 P F04CA03P     1.000000000 P 304CAC

3040AD          EQ     164  -1.000000000 P 3040A       -1.000000000 P 1040A03M    -1.000000000 P 1040A03P    -1.000000000 P 2040A03M
  RHS LO:   0.000000000     -1.000000000 P 2040A03P     1.000000000 P 3040ACFM     1.000000000 P 3040A0FP     1.000000000 P 3040A01M
  RHS UP:   0.000000000      1.000000000 P 3040A01P     1.000000000 P 3040A02M     1.000000000 P 3040A02P     1.000000000 P 3040A04P
                             1.000000000 P 3040A05M     1.000000000 P 3040A05P    -1.000000000 P 4040A03P    -1.000000000 P 5040A03M
                            -1.000000000 P 5040A03P    -1.000000000 P F040A03M    -1.000000000 P F040A03P     1.000000000 P 3040AC

30SGASO         EQ     165  -1.000000000 P 304AAC      -1.000000000 P 304BAC      -1.000000000 P 304CAC      -1.000000000 P 304DAC
  RHS LO:   0.000000000      1.000000000 X 30TGASC
  RHS UP:   0.000000000

305AAD          EQ     166  -1.000000000 P 305AA       -1.000000000 P 105AA03M    -1.000000000 P 105AA03P    -1.000000000 P 205AA03M
  RHS LO:   0.000000000     -1.000000000 P 205AA03P     1.000000000 P 305AACFM     1.000000000 P 305AA0FP     1.000000000 P 305AA01M
  RHS UP:   0.000000000      1.000000000 P 305AA01P     1.000000000 P 305AA02M     1.000000000 P 305AA02P     1.000000000 P 305AA04P
                             1.000000000 P 305AA05M     1.000000000 P 305AA05P    -1.000000000 P 405AA03P    -1.000000000 P 505AA03M
                            -1.000000000 P 505AA03P    -1.000000000 P F05AA03M    -1.000000000 P F05AA03P     1.000000000 L 305AAC

305BBO          EQ     167  -1.000000000 P 305BB       -1.000000000 P 105BB03M    -1.000000000 P 105BB03P    -1.000000000 P 205BB03M
  RHS LO:   0.000000000     -1.000000000 P 205BB03P     1.000000000 P 305BBCFM     1.000000000 P 305BBCFP     1.000000000 P 305BB01M
  RHS UP:   0.000000000      1.000000000 P 305BB01P     1.000000000 P 305BB02M     1.000000000 P 305BB02P     1.000000000 P 305BB04P
                             1.000000000 P 305BB05M     1.000000000 P 305BBC5P    -1.000000000 P 405BB03P    -1.000000000 P 505BB03M
                            -1.000000000 P 505BB03P    -1.000000000 P F05BB03M    -1.000000000 P F05BB03P     1.000000000 L 305BBC

305CAO          EQ     168  -1.000000000 P 305CA       -1.000000000 P 105CAC3M    -1.000000000 P 105CA03P    -1.000000000 P 205CA03M
  RHS LO:   0.000000000     -1.000000000 P 205CA03P     1.000000000 P 305CA0FM     1.000000000 P 305CA0FP     1.000000000 P 305CA01M
  RHS UP:   0.000000000      1.000000000 P 305CA01P     1.000000000 P 305CA02M     1.000000000 P 305CA02P     1.000000000 P 305CA04P
                             1.000000000 P 305CA05M     1.000000000 P 305CA05P    -1.000000000 P 405CA03P    -1.000000000 P 505CA03P
                            -1.000000000 P 505CA03P    -1.000000000 P F05CA03M    -1.000000000 P F05CA03P     1.000000000 L 305CAC
                             1.000000000 L 305CCC

3050LIM         GE     169   -.750000000 L 305CAC       1.000000000 L 305CCC
  RHS LO:   0.000000000
  RHS UP:  +INF

305CBO          EQ     170  -1.000000000 P 305CB       -1.000000000 P 105CB03M    -1.000000000 P 105CB03P    -1.000000000 P 205CB03M
  RHS LO:   0.000000000     -1.000000000 P 205CB03P     1.000000000 P 305CB0FM     1.000000000 P 305CB0FP     1.000000000 P 305CB01M
  RHS UP:   0.000000000      1.000000000 P 305CB01P     1.000000000 P 305CB02M     1.000000000 P 305CB02P     1.000000000 P 305CB04P
                             1.000000000 P 305CB05M     1.000000000 P 305CB05P    -1.000000000 P 405CB03P    -1.000000000 P 505CB03M
                            -1.000000000 P 505CB03P    -1.000000000 P F05CB03M    -1.000000000 P F05CB03P     1.000000000 L 305CBC

30VGOO          EQ     171  -1.000000000 P 30VGD       -1.000000000 P 10VGD03M    -1.000000000 P 20VGD03M     1.000000000 P 30VGD0FM
  RHS LO:   0.000000000      1.000000000 P 30VGD01M     1.000000000 P 30VGD02M     1.000000000 P 30VGD05M     1.000000000 P 30VGDC
  RHS UP:   0.000000000

305DAD          EQ     172  -1.000000000 P 305DA       -1.000000000 P 105DA03M    -1.000000000 P 205DA03M     1.000000000 P 305DA0FM
  RHS LO:   0.000000000      1.000000000 P 305DA01M     1.000000000 P 305DA02M     1.000000000 P 305DA05M    -1.000000000 P 505DA03M
  RHS UP:   0.000000000     -1.000000000 P F05DA03M     1.000000000 L 305DAC

305DBD          EQ     173  -1.000000000 P 305DB       -1.000000000 P 105DB03M    -1.000000000 P 205DB03M     1.000000000 P 305DB0FM
  RHS LO:   0.000000000      1.000000000 P 305DB01M     1.000000000 P 305DB02M     1.000000000 P 305DB05M    -1.000000000 P 505DB03M
  RHS UP:   0.000000000     -1.000000000 P F05DB03M     1.000000000 L 305DBC

30VROD          EQ     174  -1.000000000 P 30VRC        1.000000000 P 30VROC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

30CKAD          EQ     175  -1.000000000 P 30CKA        1.000000000 P 30CKAC
  RHS LO:   0.000000000
  RHS UP:   0.000000000
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301A6D         EQ     177  -1.000000000 P 301A6        1.000000000 P 301A6C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

301A7D         EQ     178  -1.000000000 P 301A7        1.000000000 P 301A7C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

301A8D         EQ     179  -1.000000000 P 301A8        1.000000000 P 301A8C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

30MISD         EQ     180  -1.000000000 P 30MIS        1.000000000 P 30MISC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

400BJ          EQ     181  -9.250000000 L 40CAIN      -9.300000000 P 40CBIN      -8.300000000 P 40NGFN      -6.900000000 P 40TNC4
  RHS LO:   0.000000000    -7.300000000 P 40TIC4      -.020000000 P 40KWH      -12.423000000 P 40BTU       -.005160000 P 40LAB
  RHS UP:   0.000000000    -1.000000000 P 400PC       -.956900000 P 40INV        .300000000 X 40ZPREM    -.092000000 P 405CXX
                            1.000000000 P 400BJT     -1.000000000 P 40TPCST

40SML          EQ     182  -1.000000000 P 40CBSBA     -1.000000000 P 40CBSLC     -1.000000000 P 40CBSHC     -1.000000000 P 40CASBA
  RHS LO:   0.000000000    -1.000000000 P 40CASHC     -1.000000000 P 40CASLC      1.000000000 L 40TSML       1.000000000 P 40SMLN
  RHS UP:   0.000000000

40CAID         EQ     183   1.000000000 L 40CAIN      -1.000000000 P 40CASBA     -1.000000000 P 40CASHC     -1.000000000 P 40CASLC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40CBID         EQ     184   1.000000000 P 40CBIN      -1.000000000 P 40CBSBA     -1.000000000 P 40CBSLC     -1.000000000 P 40CBSHC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40NGFD         EQ     185   1.000000000 P 40NGFN      -.073000000 P 40CBSBA     -.037900000 P 40CBSLC     -.073000000 P 40CBSHC
  RHS LO:   0.000000000    -.073000000 P 40CASBA      -.073000000 P 40CASHC     -.058400000 P 40CASLC
  RHS UP:   0.000000000

40NC4D         EQ     186   1.000000000 P 40TNC4      -.012600000 P 40CBSBA     -.005900000 P 40CBSLC     -.006700000 P 40CBSHC
  RHS LO:   0.000000000    -.011000000 P 40CASBA      -.009100000 P 40CASHC     -.001400000 P 40DSHTA
  RHS UP:   0.000000000

40IC4D         EQ     187   1.000000000 P 40TIC4      -.003400000 P 40CBSBA     -.005900000 P 40CBSLC     -.004500000 P 40CASBA
  RHS LO:   0.000000000    -.000600000 P 40CASHC      -.003300000 P 40CASLC     -.007000000 P 40DSHTA
  RHS UP:   0.000000000

40C3PP         EQ     188    .012800000 P 40CBSBA      .012800000 P 40CBSLC      .012800000 P 40CBSHC      .010600000 P 40CASBA
  RHS LO:   0.000000000     .012600000 P 40CASHC      .012600000 P 40CASLC     -.027100000 L 40DLHC2    -1.000000000 P 40C3P
  RHS UP:   0.000000000

40C4PP         EQ     189    .003100000 P 40CBSBA      .003100000 P 40CBSLC      .003100000 P 40CBSHC      .003100000 P 40CASBA
  RHS LO:   0.000000000     .003100000 P 40CASHC      .003100000 P 40CASLC     -.035300000 L 40DLHC2    -1.000000000 P 40C4P
  RHS UP:   0.000000000

40NAPP         EQ     190  -1.000000000 P 40NAP
  RHS LO:   0.000000000
  RHS UP:   0.000000000

404BAP         EQ     191    .138600000 P 40CBSBA      .047000000 P 40CBSLC      .058700000 P 40CBSHC      .136800000 P 40CASBA
  RHS LO:   [illegible]     .055600000 P 40CASHC      .034050000 P 40CASLC     -.400000000 L 40DLHC1     -.400000000 L 40DLHC2
  RHS UP:   0.000000000    -1.000000000 P 404BA      -1.000000000 X 40ZPREM

404AAP         EQ     192    .345200000 P 40CBSBA      .140000000 P 40CBSLC      .188700000 P 40CBSHC      .270300000 P 40CASBA
  RHS LO:   [illegible]     .17[illegible] P 40CASHC   .121500000 P 40CASLC     -.300000000 L 40DLHC1     -.300000000 L 40DLHC2
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404CAP        EQ     193   .039500000 P 40CBSBA     .140000000 P 40CBSLC     .175000000 P 40CBSHC     .039500000 P 40CASBA
  RHS LO:  0.000000000     .152000000 P 40CASHC     .121500000 P 40CASLC    -.150000000 P 40DLHC1    -.150000000 L 40DLHC2
  RHS UP:  0.000000000   -1.000000000 P 404CA

404DAP        EQ     194   .039700000 P 40CBSBA     .140000000 P 40CBSLC     .175000000 P 40CBSHC     .039700000 P 40CASBA
  RHS LO:  0.000000000     .152000000 P 40CASHC     .121500000 P 40CASLC    -.150000000 P 40DLHC1    -.150000000 L 40DLHC2
  RHS UP:  0.000000000   -1.000000000 P 404DA      1.000000000 X 40ZPPEM

405GASP       EQ     195  1.000000000 P 404BA      1.000000000 P 404AA      1.000000000 P 404CA      1.000000000 P 404DA
  RHS LO:  0.000000000   -1.000000000 P 40TGAS
  RHS UP:  0.000000000

405AAP        EQ     196   .035200000 P 40CBSBA     .035200000 P 40CBSLC     .030900000 P 40CBSHC     .023400000 P 40CASBA
  RHS LO:  0.000000000     .023400000 P 40CASHC     .023400000 P 40CASLC   -1.000000000 P 405AA
  RHS UP:  0.000000000

405BBP        EQ     197   .045700000 P 40CBSBA     .043300000 P 40CBSLC     .045600000 P 40CBSHC     .056200000 P 40CASBA
  RHS LO:  0.000000000     .053800000 P 40CASHC     .053800000 P 40CASLC   -1.000000000 P 405BB     1.000000000 P 405BBX
  RHS UP:  0.000000000

405CAP        EQ     198   .168600000 P 40CBSBA     .268900000 P 40CBSLC     .146000000 P 40CBSHC     .209700000 P 40CASBA
  RHS LO:  0.000000000     .190300000 P 40CASHC     .304300000 P 40CASLC    1.235000000 P 40DLHC1     .974000000 L 40DLHC2
  RHS UP:  0.000000000    1.000000000 P 40DLHT1   -1.000000000 P 405CA     1.000000000 P 405CXX    -.600000000 P 405BBX

405CBP        EQ     199   .088000000 P 40CBSBA     .088000000 P 40CBSLC     .088300000 P 40CBSHC     .132000000 P 40CASBA
  RHS LO:  0.000000000     .132000000 P 40CASHC     .113600000 P 40CASLC   -1.000000000 P 40DLHT1    -.005000000 P 40DSHTA
  RHS UP:  0.000000000   -1.000000000 P 405CB     -1.000000000 P 405CXX    -.400000000 P 405BBX

40V60P        EQ     200   .002400000 P 40CBSBA     .002400000 P 40CBSLC     .002400000 P 40CBSHC     .002400000 P 40CASBA
  RHS LO:  0.000000000     .002400000 P 40CASHC     .002400000 P 40CASLC   -1.000000000 P 40VGO
  RHS UP:  0.000000000

405DAP        EQ     201   .032000000 P 40CBSBA     .032000000 P 40CBSLC     .032000000 P 40CBSHC     .032000000 P 40CASBA
  RHS LO:  0.000000000     .032000000 P 40CASHC     .032000000 P 40CASLC   -1.000000000 P 405DA
  RHS UP:  0.000000000

405DBP        EQ     202   .032000000 P 40CBSBA     .032000000 P 40CBSLC     .032000000 P 40CBSHC     .032000000 P 40CASBA
  RHS LO:  0.000000000     .032000000 P 40CASHC     .032000000 P 40CASLC    -.458000000 P 40DLHC1    -.022000000 P 40DLHT1
  RHS UP:  0.000000000   -1.000000000 P 405DB

40VRDP        EQ     203   .054500000 P 40CBSBA     .054500000 P 40CBSLC     .056400000 P 40CBSHC     .054500000 P 40CASBA
  RHS LO:  0.000000000     .054500000 P 40CASHC     .054500000 P 40CASLC   -1.000000000 P 40VRO
  RHS UP:  0.000000000

40CKAP        EQ     204   .003200000 P 40CASBA     .004600000 P 40CASHC     .004600000 P 40CASLC   -1.000000000 P 40CKA
  RHS LO:  0.000000000
  RHS UP:  0.000000000

40CKBP        EQ     205   .005800000 P 40CBSBA     .005800000 P 40CBSLC     .005800000 P 40CBSHC   -1.000000000 P 40CKB
  RHS LO:  0.000000000
  RHS UP:  0.000000000

401A6P        EQ     206 -1.000000000 P 401A6
  RHS LO:  0.000000000
  RHS UP:  0.000000000

401A7P        EQ     207 -1.000000000 P 401A7
  RHS LO:  0.000000000
  RHS UP:  0.000000000

401A8P        EQ     208 -1.000000000 P 401A8
  RHS LO:  0.000000000
  RHS UP:  0.000000000
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40KWHR	EQ 210	3.265000000 P 40CBSBA	3.241400000 P 40CBSLC	3.258700000 P 40CBSHC	2.729000000 P 40CASBA
RHS LO:	0.000000000	2.925700000 P 40CASHC	3.098000000 P 40CASLC	33.16300000 P 40DLHC1	.068000000 P 40DLHT1
RHS UP:	0.000000000	1.050000000 P 40DSHTA	3.120000000 P 40DSHTC	-1.000000000 P 40KWH	
40BTUR	EQ 211	.054550000 P 40CBSBA	.053170000 P 40CBSLC	.056650000 P 40CBSHC	.051630000 P 40CASBA
RHS LO:	0.000000000	.054800000 P 40CASHC	.054380000 P 40CASLC	-.055000000 L 40DLHC2	.016000000 P 40DSHTA
RHS UP:	0.000000000	.006000000 P 40DSHTC	-1.000000000 P 40BTU		
40ENER	EQ 212	.060690000 P 40CBSBA	.059260000 P 40CBSLC	.062780000 P 40CBSHC	.056760000 P 40CASBA
RHS LO:	0.000000000	.060300000 P 40CASHC	.060200000 P 40CASLC	.520000000 P 40DLHC1	-.055000000 L 40DLHC2
RHS UP:	0.000000000	.025000000 P 40DLHT1	.018000000 P 40DSHTA	.014900000 P 40DSHTC	-1.000000000 P 40ENE
40LABR	EQ 213	5.000000000 P 40CBSBA	5.000000000 P 40CBSLC	5.000000000 P 40CBSHC	5.000000000 P 40CASBA
RHS LO:	0.000000000	5.000000000 P 40CASHC	5.000000000 P 40CASLC	.800000000 P 40DLHC1	.500000000 P 40DLHT1
RHS UP:	0.000000000	.600000000 P 40DSHTA	.600000000 P 40DSHTC	-1.000000000 P 40LAB	
40OPCR	EQ 214	.195000000 P 40CBSBA	.099100000 P 40CBSLC	.130400000 P 40CBSHC	.170200000 P 40CASBA
RHS LO:	0.000000000	.118900000 P 40CASHC	.097100000 P 40CASLC	-.038200000 P 40DLHC1	-.557000000 L 40DLHC2
RHS UP:	0.000000000	.012500000 P 40DLHT1	.013000000 P 40DSHTA	.006900000 P 40DSHTC	-1.000000000 P 40OPC
40INVR	EQ 215	3.800000000 P 40DLHC1	.100000000 L 40DLHC2	.510000000 P 40DLHT1	.400000000 P 40DSHTA
RHS LO:	0.000000000	1.134000000 P 40DSHTC	6.000000000 P 40SMLN	-1.000000000 P 40INV	
RHS UP:	0.000000000				
40C3PO	EQ 216	-1.000000000 P 40C3P	-1.000000000 P 10C3P04P	-1.000000000 P 20C3P04P	-1.000000000 P 30C3P04P
RHS LO:	0.000000000	1.000000000 P 40C3P0FP	1.000000000 P 40C3P01P	1.000000000 P 40C3P02P	1.000000000 P 40C3P03P
RHS UP:	0.000000000	1.000000000 P 40C3P05P	-1.000000000 P 50C3P04P	-1.000000000 P F0C3P04P	1.000000000 L 40C3PC
40C4PD	EQ 217	-1.000000000 P 40C4P	-1.000000000 P 10C4P04P	-1.000000000 P 20C4P04P	-1.000000000 P 30C4P04P
RHS LO:	0.000000000	1.000000000 P 40C4P0FP	1.000000000 P 40C4P01P	1.000000000 P 40C4P02P	1.000000000 P 40C4P03P
RHS UP:	0.000000000	1.000000000 P 40C4P05P	-1.000000000 P 50C4P04P	-1.000000000 P F0C4P04P	1.000000000 L 40C4PC
40NAPD	EQ 218	-1.000000000 P 40NAP	-1.000000000 P 10NAP04P	-1.000000000 P 20NAP04P	-1.000000000 P 30NAP04P
RHS LO:	0.000000000	1.000000000 P 40NAP0FP	1.000000000 P 40NAP01P	1.000000000 P 40NAP02P	1.000000000 P 40NAP03P
RHS UP:	0.000000000	1.000000000 P 40NAP05P	-1.000000000 P 50NAP04P	-1.000000000 P F0NAP04P	1.000000000 P 40NAPC
404BAD	EQ 219	-1.000000000 P 404BA	-1.000000000 P 104BA04P	-1.000000000 P 204BA04P	-1.000000000 P 304BA04P
RHS LO:	0.000000000	1.000000000 P 404BA0FP	1.000000000 P 404BA01P	1.000000000 P 404BA02P	1.000000000 P 404BA03P
RHS UP:	0.000000000	1.000000000 P 404BA05P	-1.000000000 P 504BA04P	-1.000000000 P F04BA04P	1.000000000 P 404BAC
404AAD	EQ 220	-1.000000000 P 404AA	-1.000000000 P 104AA04P	-1.000000000 P 204AA04P	-1.000000000 P 304AA04P
RHS LO:	0.000000000	1.000000000 P 404AA0FP	1.000000000 P 404AA01P	1.000000000 P 404AA02P	1.000000000 P 404AA03P
RHS UP:	0.000000000	1.000000000 P 404AA05P	-1.000000000 P 504AA04P	-1.000000000 P F04AA04P	1.000000000 P 404AAC
404CAD	EQ 221	-1.000000000 P 404CA	-1.000000000 P 104CA04P	-1.000000000 P 204CA04P	-1.000000000 P 304CA04P
RHS LO:	0.000000000	1.000000000 P 404CA0FP	1.000000000 P 404CA01P	1.000000000 P 404CA02P	1.000000000 P 404CA03P
RHS UP:	0.000000000	1.000000000 P 404CA05P	-1.000000000 P 504CA04P	1.000000000 P 404CAC	
404DAD	EQ 222	-1.000000000 P 404DA	-1.000000000 P 104DA04P	-1.000000000 P 204DA04P	-1.000000000 P 304DA04P
RHS LO:	0.000000000	1.000000000 P 404DA0FP	1.000000000 P 404DA01P	1.000000000 P 404DA02P	1.000000000 P 404DA03P
RHS UP:	0.000000000	1.000000000 P 404DA05P	-1.000000000 P 504DA04P	-1.000000000 P F04DA04P	1.000000000 P 404DAC
40SGASD	EQ 223	-1.000000000 P 404AAC	-1.000000000 P 404BAC	-1.000000000 P 404CAC	-1.000000000 P 404DAC
RHS LO:	0.000000000	1.000000000 X 40TGASC			
RHS UP:	0.000000000				
405AAD	EQ 224	-1.000000000 P 405AA	-1.000000000 P 105AA04P	-1.000000000 P 205AA04P	-1.000000000 P 305AA04P
RHS LO:	0.000000000	1.000000000 P 405AA0FP	1.000000000 P 405AA01P	1.000000000 P 405AA02P	1.000000000 P 405AA03P
RHS UP:	0.000000000	1.000000000 P 405AA05P	-1.000000000 P 505AA04P	-1.000000000 P F05AA04P	1.000000000 L 405AAC
405BBD	EQ 225	-1.000000000 P 405BB	-1.000000000 P 105BB04P	-1.000000000 P 205BB04P	-1.000000000 P 305BB04P
RHS LO:	[illegible]	1.000000000 P 405BB0FP	1.000000000 P 405BB01P	1.000000000 P 405BB02P	1.000000000 P 405BB03P
RHS UP:	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] L 405BBC

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405CAO          EQ     226  -1.000000000 P 405CA      -1.000000000 P 105CA04P   -1.000000000 P 205CA04P   -1.000000000 P 305CA04P
  RHS LO:   0.000000000      1.000000000 P 405CA0FP    1.000000000 P 405CA01P    1.000000000 P 405CA02P    1.000000000 P 405CA03P
  RHS UP:   0.000000000      1.000000000 P 405CAC5P   -1.000000000 P 505CA04P   -1.000000000 P F05CA04P    1.000000000 L 405CAC
                             1.000000000 L 405CCC

405DLIM         GE     227   -.750000000 L 405CAC      1.000000000 L 405CCC
  RHS LO:   0.000000000
  RHS UP:  +INF

405CBO          EQ     228  -1.000000000 P 405CB      -1.000000000 P 105CB04P   -1.000000000 P 205CB04P   -1.000000000 P 305CB04P
  RHS LO:   0.000000000      1.000000000 P 405CB0FP    1.000000000 P 405CB01P    1.000000000 P 405CB02P    1.000000000 P 405CB03P
  RHS UP:   0.000000000      1.000000000 P 405CB05P   -1.000000000 P 505CB04P   -1.000000000 P F05CB04P    1.000000000 L 405CBC

40VGOO          EQ     229  -1.000000000 P 40VGO       1.000000000 P 40VGOC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

405OAO          EQ     230  -1.000000000 P 405OA       1.000000000 L 405OAC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

405OBO          EQ     231  -1.000000000 P 405OB       1.000000000 L 405OBC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40VROD          EQ     232  -1.000000000 P 40VRO       1.000000000 P 40VROC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40CKAO          EQ     233  -1.000000000 P 40CKA       1.000000000 P 40CKAC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40CKBD          EQ     234  -1.000000000 P 40CKB       1.000000000 P 40CKBC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

401A6O          EQ     235  -1.000000000 P 401A6       1.000000000 P 401A6C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

401A7O          EQ     236  -1.000000000 P 401A7       1.000000000 P 401A7C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

401A8O          EQ     237  -1.000000000 P 401A8       1.000000000 P 401A8C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40MISO          EQ     238  -1.000000000 P 40MIS       1.000000000 P 40MISC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50OBJ           EQ     239  -9.250000000 L 50CAIN     -9.000000000 P 50CBIN     -8.500000000 P 50CCIN     -8.750000000 L 50CDIN
  RHS LO:   0.000000000     -6.300000000 P 50NGFN     -6.900000000 P 50TNC4     -7.300000000 P 50TIC4      -.020000000 P 50KWH
  RHS UP:   0.000000000    -10.800000000 P 50BTU       -.005490000 P 50LAB      -1.000000000 P 50OPC       -.958900000 P 50INV
                              .300000000 X 50ZPREM     -.092000000 P 505CXX      1.000000000 P 50OBJT     -1.000000000 P 50TPCST
                            -1.000000000 P 50TMCST

50LRG           EQ     240  -1.000000000 P 50CALBA    -1.000000000 P 50CALHC    -1.000000000 P 50CALLC    -1.000000000 P 50CCLBA
  RHS LO:   0.000000000     -1.000000000 P 50CCLLC    -1.000000000 P 50CCLHC    -1.000000000 P 50CDLBA     1.000000000 L 50TLRG
  RHS UP:   0.000000000      1.000000000 P 50LRGN

'50SML          EQ     241  -1.000000000 P 50CASBA    -1.000000000 P 50CASHC    -1.000000000 P 50CASLC     1.000000000 L 50TSML
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50CA1D         EQ     242   1.000000000 L 50CAIN      -1.000000000 P 50CALBA     -1.000000000 P 50CALHC     -1.000000000 P 50CALLC
  RHS LO:    0.000000000   -1.000000000 P 50CASBA     -1.000000000 P 50CASHC     -1.000000000 P 50CASLC
  RHS UP:    0.000000000

50CB10         EQ     243   1.000000000 P 50CBIN
  RHS LO:    0.000000000
  RHS UP:    0.000000000

50CC10         EQ     244   1.000000000 P 50CCIN      -1.000000000 P 50CCLBA     -1.000000000 P 50CCLLC     -1.000000000 P 50CCLHC
  RHS LO:    0.000000000
  RHS UP:    0.000000000

50CD10         EQ     245   1.000000000 L 50COIN      -1.000000000 P 50COLBA
  RHS LO:    0.000000000
  RHS UP:    0.000000000

50NGFO         EQ     246   1.000000000 P 50NGFN       -.014000000 P 50CALBA      -.014000000 P 50CALHC      -.014000000 P 50CALLC
  RHS LO:    0.000000000    -.014000000 P 50CCLBA      -.014000000 P 50CCLLC      -.014000000 P 50CCLHC      -.014000000 P 50COLBA
  RHS UP:    0.000000000    -.014000000 P 50CASBA      -.017200000 P 50CASHC      -.014000000 P 50CASLC

50NC4D         EQ     247   1.000000000 P 50TNC4       -.015000000 P 5CCALBA      -.011700000 P 50CALHC      -.015000000 P 50CALLC
  RHS LO:    0.000000000    -.015300000 P 50CCLBA      -.015000000 P 5CCCLLC      -.015300000 P 50CCLHC      -.015000000 P 50COLBA
  RHS UP:    0.000000000    -.010000000 P 50CASBA      -.018400000 P 50CASHC      -.006600000 P 50CASLC      -.001400000 P 500SHTA

50IC4D         EQ     248   1.000000000 P 50TIC4       -.000700000 P 50CALBA      -.010000000 P 50CALLC      -.006000000 P 50CCLBA
  RHS LO:    0.000000000    -.010000000 P 50CCLLC      -.006600000 P 50CCLHC      -.004610000 P 50CDLBA      -.007000000 P 50DSHTA
  RHS UP:    0.000000000

50C3PP         EQ     249    .015000000 P 50CALBA       .015000000 P 50CALHC       .015000000 P 50CALLC       .015000000 P 50CCLBA
  RHS LO:    0.000000000     .015000000 P 50CCLLC       .015000000 P 50CCLHC       .015300000 P 50CDLBA       .015000000 P 50CASBA
  RHS UP:    0.000000000     .018400000 P 50CASHC       .012300000 P 50CASLC      -.027100000 L 500LHC2     -1.000000000 P 50C3P

50C4PP         EQ     250    .009100000 P 50CALBA       .010000000 P 50CALHC       .005500000 P 50CALLC       .003100000 P 50CCLBA
  RHS LO:    0.000000000     .001900000 P 50CCLLC       .004300000 P 50CCLHC       .010000000 P 50COLBA       .010000000 P 50CASBA
  RHS UP:    0.000000000     .021000000 P 50CASHC       .010000000 P 50CASLC      -.035000000 L 500LHC2     -1.000000000 P 50C4P

50NAPP         EQ     251    .009600000 P 50CALBA       .006400000 P 50CALHC       .006400000 P 50CALLC       .009600000 P 50CCLBA
  RHS LO:    0.000000000     .005300000 P 50CCLLC       .005000000 P 50CCLHC       .009600000 P 50COLBA       .037000000 P 50CASBA
  RHS UP:    0.000000000     .006300000 P 50CASHC       .037800000 P 50CASLC      -1.000000000 P 50NAP

504AAP         EQ     252    .135600000 P 50CALBA       .166600000 P 50CALHC       .133200000 P 50CALLC       .163000000 P 50CCLBA
  RHS LO:    0.000000000     .154000000 P 50CCLLC       .181100000 P 50CCLHC       .114000000 P 50COLBA       .045000000 P 50CASBA
  RHS UP:    0.000000000     .079900000 P 50CASHC       .058600000 P 50CASLC      -.300000000 P 500LHC1      -.300000000 L 50DLHC2
                           -1.000000000 P 504AA

504BAP         EQ     253    .315600000 P 50CALBA       .055500000 P 50CALHC       .044200000 P 50CALLC       .316000000 P 50CCLBA
  RHS LO:    0.000000000     .051300000 P 50CCLLC       .060400000 P 50CCLHC       .316000000 P 50COLBA       .105000000 P 50CASBA
  RHS UP:    0.000000000     .026600000 P 50CASHC       .023100000 P 50CASLC      -.400000000 P 50DLHC1      -.400000000 L 500LHC2
                           -1.000000000 P 504BA      -1.000000000 X 50ZPREM

504CAP         EQ     254    .062400000 P 50CALBA       .166600000 P 50CALHC       .133200000 P 50CALLC       .062400000 P 50CCLBA
  RHS LO:    0.000000000     .154000000 P 50CCLLC       .181100000 P 50CCLHC       .062400000 P 50COLBA       .022000000 P 50CASBA
  RHS UP:    0.000000000     .067600000 P 50CASHC       .050000000 P 50CASLC      -.150000000 P 500LHC1      -.150000000 L 50DLHC2
                           -1.000000000 P 504CA

504DAP         EQ     255    .041600000 P 50CALBA       .195600000 P 50CALHC       .133200000 P 50CALLC       .062400000 P 50CCLBA
  RHS LO:    0.000000000     .154000000 P 50CCLLC       .227500000 P 50CCLHC       .041600000 P 50COLBA       .023000000 P 50CASBA
  RHS UP:    0.000000000     .079900000 P 50CASHC       .058600000 P 50CASLC      -.150000000 P 50DLHC1      -.150000000 L 50DLHC2
                           -1.000000000 P 504DA       1.000000000 X 50ZPREM

50SGASP        EQ     256   1.000000000 P 504BA       1.000000000 P 504AA       1.000000000 P 504CA       1.000000000 P 504DA
  RHS LO:    0.000000000   -1.000000000 P 50TGAS
  RHS UP:    0.000000000
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505AAP        EQ     257   .033600000 P 50CALBA    .027700000 P 50CALHC    .022400000 P 50CALLC    .033600000 P 50CCLBA
  RHS LO:   0.000000000    .022400000 P 50CCLLC    .022400000 P 50CCLHC    .022400000 P 50CDLBA    .022400000 P 50CASBA
  RHS UP:   0.000000000    .027500000 P 50CASHC    .022400000 P 50CASLC  -1.000000000 P 505AA

505BBP        EQ     258   .071400000 P 50CALBA    .071400000 P 50CALHC    .069400000 P 50CALLC    .071400000 P 50CCLBA
  RHS LO:   0.000000000    .069400000 P 50CCLLC    .069400000 P 50CCLHC    .065600000 P 50COLBA    .051800000 P 50CASBA
  RHS UP:   0.000000000    .066000000 P 50CASHC    .051800000 P 50CASLC  -1.000000000 P 505BB     1.000000000 P 505BBX

505CAP        EQ     259   .088800000 P 50CALBA    .088800000 P 50CALHC    .274200000 P 50CALLC    .059200000 P 50CCLBA
  RHS LO:   0.000000000    .212400000 P 50CCLLC    .059200000 P 50CCLHC    .095100000 P 50COLBA    .120000000 P 50CASBA
  RHS UP:   0.000000000    .120000000 P 50CASHC    .252600000 P 50CASLC   1.235000000 P 50DLHC1    .974000000 L 50DLHC2
                          1.000000000 P 50DLHT1  -1.000000000 P 505CA     1.000000000 P 505CXX   -.600000000 P 505BBX

505CBP        EQ     260   .055200000 P 50CALBA    .055200000 P 50CALHC    .036810000 P 50CALLC    .044300000 P 50CCLBA
  RHS LO:   0.000000000    .036800000 P 50CCLLC    .036800000 P 50CCLHC    .055200000 P 50CDLBA    .118700000 P 50CASBA
  RHS UP:   0.000000000    .074500000 P 50CASHC    .118700000 P 50CASLC  -1.000000000 P 50DLHT1  -.005000000 P 50DSHTA
                         -1.000000000 P 505CB    -1.000000000 P 505CXX   -.400000000 P 505BBX

50VGDP        EQ     261   .010200000 P 50CALBA    .010200000 P 50CALHC    .010200000 P 50CALLC    .010200000 P 50CCLBA
  RHS LO:   0.000000000    .010200000 P 50CCLLC    .010200000 P 50CCLHC    .010300000 P 50CASBA    .010300000 P 50CASHC
  RHS UP:   0.000000000    .005600000 P 50CASLC  -1.000000000 P 50VGD

505DAP        EQ     262   .072800000 P 50CALBA    .072800000 P 50CALHC    .072800000 P 50CALLC    .072800000 P 50CCLBA
  RHS LO:   0.000000000    .072800000 P 50CCLLC    .072800000 P 50CCLHC    .072800000 P 50COLBA    .167000000 P 50CASBA
  RHS UP:   0.000000000    .147500000 P 50CASHC    .160000000 P 50CASLC  -1.000000000 P 505DA

505DBP        EQ     263   .072800000 : 50CALBA    .072800000 P 50CALHC    .072800000 P 50CALLC    .072800000 P 50CCLBA
  RHS LO:   0.000000000    .072800000 P 50CCLLC    .072800000 P 50CCLHC    .072800000 P 50CDLBA    .167000000 P 50CASBA
  RHS UP:   0.000000000    .147500000 P 50CASHC    .072800000 P 50CASLC   -.458000000 P 50DLHC1   -.022000000 P 50DLHT1
                         -1.000000000 P 505DB

50VRDP        EQ     264   .020000000 P 50CALBA    .020000000 P 50CALHC    .020000000 P 50CALLC    .020000000 P 50CCLBA
  RHS LO:   0.000000000    .020000000 P 50CCLLC    .020000000 P 50CCLHC    .020000000 P 50COLBA    .079800000 P 50CASBA
  RHS UP:   0.000000000    .079800000 P 50CASHC    .057600000 P 50CASLC  -1.000000000 P 50VRD

50CKAP        EQ     265   .001400000 P 50CALHC    .002700000 P 50CASBA    .002700000 P 50CASHC    .002200000 P 50CASLC
  RHS LO:   0.000000000  -1.000000000 P 50CKA
  RHS UP:   0.000000000

50CKBP        EQ     266   .015500000 P 50CDLBA  -1.000000000 P 50CKB
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50CKCP        EQ     267   .006500000 P 50CCLBA    .007400000 P 50CCLLC    .016200000 P 50CCLHC  -1.000000000 P 50CKC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

501A6P        EQ     268   .001200000 P 50CALBA    .001200000 P 50CALHC    .001200000 P 50CALLC    .001400000 P 50CCLBA
  RHS LO:   0.000000000    .001200000 P 50CCLLC    .001200000 P 50CCLHC    .001370000 P 50CDLBA  -1.000000000 P 501A6
  RHS UP:   0.000000000

501A7P        EQ     269   .002900000 P 50CALBA    .002900000 P 50CALHC    .002900000 P 50CALLC    .002900000 P 50CCLBA
  RHS LO:   0.000000000    .002900000 P 50CCLLC    .002900000 P 50CCLHC    .002900000 P 50CDLBA  -1.000000000 P 501A7
  RHS UP:   0.000000000

501A8P        EQ     270   .002600000 P 50CALBA    .002600000 P 50CALHC    .002600000 P 50CALLC    .002600000 P 50CCLBA
  RHS LO:   0.000000000    .002500000 P 50CCLLC    .002600000 P 50CCLHC    .003500000 P 50CDLBA  -1.000000000 P 501A8
  RHS UP:   0.000000000

50MISP        EQ     271   .005000000 P 50CCLBA    .005000000 P 50CASBA    .014400000 P 50CASHC    .005000000 P 50CASLC
  RHS LO:   0.000000000  -1.000000000 P 50MIS
  RHS UP:   0.000000000
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50BTUR         EQ     273   .072600000 P 50CALBA    .073620000 P 50CALHC    .062390000 P 50CALLC    .084040000 P 50CCLBA
  RHS LO:   0.000000000     .066910000 P 50CCLLC    .072960000 P 50CCLHC    .072240000 P 50CDLBA    .040500000 P 50CASBA
  RHS UP:   0.000000000     .040500000 P 50CASHC    .034570000 P 50CASLC   -.055000000 L 50DLHC2    .016000000 P 50DSHTA
                            .008000000 P 50DSHTC   -1.000000000 P 50BTU

50ENER         EQ     274   .085110000 P 50CALBA    .085840000 P 50CALHC    .071910000 P 50CALLC    .096200000 P 50CCLBA
  RHS LO:   0.000000000     .077950000 P 50CCLLC    .086200000 P 50CCLHC    .084300000 P 50CDLBA    .044500000 P 50CASBA
  RHS UP:   0.000000000     .045300000 P 50CASHC    .038620000 P 50CASLC    .520000000 P 50DLHC1   -.055000000 L 50DLHC2
                            .025000000 P 50DLHT1    .018000000 P 50DSHTA    .014000000 P 50DSHTC   -1.000000000 P 50ENE

50LABR         EQ     275  5.000000000 P 30COLBA   5.000000000 P 50CALBA   5.000000000 P 50CALHC   5.000000000 P 50CALLC
  RHS LO:   0.000000000    5.000000000 P 50CCLBA   5.000000000 P 50CCLLC   5.000000000 P 50CCLHC   5.000000000 P 50COLBA
  RHS UP:   0.000000000    5.000000000 P 50CASBA   5.000000000 P 50CASHC   5.000000000 P 50CASLC    .800000000 P 50DLHC1
                            .500000000 P 50DLHT1    .600000000 P 50DSHTA    .600000000 P 50DSHTC   -1.000000000 P 50LAB

50OPCR         EQ     276   .235900000 P 30CDLBA    .215100000 P 50CALBA    .125900000 P 50CALHC    .096700000 P 50CALLC
  RHS LO:   0.000000000     .219400000 P 50CCLBA    .105400000 P 50CCLLC    .144800000 P 50CCLHC    .235900000 P 50CDLBA
  RHS UP:   0.000000000     .043700000 P 50CASBA    .058300000 P 50CASHC    .043700000 P 50CASLC   -.038200000 P 50DLHC1
                           -.557000000 L 50DLHC2    .012500000 P 50DLHT1    .013000000 P 50DSHTA    .006000000 P 50DSHTC
                          -1.000000000 P 50OPC

50INVR         EQ     277  3.800000000 P 50DLHC1    .100000000 L 50DLHC2    .510000000 P 50DLHT1    .400000000 P 50DSHTA
  RHS LO:   0.000000000    1.134000000 P 50DSHTC   4.000000000 P 50LRGN    6.000000000 P 50SMLN   -1.000000000 P 50INV
  RHS UP:   0.000000000    5.000000000 X 50TPIP01  4.000000000 X 50TPIP02  3.000000000 X 50TPIP03  2.000000000 X 50TPIP04

10DSGAS        EQ     278  1.000000000 P 10DSHTA  -1.000000000 P 10TGAS
  RHS LO:   0.000000000
  RHS UP:   0.000000000

20DSGAS        EQ     279  1.000000000 P 20DSHTA  -1.000000000 P 20TGAS
  RHS LO:   0.000000000
  RHS UP:   0.000000000

30DSGAS        EQ     280  1.000000000 P 30DSHTA  -1.000000000 P 30TGAS
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40DSGAS        EQ     281  1.000000000 P 40DSHTA  -1.000000000 P 40TGAS
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50DSGAS        EQ     282  1.000000000 P 50DSHTA  -1.000000000 P 50TGAS
  RHS LO:   0.000000000
  RHS UP:   0.000000000

10DSDSL        EQ     283  1.000000000 P 10DSHTC  -1.000000000 P 10SCA
  RHS LO:   0.000000000
  RHS UP:   0.000000000

20DSDSL        EQ     284  1.000000000 P 20DSHTC  -1.000000000 P 20SCA
  RHS LO:   0.000000000
  RHS UP:   0.000000000

30DSDSL        EQ     285  1.000000000 P 30DSHTC  -1.000000000 P 30SCA
  RHS LO:   0.000000000
  RHS UP:   0.000000000

40DSDSL        EQ     286  1.000000000 P 40DSHTC  -1.000000000 P 40SCA
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50DSDSL        EQ     287  1.000000000 P 50DSHTC  -1.000000000 P 50SCA
  RHS LO:   [illegible]
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50C3PO      EQ    288  -1.000000000 P 50C3P       -1.000000000 P 10C3P05M    -1.000000000 P 10C3P05P    -1.000000000 P 20C3P05M
  RHS LO:  0.000000000 -1.000000000 P 20C3P05P    -1.000000000 P 30C3P05M    -1.000000000 P 30C3P05P    -1.000000000 P 40C3P05P
  RHS UP:  0.000000000  1.000000000 P 50C3P0FM     1.000000000 P 50C3P0FP     1.000000000 P 50C3P01M     1.000000000 P 50C3P01P
                        1.000000000 P 50C3P02M     1.000000000 P 50C3P02P     1.000000000 P 50C3P03M     1.000000000 P 50C3P03P
                        1.000000000 P 50C3P04P    -1.000000000 P F0C3P05M    -1.000000000 P F0C3P05P     1.000000000 L 50C3PC

50C4PO      EQ    289  -1.000000000 P 50C4P       -1.000000000 P 10C4P05M    -1.000000000 P 10C4P05P    -1.000000000 P 20C4P05M
  RHS LO:  0.000000000 -1.000000000 P 20C4P05P    -1.000000000 P 30C4P05M    -1.000000000 P 30C4P05P    -1.000000000 P 40C4P05P
  RHS UP:  0.000000000  1.000000000 P 50C4P0FM     1.000000000 P 50C4P0FP     1.000000000 P 50C4P01M     1.000000000 P 50C4P01P
                        1.000000000 P 50C4P02M     1.000000000 P 50C4P02P     1.000000000 P 50C4P03M     1.000000000 P 50C4P03P
                        1.000000000 P 50C4P04P    -1.000000000 P F0C4P05M    -1.000000000 P F0C4P05P     1.000000000 L 50C4PC

50NAPO      EQ    290  -1.000000000 P 50NAP       -1.000000000 P 10NAP05M    -1.000000000 P 10NAP05P    -1.000000000 P 20NAP05M
  RHS LO:  0.000000000 -1.000000000 P 20NAP05P    -1.000000000 P 30NAP05M    -1.000000000 P 30NAP05P    -1.000000000 P 40NAP05P
  RHS UP:  0.000000000  1.000000000 P 50NAP0FM     1.000000000 P 50NAP0FP     1.000000000 P 50NAP01M     1.000000000 P 50NAP01P
                        1.000000000 P 50NAP02M     1.000000000 P 50NAP02P     1.000000000 P 50NAP03M     1.000000000 P 50NAP03P
                        1.000000000 P 50NAP04P    -1.000000000 P F0NAP05M    -1.000000000 P F0NAP05P     1.000000000 P 50NAPC

504BAO      EQ    291  -1.000000000 P 504BA       -1.000000000 P 104BA05M    -1.000000000 P 104BA05P    -1.000000000 P 204BA05M
  RHS LO:  0.000000000 -1.000000000 P 204BA05P    -1.000000000 P 304BA05M    -1.000000000 P 304BA05P    -1.000000000 P 404BA05P
  RHS UP:  0.000000000  1.000000000 P 504BA0FM     1.000000000 P 504BA0FP     1.000000000 P 504BA01M     1.000000000 P 504BA01P
                        1.000000000 P 504BA02M     1.000000000 P 504BA02P     1.000000000 P 504BA03M     1.000000000 P 504BA03P
                        1.000000000 P 504BA04P    -1.000000000 P F04BA05M    -1.000000000 P F04BA05P     1.000000000 P 504BAC

504AAO      EQ    292  -1.000000000 P 504AA       -1.000000000 P 104AA05M    -1.000000000 P 104AA05P    -1.000000000 P 204AA05M
  RHS LO:  0.000000000 -1.000000000 P 204AA05P    -1.000000000 P 304AA05M    -1.000000000 P 304AA05P    -1.000000000 P 404AA05P
  RHS UP:  0.000000000  1.000000000 P 504AA0FM     1.000000000 P 504AA0FP     1.000000000 P 504AA01M     1.000000000 P 504AA01P
                        1.000000000 P 504AA02M     1.000000000 P 504AA02P     1.000000000 P 504AA03M     1.000000000 P 504AA03P
                        1.000000000 P 504AA04P    -1.000000000 P F04AA05M    -1.000000000 P F04AA05P     1.000000000 P 504AAC

504CAO      EQ    293  -1.000000000 P 504CA       -1.000000000 P 104CA05M    -1.000000000 P 104CA05P    -1.000000000 P 204CA05M
  RHS LO:  0.000000000 -1.000000000 P 204CA05P    -1.000000000 P 304CA05M    -1.000000000 P 304CA05P    -1.000000000 P 404CA05P
  RHS UP:  0.000000000  1.000000000 P 504CA0FM     1.000000000 P 504CA0FP     1.000000000 P 504CA01M     1.000000000 P 504CA01P
                        1.000000000 P 504CA02M     1.000000000 P 504CA02P     1.000000000 P 504CA03M     1.000000000 P 504CA03P
                        1.000000000 P 504CA04P    -1.000000000 P F04CA05M    -1.000000000 P F04CA05P     1.000000000 P 504CAC

504DAO      EQ    294  -1.000000000 P 504DA       -1.000000000 P 104DA05M    -1.000000000 P 104DA05P    -1.000000000 P 204DA05M
  RHS LO:  0.000000000 -1.000000000 P 204DA05P    -1.000000000 P 304DA05M    -1.000000000 P 304DA05P    -1.000000000 P 404DA05P
  RHS UP:  0.000000000  1.000000000 P 504DA0FM     1.000000000 P 504DA0FP     1.000000000 P 504DA01M     1.000000000 P 504DA01P
                        1.000000000 P 504DA02M     1.000000000 P 504DA02P     1.000000000 P 504DA03M     1.000000000 P 504DA03P
                        1.000000000 P 504DA04P    -1.000000000 P F04DA05M    -1.000000000 P F04DA05P     1.000000000 P 504DAC

505GASO     EQ    295  -1.000000000 P 504AAC      -1.000000000 P 504BAC      -1.000000000 P 504CAC      -1.000000000 P 504DAC
  RHS LO:  0.000000000  1.000000000 X 50TGASC
  RHS UP:  0.000000000

505AAO      EQ    296  -1.000000000 P 505AA       -1.000000000 P 105AA05M    -1.000000000 P 105AA05P    -1.000000000 P 205AA05M
  RHS LO:  0.000000000 -1.000000000 P 205AA05P    -1.000000000 P 305AA05M    -1.000000000 P 305AA05P    -1.000000000 P 405AA05P
  RHS UP:  0.000000000  1.000000000 P 505AA0FM     1.000000000 P 505AA0FP     1.000000000 P 505AA01M     1.000000000 P 505AA01P
                        1.000000000 P 505AA02M     1.000000000 P 505AA02P     1.000000000 P 505AA03M     1.000000000 P 505AA03P
                        1.000000000 P 505AA04P    -1.000000000 P F05AA05M    -1.000000000 P F05AA05P     1.000000000 L 505AAC

505BBO      EQ    297  -1.000000000 P 505BB       -1.000000000 P 105BB05M    -1.000000000 P 105BB05P    -1.000000000 P 205BB05M
  RHS LO:  0.000000000 -1.000000000 P 205BB05P    -1.000000000 P 305BB05M    -1.000000000 P 305BB05P    -1.000000000 P 405BB05P
  RHS UP:  0.000000000  1.000000000 P 505BB0FM     1.000000000 P 505BB0FP     1.000000000 P 505BB01M     1.000000000 P 505BB01P
                        1.000000000 P 505BB02M     1.000000000 P 505BB02P     1.000000000 P 505BB03M     1.000000000 P 505BB03P
                        1.000000000 P 505BB04P    -1.000000000 P F05BB05M    -1.000000000 P F05BB05P     1.000000000 L 505BBC

505CAO      EQ    298  -1.000000000 P 505CA       -1.000000000 P 105CA05M    -1.000000000 P 105CA05P    -1.000000000 P 205CA05M
  RHS LO:  0.000000000 -1.000000000 P 205CA05P    -1.000000000 P 305CA05M    -1.000000000 P 305CA05P    -1.000000000 P 405CA05P
  RHS UP:  0.000000000  1.000000000 P 505CA0FM     1.000000000 P 505CA0FP     1.000000000 P 505CA01M     1.000000000 P 505CA01P
                        1.000000000 P 505CA02M     1.000000000 P 505CA02P     1.000000000 P 505CA03M     1.000000000 P 505CA03P
                        1.000000000 P 505CA04P    -1.000000000 P F05CA05M    -1.000000000 P F05CA05P     1.000000000 L 505CAC
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505DLIM       GE     299  -.750000000 L 505CAC        1.000000000 L 505CCC
  RHS LO:   0.000000000
  RHS UP:   +INF

505CB0        EQ     300  -1.000000000 P 505CB        -1.000000000 P 105CBC5M     -1.000000000 P 105CB05P     -1.000000000 P 205CB05M
  RHS LO:   0.000000000   -1.000000000 P 205CB05P     -1.000000000 P 305CBC5M     -1.000000000 P 305CB05P     -1.000000000 P 405CB05P
  RHS UP:   0.000000000    1.000000000 P 505CB0FM      1.000000000 P 505CBCFP      1.000000000 P 505CB01M      1.000000000 P 505CB01P
                           1.000000000 P 505CB02M      1.000000000 P 505CB02P      1.000000000 P 505CBC3M      1.000000000 P 505CB03P
                           1.000000000 P 505CB04P     -1.000000000 P F05CBC5M     -1.000000000 P F05CB05P      1.000000000 L 505CBC

50VGUD        EQ     301  -1.000000000 P 50VGD        -1.000000000 P 10VGDC5M     -1.000000000 P 20VG005M     -1.000000000 P 30VG005M
  RHS LO:   0.000000000    1.000000000 P 50VGD0FM      1.000000000 P 50VGDC
  RHS UP:   0.000000000

505OAD        EQ     302  -1.000000000 P 505DA        -1.000000000 P 105DAC5M     -1.000000000 P 205DA05M     -1.000000000 P 305DA05M
  RHS LO:   0.000000000    1.000000000 P 505DA0FM      1.000000000 P 505DAC1M      1.000000000 P 505DA03M     -1.000000000 P F050A05M
  RHS UP:   0.000000000    1.000000000 L 505DAC

505D8D        EQ     303  -1.000000000 P 50508        -1.000000000 P 105DB05M     -1.000000000 P 205DB05M     -1.000000000 P 305DB05M
  RHS LO:   0.000000000    1.000000000 P 50508UFM      1.000000000 P 505DBC1M      1.000000000 P 5C5DB03M     -1.000000000 P F05DB05M
  RHS UP:   0.000000000    1.000000000 L 5050BC

50VRDD        EQ     304  -1.000000000 P 50VRO         1.000000000 P 50VRDC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50CKAD        EQ     305  -1.000000000 P 50CKA         1.000000000 P 50CKAC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50CKBD        EQ     306  -1.000000000 P 50CKB         1.000000000 P 50CKBC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50CKCD        EQ     307  -1.000000000 P 50CKC         1.000000000 P 50CKCC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

501A6D        EQ     308  -1.000000000 P 501A6         1.000000000 P 501A6C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

501A7D        EQ     309  -1.000000000 P 501A7         1.000000000 P 501A7C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

501A8D        EQ     310  -1.000000000 P 501A8         1.000000000 P 501A8C
  RHS LO:   0.000000000
  RHS UP:   0.000000000

50MISO        EQ     311  -1.000000000 P 50MIS         1.000000000 P 50MISC
  RHS LO:   0.000000000
  RHS UP:   0.000000000

F0OBJ         EQ     312  -8.190000000 P F0C3P        -9.030000000 P F0C4P       -14.15000000 P FCNAP       -14.95000000 L F04AA
  RHS LO:   0.000000000  -15.83000000 L F04BA       -15.37000000 L FC4CA       -15.83000000 L F040A       -14.53000000 L F05AA
  RHS UP:   0.000000000  -15.75000000 L F05BB       -14.32000000 L F05CA       -14.32000000 L F05CB       -10.48000000 P F050A
                         -12.48500000 P F0508       -21.00000000 P F0VGO       -10.00000000 P F0VRD       -40.00000000 P F0CKA
                         -60.00000000 P F0CKB       -30.00000000 P F0CKC       -35.70000000 P FC1A6       -25.20000000 P F01A7
                         -21.00000000 P F01A8       -20.00000000 P F0MIS        1.000000000 P F0OBJT      -1.000000000 P F0TPCST
                          -1.000000000 P F0TMCST

F0C3PO        EQ     313  -1.000000000 P F0C3P        -1.000000000 P F0C4P        -1.000000000 P 10C3P0FM     -1.000000000 P 10C3P0FP
  RHS LO:   0.000000000   -1.000000000 P 20C3P0FM     -1.000000000 P 20C3P0FP     -1.000000000 P 30C3P0FM     -1.000000000 P 30C3P0FP
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FOC4PO        EQ      314  -1.000000000 P 10C4POFM    -1.000000000 P 10C4POFP    -1.000000000 P 20C4POFM    -1.000000000 P 20C4POFP
   RHS LO:   0.000000000  -1.000000000 P 30C4POFM    -1.000000000 P 30C4POFP    -1.000000000 P 40C4POFP    -1.000000000 P 50C4POFM
   RHS UP:   0.000000000  -1.000000000 P 50C4POFP     1.000000000 P FOC4PO1M     1.000000000 P FOC4PO1P     1.000000000 P FOC4PO2M
                           1.000000000 P FOC4PO2P     1.000000000 P FOC4PO3M     1.000000000 P FOC4PO3P     1.000000000 P FOC4PO4P
                           1.000000000 P FOC4PO5M     1.000000000 P FOC4PO5P     1.000000000 P FOC4PC

FONAPD        EQ      315  -1.000000000 P FONAP       -1.000000000 P 10NAPOFM    -1.000000000 P 10NAPOFP    -1.000000000 P 20NAPOFM
   RHS LO:   0.000000000  -1.000000000 P 20NAPOFP    -1.000000000 P 30NAPOFM    -1.000000000 P 30NAPOFP    -1.000000000 P 40NAPOFP
   RHS UP:   0.000000000  -1.000000000 P 50NAPOFM    -1.000000000 P 50NAPOFP     1.000000000 P FONAPO1M     1.000000000 P FONAPO1P
                           1.000000000 P FONAPO2M     1.000000000 P FONAPO2P     1.000000000 P FONAPO3M     1.000000000 P FONAPO3P
                           1.000000000 P FONAPO4P     1.000000000 P FONAPO5M     1.000000000 P FONAPO5P     1.000000000 P FONAPC

FO4AAD        EQ      316  -1.000000000 L FO4AA       -1.000000000 P 104AAOFM    -1.000000000 P 104AAOFP    -1.000000000 P 204AAOFM
   RHS LO:   0.000000000  -1.000000000 P 204AAOFP    -1.000000000 P 304AAOFM    -1.000000000 P 304AAOFP    -1.000000000 P 404AAOFP
   RHS UP:   0.000000000  -1.000000000 P 504AAOFM    -1.000000000 P 504AAOFP     1.000000000 P FO4AAO1M     1.000000000 P FO4AAO1P
                           1.000000000 P FO4AAO2M     1.000000000 P FO4AAO2P     1.000000000 P FO4AAO3M     1.000000000 P FO4AAO3P
                           1.000000000 P FO4AAO4P     1.000000000 P FO4AAO5M     1.000000000 P FO4AAO5P     1.000000000 P FO4AAC

FO4BAD        EQ      317  -1.000000000 L FO4BA       -1.000000000 P 104BAOFM    -1.000000000 P 104BAOFP    -1.000000000 P 204BAOFM
   RHS LO:   0.000000000  -1.000000000 P 204BAOFP    -1.000000000 P 304BAOFM    -1.000000000 P 304BAOFP    -1.000000000 P 404BAOFP
   RHS UP:   0.000000000  -1.000000000 P 504BAOFM    -1.000000000 P 504BAOFP     1.000000000 P FO4BAO1M     1.000000000 P FO4BAO1P
                           1.000000000 P FO4BAO2M     1.000000000 P FO4BAO2P     1.000000000 P FO4BAO3M     1.000000000 P FO4BAO3P
                           1.000000000 P FO4BAO4P     1.000000000 P FO4BAO5M     1.000000000 P FO4BAO5P     1.000000000 P FO4BAC

FO4CAD        EQ      318  -1.000000000 L FO4CA       -1.000000000 P 104CAOFM    -1.000000000 P 104CAOFP    -1.000000000 P 204CAOFM
   RHS LO:   0.000000000  -1.000000000 P 204CAOFP    -1.000000000 P 304CAOFM    -1.000000000 P 304CAOFP    -1.000000000 P 404CAOFP
   RHS UP:   0.000000000  -1.000000000 P 504CAOFM    -1.000000000 P 504CAOFP     1.000000000 P FO4CAO1M     1.000000000 P FO4CAO1P
                           1.000000000 P FO4CAO2M     1.000000000 P FO4CAO2P     1.000000000 P FO4CAO3M     1.000000000 P FO4CAO3P
                           1.000000000 P FO4CAO5M     1.000000000 P FO4CAO5P     1.000000000 P FO4CAC

FO4DAD        EQ      319  -1.000000000 L FO4DA       -1.000000000 P 104DAOFM    -1.000000000 P 104DAOFP    -1.000000000 P 204DAOFM
   RHS LO:   0.000000000  -1.000000000 P 204DAOFP    -1.000000000 P 304DAOFM    -1.000000000 P 304DAOFP    -1.000000000 P 404DAOFP
   RHS UP:   0.000000000  -1.000000000 P 504DAOFM    -1.000000000 P 504DAOFP     1.000000000 P FO4DAO1M     1.000000000 P FO4DAO1P
                           1.000000000 P FO4DAO2M     1.000000000 P FO4DAO2P     1.000000000 P FO4DAO3M     1.000000000 P FO4DAO3P
                           1.000000000 P FO4DAO4P     1.000000000 P FO4DAO5M     1.000000000 P FO4DAO5P     1.000000000 P FO4DAC

FOSGASP       EQ      320   1.000000000 L FO4AA        1.000000000 L FO4BA        1.000000000 L FO4CA        1.000000000 L FO4DA
   RHS LO:   0.000000000  -1.000000000 P FOTGAS
   RHS UP:   0.000000000

FOSGASD       EQ      321  -1.000000000 P FO4AAC      -1.000000000 P FO4BAC      -1.000000000 P FO4CAC      -1.000000000 P FO4DAC
   RHS LO:   0.000000000   1.000000000 P FOTGASC
   RHS UP:   0.000000000

FO5AAD        EQ      322  -1.000000000 L FO5AA       -1.000000000 P 105AAOFM    -1.000000000 P 105AAOFP    -1.000000000 P 205AAOFM
   RHS LO:   0.000000000  -1.000000000 P 205AAOFP    -1.000000000 P 305AAOFM    -1.000000000 P 305AAOFP    -1.000000000 P 405AAOFP
   RHS UP:   0.000000000  -1.000000000 P 505AAOFM    -1.000000000 P 505AAOFP     1.000000000 P FO5AAO1M     1.000000000 P FO5AAO1P
                           1.000000000 P FO5AAO2M     1.000000000 P FO5AAO2P     1.000000000 P FO5AAO3M     1.000000000 P FO5AAO3P
                           1.000000000 P FO5AAO4P     1.000000000 P FO5AAO5M     1.000000000 P FO5AAO5P     1.000000000 P FO5AAC

FO5BBD        EQ      323  -1.000000000 L FO5BB       -1.000000000 P 105BBOFM    -1.000000000 P 105BBOFP    -1.000000000 P 205BBOFM
   RHS LO:   0.000000000  -1.000000000 P 205BBOFP    -1.000000000 P 305BBOFM    -1.000000000 P 305BBOFP    -1.000000000 P 405BBOFP
   RHS UP:   0.000000000  -1.000000000 P 505BBOFM    -1.000000000 P 505BBOFP     1.000000000 P FO5BBO1M     1.000000000 P FO5BBO1P
                           1.000000000 P FO5BBO2M     1.000000000 P FO5BBO2P     1.000000000 P FO5BBO3M     1.000000000 P FO5BBO3P
                           1.000000000 P FO5BBO4P     1.000000000 P FO5BBO5M     1.000000000 P FO5BBO5P     1.000000000 P FO5BBC

FO5CAD        EQ      324  -1.000000000 L FO5CA       -1.000000000 P 105CAOFM    -1.000000000 P 105CAOFP    -1.000000000 P 205CAOFM
   RHS LO:   0.000000000  -1.000000000 P 205CAOFP    -1.000000000 P 305CAOFM    -1.000000000 P 305CAOFP    -1.000000000 P 405CAOFP
   RHS UP:   0.000000000  -1.000000000 P 505CAOFM    -1.000000000 P 505CAOFP     1.000000000 P FO5CAO1M     1.000000000 P FO5CAO1P
                           1.000000000 P FO5CAO2M     1.000000000 P FO5CAO2P     1.000000000 P FO5CAO3M     1.000000000 P FO5CAO3P
                           1.000000000 P FO5CAO4P     1.000000000 P FO5CAO5M     1.000000000 P FO5CAO5P     1.000000000 P FO5CAC
                           1.000000000 P FO5CCC
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F05DLIM         GE      325  -.750000000 P F05CAC       1.000000000 P F05CCC
  RHS LO:    0.000000000
  RHS UP:   +INF

F05CBD          EQ      326  -1.000000000 L F05CB      -1.000000000 P 105CB0FM    -1.000000000 P 105CB0FP    -1.000000000 P 205CB0FM
  RHS LO:    0.000000000     -1.000000000 P 205CB0FP   -1.000000000 P 305CB0FM    -1.000000000 P 305CB0FP    -1.000000000 P 405CB0FP
  RHS UP:    0.000000000     -1.000000000 P 505CB0FM   -1.000000000 P 505CBCFP     1.000000000 P F05CB01M     1.000000000 P F05CB01P
                              1.000000000 P F05CB02M    1.000000000 P F05CB02P     1.000000000 P F05CB03M     1.000000000 P F05CB03P
                              1.000000000 P F05CB04P    1.000000000 P F05CB05M     1.000000000 P F05CB05P     1.000000000 P F05CBC

F05DAD          EQ      327  -1.000000000 P F05DA      -1.000000000 P 105DA0FM    -1.000000000 P 205DA0FM    -1.000000000 P 305DA0FM
  RHS LO:    0.000000000     -1.000000000 P 505DA0FM    1.000000000 P F05DA01M     1.000000000 P F05DA02M     1.000000000 P F05DA03M
  RHS UP:    0.000000000      1.000000000 P F05DA05M    1.000000000 P F05DAC

F05DBD          EQ      328  -1.000000000 P F05DB      -1.000000000 P 105DB0FM    -1.000000000 P 205DB0FM    -1.000000000 P 305DB0FM
  RHS LO:    0.000000000     -1.000000000 P 505DB0FM    1.000000000 P F05DB01M     1.000000000 P F05DB02M     1.000000000 P F05DB03M
  RHS UP:    0.000000000      1.000000000 P F05DB05M    1.000000000 P F05DBC

F0VGOD          EQ      329  -1.000000000 P F0VGO      -1.000000000 P 10VGO0FM    -1.000000000 P 20VGO0FM    -1.000000000 P 30VGO0FM
  RHS LO:    0.000000000     -1.000000000 P 50VGO0FM    1.000000000 P F0VGOC
  RHS UP:    0.000000000

F0VRDD          EQ      330  -1.000000000 P F0VRD       1.000000000 P F0VRDC
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F0CKAD          EQ      331  -1.000000000 P F0CKA       1.000000000 P F0CKAC
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F0CKBD          EQ      332  -1.000000000 P F0CKB       1.000000000 P F0CKBC
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F0CKCD          EQ      333  -1.000000000 P F0CKC       1.000000000 P F0CKCC
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F01A6D          EQ      334  -1.000000000 P F01A6       1.000000000 P F01A6C
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F01A7D          EQ      335  -1.000000000 P F01A7       1.000000000 P F01A7C
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F01A8D          EQ      336  -1.000000000 P F01A8       1.000000000 P F01A8C
  RHS LO:    0.000000000
  RHS UP:    0.000000000

F0MISD          EQ      337  -1.000000000 P F0MIS       1.000000000 P F0MISC
  RHS LO:    0.000000000
  RHS UP:    0.000000000

10PCAP02        EQ      338  -1.000000000 L 10TPIP02   -1.000000000 P 10NPIP02     1.000000000 P 10C3P02P     1.000000000 P 10C4P02P
  RHS LO:    0.000000000      1.000000000 P 10NAP02P    1.000000000 P 104AA02P     1.000000000 P 104BA02P     1.000000000 P 104CA02P
  RHS UP:    0.000000000      1.000000000 P 104DA02P    1.000000000 P 105AA02P     1.000000000 P 105BB02P     1.000000000 P 105CA02P
                              1.000000000 P 105CB02P

10PCAP03        EQ      339  -1.000000000 X 10TPIP03    1.000000000 P 10C3P03P     1.000000000 P 10C4P03P     1.000000000 P 10NAP03P
  RHS LO:    0.000000000      1.000000000 P 104AA03P    1.000000000 P 104BA03P     1.000000000 P 104CA03P     1.000000000 P 104DA03P
  RHS UP:    0.000000000      1.000000000 P 105AA03P    1.000000000 P 105BB03P     1.000000000 P 105CA03P     1.000000000 P 105CB03P

10PCAP04        EQ      34.  -.......... X 10TPIP04     1.000000000 P 10C3P04P     1.000000000 P 10C4P04P     1.000000000 P 10NAP04P
                                                                                                          .. P 104DA04P
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10PCAP05      EQ      341  -1.000000000 X 10TPIP05     1.000000000 P 10C3P05P     1.000000000 P 10C4P05P     1.000000000 P 10NAP05P
  RHS LO:   0.000000000     1.000000000 P 104AA05P     1.000000000 P 104BA05P     1.000000000 P 104CA05P     1.000000000 P 1040A05P
  RHS UP:   0.000000000     1.000000000 P 105AA05P     1.000000000 P 105BBC5P     1.000000000 P 105CA05P     1.000000000 P 105CB05P

10PCAPOF      EQ      342  -1.000000000 L 10TPIPOF     1.000000000 P 10C3POFP     1.000000000 P 10C4POFP     1.000000000 P 10NAPOFP
  RHS LO:   0.000000000     1.000000000 P 104AAOFP     1.000000000 P 104BAOFP     1.000000000 P 104CAOFP     1.000000000 P 1040AOFP
  RHS UP:   0.000000000     1.000000000 P 105AAOFP     1.000000000 P 105BBOFP     1.000000000 P 105CAOFP     1.000000000 P 105CBOFP

20PCAP01      EQ      343  -1.000000000 L 20TPIP01    -1.000000000 P 20NPIP01     1.000000000 P 20C3P01P     1.000000000 P 20C4P01P
  RHS LO:   0.000000000     1.000000000 P 20NAP01P     1.000000000 P 204AAC1P     1.000000000 P 204BAC1P     1.000000000 P 204CA01P
  RHS UP:   0.000000000     1.000000000 P 204DA01P     1.000000000 P 205AA01P     1.000000000 P 205BB01P     1.000000000 P 205CA01P
                            1.000000000 P 205CB01P

20PCAP03      EQ      344  -1.000000000 L 20TPIP03    -1.000000000 P 20NPIP03     1.000000000 P 20C3P03P     1.000000000 P 20C4P03P
  RHS LO:   0.000000000     1.000000000 P 20NAP03P     1.000000000 P 204AA03P     1.000000000 P 204BA03P     1.000000000 P 204CA03P
  RHS UP:   0.000000000     1.000000000 P 204DA03P     1.000000000 P 205AA03P     1.000000000 P 205BBC3P     1.000000000 P 205CA03P
                            1.000000000 P 205CB03P

20PCAP04      EQ      345  -1.000000000 L 20TPIP04     1.000000000 P 20C3P04P     1.000000000 P 20C4P04P     1.000000000 P 20NAP04P
  RHS LO:   0.000000000     1.000000000 P 204AA04P     1.000000000 P 204BA04P     1.000000000 P 204CA04P     1.000000000 P 204DA04P
  RHS UP:   0.000000000     1.000000000 P 205AA04P     1.000000000 P 205BBC4P     1.000000000 P 205CA04P     1.000000000 P 205CB04P

20PCAP05      EQ      346  -1.000000000 X 20TPIP05     1.000000000 P 20C3P05P     1.000000000 P 20C4P05P     1.000000000 P 20NAP05P
  RHS LO:   0.000000000     1.000000000 P 204AA05P     1.000000000 P 204BA05P     1.000000000 P 204CA05P     1.000000000 P 204DA05P
  RHS UP:   0.000000000     1.000000000 P 205AA05P     1.000000000 P 205BB05P     1.000000000 P 205CA05P     1.000000000 P 205CB05P

20PCAPOF      EQ      347  -1.000000000 L 20TPIPOF     1.000000000 P 20C3POFP     1.000000000 P 20C4POFP     1.000000000 P 20NAPOFP
  RHS LO:   0.000000000     1.000000000 P 204AAOFP     1.000000000 P 204BAOFP     1.000000000 P 204CAOFP     1.000000000 P 2040AOFP
  RHS UP:   0.000000000     1.000000000 P 205AAOFP     1.000000000 P 205BBOFP     1.000000000 P 205CAOFP     1.000000000 P 205CBOFP

30PCAP01      EQ      348  -1.000000000 L 30TPIP01    -1.000000000 P 30NPIP01     1.000000000 P 30C3P01P     1.000000000 P 30C4P01P
  RHS LO:   0.000000000     1.000000000 P 30NAP01P     1.000000000 P 304AA01P     1.000000000 P 304BA01P     1.000000000 P 304CA01P
  RHS UP:   0.000000000     1.000000000 P 304DA01P     1.000000000 P 305AA01P     1.000000000 P 305BB01P     1.000000000 P 305CA01P
                            1.000000000 P 305CB01P

30PCAP02      EQ      349  -1.000000000 P 30NPIP02    -1.000000000 L 30TPIP02     1.000000000 P 30C3P02P     1.000000000 P 30C4P02P
  RHS LO:   0.000000000     1.000000000 P 30NAP02P     1.000000000 P 3C4AA02P     1.000000000 P 304BA02P     1.000000000 P 304CA02P
  RHS UP:   0.000000000     1.000000000 P 304DA02P     1.000000000 P 305AA02P     1.000000000 P 305BB02P     1.000000000 P 305CA02P
                            1.000000000 P 305CB02P

30PCAP04      EQ      350  -1.000000000 L 30TPIP04     1.000000000 P 30C3P04P     1.000000000 P 30C4P04P     1.000000000 P 30NAP04P
  RHS LO:   0.000000000     1.000000000 P 304AA04P     1.000000000 P 304BA04P     1.000000000 P 304CA04P     1.000000000 P 304DA04P
  RHS UP:   0.000000000     1.000000000 P 305AA04P     1.000000000 P 305BB04P     1.000000000 P 305CA04P     1.000000000 P 305CB04P

30PCAP05      EQ      351  -1.000000000 L 30TPIP05     1.000000000 P 30C3P05P     1.000000000 P 30C4P05P     1.000000000 P 30NAP05P
  RHS LO:   0.000000000     1.000000000 P 304AA05P     1.000000000 P 304BA05P     1.000000000 P 304CA05P     1.000000000 P 304DA05P
  RHS UP:   0.000000000     1.000000000 P 305AA05P     1.000000000 P 305BB05P     1.000000000 P 305CA05P     1.000000000 P 305CB05P

30PCAPOF      EQ      352  -1.000000000 X 30TPIPOF     1.000000000 P 30C3POFP     1.000000000 P 30C4POFP     1.000000000 P 30NAPOFP
  RHS LO:   0.000000000     1.000000000 P 304AAOFP     1.000000000 P 304BAOFP     1.000000000 P 304CAOFP     1.000000000 P 304DAOFP
  RHS UP:   0.000000000     1.000000000 P 305AAOFP     1.000000000 P 305BBOFP     1.000000000 P 305CAOFP     1.000000000 P 305CBOFP

40PCAP01      EQ      353  -1.000000000 X 40TPIP01     1.000000000 P 40C3P01P     1.000000000 P 40C4P01P     1.000000000 P 40NAP01P
  RHS LO:   0.000000000     1.000000000 P 404AA01P     1.000000000 P 404BAC1P     1.000000000 P 404CA01P     1.000000000 P 4040A01P
  RHS UP:   0.000000000     1.000000000 P 405AA01P     1.000000000 P 405BBC1P     1.000000000 P 405CA01P     1.000000000 P 405CB01P

40PCAP02      EQ      354  -1.000000000 L 40TPIP02     1.000000000 P 40C3P02P     1.000000000 P 40C4P02P     1.000000000 P 40NAP02P
  RHS LO:   0.000000000     1.000000000 P 404AA02P     1.000000000 P 404BA02P     1.000000000 P 404CA02P     1.000000000 P 4040A02P
  RHS UP:   0.000000000     1.000000000 P 405AA02P     1.000000000 P 405BB02P     1.000000000 P 405CA02P     1.000000000 P 405CB02P

40PCAP03      EQ      355  -1.000000000 L 40TPIP03     1.000000000 P 40C3P03P     1.000000000 P 40C4P03P     1.000000000 P 40NAP03P
  RHS LO:   0.000000000     1.000000000 P 404AA03P     1.000000000 P 404BA03P     1.000000000 P 404CA03P     1.000000000 P 4040A03P
  RHS UP:   0.000000000     1.000000000 P 405AA03P     1.000000000 P 405BB03P     1.000000000 P 405CA03P     1.000000000 P 405CB03P
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40PCAPOF       EQ      357  -1.000000000 X 40TP1P0F    1.000000000 P 40C3P0FP    1.000000000 P 40C4P0FP    1.000000000 P 40NAP0FP
  RHS LO:  0.000000000       1.000000000 P 404AA0FP    1.000000000 P 404BA0FP    1.000000000 P 404CA0FP    1.000000000 P 4040A0FP
  RHS UP:  0.000000000       1.000000000 P 405AA0FP    1.000000000 P 405BB0FP    1.000000000 P 405CA0FP    1.000000000 P 405CB0FP

50PCAP01       EQ      358  -1.000000000 X 50TP1P01    1.000000000 P 50C3P01P    1.000000000 P 50C4P01P    1.000000000 P 50NAP01P
  RHS LO:  0.000000000       1.000000000 P 504AA01P    1.000000000 P 504BA01P    1.000000000 P 504CA01P    1.000000000 P 5040A01P
  RHS UP:  0.000000000       1.000000000 P 505AA01P    1.000000000 P 505BB01P    1.000000000 P 505CA01P    1.000000000 P 505CB01P

50PCAP02       EQ      359  -1.000000000 X 50TP1P02    1.000000000 P 50C3P02P    1.000000000 P 50C4P02P    1.000000000 P 50NAP02P
  RHS LO:  0.000000000       1.000000000 P 504AA02P    1.000000000 P 504BA02P    1.000000000 P 504CA02P    1.000000000 P 5040A02P
  RHS UP:  0.000000000       1.000000000 P 505AA02P    1.000000000 P 505BB02P    1.000000000 P 505CA02P    1.000000000 P 505CB02P

50PCAP03       EQ      360  -1.000000000 X 50TP1P03    1.000000000 P 50C3P03P    1.000000000 P 50C4P03P    1.000000000 P 50NAP03P
  RHS LO:  0.000000000       1.000000000 P 504AA03P    1.000000000 P 504BA03P    1.000000000 P 504CA03P    1.000000000 P 5040A03P
  RHS UP:  0.000000000       1.000000000 P 505AA03P    1.000000000 P 505BB03P    1.000000000 P 505CA03P    1.000000000 P 505CB03P

50PCAP04       EQ      361  -1.000000000 X 50TP1P04    1.000000000 P 50C3P04P    1.000000000 P 50C4P04P    1.000000000 P 50NAP04P
  RHS LO:  0.000000000       1.000000000 P 504AA04P    1.000000000 P 504BA04P    1.000000000 P 504CA04P    1.000000000 P 5040A04P
  RHS UP:  0.000000000       1.000000000 P 505AA04P    1.000000000 P 505BB04P    1.000000000 P 505CA04P    1.000000000 P 505CB04P

50PCAP0F       EQ      362  -1.000000000 L 50TP1P0F    1.000000000 P 50C3P0FP    1.000000000 P 50C4P0FP    1.000000000 P 50NAP0FP
  RHS LO:  0.000000000       1.000000000 P 504AA0FP    1.000000000 P 504BA0FP    1.000000000 P 504CA0FP    1.000000000 P 5040A0FP
  RHS UP:  0.000000000       1.000000000 P 505AA0FP    1.000000000 P 505BB0FP    1.000000000 P 505CA0FP    1.000000000 P 505CB0FP

F0PCAP01       EQ      363  -1.000000000 X F0TP1P01    1.000000000 P F0C3P01P    1.000000000 P F0C4P01P    1.000000000 P F0NAP01P
  RHS LO:  0.000000000       1.000000000 P F04AA01P    1.000000000 P F04BA01P    1.000000000 P F04CA01P    1.000000000 P F040A01P
  RHS UP:  0.000000000       1.000000000 P F05AA01P    1.000000000 P F05BBC1P    1.000000000 P F05CA01P    1.000000000 P F05CA02P
                             1.000000000 P F05CA03P    1.000000000 P F05CB01P

F0PCAP02       EQ      364  -1.000000000 X F0TP1P02    1.000000000 P F0C3P02P    1.000000000 P F0C4P02P    1.000000000 P F0NAP02P
  RHS LO:  0.000000000       1.000000000 P F04AA02P    1.000000000 P F04BA02P    1.000000000 P F04CA02P    1.000000000 P F040A02P
  RHS UP:  0.000000000       1.000000000 P F05AA02P    1.000000000 P F05BB02P    1.000000000 P F05CB02P

F0PCAP03       EQ      365  -1.000000000 X F0TP1P03    1.000000000 P F0C3P03P    1.000000000 P F0C4P03P    1.000000000 P F0NAP03P
  RHS LO:  0.000000000       1.000000000 P F04AA03P    1.000000000 P F04BA03P    1.000000000 P F04CA03P    1.000000000 P F04DA03P
  RHS UP:  0.000000000       1.000000000 P F05AA03P    1.000000000 P F05BB03P    1.000000000 P F05CB03P

F0PCAP04       EQ      366  -1.000000000 X F0TP1P04    1.000000000 P F0C3P04P    1.000000000 P F0C4P04P    1.000000000 P F0NAP04P
  RHS LO:  0.000000000       1.000000000 P F04AA04P    1.000000000 P F04BA04P    1.000000000 P F040A04P    1.000000000 P F05AA04P
  RHS UP:  0.000000000       1.000000000 P F05BB04P    1.000000000 P F05CA04P    1.000000000 P F05CB04P

F0PCAP05       EQ      367  -1.000000000 X F0TP1P05    1.000000000 P F0C3P05P    1.000000000 P F0C4P05P    1.000000000 P F0NAP05P
  RHS LO:  0.000000000       1.000000000 P F04AA05P    1.000000000 P F04BA05P    1.000000000 P F04CA05P    1.000000000 P F040A05P
  RHS UP:  0.000000000       1.000000000 P F05AA05P    1.000000000 P F05BB05P    1.000000000 P F05CA05P    1.000000000 P F05CB05P

10MCAP02       EQ      368  -1.000000000 P 10TMAR02    1.000000000 P 10C3P02M    1.000000000 P 10C4P02M    1.000000000 P 10NAP02M
  RHS LO:  0.000000000       1.000000000 P 104AA02M    1.000000000 P 104BA02M    1.000000000 P 104CA02M    1.000000000 P 1040A02M
  RHS UP:  0.000000000       1.000000000 P 105AA02M    1.000000000 P 105BB02M    1.000000000 P 105CA02M    1.000000000 P 105CB02M
                             1.000000000 P 105DA02M    1.000000000 P 105DB02M    1.000000000 P 10VG002M

10MCAP03       EQ      369  -1.000000000 P 10TMAR03    1.000000000 P 10C3P03M    1.000000000 P 10C4P03M    1.000000000 P 10NAP03M
  RHS LO:  0.000000000       1.000000000 P 104AA03M    1.000000000 P 104BA03M    1.000000000 P 104CA03M    1.000000000 P 104DA03M
  RHS UP:  0.000000000       1.000000000 P 105AA03M    1.000000000 P 105BB03M    1.000000000 P 105CA03M    1.000000000 P 105CB03M
                             1.000000000 P 105DA03M    1.000000000 P 105DB03M    1.000000000 P 10VG003M

10MCAP05       EQ      370  -1.000000000 P 10TMAR05    1.000000000 P 10C3P05M    1.000000000 P 10C4P05M    1.000000000 P 10NAP05M
  RHS LO:  0.000000000       1.000000000 P 104AA05M    1.000000000 P 104BA05M    1.000000000 P 104CA05M    1.000000000 P 1040A05M
  RHS UP:  0.000000000       1.000000000 P 105AA05M    1.000000000 P 105BB05M    1.000000000 P 105CA05M    1.000000000 P 105CB05M
                             1.000000000 P 105DA05M    1.000000000 P 105DB05M    1.000000000 P 10VG005M

10MCAP0F       EQ      371  -1.000000000 P 10TMAR0F    1.000000000 P 10C3P0FM    1.000000000 P 10C4P0FM    1.000000000 P 10NAP0FM
  RHS LO:  0.000000000       1.000000000 P 104AA0FM    1.000000000 P 104BA0FM    1.000000000 P 104CA0FM    1.000000000 P 1040A0FM
  RHS UP:  0.000000000       1.000000000 P 105AA0FM    1.000000000 P 105BB0FM    1.000000000 P 105CA0FM    1.000000000 P 105CB0FM
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20MCAP01     EQ      372  -1.000000000 P 20TMAR01    1.000000000 P 20C3P01M    1.000000000 P 20C4P01M    1.000000000 P 20NAP01M
  RHS LO:  0.000000000    1.000000000 P 204AA01M    1.000000000 P 204BA01M    1.000000000 P 204CA01M    1.000000000 P 204DA01M
  RHS UP:  0.000000000    1.000000000 P 205AA01M    1.000000000 P 205BB01M    1.000000000 P 205CA01M    1.000000000 P 205CB01M
                          1.000000000 P 205DA01M    1.000000000 P 205DB01M    1.000000000 P 20VG001M

20MCAP03     EQ      373  -1.000000000 P 20TMAR03    1.000000000 P 20C3P03M    1.000000000 P 20C4P03M    1.000000000 P 20NAP03M
  RHS LO:  0.000000000    1.000000000 P 204AA03M    1.000000000 P 204BA03M    1.000000000 P 204CA03M    1.000000000 P 204DA03M
  RHS UP:  0.000000000    1.000000000 P 205AA03M    1.000000000 P 205BB03M    1.000000000 P 205CA03M    1.000000000 P 205CB03M
                          1.000000000 P 205DA03M    1.000000000 P 205DB03M    1.000000000 P 20VG003M

20MCAP05     EQ      374  -1.000000000 P 20TMAR05    1.000000000 P 20C3P05M    1.000000000 P 20C4P05M    1.000000000 P 20NAP05M
  RHS LO:  0.000000000    1.000000000 P 204AA05M    1.000000000 P 204BA05M    1.000000000 P 204CA05M    1.000000000 P 204DA05M
  RHS UP:  0.000000000    1.000000000 P 205AA05M    1.000000000 P 205BB05M    1.000000000 P 205CA05M    1.000000000 P 205CB05M
                          1.000000000 P 205DA05M    1.000000000 P 205DB05M    1.000000000 P 20VG005M

20MCAP0F     EQ      375  -1.000000000 P 20TMAR0F    1.000000000 P 20C3P0FM    1.000000000 P 20C4P0FM    1.000000000 P 20NAP0FM
  RHS LO:  0.000000000    1.000000000 P 204AA0FM    1.000000000 P 204BA0FM    1.000000000 P 204CA0FM    1.000000000 P 204DA0FM
  RHS UP:  0.000000000    1.000000000 P 205AA0FM    1.000000000 P 205BB0FM    1.000000000 P 205CA0FM    1.000000000 P 205CB0FM
                          1.000000000 P 205DA0FM    1.000000000 P 205DB0FM    1.000000000 P 20VG00FM

30MCAP01     EQ      376  -1.000000000 P 30TMAR01    1.000000000 P 30C3P01M    1.000000000 P 30C4P01M    1.000000000 P 30NAP01M
  RHS LO:  0.000000000    1.000000000 P 304AA01M    1.000000000 P 304BA01M    1.000000000 P 304CA01M    1.000000000 P 304DA01M
  RHS UP:  0.000000000    1.000000000 P 305AA01M    1.000000000 P 305BB01M    1.000000000 P 305CA01M    1.000000000 P 305CB01M
                          1.000000000 P 305DA01M    1.000000000 P 305DB01M    1.000000000 P 30VG001M    1.000000000 P 30VAC01M

30MCAP02     EQ      377  -1.000000000 P 30TMAR02    1.000000000 P 30C3P02M    1.000000000 P 30C4P02M    1.000000000 P 30NAP02M
  RHS LO:  0.000000000    1.000000000 P 304AA02M    1.000000000 P 304BA02M    1.000000000 P 304CA02M    1.000000000 P 304DA02M
  RHS UP:  0.000000000    1.000000000 P 305AA02M    1.000000000 P 305BB02M    1.000000000 P 305CA02M    1.000000000 P 305CB02M
                          1.000000000 P 305DA02M    1.000000000 P 305DB02M    1.000000000 P 30VG002M

30MCAP05     EQ      378  -1.000000000 P 30TMAR05    1.000000000 P 30C3P05M    1.000000000 P 30C4P05M    1.000000000 P 30NAP05M
  RHS LO:  0.000000000    1.000000000 P 304AA05M    1.000000000 P 304BA05M    1.000000000 P 304CA05M    1.000000000 P 304DA05M
  RHS UP:  0.000000000    1.000000000 P 305AA05M    1.000000000 P 305BB05M    1.000000000 P 305CA05M    1.000000000 P 305CB05M
                          1.000000000 P 305DA05M    1.000000000 P 305DB05M    1.000000000 P 30VG005M

30MCAP0F     EQ      379  -1.000000000 P 30TMAR0F    1.000000000 P 30C3P0FM    1.000000000 P 30C4P0FM    1.000000000 P 30NAP0FM
  RHS LO:  0.000000000    1.000000000 P 304AA0FM    1.000000000 P 304BA0FM    1.000000000 P 304CA0FM    1.000000000 P 304DA0FM
  RHS UP:  0.000000000    1.000000000 P 305AA0FM    1.000000000 P 305BB0FM    1.000000000 P 305CA0FM    1.000000000 P 305CB0FM
                          1.000000000 P 305DA0FM    1.000000000 P 305DB0FM    1.000000000 P 30VG00FM

50MCAP01     EQ      380  -1.000000000 P 50TMAR01    1.000000000 P 50C3P01M    1.000000000 P 50C4P01M    1.000000000 P 50NAP01M
  RHS LO:  0.000000000    1.000000000 P 504AA01M    1.000000000 P 504BA01M    1.000000000 P 504CA01M    1.000000000 P 504DA01M
  RHS UP:  0.000000000    1.000000000 P 505AA01M    1.000000000 P 505BB01M    1.000000000 P 505CA01M    1.000000000 P 505CB01M
                          1.000000000 P 505DA01M    1.000000000 P 505DB01M

50MCAP02     EQ      381  -1.000000000 P 50TMAR02    1.000000000 P 50C3P02M    1.000000000 P 50C4P02M    1.000000000 P 50NAP02M
  RHS LO:  0.000000000    1.000000000 P 504AA02M    1.000000000 P 504BA02M    1.000000000 P 504CA02M    1.000000000 P 504DA02M
  RHS UP:  0.000000000    1.000000000 P 505AA02M    1.000000000 P 505BB02M    1.000000000 P 505CA02M    1.000000000 P 505CB02M

50MCAP03     EQ      382  -1.000000000 P 50TMAR03    1.000000000 P 50C3P03M    1.000000000 P 50C4P03M    1.000000000 P 50NAP03M
  RHS LO:  0.000000000    1.000000000 P 504AA03M    1.000000000 P 504BA03M    1.000000000 P 504CA03M    1.000000000 P 504DA03M
  RHS UP:  0.000000000    1.000000000 P 505AA03M    1.000000000 P 505BB03M    1.000000000 P 505CA03M    1.000000000 P 505CB03M
                          1.000000000 P 505DA03M    1.000000000 P 505DB03M

50MCAP0F     EQ      383  -1.000000000 P 50TMAR0F    1.000000000 P 50C3P0FM    1.000000000 P 50C4P0FM    1.000000000 P 50NAP0FM
  RHS LO:  0.000000000    1.000000000 P 504AA0FM    1.000000000 P 504BA0FM    1.000000000 P 504CA0FM    1.000000000 P 504DA0FM
  RHS UP:  0.000000000    1.000000000 P 505AA0FM    1.000000000 P 505BB0FM    1.000000000 P 505CA0FM    1.000000000 P 505CB0FM
                          1.000000000 P 505DA0FM    1.000000000 P 505DB0FM    1.000000000 P 50VG00FM

F0MCAP01     EQ      384  -1.000000000 P F0TMAR01    1.000000000 P F0C3P01M    1.000000000 P F0C4P01M    1.000000000 P F0NAP01M
  RHS LO:  0.000000000    1.000000000 P F04AA01M    1.000000000 P F04BA01M    1.000000000 P F04CA01M    1.000000000 P F04DA01M
  RHS UP:  0.000000000    1.000000000 P F05AA01M    1.000000000 P F05BB01M    1.000000000 P F05CA01M    1.000000000 P F05CB01M
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FOMCAP02      EQ     385   -1.000000000 P FOTMAR02     1.000000000 P FOC3P02M     1.000000000 P FOC4P02M     1.000000000 P FONAP02M
  RHS LO:  0.000000000      1.000000000 P F04AA02M     1.000000000 P F04BA02M     1.000000000 P F04CA02M     1.000000000 P F04DA02M
  RHS UP:  0.000000000      1.000000000 P F05AA02M     1.000000000 P F05BB02M     1.000000000 P F05CA02M     1.000000000 P F05CB02M
                            1.000000000 P F05DA02M     1.000000000 P F05DBC2M

FOMCAP03      EQ     386   -1.000000000 P FOTMAR03     1.000000000 P FOC3P03M     1.000000000 P FOC4P03M     1.000000000 P FONAP03M
  RHS LO:  0.000000000      1.000000000 P F04AA03M     1.000000000 P F04BA03M     1.000000000 P F04CA03M     1.000000000 P F04DA03M
  RHS UP:  0.000000000      1.000000000 P F05AA03M     1.000000000 P F05BBC3M     1.000000000 P F05CA03M     1.000000000 P F05CB03M
                            1.000000000 P F05DA03M     1.000000000 P F05DBC3M

FOMCAP05      EQ     387   -1.000000000 P FOTMAR05     1.000000000 P FOC3P05M     1.000000000 P FOC4P05M     1.000000000 P FONAP05M
  RHS LO:  0.000000000      1.000000000 P F04AAC5M     1.000000000 P F04BA05M     1.000000000 P F04CA05M     1.000000000 P F04DA05M
  RHS UP:  0.000000000      1.000000000 P F05AA05M     1.000000000 P F05BB05M     1.000000000 P F05CA05M     1.000000000 P F05CB05M
                            1.000000000 P F05DA05M     1.000000000 P F05DB05M

10PCOST       EQ     388    -.300000000 L 10TPIP02     -.300000000 P 10NPIP02    -9.900000000 X 10TPIP03     -.580000000 X 10TPIP04
  RHS LO:  0.000000000     -9.900000000 X 10TPIP05    -12.00000000 L 10TPIPOF     1.000000000 P 10TPCST
  RHS UP:  0.000000000

20PCOST       EQ     389    -.270000000 L 20TPIP01     -.270000000 P 20NPIP01     -.990000000 L 20TPIP03     -.990000000 P 20NPIP03
  RHS LO:  0.000000000      -.580000000 L 20TPIP04    -9.900000000 X 20TPIP05    -12.00000000 L 20TPIPOF     1.000000000 P 20TPCST
  RHS UP:  0.000000000

30PCOST       EQ     390    -.420000000 L 30TPIP01     -.420000000 P 30NPIP01     -.500000000 P 30NPIP02     -.500000000 L 30TPIP02
  RHS LO:  0.000000000      -.600000000 L 30TPIP04    -1.000000000 L 30TPIP05    -12.00000000 X 30TPIPOF     1.000000000 P 30TPCST
  RHS UP:  0.000000000

40PCOST       EQ     391   -9.900000000 X 40TPIP01     -.580000000 L 40TPIP02     -.600000000 L 40TPIP03     -.600000000 L 40TPIP05
  RHS LO:  0.000000000    -12.00000000 X 40TPIPOF     1.000000000 P 40TPCST
  RHS UP:  0.000000000

50PCOST       EQ     392   -9.900000000 X 50TPIP01    -9.900000000 X 50TPIP02    -1.050000000 X 50TPIP03     -.800000000 X 50TPIP04
  RHS LO:  0.000000000    -12.00000000 L 50TPIPOF     1.000000000 P 50TPCST
  RHS UP:  0.000000000

FOPCOST       EQ     393   -1.100000000 X FOTPIP01     -.750000000 X FOTPIP02    -9.900000000 X FOTPIP03     -.500000000 X FOTPIP04
  RHS LO:  0.000000000      -.600000000 X FOTPIP05     1.000000000 P FOTPCST
  RHS UP:  0.000000000

10MCOST       EQ     394   -9.900000000 P 10TMAR02    -1.200000000 P 10TMAR03    -3.000000000 P 10TMAR05    -12.00000000 P 10TMAROF
  RHS LO:  0.000000000      1.000000000 P 10TMCST
  RHS UP:  0.000000000

20MCOST       EQ     395   -9.900000000 P 20TMAR01     -.600000000 P 20TMAR03    -9.900000000 P 20TMAR05    -12.00000000 P 20TMAROF
  RHS LO:  0.000000000      1.000000000 P 20TMCST
  RHS UP:  0.000000000

30MCOST       EQ     396   -1.200000000 P 30TMAR01    -1.800000000 P 30TMAR02    -2.500000000 P 30TMAR05    -12.00000000 P 30TMAROF
  RHS LO:  0.000000000      1.000000000 P 30TMCST
  RHS UP:  0.000000000

50MCOST       EQ     397   -3.000000000 P 50TMAR01    -9.900000000 P 50TMAR02    -3.500000000 P 50TMAR03    -12.00000000 P 50TMAROF
  RHS LO:  0.000000000      1.000000000 P 50TMCST
  RHS UP:  0.000000000

FOMCOST       EQ     398    -.300000000 P FOTMAR01     -.200000000 P FOTMAR02    -1.500000000 P FOTMAR03     -.400000000 P FOTMAR05
  RHS LO:  0.000000000      1.000000000 P FOTMCST
  RHS UP:  0.000000000

END EQUATION LISTING
```

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 District					
	I	II	III	IV	V	U.S. Total
Small refineries*						
Lower limit	180	700	700	420	500	
Upper limit	190	890	835	550	630	
1974 reported†	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 x 10^3 b/d.

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

‡More than 50 x 10^3 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
C_3 LPG		0.23 X
C_4 LPG		X
Naphtha	X	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	X	X
Jet-A	X	X
Kerosine	X	
Distillate fuel oil	X	0.332
Diesel		0.668 X
No. 2 fuel oil		X
Vacuum gas oil		X
Lubricants	X	
Wax	X	
Asphalt	X	
Road oil	X	
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		0.25 X
Toluene		0.10 X
Xylenes		0.5 X
C_9 aromatics		X
Coke	X	
Low-sulfur coke		X
High-sulfur coke		X

*Allocations were based on the following sources:

Gasoline--"National Petroleum News, Factbook Issue" (May 1975)
Distillates--Mineral Industry Surveys, "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)

	PAD District				
	1	2	3	4	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: Platt's Oil Price Handbook and Oil Manual, 1974 prices, McGraw-Hill, New York (1974)
Federal Energy Administration, "Monthly Energy Review" (July 1976)

Table C-4

SECTION A. 8

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

GASOLINE BLEND (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	814.5 (700)	2004.4 (1947)	2527.0 (260)	256.0 (225)	98[illegible].1 (883)	6582.0 (6365)
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1		(126)				
PIPE-LINE						
MARINE						
DISTRICT 2	(34)		(54)	(7)		
PIPE-LINE						
MARINE						
DISTRICT 3	1324.4 (1373)	214.6 (259)		(14)		
PIPE-LINE	1230.9	214.6				
MARINE	93.5					
DISTRICT 4		30.0 (14)	15.0		(36)	
PIPE-LINE		30.0	15.0			
MARINE						
DISTRICT 5	21.1					
PIPE-LINE						
MARINE	21.1					
TOTAL DOMESTIC RECEIPTS	1345.5 (1407)	244.6 (399)	15.0 (54)	(33)	(36)	1605.1 (1929)
PIPE-LINE	1230.9	244.6	15.0			1490.5
MARINE	114.6					114.6
DOMESTIC SHIPMENTS	(126)	(95)	1539.0 (1646)	45.0 (50)	21.1 (12)	
FOREIGN IMPORTS/-EXPORTS	(176)	(1)	(19)	(1)	(7)	
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	1345.5 (1407)	244.6 (399)	15.0 (54)	(33)	(36)	1605.1 (1929)
PIPE-LINE	1230.9	244.6	15.0			1490.5
MARINE	114.6					114.6
DISTRICT DEMAND	2160.0 (2160)	2249.0 (2249)	1003.0 (1003)	211.0 (211)	959.0 (959)	6582.0 (6582)

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

Table C-5

D. O. T. TRANSPORTATION SYSTEMS CENTER

SECTION A. 10

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

JET A JET FUEL (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	47.0(42)	177.4(163)	473.6(405)	25.0(16)	224.0(170)	947.0(796)
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1				5		
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	339.0(266)	24.6 (23)		10	7	
PIPE-LINE		24.6				
MARINE	339.0					
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	339.0 (266)	24.6 (23)		15	9	363.6 (313)
PIPE-LINE		24.6				24.6
MARINE	339.0					339.0
DOMESTIC SHIPMENTS	5		363.6 (306)	2		0.0
FOREIGN IMPORTS/-EXPORTS	79	5	9		47	
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	339.0(345)	24.6 (28)	9	15	9	363.6
PIPE-LINE		24.6				24.6
MARINE	339.0					339.0
DISTRICT DEMAND	386.0 (386)	202.0 (202)	110.0 (110)	25.0 (25)	224.0(224)	947.0(947)

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

Table C-6

SECTION 4. 13

U. S. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

MIDDLE DISTILLATE BLEND (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	360.7 (372.0)	748.8 (769.0)	1347.1 (1177.0)	181.1 (125.0)	183.7 (225.0)	2911.4 (2668.0)
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1		(32.0)				
PIPE-LINE						
MARINE						
DISTRICT 2	66.4 (3.0)		(15.0)	(1.0)		
PIPE-LINE	66.4					
MARINE						
DISTRICT 3	862.2 (731.0)	147.7 (86.0)		(2.0)	23.3 (19.0)	
PIPE-LINE	769.1	147.7			23.3	
MARINE	91.1					
DISTRICT 4					53.1	
PIPE-LINE					53.1	
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	926.6	147.7			76.3	1150.7
PIPE-LINE	835.5	147.7			76.3	1059.6
MARINE	91.1					91.1
DOMESTIC SHIPMENTS		66.4	1031.1	53.1		
FOREIGN IMPORTS/-EXPORTS	50.7 (257.0)	(1.0)	(15.0)		(7.0)	50.7
PIPE-LINE	0.0					0.0
MARINE	50.7					50.7
TOTAL SUPPLY MOVEMENTS	977.3	147.7			76.3	1201.3
PIPE-LINE	835.5	147.7			76.3	1059.6
MARINE	141.8					141.8
DISTRICT DEMAND	1338.[illegible] (1338.0)	88[illegible].[illegible] (879.0)	35[illegible].[illegible] (355.0)	128.0 (107.0)	26[illegible].[illegible] (260.0)	2962.0 (2939.0)

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

Table C-6 (Concluded)

D. O. T. TRANSPORTATION SYSTEMS CENTER

SECTION A. 6

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

RESID FUEL OIL (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	126.6 (154)	155.4 (180)	355.8 (362)	34.0 (34)	370.8 (340)	1062.6 (1070)
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	155.8 99	36			1	
PIPE-LINE						
MARINE	155.8				1	
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	155.8					
PIPE-LINE						
MARINE	155.8					
DOMESTIC SHIPMENTS			155.8 (136)	1		
FOREIGN IMPORTS/-EXPORTS	1417.6 (1459)	24.6 (22)	32		29.2 (59)	1471.4 (1572)
PIPE-LINE						
MARINE	1417.6	24.6			29.2	1471.4
TOTAL SUPPLY MOVEMENTS	1573.4 (1558)	24.6 (58)		1		1627.2
PIPE-LINE						
MARINE	1573.4	24.6				1627.2
DISTRICT DEMAND	1700 (1706)	200(2400	200. (252)	34.0(340	400 (392)	2534.0(2624)

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
A.	Refinery output, inter-PAD transfers, imports, and demand by product
B.	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

SECTION A. 1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 197- VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

C3 LPG (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	54.6	79.6	45.0	6.9	28.5	214.6
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	54.6	79.6	45.0	6.9	28.5	214.6

SECTION A. 2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

C4 LPG (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	19.1	17.9	13.4	1.6	10.5	62.7
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	19.1	17.9	13.4	1.6	10.5	62.7

SECTION A. 3

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

NAPHTHA (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT		29.1	45.5		25.5	100.2
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND		29.1	45.5		25.5	100.2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

REGULAR GASOLINE (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	212.9	820.4	753.6	77.5	273.6	2135.1
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	539.0	214.6				
PIPE-LINE	539.0	214.6				
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	539.0	214.6				753.6
PIPE-LINE	539.0	214.6				753.6
MARINE						
DOMESTIC SHIPMENTS			753.6			
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	539.0	214.6				753.6
PIPE-LINE	539.0	214.6				753.6
MARINE						
DISTRICT DEMAND	751.9	1035.0		77.5	273.6	2135.1

SECTION 6. 5

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

PREMIUM GASOLINE (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	128.6	519.1	285.3	25.6	135.2	1093.8
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4		25.6				
PIPE-LINE		25.6				
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS		25.6				25.6
PIPE-LINE		25.6				25.6
MARINE						
DOMESTIC SHIPMENTS				25.6		
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS		25.6				25.6
PIPE-LINE		25.6				25.6
MARINE						
DISTRICT DEMAND	128.6	544.7	285.3		[illegible]	1093.8

SECTION A. 6

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

LOW LEAD GASOLINE (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	223.7	356.5	692.0	76.4	253.1	1607.7
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	692.0					
PIPE-LINE	692.0					
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	692.0					692.0
PIPE-LINE	692.0					692.0
MARINE						
DOMESTIC SHIPMENTS			692.0			
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	692.0					692.0
PIPE-LINE	692.0					692.0
MARINE						
DISTRICT DEMAND	915.7	356.5		76.4	253.1	1607.7

SECTION A. 7

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

LEAD FREE GASOLINE (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	249.2	308.4	796.2	76.4	315.2	1745.4
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	93.5					
PIPE-LINE						
MARINE	93.5					
DISTRICT 4		4.4	15.0			
PIPE-LINE		4.4	15.0			
MARINE						
DISTRICT 5	21.1					
PIPE-LINE						
MARINE	21.1					
TOTAL DOMESTIC RECEIPTS	114.6	4.4	15.0			134.0
PIPE-LINE		4.4	15.0			19.4
MARINE	114.6					114.6
DOMESTIC SHIPMENTS			93.5	19.4	21.1	
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	114.6	4.4	15.0			134.0
PIPE-LINE		4.4	15.0			19.4
MARINE	114.6					114.6
DISTRICT DEMAND	363.6	312.8	717.7	57.0	294.1	1745.4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

JP-4 JET FUEL (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	7.7	45.1	67.8	18.2	42.6	181.2
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2	13.6					
PIPE-LINE	13.6					
MARINE						
DISTRICT 3	21.5					
PIPE-LINE						
MARINE	21.5					
DISTRICT 4					6.9	
PIPE-LINE					6.9	
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	35.1				6.9	42.0
PIPE-LINE	13.6				6.9	20.5
MARINE	21.5					21.5
DOMESTIC SHIPMENTS		13.6	21.5	6.9		
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	35.1				6.9	42.0
PIPE-LINE	13.6				6.9	20.5
MARINE	21.5					21.5
DISTRICT DEMAND	42.8	31.5	46.2	11.3	43.5	181.2

SECTION A. 11

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

DIESEL (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	95.6	232.3	552.1	133.9	113.2	1127.0
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	172.4	147.7				
PIPE-LINE	172.4	147.7				
MARINE						
DISTRICT 4					46.8	
PIPE-LINE					46.8	
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	172.4	147.7			46.8	366.9
PIPE-LINE	172.4	147.7			46.8	366.9
MARINE						
DOMESTIC SHIPMENTS			320.1	46.8		
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS	172.4	147.7			46.8	366.9
PIPE-LINE	172.4	147.7			46.8	366.9
MARINE						
TOTAL DISTRICT DEMAND	268.0	388.0	232.0	87.0	160.0	1127.0
LIGHT DIESEL	134.0	193.0	116.0	33.0	80.0	553.0
HEAVY DIESEL	134.0	195.0	116.0	54.0	80.0	574.0

SECTION A. 12

U. S. D. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

NO. 2 FUEL OIL (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	265.1	566.4	835.1	47.2	73.5	1784.3
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2	66.4					
PIPE-LINE	66.4					
MARINE						
DISTRICT 3	687.8				23.3	
PIPE-LINE	596.7				23.3	
MARINE	91.1					
DISTRICT 4					6.2	
PIPE-LINE					6.2	
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	754.2				29.5	763.7
PIPE-LINE	663.1				29.5	692.6
MARINE	91.1					91.1
DOMESTIC SHIPMENTS		66.4	711.1	6.2		
FOREIGN IMPORTS/-EXPORTS	50.7					53.7
PIPE-LINE	0.0					0.0
MARINE	50.7					50.7
TOTAL SUPPLY MOVEMENTS	834.9				29.5	834.4
PIPE-LINE	663.1				29.5	692.6
MARINE	141.8					141.8
DISTRICT DEMAND	1070.0	503.0	124.0	41.0	100.0	1835.0

SECTION A. 14

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

HI SULFUR NO. 6 (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	63.3	87.7	176.0	17.0	185.4	529.4
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	76.0					
PIPE-LINE						
MARINE	76.0					
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	76.0					76.0
PIPE-LINE						
MARINE	76.0					76.0
DOMESTIC SHIPMENTS			76.0			
FOREIGN IMPORTS/-EXPORTS	710.7	12.3			14.6	737.6
PIPE-LINE	0.0	0.0			0.0	0.0
MARINE	710.7	12.3			14.6	737.6
TOTAL SUPPLY MOVEMENTS	786.7	12.3			14.6	813.6
PIPE-LINE						
MARINE	786.7	12.3			14.6	813.6
DISTRICT DEMAND	850.0	100.0	100.0	17.0	200.0	1267.0

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

LO SULFUR NO. 6 (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	63.3	87.7	179.8	17.0	185.4	533.2
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3	79.8					
PIPE-LINE						
MARINE	79.8					
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS	79.8					79.8
PIPE-LINE						
MARINE	79.8					79.8
DOMESTIC SHIPMENTS			79.8			
FOREIGN IMPORTS/-EXPORTS	706.9	12.3			14.6	733.8
PIPE-LINE	0.0	0.0			0.0	0.0
MARINE	706.9	12.3			14.6	733.8
TOTAL SUPPLY MOVEMENTS	786.7	12.3			14.6	813.6
PIPE-LINE						
MARINE	786.7	12.3			14.6	813.6
DISTRICT DEMAND	850.0	100.0	100.0	17.0	200.0	1267.0

SECTION A. 16

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

LUBE STOCKS

(MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	39.5	32.9	122.8	1.3	13.4	216.0
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	39.5	32.9	122.8	1.3	13.4	216.0

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

ASPHALT AND ROAD OILS (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	58.9	134.8	134.3	29.0	67.9	424.9
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	58.9	134.8	134.3	29.0	67.9	424.9

SECTION A. 18

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

COKE (LO SULFUR) (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT			5.4	.1	1.4	6.9
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND			5.4	.1	1.4	6.9

SECTION A. 19

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

COKE (HI SULFUR) (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	5.9	25.2	19.3	2.4		52.3
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	5.9	25.2	19.3	2.4		52.3

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

COKE (CAL CRUDE)

(MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT					20.9	20.9
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND					20.9	20.9

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

BENZENE (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	1.8	3.8	16.3		1.7	23.6
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	1.8	3.8	16.3		1.7	23.6

SECTION A. 22

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

TOLUENE

(MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	1.2	2.6	27.6		4.1	35.5
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	1.2	2.6	27.6		4.1	35.5

SECTION A. 23

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

MIXED XYLENES (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	.9	5.2	29.0		3.6	39.7
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	.9	5.2	29.0		3.6	39.7

SECTION A. 24

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY PRODUCT

MISC. PRODUCTS (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
REFINERY OUTPUT	11.9	47.4	42.4		2.5	104.1
INTER-PAD MOVEMENTS FROM..						
DISTRICT 1						
PIPE-LINE						
MARINE						
DISTRICT 2						
PIPE-LINE						
MARINE						
DISTRICT 3						
PIPE-LINE						
MARINE						
DISTRICT 4						
PIPE-LINE						
MARINE						
DISTRICT 5						
PIPE-LINE						
MARINE						
TOTAL DOMESTIC RECEIPTS						
PIPE-LINE						
MARINE						
DOMESTIC SHIPMENTS						
FOREIGN IMPORTS/-EXPORTS						
PIPE-LINE						
MARINE						
TOTAL SUPPLY MOVEMENTS						
PIPE-LINE						
MARINE						
DISTRICT DEMAND	11.9	47.4	42.4		2.5	104.1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE Case 1

REFINERY INPUT/OUTPUT SUMMARY

P. A. D. DISTRICT

Thousands of barrels per calendar day(2)

	1	2	3	4	5	U.S.	IMPORT	EXPORT	TOTAL
INPUT									
SWEET CRUDE	196.0	[illegible]	2078.4	25.3	[illegible]	3483.7	(Note 1)		3483.7
SOUR CRUDE	1330.0	2698.8	3141.6	505.3		7646.4			7646.4
CALIF CRUDE					1400.0	1400.0			1400.0
ALASKAN CRUDE									
NATURAL GASOLINE	14.8	64.9	133.5	22.7	26.6	262.6			262.5
NORMAL BUTANE	8.9	46.3	54.8	3.3	26.0	139.1			139.1
ISOBUTANE	.5	46.3	50.5	2.7	9.9	109.6			109.8
TOTAL INPUT	1504.1	3556.3	3458.7	560.0	1962.5	13641.6			13641.6
OUTPUT									
C3 LPG	54.6	79.6	45.0	6.8	28.5	214.6			214.6
C4 LPG	19.1	17.9	13.4	1.6	10.5	62.7			62.7
NAPHTHA		29.1	45.5		25.5	100.2			100.2
REGULAR GASOLINE	212.3	822.4	753.6	77.6	270.6	2135.1			2135.1
PREMIUM GASOLINE	128.6	519.1	285.3	25.6	135.2	1093.8			1093.8
LOW LEAD GASOLINE	223.7	356.6	692.0	76.4	259.1	1607.7			1607.7
LEAD FREE GASOLINE	249.2	308.4	796.2	76.4	315.2	1745.4			1745.4
JP-4 JET FUEL	7.7	45.1	67.8	18.2	42.0	181.2			181.2
JET A JET FUEL	47.0	177.4	473.6	25.0	224.0	947.0			947.0
DIESEL	35.6	232.3	552.1	133.9	113.2	1127.0			1127.0
NO. 2 FUEL OIL	265.1	566.4	835.1	47.2	73.5	1784.3	50.7		1835.0
HI SULFUR NO. 6	63.3	67.7	176.0	17.0	135.4	529.4	737.6		1267.0
LO SULFUR NO. 6	63.3	87.7	173.8	17.0	135.4	533.2	733.8		1267.0
LUBE STOCKS	39.5	32.9	122.8	1.3	19.4	216.0			216.0
ASPHALT AND ROAD OIL	58.9	134.8	134.3	29.0	67.9	424.9			424.9
COKE (LO SULFUR)			5.4	.1	1.4	6.9			6.9
COKE (HI SULFUR)	5.9	25.2	19.3	2.9		52.3			52.3
COKE (CAL CRUDE)					20.9	20.9			20.9
BENZENE	1.8	3.8	16.3		1.7	23.6			23.6
TOLUENE	1.2	2.6	27.6		4.1	35.5			35.5
MIXED XYLENES	.9	5.2	29.0		3.0	38.7			38.7
MISC. PRODUCTS	11.9	47.4	42.4		2.5	104.1			104.1
TOTAL OUTPUT	[illegible]	[illegible]	[illegible]	556.1	[illegible]	[illegible]	1522.1		14506.7
OUTPUT/INPUT,PCT	103.1	[illegible]	97.3	99.3	101.3	[illegible]			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.

SECTION B. 1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 1

	INTER-STATE RECEIPTS FROM									
	1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
C3 LPG									54.6	54.6
PIPE-LINE										
MARINE										
C4 LPG									19.1	19.1
PIPE-LINE										
MARINE										
NAPHTHA										
PIPE-LINE										
MARINE										
REGULAR GASOLINE			539.0			539.0		539.0	212.9	751.9
PIPE-LINE			539.0			539.0		539.0		
MARINE										
PREMIUM GASOLINE									128.6	128.6
PIPE-LINE										
MARINE										
LOW LEAD GASOLINE			692.0			692.0		692.0	223.7	915.7
PIPE-LINE			692.0			692.0		692.0		
MARINE										
LEAD FREE GASOLINE			93.5		21.1	114.6		114.6	249.2	363.8
PIPE-LINE										
MARINE			93.5		21.1	114.6		114.6		
JP-4 JET FUEL		13.6	21.5			35.1		35.1	7.7	42.8
PIPE-LINE		13.6				13.6		13.6		
MARINE			21.5			21.5		21.5		
JET A JET FUEL			339.0			339.0		339.0	47.0	386.0
PIPE-LINE										
MARINE			339.0			339.0		339.0		
DIESEL			172.4			172.4		172.4	95.6	134.0
PIPE-LINE			172.4			172.4		172.4		
MARINE										
NO. 2 FUEL OIL		66.4	687.8			754.2	50.7	804.9	265.1	1070.0
PIPE-LINE		66.4	596.7			663.1		663.1		
MARINE			91.1			91.1	50.7	141.8		

SECTION N. 2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 1

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
HI SULFUR NO. 6			76.0			76.0	710.7	786.7	63.3	850.0
PIPE-LINE										
MARINE			76.0			76.0	710.7	786.7		
LO SULFUR NO. 6			79.8			79.8	706.9	786.7	63.3	850.0
PIPE-LINE										
MARINE			79.8			79.8	706.9	786.7		
LUBE STOCKS									39.5	39.5
PIPE-LINE										
MARINE										
ASPHALT AND ROAD OIL									58.9	58.9
PIPE-LINE										
MARINE										
COKE (LO SULFUR)										
PIPE-LINE										
MARINE										
COKE (HI SULFUR)									5.9	5.9
PIPE-LINE										
MARINE										
COKE (CAL CRUDE)										
PIPE-LINE										
MARINE										
BENZENE									1.8	1.8
PIPE-LINE										
MARINE										
TOLUENE									1.2	1.2
PIPE-LINE										
MARINE										
MIXED XYLENES									.9	.9
PIPE-LINE										
MARINE										
MISC. PRODUCTS									11.9	11.9
PIPE-LINE										
MARINE										
TOTAL IMPORTS		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5686.6
PIPE-LINE		[illegible]	[illegible]			[illegible]		[illegible]		
MARINE			[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		

SECTION 9. 3

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 2

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
C3 LPG									79.6	79.6
PIPE-LINE										
MARINE										
C4 LPG									17.9	17.9
PIPE-LINE										
MARINE										
NAPHTHA									29.1	29.1
PIPE-LINE										
MARINE										
REGULAR GASOLINE			214.6			214.6		214.6	820.4	1035.0
PIPE-LINE			214.6			214.6		214.6		
MARINE										
PREMIUM GASOLINE				25.6		25.6		25.6	519.1	544.7
PIPE-LINE				25.6		25.6		25.6		
MARINE										
LOW LEAD GASOLINE									356.5	356.5
PIPE-LINE										
MARINE										
LEAD FREE GASOLINE				4.4		4.4		4.4	308.4	312.8
PIPE-LINE				4.4		4.4		4.4		
MARINE										
JP-4 JET FUEL									45.1	31.5
PIPE-LINE										
MARINE										
JET A JET FUEL			24.6			24.6		24.6	177.4	202.0
PIPE-LINE			24.6			24.6		24.6		
MARINE										
DIESEL			147.7			147.7		147.7	232.3	190.0
PIPE-LINE			147.7			147.7		147.7		
MARINE										
NO. 2 FUEL OIL									566.4	500.0
PIPE-LINE										
MARINE										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 2

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
HI SULFUR NO. 6							12.3	12.3	87.7	100.0
PIPE-LINE										
MARINE							12.3	12.3		
LO SULFUR NO. 6							12.3	12.3	87.7	100.0
PIPE-LINE										
MARINE							12.3	12.3		
LUBE STOCKS									32.9	32.9
PIPE-LINE										
MARINE										
ASPHALT AND ROAD OIL									134.8	134.8
PIPE-LINE										
MARINE										
COKE (LO SULFUR)										
PIPE-LINE										
MARINE										
COKE (HI SULFUR)									25.2	25.2
PIPE-LINE										
MARINE										
COKE (CAL CRUDE)										
PIPE-LINE										
MARINE										
BENZENE									3.8	3.8
PIPE-LINE										
MARINE										
TOLUENE									2.6	2.6
PIPE-LINE										
MARINE										
MIXED XYLENES									5.2	5.2
PIPE-LINE										
MARINE										
MISC. PRODUCTS									47.4	47.4
PIPE-LINE										
MARINE										
TOTAL IMPORTS			[illegible]	[illegible]		[illegible]	[illegible]	+41.5	3579.6	3751.1
PIPE-LINE			[illegible]	[illegible]		[illegible]		416.9		
MARINE							[illegible]	[illegible]		

SECTION B. 5

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 3

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
C3 LPG									45.0	45.0
PIPE-LINE										
MARINE										
C4 LPG									13.4	13.4
PIPE-LINE										
MARINE										
NAPHTHA									45.5	45.5
PIPE-LINE										
MARINE										
REGULAR GASOLINE									753.6	
PIPE-LINE										
MARINE										
PREMIUM GASOLINE									285.3	285.3
PIPE-LINE										
MARINE										
LOW LEAD GASOLINE									692.0	
PIPE-LINE										
MARINE										
LEAD FREE GASOLINE				15.0		15.0		15.0	796.2	717.7
PIPE-LINE				15.0		15.0		15.0		
MARINE										
JP-4 JET FUEL									67.8	46.2
PIPE-LINE										
MARINE										
JET A JET FUEL									473.6	110.0
PIPE-LINE										
MARINE										
DIESEL									552.1	116.0
PIPE-LINE										
MARINE										
NO. 2 FUEL OIL									835.1	124.0
PIPE-LINE										
MARINE										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 3

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
HI SULFUR NO. 6									176.0	100.0
PIPE-LINE										
MARINE										
LO SULFUR NO. 6									179.8	100.0
PIPE-LINE										
MARINE										
LUBE STOCKS									122.8	122.8
PIPE-LINE										
MARINE										
ASPHALT AND ROAD OIL									134.3	134.3
PIPE-LINE										
MARINE										
COKE (LO SULFUR)									5.4	5.4
PIPE-LINE										
MARINE										
COKE (HI SULFUR)									18.3	18.3
PIPE-LINE										
MARINE										
COKE (CAL CRUDE)										
PIPE-LINE										
MARINE										
BENZENE									16.3	16.3
PIPE-LINE										
MARINE										
TOLUENE									27.6	27.6
PIPE-LINE										
MARINE										
MIXED XYLENES									29.0	29.0
PIPE-LINE										
MARINE										
MISC. PRODUCTS									42.4	42.4
PIPE-LINE										
MARINE										
TOTAL IMPORTS				15.0		[illegible]		15.0	5311.5	2699.4
PIPE-LINE										
MARINE				15.0		[illegible]		15.0		

SECTION B. 7

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 4

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
C3 LPG									6.8	6.8
PIPE-LINE										
MARINE										
C4 LPG									1.6	1.6
PIPE-LINE										
MARINE										
NAPHTHA										
PIPE-LINE										
MARINE										
REGULAR GASOLINE									77.6	77.6
PIPE-LINE										
MARINE										
PREMIUM GASOLINE									25.6	
PIPE-LINE										
MARINE										
LOW LEAD GASOLINE									76.4	76.4
PIPE-LINE										
MARINE										
LEAD FREE GASOLINE									76.4	57.0
PIPE-LINE										
MARINE										
JP-4 JET FUEL									18.2	11.3
PIPE-LINE										
MARINE										
JET A JET FUEL									25.0	25.0
PIPE-LINE										
MARINE										
DIESEL									133.9	33.0
PIPE-LINE										
MARINE										
NO. 2 FUEL OIL									47.2	41.0
PIPE-LINE										
MARINE										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 4

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
HI SULFUR NO. 6									17.0	17.0
PIPE-LINE										
MARINE										
LO SULFUR NO. 6									17.0	17.0
PIPE-LINE										
MARINE										
LUBE STOCKS									1.3	1.3
PIPE-LINE										
MARINE										
ASPHALT AND ROAD OIL									29.0	29.0
PIPE-LINE										
MARINE										
COKE (LO SULFUR)									.1	.1
PIPE-LINE										
MARINE										
COKE (HI SULFUR)									2.9	2.9
PIPE-LINE										
MARINE										
COKE (CAL CRUDE)										
PIPE-LINE										
MARINE										
BENZENE										
PIPE-LINE										
MARINE										
TOLUENE										
PIPE-LINE										
MARINE										
MIXED XYLENES										
PIPE-LINE										
MARINE										
MISC. PRODUCTS										
PIPE-LINE										
MARINE										
TOTAL IMPORTS									556.1	397.1
PIPE-LINE										
MARINE										

SECTION B. 9

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 5

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXPORT	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
C3 LPG									28.5	28.5
PIPE-LINE										
MARINE										
C4 LPG									10.5	10.5
PIPE-LINE										
MARINE										
NAPHTHA									25.5	25.5
PIPE-LINE										
MARINE										
REGULAR GASOLINE									270.6	270.6
PIPE-LINE										
MARINE										
PREMIUM GASOLINE									135.2	135.2
PIPE-LINE										
MARINE										
LOW LEAD GASOLINE									259.1	259.1
PIPE-LINE										
MARINE										
LEAD FREE GASOLINE									315.2	294.1
PIPE-LINE										
MARINE										
JP-4 JET FUEL				6.9		6.9		6.9	42.6	49.5
PIPE-LINE				6.9		6.9		6.9		
MARINE										
JET A JET FUEL									224.0	224.0
PIPE-LINE										
MARINE										
DIESEL				46.8		46.8		46.8	113.2	80.0
PIPE-LINE				46.8		46.8		46.8		
MARINE										
NO. 2 FUEL OIL			23.3	6.2		29.5		29.5	70.5	100.0
PIPE-LINE			23.3	6.2		29.5		29.5		
MARINE										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUPPLY DEMAND BALANCE BY DISTRICT

DISTRICT 5

	INTER-STATE RECEIPTS FROM 1	2	3	4	5	TOTAL DOMESTIC	IMPORT /-EXP...	TOTAL MOVEMENTS	DISTRICT OUTPUT	DISTRICT DEMAND
HI SULFUR NO. 6							14.6	14.6	185.4	200.0
PIPE-LINE										
MARINE							14.6	14.6		
LO SULFUR NO. 6							14.6	14.6	185.4	200.0
PIPE-LINE										
MARINE							14.6	14.6		
LUBE STOCKS									19.4	19.4
PIPE-LINE										
MARINE										
ASPHALT AND ROAD OIL									67.9	67.9
PIPE-LINE										
MARINE										
COKE (LO SULFUR)									1.4	1.4
PIPE-LINE										
MARINE										
COKE (HI SULFUR)										
PIPE-LINE										
MARINE										
COKE (CAL CRUDE)									20.9	20.9
PIPE-LINE										
MARINE										
BENZENE									1.7	1.7
PIPE-LINE										
MARINE										
TOLUENE									4.1	4.1
PIPE-LINE										
MARINE										
MIXED XYLENES									3.6	3.6
PIPE-LINE										
MARINE										
MISC. PRODUCTS									2.5	2.5
PIPE-LINE										
MARINE										
TOTAL IMPORTS			23.3	60.0		93.3	29.2	112.4	1987.2	1998.5
PIPE-LINE			23.3	60.0		83.3		83.3		
MARINE							29.2	29.2		

SECTION B. 11

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

PRODUCT CONSUMPTION SUMMARY

P. A. D. DISTRICT

	1	2	3	4	5	U.S.	EXPORTS	EXP TOT	TOTAL
C3 LPG	54.5	73.6	45.0	6.8	28.5	214.6			214.5
C4 LPG	19.1	17.9	13.4	1.6	10.5	62.7			62.7
NAPHTHA		33.1	45.5		25.5	100.2			100.2
REGULAR GASOLINE	731.9	1035.0		77.6	270.6	2135.1			2135.1
PREMIUM GASOLINE	128.6	544.7	285.3		135.2	1093.8			1093.8
LOW LEAD GASOLINE	915.7	356.5		76.4	259.1	1627.7			1627.7
LEAD FREE GASOLINE	363.8	312.9	717.7	57.0	294.1	1745.4			1745.4
JP-4 JET FUEL	42.9	31.5	46.2	11.3	49.5	181.2			181.2
JET A JET FUEL	396.3	202.0	110.0	25.3	224.0	947.0			947.0
DIESEL	268.0	380.0	232.0	87.0	160.0	1127.0			1127.0
NO. 2 FUEL OIL	1970.0	500.0	124.0	41.0	100.0	1935.0			1835.0
HI SULFUR NO. 5	850.0	100.0	100.0	17.0	200.0	1267.0			1267.0
LO SULFUR NO. 6	950.0	100.0	100.0	17.0	200.0	1267.0			1267.0
LUBE STOCKS	39.5	32.0	122.8	1.3	13.4	216.0			216.0
ASPHALT AND ROAD OIL	53.3	134.9	134.3	29.0	67.4	424.9			424.9
COKE (LO SULFUR)			5.4	.1	1.4	6.9			6.9
COKE (HI SULFUR)	5.3	25.2	18.3	2.9		52.3			52.3
COKE (CAL CRUDE)					20.9	20.9			20.9
BENZENE	1.8	3.8	16.3		1.7	23.6			23.6
TOLUENE	1.2	2.6	27.6		4.1	35.5			35.5
MIXED XYLENES	.9	5.2	29.0		3.6	38.7			38.7
MISC. PRODUCTS	11.3	47.4	42.4		2.5	104.1			104.1
TOTAL	5820.6	3941.1	2215.4	451.1	2079.5	14506.7			14506.7

SECTION C. 1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY CAPACITY UTILIZATION (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
LARGE REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
SOUR CRUDE						
BASE CASE		2698.8				2698.8
HIGH CONV	1300.0		2950.0			4250.0
LOW CONV						
SUBTOTAL	1300.0	2698.8	2950.0			6949.8
CALIF CRUDE						
BASE CASE						
HIGH CONV					1199.7	1198.7
LOW CONV					201.3	201.3
SUBTOTAL					1400.0	1400.0
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR LARGE REFINERY	1300.0	2699.8	2950.0		1400.0	8348.8
MED REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV			1378.4			1378.4
SUBTOTAL			1378.4			1378.4
SOUR CRUDE						
BASE CASE						
HIGH CONV			191.6			191.6
LOW CONV						
SUBTOTAL			191.6			191.6

SECTION C. 2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY CAPACITY UTILIZATION (MBPD)

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
MED REFINERY						
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR MED REFINERY			1570.0			1570.0
SMALL REFINERY						
SWEET CRUDE						
BASE CASE		700.0	700.0		500.0	1900.0
HIGH CONV				25.3		25.3
LOW CONV	180.0					180.0
SUBTOTAL	180.0	700.0	700.0	25.3	500.0	2105.3
SOUR CRUDE						
BASE CASE						
HIGH CONV				49.1		49.1
LOW CONV				456.8		456.8
SUBTOTAL				505.9		505.9
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR SMALL REFINERY	180.0	700.0	700.0	531.2	500.0	2611.3
GRAND TOTAL	1480.0	3398.8	5220.0	531.2	1900.0	12530.1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY CAPACITY UTILIZATION (MBPD)

PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS (PAD)

INCREMENTAL PROCESSES	1	2	3	4	5	U.S.
DIESEL						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
TOTAL FOR DIESEL						
DESULFURIZATION						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
TOTAL FOR DESULFURIZATION						

SECTION D. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

UTILITY SUMMARY

PETROLEUM ADMINSTRATION FOR DEFENSE DISTRICTS (PAD)

	1	2	3	4	5	U.S.
ELEC. PWR (1000KWH/D)	5739.4	13904.1	19730.0	1714.9	10638.2	51866.5
FUEL REQD. (1000FOEB/D)	76.2	190.7	305.7	28.5	121.2	722.2
ENERGY CONS. (1000FOEB/D	87.0	216.9	342.8	31.7	141.3	819.7
LABOR (NO. EMPLOYEES)	7406.0	16994.2	26130.0	2656.3	9505.0	62650.5
OPER COSTS (M$/D)	190.3	521.5	592.7	54.7	215.6	1575.9
INVESTMENTS (MM$)						

SECTION D. 1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ELEC. PWR (1000KWH/D)

	1	2	3	4	5	U.S.
LARGE REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
SOUR CRUDE						
BASE CASE		12063.8				12063.8
HIGH CONV	5391.2		12977.3			18368.6
LOW CONV						
SUBTOTAL	5391.2	12063.8	12977.3			30432.4
CALIF CRUDE						
BASE CASE						
HIGH CONV					8440.1	8440.1
LOW CONV					1182.0	1182.0
SUBTOTAL					9622.1	9622.1
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR LARGE REFINERY	5391.2	12063.8	12977.3		9622.1	40054.5
MED REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV			4360.8			4360.8
SUBTOTAL			4360.8			4360.8

SECTION D. 2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ELEC. PWR (1000KWH/D)

	1	2	3	4	5	U.S.
MED REFINERY						
SOUR CRUDE						
BASE CASE						
HIGH CONV			653.8			653.8
LOW CONV						
SUBTOTAL			653.8			653.8
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR MED REFINERY			5014.5			5014.5
SMALL REFINERY						
SWEET CRUDE						
BASE CASE		1843.3	1738.1		1076.1	4654.5
HIGH CONV				74.1		74.1
LOW CONV	368.2					368.2
SUBTOTAL	368.2	1843.3	1738.1	74.1	1076.1	5396.7
SOUR CRUDE						
BASE CASE						
HIGH CONV				160.1		160.1
LOW CONV				1480.7		1480.7
SUBTOTAL				1640.8		1640.8

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ELEC. PWR (1000KWH/D)

	1	2	3	4	5	U.S.
SMALL REFINERY						
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR SMALL REFINERY	368.2	1840.3	1738.1	1714.9	1075.1	6737.5
INCREMENTAL PROCESSES						
DIESEL						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
DESULFURIZATION						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
UTILITY TOTAL	5759.39	13994.13	19729.98	1714.95	10039.17	51806.52

SECTION D. 4

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ENERGY CONSUMPTION (FOEB/D)

	1	2	3	4	5	U.S.
LARGE REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
SOUR CRUDE						
BASE CASE		157.8				157.8
HIGH CONV	70.8		186.1			256.9
LOW CONV						
SUBTOTAL	70.8	157.8	186.1			414.7
CALIF CRUDE						
BASE CASE						
HIGH CONV					87.5	87.5
LOW CONV					13.5	13.5
SUBTOTAL					100.9	100.9
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR LARGE REFINERY	70.8	157.8	186.1		100.9	515.6
MED REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV			78.5			78.5
SUBTOTAL			78.5			78.5

SECTION D. 5

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF FUEL REQD. (1000FOEB/D)

	1	2	3	4	5	U.S.
MED REFINERY						
SOUR CRUDE						
BASE CASE						
HIGH CONV			11.0			11.0
LOW CONV						
SUBTOTAL			11.0			11.0
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR MED REFINERY			89.5			89.5
SMALL REFINERY						
SWEET CRUDE						
BASE CASE		32.9	30.0		20.3	83.2
HIGH CONV				1.4		1.4
LOW CONV	5.4					5.4
SUBTOTAL	5.4	32.9	30.0	1.4	20.3	90.0
SOUR CRUDE						
BASE CASE						
HIGH CONV				2.8		2.8
LOW CONV				24.3		24.3
SUBTOTAL				27.1		27.1

SECTION D. 6

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF FUEL REQD. (1000FOEB/D)

	1	2	3	4	5	U.S.
SMALL REFINERY						
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR SMALL REFINERY	5.4	32.9	30.0	28.5	20.3	117.0
INCREMENTAL PROCESSES						
DIESEL						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
DESULFURIZATION						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
UTILITY TOTAL	76.15	190.70	305.66	28.46	121.18	722.15

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ENERGY CONS. (10 FOE9/D)

	1	2	3	4	5	U.S.
LARGE REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
SOUR CRUDE						
BASE CASE		180.6				180.6
HIGH CONV	80.9		210.6			291.5
LOW CONV						
SUBTOTAL	80.9	180.6	210.6			472.1
CALIF CRUDE						
BASE CASE						
HIGH CONV					103.3	103.3
LOW CONV					15.7	15.7
SUBTOTAL					119.0	119.0
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR LARGE REFINERY	80.9	180.6	210.6		119.0	591.1
MED REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV			86.7			86.7
SUBTOTAL			86.7			86.7

SECTION D. 8

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ENERGY CONS. (1000FOEB/D)

	1	2	3	4	5	U.S.
MED REFINERY						
SOUR CRUDE						
BASE CASE						
HIGH CONV			12.2			12.2
LOW CONV						
SUBTOTAL			12.2			12.2
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR MED REFINERY			98.9			98.9
SMALL REFINERY						
SWEET CRUDE						
BASE CASE		36.4	33.3		22.3	91.9
HIGH CONV				1.5		1.5
LOW CONV	6.1					6.1
SUBTOTAL	6.1	36.4	33.3	1.5	22.3	99.5
SOUR CRUDE						
BASE CASE						
HIGH CONV				3.1		3.1
LOW CONV				27.1		27.1
SUBTOTAL				30.2		30.2

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF ENERGY CONS. (1000FOEB/D)

	1	2	3	4	5	U.S.
SMALL REFINERY						
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR SMALL REFINERY	6.1	36.4	33.3	31.7	22.3	129.7
INCREMENTAL PROCESSES						
DIESEL						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
DESULFURIZATION						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
UTILITY TOTAL	46.[illegible]	216.94	342.84	31.5[illegible]	141.27	8[illegible].72

SECTION D. 1J

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF LABOR (NO. EMPLOYEES)

	1	2	3	4	5	U.S.
LARGE REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
SOUR CRUDE						
BASE CASE		13494.2				13494.2
HIGH CONV	6500.0		14750.0			21250.0
LOW CONV						
SUBTOTAL	6500.0	13494.2	14750.0			34744.2
CALIF CRUDE						
BASE CASE						
HIGH CONV					5993.4	5993.4
LOW CONV					1006.6	1006.6
SUBTOTAL					7000.0	7000.0
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR LARGE REFINERY	6500.0	13494.2	14750.0		7000.0	41744.2
MED REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV			6592.1			6892.1
SUBTOTAL			6892.1			6892.1

SECTION D. 11

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF LABOR (NO. EMPLOYEES)

	1	2	3	4	5	U.S.
MED REFINERY						
SOUR CRUDE						
BASE CASE						
HIGH CONV			957.9			957.9
LOW CONV						
SUBTOTAL			957.9			957.9
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR MED REFINERY			7850.0			7850.0
SMALL REFINERY						
SWEET CRUDE						
BASE CASE		3500.0	3500.0		2500.0	9500.0
HIGH CONV				126.6		126.6
LOW CONV	900.0					900.0
SUBTOTAL	900.0	3500.0	3500.0	126.6	2500.0	10526.6
SOUR CRUDE						
BASE CASE						
HIGH CONV				245.6		245.6
LOW CONV				2284.1		2284.0
SUBTOTAL				2529.7		2529.7

SECTION D. 12

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF LABOR (NO. EMPLOYEES)

	1	2	3	4	5	U.S.
SMALL REFINERY						
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR SMALL REFINERY	900.[illegible]	3500.0	3500.0	2656.3	2500.0	13056.3
INCREMENTAL PROCESSES						
DIESEL						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
DESULFURIZATION						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
UTILITY TOTAL	74[illegible].0	16994.22	2[illegible]	[illegible].23	[illegible]	626[illegible].47

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 197- VALIDATION CASE

SUMMARY OF OPER COSTS (M$/D)

	1	2	3	4	5	U.S.
LARGE REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
SOUR CRUDE						
BASE CASE		442.6				442.6
HIGH CONV	177.3		357.8			535.2
LOW CONV						
SUBTOTAL	177.3	442.6	357.8			977.8
CALIF CRUDE						
BASE CASE						
HIGH CONV					173.6	173.6
LOW CONV					21.2	21.2
SUBTOTAL					194.8	194.8
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR LARGE REFINERY	177.3	442.6	357.8		194.8	1172.6
MED REFINERY						
SWEET CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV			135.9			135.9
SUBTOTAL			135.9			135.9

SECTION D. 14

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF OPER COSTS (M$/D)

	1	2	3	4	5	U.S.
MED REFINERY						
SOUR CRUDE						
BASE CASE						
HIGH CONV			20.8			20.8
LOW CONV						
SUBTOTAL			20.8			20.8
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR MED REFINERY			156.7			156.7
SMALL REFINERY						
SWEET CRUDE						
BASE CASE		78.9	78.2		21.9	178.9
HIGH CONV				3.0		3.0
LOW CONV	13.0					13.0
SUBTOTAL	13.0	78.9	78.2	3.0	21.9	195.0
SOUR CRUDE						
BASE CASE						
HIGH CONV				6.4		6.4
LOW CONV				45.3		45.3
SUBTOTAL				51.7		51.7

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

SUMMARY OF OPEP COSTS (M$/D)

	1	2	3	4	5	U.S.
SMALL REFINERY						
CALIF CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
ALASKAN CRUDE						
BASE CASE						
HIGH CONV						
LOW CONV						
SUBTOTAL						
TOTAL FOR SMALL REFINERY	13.0	78.9	78.2	54.7	21.9	246.6
INCREMENTAL PROCESSES						
DIESEL						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
DESULFURIZATION						
HYDROCRACKING						
EXIST. HC FOR DSL						
HYDROTREATING						
GASO DESULF						
DIESEL DESULF						
SUBTOTAL						
UTILITY TOTAL	190.33	521.50	592.72	54.69	216.64	1575.88

SECTION E. 1

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

	10CALBA	10CALHC	10CALLC	10CASBA	10CASHC	10CASLC	10CBLBA	10CBLLC	10CBLHC	20CALBA
INPUT										
SWEET CRUDE	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00				-100.00
SOUR CRUDE							-100.00	-100.00	-100.00	
CALIF CRUDE										
ALASKAN CRUDE										
NATURAL GASOLINE	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.88
ISOBUTANE	-.31		-.29	-.25	-.25	-.25	-.28	-.60		-1.35
NORMAL BUTANE	-.60	-.57	-.60	-.60	-.60	-.60	-.60	-.60	-.60	-1.35
TOTAL	-101.91	-101.57	-101.89	-101.85	-101.85	-101.85	-101.88	-102.20	-101.60	-104.58
OUTPUT										
C3 LPG	2.74	3.40	2.74	1.45	1.45	1.45	3.40	3.04	4.00	2.48
C4 LPG	.86	1.50	.86	.01	.01	.01	.71	.86	1.47	.55
NAPHTHA	.34	.34	.34							1.09
REGULAR GASOLINE	13.35	14.82	13.83	11.50	9.13	8.45	14.60	14.97	15.21	21.11
PREMIUM GASOLINE	14.60	4.94	4.61	7.50	3.04	2.82	23.40	4.99	9.50	16.32
LOW LEAD GASOLINE	7.70	14.82	13.83	4.90	9.13	8.45	9.60	14.97	16.04	9.15
LEAD FREE GASOLINE	5.60	14.82	13.83	4.20	9.13	8.45	8.80	14.97	18.00	8.91
JP-4 JET FUEL	.70	.70	.70	1.00	1.00	1.00	.70	.45	.45	1.36
JET A JET FUEL	3.20	3.20	3.21	5.00	5.00	3.00	3.20	2.00	3.20	5.45
DIESEL	9.70	9.70	14.60	15.00	15.00	17.00	6.30	21.05	5.00	7.88
NO. 2 FUEL OIL	19.50	19.50	19.51	17.50	15.50	17.80	17.71	12.70	17.93	15.86
HI SULFUR NO. 5	6.10	6.10	6.11	7.00	7.00	7.00	3.90	3.90	3.90	2.77
LO SULFUR NO. 6	5.26	3.90	3.90	7.00	7.00	7.00	3.90	3.90	3.93	2.77
LUBE STOCKS	1.20	1.20	1.20	13.30	13.30	13.35	1.20	1.20	1.20	1.52
ASPHALT AND ROAD OIL	3.70	3.70	3.70	3.56	3.50	3.52	5.82	4.60	4.04	3.06
COKE (LO SULFUR)	.36	.36	.36							.61
COKE (HI SULFUR)							.45	.45	.45	
COKE (CAL CRUDE)										
BENZENE	.14						.14	.13	.14	.14
TOLUENE	.10						.10	.10	.10	.10
MIXED XYLENES	.07						.19	.19	.07	.07
MISC. PRODUCTS	.94	.94	.74	.82	.82	.82	.46	.27	.80	2.46
TOTAL	102.16	103.94	104.07	99.68	100.01	100.07	104.52	103.94	105.40	103.66
INPUT-OUTPUT	.25	2.37	2.18	-2.17	-1.84	-1.78	2.64	1.74	3.80	-.92
OPERATING COST FACTORS										
ELEC. PWR (1000KWH/D	344.20	353.15	335.62	210.66	214.70	204.53	403.00	392.84	414.71	408.00
FUEL REQD. (1000FOEB	5.07	5.11	5.01	3.08	3.14	2.99	5.42	5.01	5.44	5.62
ENERGY CONS. (1000FO	5.72	5.69	5.65	3.49	3.55	3.36	6.18	5.74	6.22	6.39
LABOR (NO. EMPLOYEES	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
OPER COSTS (M$/D)	14.76	8.99	11.60	7.23	7.23	7.23	16.03	11.31	13.64	14.58
INVESTMENTS (MM$)										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

	20CALHC	20CALLC	20CASBA	20CASHC	20CASLC	20CCBLBA	20CBLLC	20CCBLHC	30CAMBA	30CAMLC
INPUT										
SWEET CRUDE	-100.00	-100.00	-100.00	-100.00	-100.00				-100.00	-100.00
SOUR CRUDE						-100.00	-100.00	-100.00		
CALIF CRUDE										
ALASKAN CRUDE										
NATURAL GASOLINE	-1.85	-1.85	-2.14	-2.14	-2.01	-1.85	-1.85	-1.85	-2.50	-2.50
ISOBUTANE	-1.33	-1.33	-1.48	-1.48	-1.39	-1.33	-1.33	-1.33	-1.00	-1.00
NORMAL BUTANE	-1.33	-1.33	-1.48	-1.48	-1.13	-1.33	-1.33	-1.33	-.15	
TOTAL	-104.51	-104.51	-105.10	-105.10	-104.53	-104.51	-104.51	-104.50	-103.65	-103.50
OUTPUT										
C3 LPG	2.44	2.44	1.97	2.30	1.85	2.44	2.44	2.44	.83	.83
C4 LPG	.54	.54	.49	.59	.46	.54	.44	.54	.25	.25
NAPHTHA	.88	.88				1.08	.88	.88	.88	.88
REGULAR GASOLINE	20.78	19.45	19.31	14.91	13.01	25.39	21.56	27.07	10.40	10.50
PREMIUM GASOLINE	16.07	16.07	12.20	4.97	4.34	16.67	16.07	16.07	9.95	3.53
LOW LEAD GASOLINE	9.31	7.20	8.37	14.91	13.01	11.64	7.20	13.24	5.50	10.50
LEAD FREE GASOLINE	13.31	9.54	7.27	14.91	13.01	9.54	9.54	12.40	3.70	10.50
JP-4 JET FUEL	1.34	1.09	1.27	1.27	1.20	1.34	1.09	1.09	1.90	1.30
JET A JET FUEL	5.36	4.37	4.01	4.01	.94	4.59	4.37	4.59	7.10	6.30
DIESEL	7.75	15.75	11.00	10.60	23.96	6.32	15.51	5.69	9.80	25.99
NO. 2 FUEL OIL	15.61	15.61	22.19	20.69	17.99	15.61	15.61	11.48	18.00	18.86
HI SULFUR NO. 6	1.78	2.24	3.89	3.54	3.65	2.24	2.24	1.78	4.30	2.80
LO SULFUR NO. 6	2.73	2.24	3.89	3.54	3.65	2.24	2.24	1.78	5.20	2.80
LUBE STOCKS	1.22	1.22				1.22	1.22	1.22	3.10	2.00
ASPHALT AND ROAD OIL	3.01	3.01	7.65	7.65	5.72	3.01	3.01	3.01	2.10	1.40
COKE (LO SULFUR)	.63	.61							.23	.23
COKE (HI SULFUR)						.94	.87	.94		
COKE (CAL CRUDE)										
BENZENE						.14	.14	.14	.53	.59
TOLUENE						.10	.10	.10	.69	.69
MIXED XYLENES						.19	.19	.07	.87	.87
MISC. PRODUCTS	2.72	1.40	1.37	1.51	1.29	1.40	1.40	1.40	2.63	2.17
TOTAL	105.19	106.[illegible]	104.8[illegible]	104.80	104.08	105.43	106.12	105.93	96.24	102.99
INPUT-OUTPUT	.65	2.1[illegible]	-.22	-.30	-.45	.92	1.69	1.42	-7.41	-.51
OPERATING COST FACTORS										
ELEC. PWR (1000KWH/D	[illegible]	[illegible]	262.9[illegible]	271.00	267.7[illegible]	[illegible]	424.00	465.00	320.[illegible]	316.36
FUEL REQD. (1000FOE/D	[illegible]	[illegible]	4.7[illegible]	4.44	[illegible]	[illegible]	[illegible]	6.09	5.63	5.70
ENERGY CONS. (1000FO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.64	6.97	6.30	6.29
LABOR (NO. EMPLOYEES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	500.00	500.00	500.00	500.00
OPER COSTS (M$/D)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14.9[illegible]	18.57	10.13	9.86
INVESTMENTS (M$)										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

	30CAMHC	30CALBA	30CALHC	30CALLC	30CASBA	30CASHC	30CASLC	30C9MBA	30C9MLC	30C9MHC
INPUT										
SWEET CRUDE	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00			
SOUR CRUDE								-100.00	-100.00	-100.00
CALIF CRUDE										
ALASKAN CRUDE										
NATURAL GASOLINE	-2.50	-2.50	-2.50	-2.50	-2.93	-2.81	-2.93	-2.50	-2.50	-2.50
ISOBUTANE	-.79	-.52	-.11	-.98	-.75	-.51	-.75	1.00	-1.00	-1.00
NORMAL BUTANE	-.16	-1.12	-1.13	-.58	-1.14	-1.19	-1.14	1.08		-1.32
TOTAL	-103.45	-104.14	-103.74	-104.06	-104.82	-104.51	-104.82	-100.42	-103.51	-104.82
OUTPUT										
C3 LPG	.83	.83	.83	.83	1.07	1.02	1.07	.83	.83	.83
C4 LPG	.25	.25	.25	.25	.30	.29	.30	.25	.25	.25
NAPHTHA	.88	.88	.88	.88	.92	.79	.80	.88	1.32	.88
REGULAR GASOLINE	11.15	21.11	14.76	12.30	15.00	11.70	10.63	21.19	11.69	14.61
PREMIUM GASOLINE	3.72	15.90	4.92	4.10	9.80	3.69	3.54	15.90	3.99	4.87
LOW LEAD GASOLINE	11.15	6.10	14.76	12.30	6.23	11.70	10.63	5.50	11.69	14.61
LEAD FREE GASOLINE	14.15	6.10	17.73	12.30	4.10	11.70	10.63	6.10	11.75	17.88
JP-4 JET FUEL	1.30	1.90	1.30	1.30	1.29	1.24	1.29	1.30	1.90	1.30
JET A JET FUEL	7.30	7.10	6.30	6.30	6.33	6.07	6.33	6.30	6.30	6.30
DIESEL	11.80	9.80	9.80	29.65	10.91	10.91	23.42	6.50	19.85	6.50
NO. 2 FUEL OIL	18.00	18.00	18.00	12.00	20.25	20.25	13.11	12.00	12.00	12.00
HI SULFUR NO. 6	4.30	2.80	2.80	2.80	7.06	4.72	4.92	2.80	2.80	2.80
LO SULFUR NO. 6	4.20	2.80	2.80	2.80	7.06	4.72	4.92	4.20	4.80	4.80
LUBE STOCKS	6.20	2.00	2.00	2.00	2.81	2.70	2.81	7.10	6.30	8.67
ASPHALT AND ROAD OIL	1.40	1.40	1.40	1.40	6.56	6.30	6.56	2.20	2.20	2.20
COKE (LO SULFUR)	.23	.30	.47	.47	.32	.31	.32			
COKE (HI SULFUR)								.29	.29	.29
COKE (CAL CRUDE)										
BENZENE	.59	.24	.24	.24				.61	.73	.59
TOLUENE	.69	.57	.57	.57				.69	.69	.69
MIXED XYLENES	.87	.52	.52	.52				.87	1.33	.87
MISC. PRODUCTS	1.01	2.18			1.43	1.57	1.43	2.57		1.29
TOTAL	102.02	100.78	100.33	103.01	101.31	99.68	102.71	98.08	100.69	102.23
INPUT-OUTPUT	-1.43	-3.36	-3.41	-1.05	-3.51	-4.83	-2.11	-2.34	-2.82	-2.59
OPERATING COST FACTORS										
ELEC. PWR (1000KWH/D)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	248.30	377.07	335.07	341.25
FUEL REQ. (1000FOEB)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.29	5.37	4.54	5.73
ENERGY CONS. (1000FOEB)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.76	[illegible]	5.17	6.37
LABOR (NO. EMPLOYEES)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	500.00	500.00	500.00	500.00
OPER COSTS (M$/D)	[illegible]	[illegible]	10.42	[illegible]	11.17	[illegible]	11.17	[illegible]	7.35	10.85
INV STMENTS (M$)										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

	30CALBA	30CALLC	30CALHC	30COLHA	40CASBA	40CASHC	40CASLC	40CBSBA	40CBSLC	40CBSHC
INPUT										
SWEET CRUDE					-100.00	-100.00	-100.00			
SOUR CRUDE	-100.00	-100.00	-100.00					-100.00	-100.00	-100.00
CALIF CRUDE										
ALASKAN CRUDE				-100.00						
NATURAL GASOLINE	-2.50	-2.50	-2.50	-1.40	-7.30	-7.30	-5.84	-7.30	-3.79	-7.30
ISOBUTANE	-1.00	-.82	-1.00	-.46	-.45	-.06	-.33	-.34	-.59	
NORMAL BUTANE	-1.50	-1.16	-1.50	-1.50	-1.10	-.91		-1.26	-.59	-.67
TOTAL	-105.00	-104.49	-105.00	-103.36	-108.85	-108.27	-106.17	-108.30	-104.97	-107.97
OUTPUT										
C3 LPG	.83	.63	.83	1.50	1.06	1.28	1.28	1.28	1.29	1.28
C4 LPG	.25	.25	.25	1.00	.31	.31	.31	.31	.31	.31
NAPHTHA	.88	1.32	.88	.96						
REGULAR GASOLINE	25.67	12.90	16.13	11.40	27.03	17.30	12.15	34.62	14.00	18.87
PREMIUM GASOLINE	15.90	4.30	5.38	31.60	13.68	5.66	4.05	13.68	4.70	5.80
LOW LEAD GASOLINE	6.10	12.90	16.13	6.24	5.95	15.20	12.15	5.95	14.00	17.50
LEAD FREE GASOLINE	6.10	12.90	19.95	4.16	3.97	15.20	12.15	3.97	14.00	17.50
JP-4 JET FUEL	1.90	1.30	1.30	2.24	2.34	2.34	2.34	3.52	3.52	3.09
JET A JET FUEL	6.30	6.30	6.30	6.56	5.62	5.38	5.38	4.57	4.33	4.56
DIESEL	6.50	24.09	6.50	9.51	20.97	19.03	30.43	16.86	26.89	14.60
NO. 2 FUEL OIL	15.33	12.00	15.87	5.52	13.20	13.20	11.36	8.90	8.80	8.80
HI SULFUR NO. 6	2.80	2.80	2.60	7.28	3.20	3.20	3.20	3.20	3.20	3.20
LO SULFUR NO. 6	2.80	2.80	2.40	7.29	3.20	3.20	3.20	3.20	3.20	3.20
LUBE STOCKS	2.00	2.00	2.00		.24	.24	.24	.24	.24	.24
ASPHALT AND ROAD OIL	2.20	2.20	2.20	2.00	5.45	5.45	5.45	5.45	5.45	5.64
COKE (LO SULFUR)					.32	.40	.46			
COKE (HI SULFUR)	.60	.60	.60	1.55				.58	.58	.58
COKE (CAL CRUDE)										
BENZENE	.24	.25	.24	.14						
TOLUENE	.57	.58	.57	.29						
MIXED XYLENES	.69	.71	.52	.35						
MISC. PRODUCTS	2.34									
TOTAL	100.00	101.04	101.25	99.58	106.54	106.85	104.15	106.23	104.50	105.17
INPUT-OUTPUT	-5.00	-3.45	-3.75	-3.78	-2.31	-1.42	-2.02	-2.67	-.47	-2.80
OPERATING COST FACTORS										
ELEC. PWR (1000KWH/D	433.45	415.07	439.91	643.80	272.90	242.57	309.60	326.50	324.14	325.87
FUEL REQD. (1000FOEB	6.09	5.63	6.31	7.22	5.16	5.48	5.44	5.46	5.32	5.67
ENERGY CONS. (1000FO	6.90	6.43	7.14	8.43	5.65	[illegible]	6.02	6.07	5.93	6.28
LABOR (NO. EMPLOYEES	510.00	500.00	500.00	550.00	530.00	500.00	500.00	500.00	500.00	500.00
OPER COSTS (M$/D)	15.21	9.34	12.13	23.59	17.02	11.99	9.71	19.50	9.91	13.04
INVESTMENTS (M$)										

D. O. T. TRANSPORTATION SYSTEMS CENTER

REFINING INDUSTRY MODEL - 1974 VALIDATION CASE

REFINERY DATA INPUT

	50CALBA	50CALHC	50CALLC	50CASBA	50CASHC	50CASLC	50CCLBA	50CCLLC	50CCLHC	50CDLBA
INPUT										
SWEET CRUDE	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00				
SOUR CRUDE										
CALIF CRUDE							-100.00	-100.00	-100.00	
ALASKAN CRUDE										-100.00
NATURAL GASOLINE	-1.40	-1.40	-1.40	-1.40	-1.72	-1.40	-1.40	-1.40	-1.43	-1.40
ISOBUTANE	-.07		-1.00				-.60	-1.00	-.66	-.46
NORMAL BUTANE	-1.50	-1.17	-1.50	-1.00	-1.84	-.66	-1.50	-1.50	-1.50	-1.50
TOTAL	-102.97	-102.57	-103.90	-102.40	-103.56	-102.06	-103.50	-103.90	-103.56	-103.36
OUTPUT										
C3 LPG	1.50	1.50	1.50	1.50	1.84	1.23	1.50	1.50	1.50	1.50
C4 LPG	.91	1.00	.55	1.00	2.10	1.30	.31	.19	.43	1.00
NAPHTHA	.96	.64	.64	3.70	.63	3.76	.96	.50	.50	.96
REGULAR GASOLINE	13.56	16.66	13.32	4.50	7.99	5.86	16.30	15.40	18.11	11.40
PREMIUM GASOLINE	31.56	5.55	4.42	10.50	2.66	2.31	31.60	5.13	6.04	31.60
LOW LEAD GASOLINE	6.24	16.66	13.32	2.20	6.76	5.00	6.24	15.40	18.11	6.24
LEAD FREE GASOLINE	4.16	19.56	13.32	2.30	7.99	5.86	6.24	15.40	22.75	4.16
JP-4 JET FUEL	3.36	2.77	2.24	2.24	2.75	2.24	3.36	2.24	2.24	2.24
JET A JET FUEL	7.14	7.14	6.94	5.18	6.60	5.18	7.14	6.94	6.94	6.56
DIESEL	8.88	8.88	27.42	12.00	12.00	25.26	5.92	21.24	5.92	9.51
NO. 2 FUEL OIL	5.52	5.52	3.68	11.87	7.45	11.87	4.43	3.68	3.69	5.52
HI SULFUR NO. 6	7.28	7.28	7.28	16.70	14.75	16.00	7.28	7.28	7.29	7.28
LO SULFUR NO. 6	7.28	7.28	7.28	16.70	14.75	7.28	7.28	7.28	7.29	7.28
LUBE STOCKS	1.02	1.02	1.02	1.03	1.03	.56	1.02	1.02	1.02	
ASPHALT AND ROAD OIL	2.00	2.00	2.00	7.98	7.98	5.76	2.00	2.00	2.00	2.00
COKE (LO SULFUR)		.14		.27	.27	.22				
COKE (HI SULFUR)										1.55
COKE (CAL CRUDE)							.65	.74	1.62	
BENZENE	.12	.12	.12				.14	.12	.12	.14
TOLUENE	.29	.29	.29				.29	.29	.29	.29
MIXED XYLENES	.26	.26	.26				.26	.26	.25	.35
MISC. PRODUCTS				.50	1.44	.50	.50			
TOTAL	102.04	104.27	105.60	100.17	98.99	99.91	103.42	106.61	106.09	99.58
INPUT-OUTPUT	-.93	1.70	1.70	-2.23	-4.57	-2.15	-.08	2.71	2.53	-3.78
OPERATING COST FACTORS										
ELEC. PWR (1000KWH/D)	661.52	650.21	506.93	215.22	258.61	215.22	647.56	587.14	704.11	643.80
FUEL REQD. (1000FOEB)	7.27	7.35	6.24	4.05	4.05	3.46	8.40	6.69	7.30	7.22
ENERGY CONS. (1000FO	9.51	8.58	7.19	4.45	4.53	3.86	9.62	7.80	8.62	8.43
LABOR (NO. EMPLOYEES	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
OPER COSTS (M$/D)	21.51	12.59	9.67	4.37	5.83	4.37	21.94	10.54	14.49	23.59
INVESTMENTS (MM$)										

```
 WC7   WCC  SCOPE 3.4.3     406E.448  11/14/77
15.14.09.S3L302J  FROM     /51
15.14.09.IP  00000576 WORDS - FILE INPUT  , DC 00. 51
15.14.09.$SEQUENCE,303.
15.14.09.RAOP,P4,T100,MT1.
15.14.11.USER(JMA72WC,)
15.14.11.ATTENTION - PLEASE CHANGE YOUR COD
15.14.11.SUPPLIED PASSWORD.
15.14.12.LABEL(MAG1,R,VSN=P16561,L=NOV77INDUSPLOD
15.14.12.,NORING)
15.15.44.MT22 VOLUME SERIAL NUMBER IS  P16561
15.15.44.MT22 ASSIGNED TO  MAG1
15.15.48.$VSN= P16561, RD ACCESS GRANTED
15.15.48. LABEL READ WAS      NOV77INDUSPLOD
15.15.48.    EDITION NUMBER    01
15.15.48.    RETENTION CYCLE   000
15.15.48.    CREATION DATE     77311
15.15.48.    REEL NUMBER       0001
15.15.48.COPYR(MAG1,OLD1,1)
15.15.51. COPYR COMPLETE
15.15.51.UNLOAD(MAG1)
15.15.52.REWIND(OLD1)
15.15.52.UPDATE(P=OLD1,N=NEW1,C=COM1,D,F)
15.15.55. UPDATE COMPLETE.
15.15.55.REWIND(COM1)
15.16.13.FTN(I=COM1,R=2,OPT=2,L=0,B=B1)
15.18.39.      9.696 CP SECONDS COMPILATION TIME
15.18.39.COPYCR(INPUT,TAPE5)
15.18.39.LABEL(MAG2,R,VSN=P14276,L=RIM74BASEN12,N
15.18.39.ORING)
15.19.11.MT23 VOLUME SERIAL NUMBER IS  P14276
15.19.11.MT23 ASSIGNED TO  MAG2
15.19.14.$VSN= P14276, RD ACCESS GRANTED
15.19.14. LABEL READ WAS      RIM74BASEN12
15.19.14.    EDITION NUMBER    01
15.19.14.    RETENTION CYCLE   000
15.19.14.    CREATION DATE     77316
15.19.14.    REEL NUMBER       0001
15.19.14.COPYCF(MAG2,TAPE13,1)
15.19.24.COPYCF(MAG2,0,1)
15.19.26.COPYBF(MAG2,TAPE12,1)
15.19.28.UNLOAD(MAG2)
15.19.28.REWIND(B1,TAPE5,TAPE12,TAPE13)
15.19.28.RFL(220000)
15.19.33.B1.
15.22.42.     STOP
15.22.42.RFL(15000)
15.22.43.REWIND(TAPE16,TAPE17,TAPE18,TAPE19,TAPE2
15.22.43.0)
15.22.43.COPY(TAPE16,OUTPUT)
15.22.46.COPY(TAPE17,OUTPUT)
15.22.47.COPY(TAPE18,OUTPUT)
15.22.47.COPY(TAPE19,OUTPUT)
15.22.49.COPY(TAPE20,OUTPUT)
15.22.49.EXIT.
15.22.49.OP  [illegible] WORDS - FILE OUTPUT , DC 40, 51
15.22.49.[illegible] [illegible] 15.10.11  [illegible]
15.22.49.[illegible]      [illegible]  XECUTION [illegible]
15.22.49.MS    35844  WORDS  (  247296 MAX [illegible])
15.22.49.CPA      17.082 SEC.
15.22.49.IO      [illegible] SEC.
15.22.49.CM   1 [illegible]
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Appendix D

INDUSTRY DATA SOURCES

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: Oil and Gas Journal, pp. 100-118 (4 April 1975)
- Supply and demand by PAD districts: Bureau of Mines, Mineral Industry Surveys, "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--Platt's Oil Price Handbook and Oilmanac, 1974 prices, McGraw-Hill, New York (1975).

Table D-1

REFINERY CAPACITY ANALYSIS

Refinery Capacity (10^3 b/cd)	PAD District										U.S. Total	
	I		II		III		IV		V			
	No.	10^3 b/cd	No.	10^3 b/cd	No.	10^3 b/cd	No.	10^3 b/cd	No.	10^3 b/cd	No.	10^3 b/cd
0-20	15	115	22	197	35	228	15	67	22	197	109	205
20-50	2	96	19	691	18	604	13	427	13	430	65	2,249
50-100	6	534	13	854	12	915	1	52	8	647	40	3,002
100-200	4	667	12	1,645	7	909	--	--	7	928	30	4,149
200+	1	265	2	643	11	3,476	--	--	1	230	15	4,614
	28	1,678	68	4,030	83	6,132	29	547	51	2,432	259	14,819

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)

	PAD Districts						
	I	II	III	IV	I-IV	V	U.S. Total
Domestic Prod.: Crude & lease condensate	120	915	5,959	691	7,685	1,080	8,765
Natural gas plant liquids	24	249	1,336	47	1,656	32	1,688
Receipts from other districts	2,947	2,610	206	61	23	185	-
Imports:							
Natural gasoline and plant condensate	8	52	--	23	83	6	89
Crude oil	1,174	687	795	45	2,701	776	3,477
Unfinished oils	39	3	52	--	94	27	121
Refined products	2,046	85	115	16	1/ 2,262	2/ 139	2,401
Other hydrocarbons and hydrogen input	2	3	18	1	24	12	36
Total new supply	6,360	4,604	8,481	884	14,528	2,257	16,577
Unaccounted for crude oil	---	58	-86	12	-16	--	-16
Processing gain	64	135	187	10	396	85	481
Total supply	6,424	4,797	8,582	906	14,908	2,342	17,042
Change in stocks of all oil	-10	+56	+92	+7	+145	+34	+179
Total disposition of primary supply	6,434	4,741	8,490	899	14,763	2,308	16,863
Exports:							
Crude oil	--	--	3	--	3	--	3
Refined products	17	10	99	--	126	92	218
Shipments to other districts	244	211	5,102	429	185	23	
Crude losses (est. for individual Dist. I-IV)	1	2	8	1	12	1	13
Domestic demand for products:							
Gasoline, total	2,160	2,249	1,003	211	5,623	959	6,582
Motor gasoline	2,150	2,238	992	209	5,589	948	6,537
Aviation gasoline	10	11	11	2	34	11	45
Jet Fuel, total	370	192	118	31	711	282	993
Naphtha - type	57	42	48	9	156	66	222
Kerosine - type	313	150	70	22	555	216	771
Ethane (including ethylene)	5	40	294	1	340	1	341
Liquefied gases	158	352	473	25	1,008	56	1,064
Kerosine	73	52	40	3	168	8	176
Distillate fuel oil	1,338	879	355	107	2,679	260	2,939
Residual fuel oil	1,706	240	252	34	2,232	392	2,624
Petrochemical feedstocks	30	30	286	---	346	17	363
Special naphthas	21	30	21	---	72	15	87
Lubricants	61	38	41	2	142	13	155
Wax	7	4	6	---	17	3	20
Coke	32	98	69	11	210	29	239
Asphalt	136	154	84	27	401	62	463
Road oil	1	11	--	2	14	5	19
Still gas for fuel	53	122	206	15	396	85	481
Plant condensate	--	17	--	--	17	--	17
Miscellaneous products	21	10	30	--	61	5	66
Total	6,172	4,518	3,278	469	14,437	2,192	16,629
Stocks of all oils (10^3 barrels)							
Crude oil and lease condensate	16,864	79,553	110,410	15,807	222,634	42,386	265,020
Unfinished oils	15,055	22,143	39,600	2,900	79,698	26,333	106,031
Natural gasoline and plant condensate	165	1,622	5,458	218	7,463	87	7,550
Refined products	194,129	201,596	213,178	17,705	626,608	68,437	695,045
Total	226,213	304,914	368,646	36,630	936,403	137,243	1,073,646

Table D-2 (Continued)

	Refinery Output	Natural gas liquids: Blended at refinery	Natural gas liquids: Plant production	Other 3/ hydrocarbons blended	Imports	DOMESTIC RECEIPTS by Districts: From I	From II	From III	From IV	From V	Stock change	Exports	4/ Shipments to other Districts	Local demand	Inventories 5/: First of year	Inventories 5/: End of year
Motor gasoline - District I	688	11	-	2	176	-	34	1,364	-	-	-1	-	126	2,150	58,891	58,641
II	1,755	106	-	3	1	126	-	254	14	-	+6	-	95	2,238	65,402	67,514
III	2,123	463	3	18	19	-	54	-	-	-	+17	2	1,669	992	54,339	60,554
IV	103	40	-	1	1	-	7	14	-	12	-1	-	50	209	7,625	7,482
I-IV	4,749	700	3	74	197	-	-	-	-	12	+21	2	73	5,589	186,757	194,191
V	826	46	-	12	7	-	-	37	36	-	+3	1	12	948	23,221	24,219
U.S. Total	5,575	746	3	36	204						+24	3		6,537	209,478	218,610
Aviation gasoline - District I	1	-	-	-	-	-	-	9	-	-	-	-	-	10	597	613
II	6	-	-	-	-	-	-	5	-	-	-	-	-	11	919	907
III	24	-	-	-	-	-	-	-	-	-	-1	-	14	11	1,668	1,229
IV	2	-	-	-	-	-	-	-	-	-	-	-	-	2	54	49
I-IV	33	-	-	-	-	-	-	-	-	-	-1	-	-	34	3,238	2,798
V	11	-	-	-	-	-	-	-	-	-	-	-	-	11	701	673
U.S. Total	44	-	-	-	-						-1	-		45	3,939	3,471
Naphtha type jet fuel - District I	9	-	-	-	19	-	-	30	-	-	-	-	1	57	293	221
II	41	-	-	-	-	1	-	1	1	-	+1	-	1	42	1,214	1,329
III	80	-	-	-	2	-	1	-	-	-	-	-	35	46	2,254	2,119
IV	12	-	-	-	-	-	-	-	-	-	-	-	3	9	230	290
I-IV	142	-	-	-	21	-	-	-	-	-	+1	-	6	156	3,991	4,167
V	53	-	-	-	6	-	-	4	2	-	-1	-	-	66	1,608	1,362
U.S. Total	195	-	-	-	27						-	-		222	5,599	5,529
Kerosine type jet fuel - District I	28	-	-	-	75	-	-	214	-	-	-	-	4	313	5,235	5,276
II	125	-	-	-	5	4	-	15	-	-	-1	-	-	150	6,026	5,480
III	312	-	-	-	8	-	-	-	-	-	+4	-	246	70	6,178	7,536
IV	14	-	-	-	-	-	-	10	-	-	-	-	2	22	385	449
I-IV	479	-	-	-	88	-	-	-	-	-	+3	-	9	555	17,824	18,741
V	162	-	-	-	47	-	-	7	2	-	-	2	-	216	5,121	5,165
U.S. Total	641	-	-	-	135						+3	2		771	22,945	23,906
Ethane (incl. ethylene) - District I	-	-	5	-	-	-	-	-	-	-	-	-	-	5	-	-
II	1	-	40	-	-	-	-	-	-	-	+1	-	-	40	1,225	1,550
III	15	-	277	-	-	-	-	-	-	-	-2	-	-	294	3,795	3,009
IV	-	-	1	-	-	-	-	-	-	-	-	-	-	1	3	3
2-IV	16	-	323	-	-	-	-	-	-	-	-1	-	-	340	5,023	4,362
V	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
U.S. Total	17	-	323	-	-						-1	-		341	5,023	4,362
Liquefied gases - District I	47	-1	16	-	15	-	29	40	-	-	-4	-	-	158	5,590	6,111
II	74	-83	152	-	53	-	-	207	-	-	+10	-	39	352	32,976	36,680
III	149	-104	691	-	26	-	10	-	10	-	+31	20	238	473	52,905	64,559
IV	5	-10	31	-	13	-	-	3	-	-	+1	-	18	23	664	830
I-IV	275	-200	890	-	109	-	-	-	-	-	+38	20	8	1,006	92,135	106,160
V	46	-19	14	-	13	-	-	-	8	-	+1	5	-	56	1,483	1,792
U.S. Total	321	-219	904	-	172						+39	25		1,064	93,618	107,980

Table D-2 (Continued)

	Refinery output	Natural gas liquids: Blended at refinery	Natural gas liquids: Plant production	Other 3/ hydrocarbons blended	Imports	Domestic receipts by Districts: From I	From II	From III	From IV	From V	Stock change	Exports	4/ Shipments to other Districts	Local demand	Inventories 5/: First of year	Inventories 5/: End of year
Kerosine - District I	14	-	-	-	4	-	-	32	-	-	-4	-	1	73	8,501	6,907
II	38	-	-	-	-	1	-	8	-	-	-3	-	-	32	6,214	4,293
III	93	-	1	-	1	-	-	-	-	-	-3	-	60	40	3,612	3,362
IV	2	-	-	-	-	-	-	-	-	-	-1	-	-	3	477	169
I-IV	147	-	1	-	5	-	-	-	-	-	-15	-	-	168	20,604	14,933
V	8	-	-	-	-	-	-	-	-	-	-	-	-	8	418	336
U.S. Total	155	-	1	-	5						-15	-		176	21,022	15,269
Distillate fuel oil - District I	372	-	-	C -	237	-	3	731	-	-	-7	-	32	1,338	79,478	76,739
II	769	-	-	C 1	1	32	-	86	10	-	+1	-	19	879	61,104	61,356
III	1,177	-	1	C -	13	-	13	-	-	-	+13	-	838	333	37,814	43,676
IV	125	-	-	C -	-	-	1	2	-	5	-	-	26	107	4,150	3,982
I-IV	2,463	-	1	C 1	273	-	-	-	-	3	+9	-	35	2,679	182,636	183,733
V	215	-	-	C 1	7	-	-	19	16	-	+1	2	5	260	13,825	16,315
U.S. Total	2,668	-	1	C 2	280						+10	2		2,939	196,461	200,068
Residual fuel oil - District I	154	-	-	C -	1,639	-	-	99	-	-	+6	-	-	1,706	23,618	27,639
II	180	-	-	C 1	21	-	-	36	-	-	-1	-	-	240	8,293	8,032
III	361	-	-	C 3	32	-	-	-	-	-	+9	2	136	232	7,066	10,072
IV	34	-	-	C 1	-	-	-	-	-	-	-	-	1	34	881	935
I-IV	730	-	-	C 7	1,313	-	-	-	-	-	+14	2	2	2,232	41,658	46,678
V	340	-	-	C 6	59	-	-	1	1	-	+3	12	-	392	11,822	13,016
U.S. Total	1,070	-	-	C 13	1,372						+17	14		2,614	53,480	59,694
Petrochemical feedstocks - District I	20	-	-	-	2	-	-	10	-	-	-	2	-	30	12	196
II	27	-	-	-	-	-	-	4	-	-	-	1	-	30	474	480
III	299	-	-	-	10	-	-	-	-	-	+2	7	14	286	1,390	2,233
IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
I-IV	346	-	-	-	12	-	-	-	-	-	+2	10	-	346	2,076	2,909
V	23	-	-	-	-	-	-	-	-	-	+1	5	-	17	311	577
U.S. Total	369	-	-	-	12						+3	13		363	2,387	3,486
Special naphtha - District I	1	-	-	-	-	-	-	21	-	-	-	1	-	21	946	1,167
II	20	-	-	-	3	-	-	9	-	-	+1	1	-	30	901	1,164
III	33	-	-	-	-	-	-	-	-	-	+2	2	30	21	1,998	2,719
IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39	22
I-IV	76	-	-	-	3	-	-	-	-	-	+3	4	-	72	3,883	5,072
V	15	-	-	-	-	-	-	-	-	-	-	-	-	15	636	648
U.S. Total	91	-	-	-	3						+3	4		87	4,521	5,720
Lubricants - District I	33	-	-	-	4	-	-	33	-	2	+4	9	-	61	3,374	4,932
II	30	-	-	-	-	-	-	11	-	-	+2	1	-	30	2,177	3,039
III	113	-	-	-	1	-	-	-	-	-	+4	20	31	41	3,229	6,444
IV	1	-	-	-	-	-	-	-	-	2	-	-	1	2	111	72
I-IV	179	-	-	-	3	-	-	-	-	4	+10	30	6	142	11,091	14,504
V	15	-	-	-	-	-	-	5	1		+1	3	4	13	1,095	1,556
U.S. Total	194	-	-	-	5						+11	33		155	12,186	16,060

Table D-2 (Continued)

	Refinery output	Natural gas liquids: Blended at refinery	Natural gas liquids: Plant production	Other 3/ hydrocarbons blended	Imports	DOMESTIC RECEIPTS by Districts: From I	From II	From III	From IV	From V	Stock change	Exports	4/ Shipments to other districts	Local demand	Inventories 5/: First of year	Inventories 5/: End of year
Wax - District I	3	-	-	-	3	-	-	1	-	-	-	-	-	7	204	222
II	4	-	-	-	-	-	-	-	-	-	-	-	-	4	228	270
III	9	-	-	-	-	-	-	-	-	-	-	2	1	6	451	544
IV	-	-	-	-		-	-	-	-	-	-	-	-	-	55	63
I-IV	16	-	-	-	3	-	-	-	-	-	-	2	-	17	938	1,099
V	3	-	-	-	-	-	-	-	-	-	-	-	-	3	52	96
U.S. Total	19	-	-	-	3						-	2		20	990	1,195
Coke 6/ -																
District I	33	-	-	-	-	-	-	-	-	-	-2	5	-	52	2,726	1,894
II	99	-	-	-	-	-	-	-	-	-	-6	7	-	98	2,533	494
III	109	-	-	-	-	-	-	-	-	-	-1	41	-	69	561	244
IV	11	-	-	-	-	-	-	-	-	-	-	-	-	11	1,825	1,651
I-IV	252	-	-	-	-	-	-	-	-	-	-9	51	-	210	7,445	4,283
V	87	-	-	-	-	-	-	-	-	-	-4	62	-	29	2,529	1,157
U.S. Total	339	-	-	-	-						-13	113		239	9,974	5,420
Asphalt -																
District I	93	-	-	-	30	-	-	16	-	-	+5	-	-	136	4,229	5,335
II	153	-	-	-	-	-	-	10	-	-	+9	-	-	154	4,634	7,031
III	113	-	-	-	1	-	-	-	-	-	+3	1	26	84	2,766	4,172
IV	27	-	-	-	-	-	-	-	-	1	+1	-	-	27	1,270	1,651
I-IV	386	-	-	-	31	-	-	-	-	1	+16	1	-	401	12,899	10,988
V	64	-	-	-	-	-	-	-	-	-	+1	-	1	62	2,125	2,382
U.S. Total	450	-	-	-	31						+17	1		463	15,024	21,370
Road oil -																
District I	1	-	-	-	-	-	-	-	-	-	-	-	-	1	64	9
II	11	-	-	-	-	-	-	-	-	-	-	-	-	11	181	551
III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IV	2	-	-	-	-	-	-	-	-	-	-	-	-	2	21	18
I-IV	14	-	-	-	-	-	-	-	-	-	-	-	-	14	267	358
V	6	-	-	-	-	-	-	-	-	-	+1	-	-	5	532	722
U.S. Total	20	-	-	-	-						+1	-		19	799	1,080
Miscellaneous products -																
District I	13	-	-	-	2	-	-	7	-	1	-	2	-	21	188	229
II	8	-	-	-	-	-	-	5	-	-	+1	-	-	10	275	435
III	40	-	2	-	-	-	-	-	-	-	-	2	10	30	640	706
IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	14
I-IV	61	-	2	-	2	-	-	-	-	1	+1	4	-	61	1,118	1,384
V	6	-	-	-	-	-	-	-	-	-	-	-	1	5	276	441
U.S. Total	67	-	2	-	2						+1	4		66	1,394	1,825
Still gas 7/ -																
TOTAL District I	1,563	10	21	2	2,046	-	66	2,637	-	5	-5	17	164	6,172	195,946	194,129
II	5,463	101	192	5	85	164	-	649	25	-	+19	10	154	4,501	194,658	201,596
III	5,281	359	975	23	115	-	80	-	10	-	+78	99	3,388	3,278	184,676	213,178
IV	433	30	32	2	16	-	8	29	-	20	-	-	101	469	17,805	17,705
I-IV	10,740	500	1,220	32	2,262	-	-	-	-	25	+92	126	139	14,420	593,085	626,608
V	1,976	27	14	19	139	-	-	73	66	-	+7	92	23	2,192	65,755	68,437
U.S. Total	12,716	527	1,234	51	2,401						199	218		16,612	658,840	695,045

Table D-2 (Concluded)

	SUPPLY											DISTRIBUTION							STOCKS (thous. barrels)	
			Domestic Receipts									Runs to stills								
	Production	Imports	From Dist. I	From Dist. II	From Dist. III	From Dist. IV	From Dist. V	Total	Total new supply	Stock change	Total supply	Domestic	Foreign	Transfers to products	Shipped to other Districts	Exports	Loss	Un-accounted for	First of year	End of year
Crude oil and lease condensate-																				
District I	120	1,174	-	36	153	1	-	190	1,484	-3	1,487	255	1,175	-	78	-	1	-	18,118	16,864
II	915	687	-	-	1,497	268	-	1,765	3,367	+35	3,334	2,654	679	2	55	-	2	38	67,425	79,553
III	5,959	795	78	19	-	11	-	108	6,862	+5	6,857	4,317	786	5	1,652	3	8	-86	108,705	110,410
IV	691	45	-	-	-	-	-	-	736	+7	729	576	44	1	319	-	1	12	13,251	13,807
I-IV	7,685	2,701	-	-	-	-	-	-	10,386	+42	10,344	7,582	2,682	8	41	3	12	-16	207,479	222,634
V	1,080	776	-	-	2	39	-	41	1,897	+20	1,877	1,099	770	7	-	-	1	-	34,999	42,386
U.S. Total	8,765	3,477							12,242	+62	12,180	8,681	3,452	15		3	13	-16	242,478	265,020
Natural gasoline, isopentane and plant condensate-																		Local 8/ demand		
District I	3	8	-	-	-	-	-	-	11	-	11	10	-	-	1	-	-	-	14	165
II	57	52	-	-	7	-	-	7	116	-2	118	101	-	-	-	-	-	17	2,278	1,623
III	561	-	1	-	-	5	-	6	367	+1	366	559	-	-	7	-	-	-	5,061	5,458
IV	15	23	-	-	-	-	-	-	38	-	38	30	-	-	8	-	-	-	392	218
I-IV	436	83	-	-	-	-	-	-	519	-1	520	500	-	-	3	-	-	17	7,745	7,463
V	18	6	-	-	-	3	-	3	27	.-	27	27	-	-	-	-	-	-	90	87
U.S. Total	454	89							545	-1	544	527	-	-		-	-	17	7,835	7,550
Unfinished oils-																				
District I	91	59	-	1	50	-	-	51	-1	-2	-	-	-	-	1	-	-	-	15,712	15,055
II	-5	3	-	-	-	-	-	-	8	+6	-	-	-	-	2	-	-	-	20,126	22,145
III	-9	52	1	1	-	-	-	2	65	+8	-	-	-	-	55	-	-	-	36,709	39,600
IV	3	-	-	-	4	-	-	4	1	-	-	-	-	-	1	-	-	-	2,795	2,900
I-IV	80	94	-	-	-	-	-	-	14	+12	-	-	-	-	2	-	-	-	75,342	79,690
V	22	27	-	-	1	1	-	2	7	+7	-	-	-	-	-	-	-	-	23,812	26,333
U.S. Total	102	121							19	+19	-	-	-	-		-	-	-	99,154	106,031

C Crude.
1/ Includes bonded naphtha jet 4, bonded kerosine jet 58, 04 distillate fuel 59, bonded distillate fuel 10, bonded residual fuel 86, and military offshore use of residual fuel 4.
2/ Includes bonded naphtha jet 1, bonded kerosine jet 52, 04 distillate fuel 8, bonded distillate fuel 1, bonded residual fuel 9, and military offshore use of residual fuel 4.
3/ Includes crude oil transfers Dist. I -, Dist. II 2, Dist. III 5, Dist. IV 1, Dist. V 7, U.S. Total 15.
4/ Includes rail and truck shipments to and from Dist. V only.
5/ Thousands of barrels.
6/ Refinery output includes marketable catalyst coke Dist. I 20, Dist. II 55, Dist. III 65, Dist. IV 8, Dist. V 24, U.S. Total 168.
7/ Still gas production-demand Dist. I 53, Dist. II 122, Dist. III 206, Dist. IV 15, Dist. V 85, U.S. Total 481.
8/ Included in domestic demand on Page of Table

Source: Bureau of Mines, "Petroleum Statement," monthly, Table 32, pp. 36-40, U.S. Department of the Interior (January 1975)

Table D-3

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

	December 1974	November 1974	December 1973	January - December (Incl.) 1974	January - December (Incl.) 1973
From District 1 to District 2:					
Gasoline, total	3,818	3,958	3,709	46,032	45,438
Motor	3,811	3,958	3,709	45,986	45,385
Aviation	7	-	-	46	53
Jet fuel, total	148	158	212	1,786	2,612
Naphtha-type	-	-	35	302	595
Kerosine-type	148	158	177	1,484	2,017
Kerosine	37	30	50	270	403
Distillate fuel oil	1,134	1,101	991	11,605	11,662
From District 2 to District 1:					
Gasoline, total	975	912	871	12,440	10,066
Motor	975	912	871	12,440	10,066
Jet fuel, total	-	-	-	-	57
Naphtha-type	-	-	-	-	57
Kerosine	21	4	-	45	49
Distillate fuel oil	147	151	69	1,167	980
Natural gas liquids	1,403	770	1,117	10,351	11,910
From District 2 to District 3:					
Gasoline, total	1,659	1,556	1,555	19,582	18,591
Motor	1,659	1,556	1,555	19,582	18,591
Jet fuel, total	1	30	1	520	47
Naphtha-type	-	30	-	513	41
Kerosine-type	1	-	1	7	6
Distillate fuel oil	484	44	452	5,466	4,743
Natural gas liquids	364	307	330	3,886	3,267
From District 2 to District 4:					
Gasoline, total	242	257	360	2,415	674
Motor	242	257	360	2,415	674
Distillate fuel oil	41	42	27	585	92
From District 3 to District 1:					
Gasoline, total	28,998	26,973	27,035	321,271	329,835
Motor	28,983	26,973	27,027	321,065	329,616
Aviation	15	-	8	206	219
Jet fuel, total	4,815	5,066	4,952	51,375	55,504
Naphtha-type	142	133	116	1,423	747
Kerosine-type	4,673	4,933	4,836	49,952	54,757
Kerosine	1,007	838	1,022	8,147	11,134
Distillate fuel oil	14,932	14,110	17,591	173,417	180,331
Natural gas liquids	2,447	1,383	1,875	15,846	18,112
From District 3 to District 2:					
Gasoline, total	4,062	6,333	5,957	66,521	64,857
Motor	3,948	6,217	5,852	65,254	63,660
Aviation	114	116	105	1,267	1,197
Jet fuel, total	147	454	503	3,178	4,614
Naphtha-type	-	2	-	69	3
Kerosine-type	147	452	503	3,109	4,611
Kerosine	25	202	355	2,043	2,505
Distillate fuel oil	1,925	2,972	3,097	25,088	30,938
Natural gas liquids	9,141	7,765	7,706	75,576	71,698
From District 3 to District 4:					
Gasoline, total	347	460	312	5,305	4,759
Motor	336	452	297	5,146	4,499
Aviation	11	8	15	159	260
Jet fuel, total	340	309	345	3,824	4,175
Kerosine-type	340	309	345	3,824	4,175
Kerosine	-	-	-	1	4
Distillate fuel oil	61	46	68	562	688
Natural gas liquids	153	106	155	963	1,259
From District 3 to District 5:					
Gasoline, total	1,031	1,028	1,164	12,190	11,873
Motor	1,031	1,028	1,164	12,190	11,873
Jet fuel, total	241	199	122	2,146	1,708
Naphtha-type	122	90	37	894	652
Kerosine-type	119	109	85	1,252	1,056
Distillate fuel oil	419	446	322	4,481	4,532
From District 4 to District 2:					
Gasoline, total	462	361	430	5,020	4,552
Motor	462	361	430	5,020	4,552
Jet fuel, total	44	67	16	450	310
Naphtha-type	44	60	16	389	310
Kerosine-type	-	7	-	61	-
Kerosine	9	-	2	19	59
Distillate fuel oil	349	321	320	3,720	3,304
Natural gas liquids	-	-	-	14	-
From District 4 to District 3:					
Natural gas liquids	288	252	285	3,751	3,699
From District 4 to District 5:					
Gasoline, total	862	715	595	10,540	7,805
Motor	862	715	595	10,540	7,805
Jet fuel, total	131	112	79	1,566	828
Naphtha-type	72	59	69	862	351
Kerosine-type	59	53	10	704	477
Distillate fuel oil	714	340	440	4,851	3,672

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)

Item	December 1974	November 1974	December 1973	January - December (Incl.) 1974	January - December (Incl.) 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 naphthas	681	692	629	7,646	7,192
Kerosine	1,224	1,076	1,328	10,879	15,078
Distillate fuel oil	13,195	10,068	8,973	93,460	96,283
Residual fuel oil	3,312	3,961	2,129	36,023	16,960
Jet fuel, total	3,072	3,136	3,734	37,475	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	-	-	-	227	14
Kerosine-type	276	175	184	2,471	2,612
Lubricating oil	329	310	259	4,125	3,692
Wax	-	-	-	8	-
Asphalt and road oil	118	212	348	3,684	3,523
Liquefied gases	-	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:					
Crude oil	-	-	-	564	-
Unfinished oils	-	-	-	288	372
Motor gasoline	-	-	-	1,392	675
Kerosine	-	-	-	-	36
Distillate 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	-	-	-	-	-
Special naphthas	-	-	-	-	4
Distillate fuel oil	-	-	-	-	-
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 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

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)

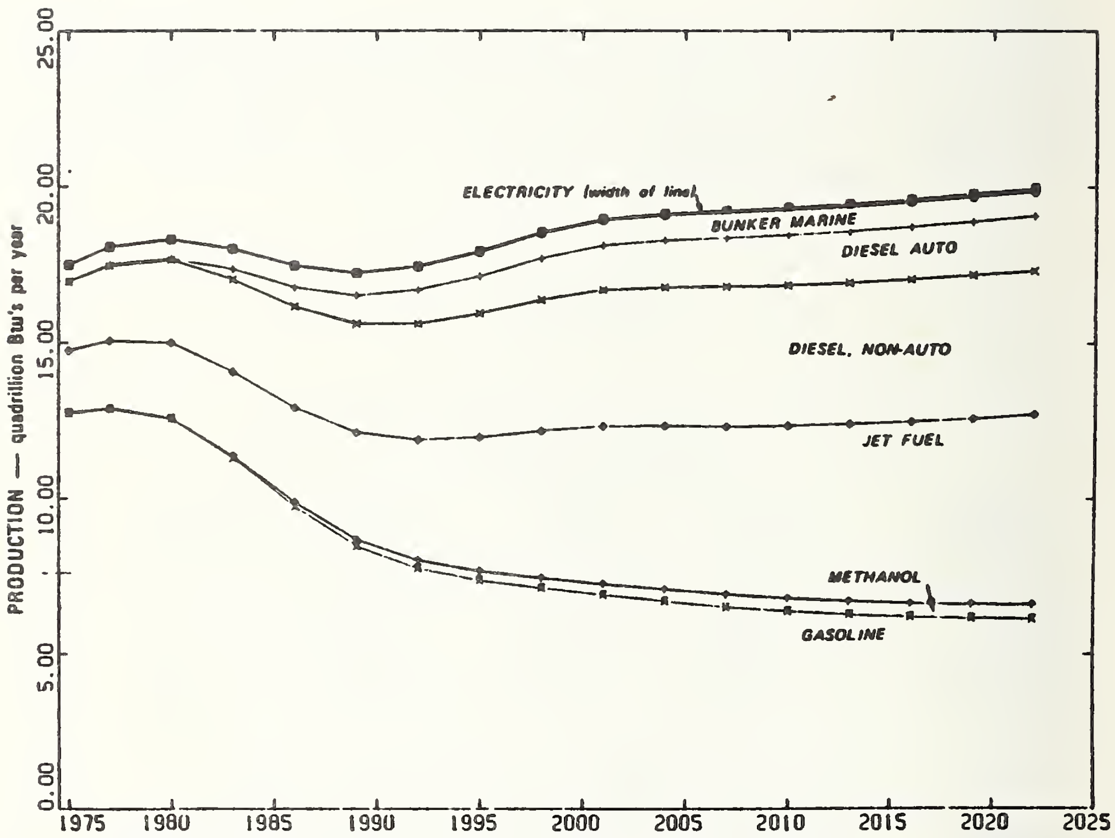
Case	1975	1985	2000	2025
High demand	$7,030	$11,200	$18,700	$40,600
Base	7,030	10,081	13,783	20,713
Low demand	7,030	8,800	10,100	9,600

(b) Growth in Per Capita Gross National Products

Case	1975-1985	1985-2000	1975-2000	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

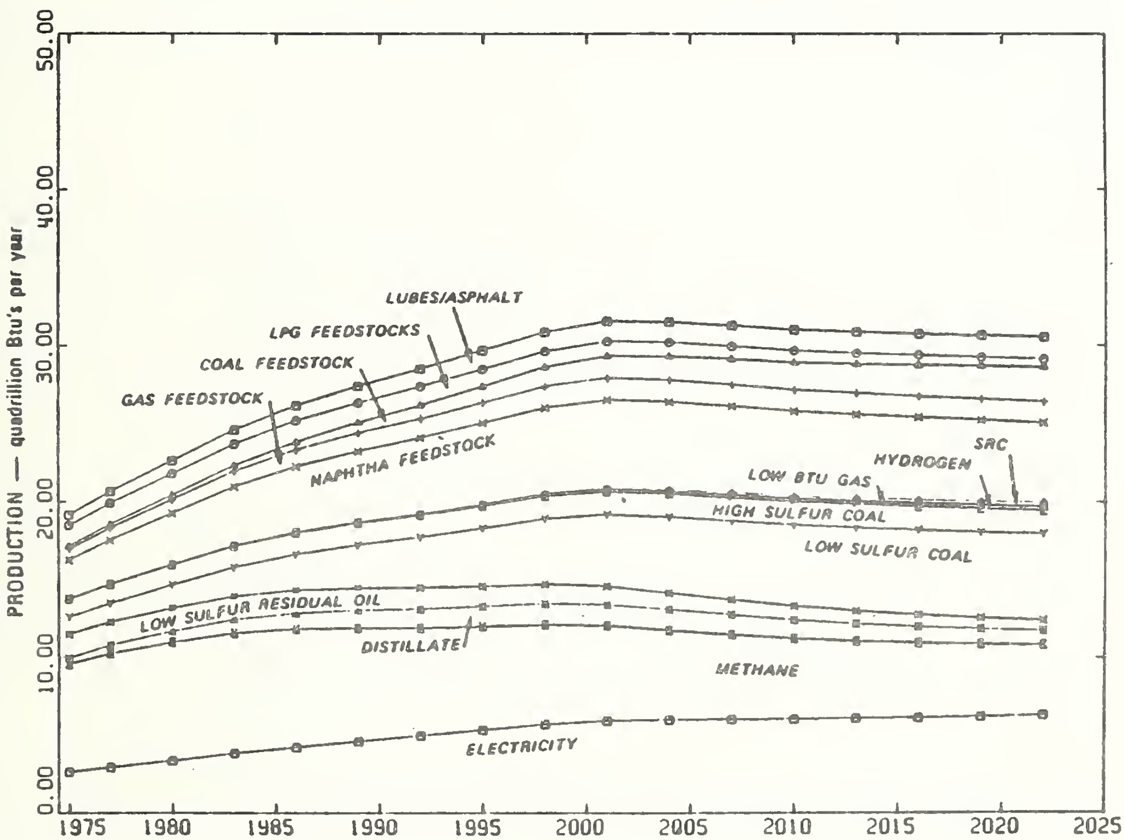
Source: EPRI EA-433, Vol. I, p. 3-2

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



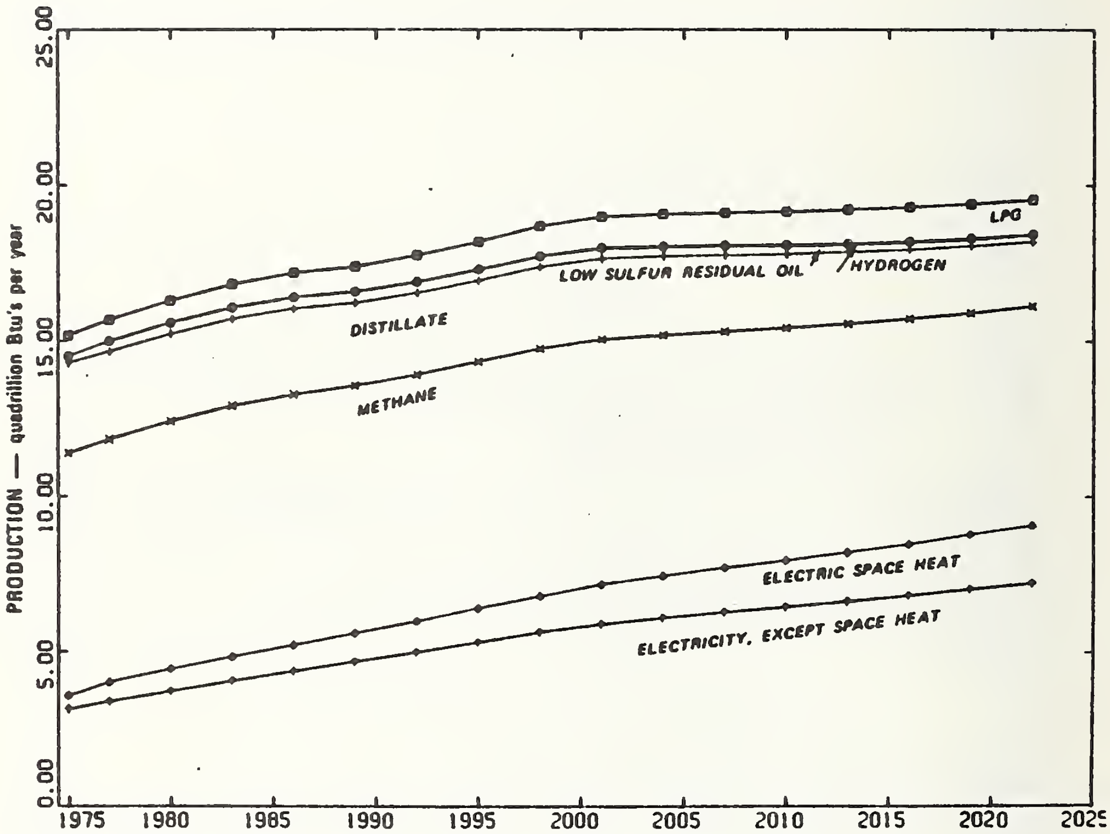
SOURCE: EPRI EA-433, p. 3-30

FIGURE E-1 DISTRIBUTED PRODUCTS IN THE TRANSPORTATION SECTOR — LOW DEMAND CASE



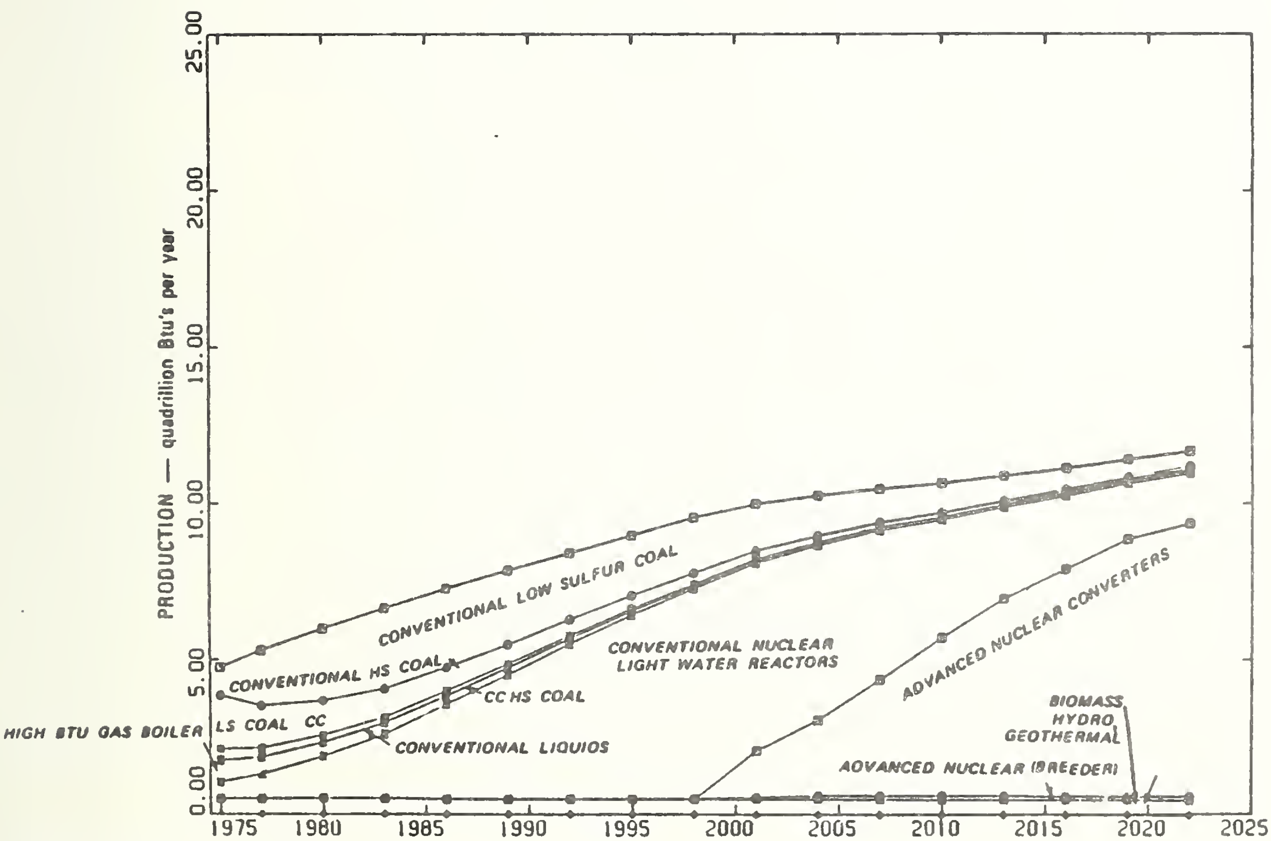
SOURCE: EPRI EA-433, p. 3-34.

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



SOURCE: EPRI EA-433, p. 3-39.

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



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

FIGURE E-4 BASE LOAD ELECTRIC POWER GENERATION — LOW DEMAND CASE

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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